When electrons are injected into the Alq layer **3** by the formation of the space charge due to the holes (Fig. **4(b)**), excitons are generated by the recombination of the holes and the electrons on both TPD/TAZ and TAZ/Alq interfaces (Fig. **4(c)**) and the TPD and the Alq whose excitation energy levels are lower those of the TAZ are excited by the excitons thus generated to emit light.

The reason why the injected holes are divided into two types in the foregoing is that the injection amount of the holes is inversely proportional to the cubic of the film thickness of the TAZ layer **2**, as described above.

Since the TAZ layer of the element in Fig. **4** allows both of the holes and the electrons to pass through, there might have a chance that the recombination of both may occur in the TAZ layer **2**. The TAZ, however, has a peak light emission at a shorter wavelength region of not more than 4000 nm. Even if the TAZ is excited by the excitons generated by the above recombination, excitation energy is transported to either or both of the TPD layer or/and the Alq layer, each having a peak light emission at a longer wavelength region. Consequently, the TAZ layer **2** itself emits no light.

As is evident from the above description, the function of the TAZ layer can be changed by adjusting its film thickness within the above range, in the combination of the TPD layer **1**, the TAZ layer **2** and the Alq layer **3**. However, the relation between the functions of the carrier-transport control layer **2** and its film thickness may not necessarily correspond with the above examples. The range of the film thickness of the layer **2** having a specific function varies depending upon factors such as material constituting the respective layers, the layer structure (e.g. a vapor deposited film, a binder dispersed film, etc.).

In the above layers' combination, when using a vapor deposited film of the PBD (the PBD layer) whose electron-transport properties is lower (i.e., hole-transport properties is higher) than that of the TAZ layer in place of the TAZ layer, it is found that the PBD layer does not show hole-block properties equal to that of the TAZ layer having the same film thickness as the PBD because the hole injection amount is proportional to the mobility. Therefore, in order to provide the PBD layer with the same function as the TAZ layer, it is required to have a larger film thickness than the TAZ layer, which will be evident from Examples described later.

As seen from the description as to Fig. **4**, it is possible to change the ratio for the luminescence intensity of the hole-transport layer **1** and the electron-transport layer **3** by adjusting the film thickness of the carrier-transport control layer **2** because the hole injection amount of the layer **2** such as the TAZ layer is inversely proportional to the cubic of its film thickness.

Accordingly, the combination of the hole-transport layer **1** and electron-transport layer **3** which emit light at different spectrums likewise in the combination of the TPD layer and the Alq layer, also offers the advantage that the color tone of the overall emission color being a mixed color of both layers' emission colors can be finely adjusted by suitably selecting the film thickness of the carrier-transport control layer **2**.

In the second element, it is essential to have three layers: a hole-transport layer **1**; a carrier-transport control layer **2** and an electron-transport layer **3**. No particular restrictions are imposed upon other constructions.

The carrier-transport control layer **2** may be solely composed of the carrier-transport control material such as the TAZ and the PBD, or may be formed by dispersing a carrier control material in a suitable binder. The carrier-transport control layer **2** may contain other ingredients such as various additives, which do not inhibit its function.

The respective layers including the carrier-transport control layer **2** can be formed by the aforesaid solution application or vapor phase deposition.

Followings are to describe the third organic electroluminescent element wherein a hole-transport luminescent layer is formed by molecularly dispersing at least one kind of dye in a polymer.

The polymer constituting the hole-transport luminescent layer may or may not have carrier-transport properties. When using the polymer having no carrier-transport properties, there may provide it with hole-transport properties by molecularly dispersing a low-molecular hole-transport material along with a dye.

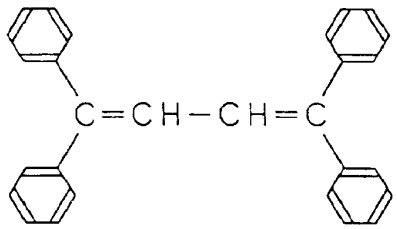
Examples of the polymer having carrier-transport properties include polyphenylenevinylene and its derivative, polyalkylthiophene, the PVK, polymethylphenylsilane, polymer having a triphenylamine group at a side chain or main chain, among others. Most preferred is the PVK because its carrier-transport properties is stable.

The polymerization degree **n** of the PVK is preferably about 20 to 5000 for the same reason above-mentioned.

For the polymer having no carrier-transport properties, there can employ various polymer having excellent optical characteristics . For example, there are polymethyl methacrylate, polycarbonate, polystyrene, polysulfon, polyether sulfon, polyallylate.

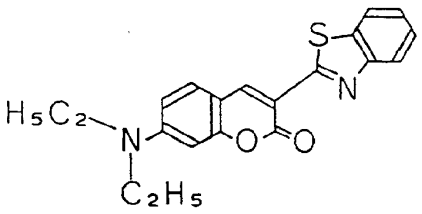
Savant Technologies LLC - 1004.617

For dye to be molecularly dispersed in the polymer, there can employ various dyes such as the aforesaid dyes for laser, which can be excited by excitons to generate fluorescence. Examples of this dye include cyanine dye, xanthene dye, oxazine dye, coumarin derivative, perylene derivative, acridine dye, acridone dye, quinoline dye, among others. More preferred are a tetraphenylbutadiene (blue light emission, hereinafter referred to as "TPB") expressed by the formula:



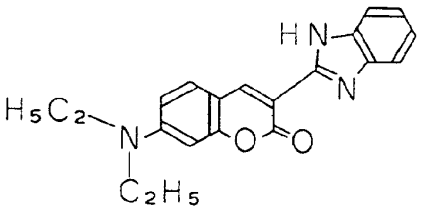
(7)

a coumarine 6 (green light emission) expressed by the formula:



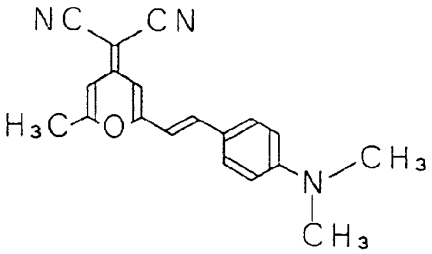
(8)

a coumarine 7 expressed by the formula:



(9)

a 4-dicyanomethylene-2-methyl-6-p-dimethylaminostyryl-4H-pyran (orange emission, hereinafter referred to as "DCM") expressed by the formula:



(10)

Savant Technologies LLC - 1004.618

For white light emission, the combination of the TPB of the formula (7), the coumarine 6 of the formula (8) and the DCM of the formula (10) is appropriate. This combination allows the emission spectrum of the hole-transport luminescent layer to extend over the whole visible light region having a wavelength of 400 to 700 nm, resulting in a good white light emission.

The proportion of the dye formulated in a polymer is not specifically limited, and a preferable range can be set depending upon the kinds of polymer and dye, luminescence intensity, color tone and the like.

When using a polymer having no carrier-transport properties, it is suitable to use a triphenylamine derivative as a lower molecular hole-transport material to be molecularly dispersed in the polymer. More preferred is the TPD.

The hole-transport luminescent layer comprising the above respective components can be formed by the aforesaid solution application.

For an electron-transport layer used in the combination with the hole-transport luminescent layer, there can employ any layers composed of the conventional electron-transport materials. More preferred are the low-molecular 1,2,4-triazole derivative layer and the two-layer structure layer wherein the layer of the 1,2,4-triazole derivative and the Alq layer are laminated with each other.

Since the 1,2,4-triazole derivative is excellent both in electron-transport properties and hole-blocking properties, the recombination of electrons and holes can be sufficiently conducted in the hole-transport luminescent layer and, at the same time, generated excitons can be efficiently contained in the hole-transport luminescent layer, resulting in a further increase in luminous efficiency and luminance of the hole-transport luminescent layer.

A suitable example of the low-molecular 1,2,4-triazole derivative is the TAZ which is excellent in both electron- transport properties and hole-blocking properties.

Although the film thickness of the 1,2,4-triazole derivative layer is not specifically limited, if it is too thin, hole-blocking properties becomes insufficient. Thus it is desirable to have an ample film thickness. Although its suitable range is not specifically limited, 100 to 200Å or more is appropriate for the vapor deposited film of the TAZ expressed by the formula (1) in order to hold a sufficient hole-blocking properties. The upper limit of its film thickness is not specifically limited, but electron-transport properties would decrease if it is too thick. Therefore, for the vapor deposited film of the TAZ, its film thickness is preferably not more than 1000Å.

In the combination of the 1,2,4-triazole derivative layer and the Alq layer, electrons injection properties to the hole-transport luminescent layer increases further, thus obtaining an element being excellent in both luminous efficiency and high luminance.

The film thickness of the Alq layer is not specifically limited, but its film thickness is preferably about 100 to 1000Å, in considering of the electron injection properties and the electron-transport properties to the hole-transport luminescent layer. If the Alq layer is laminated, it can be complementary to the hole-blocking properties of the 1,2,4-triazole derivative layer. Therefore, the film thickness of the 1,2,4-triazole derivative layer may be smaller than the aforesaid range for the vapor deposited film of the TAZ.

Although the total film thickness of both layers is not specifically limited, it is preferably about 200 to 1500Å. If it is smaller than this range, hole- block properties tends to be insufficient. On the other hand, if it is larger than that, electron-transport properties tends to decrease.

The electron-transport layer such as the 1,2,4-triazole derivative layer and the Alq layer may be solely composed by an electron-transport material such as the 1,2,4-triazole derivative and the Alq, or be formed by dispersing an electron-transport material in a suitable binder. The electron-transport layer may contain other ingredients such as various additives which do not inhibit its function.

The electron-transport layer can be formed by the aforesaid solution application or vapor phase deposition.

The layer construction of the third element is not specifically limited.

However, if considered that the polymer constituting the hole-transport luminescent layer is excellent in adhesion to substrates such as the ITO glass and the ITO film, and is formed exclusively by the solution application , it is preferable to use those prepared by laminating two layers: a hole-transport luminescent layer **11** and an electron-transport layer **31** on an anode **40** of a transparent conductive material such as ITO (indium-tin-oxide) being formed on a glass substrate **4** in this order, as shown in Figs. **6(a)** and **6(b)**.

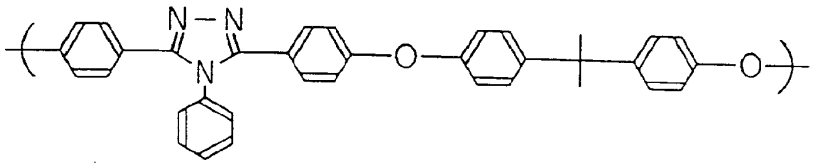
The electron-transport layer **31** of Fig. **6(a)** has a two-layer structure wherein two layers of the 1,2,4-triazole derivative layer (the TAZ layer) **31a** and the Alq layer **31b** are laminated on a hole-transport luminescent layer **11** in this order.

In Figs. **6(a)** and **6(b)**, the reference numerals **5** and **B** denote a cathode of metal deposited film such as Mg/Ag and Al/Li and a power source for applying a drive voltage to the element, respectively.

Savant Technologies LLC - 1004.619

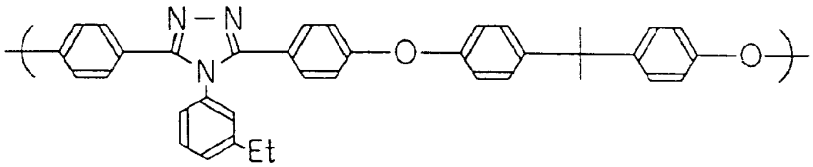
Followings are to describe the fourth organic electroluminescent element comprising a hole-transport layer which contains the PTAZ as a hole-transport material, and the fifth organic electroluminescent element comprising a hole-transport layer which contains the PTAZ as a resin binder in the present invention.

For the PTAZ expressed by the formula (6), there can suitably employ those having a repeating unit expressed by the formula:



(6a)

(hereinafter referred to as "PTAZ-1") or those having a repeating unit expressed by the formula:



(6b)

(hereinafter referred to as "PTAZ-2").

The polymerization degree of the PTAZ is not specifically limited in the present invention, but it is preferably about 3000 to about 30000. If it is below this range, heat resistance tends to be insufficient. On the other hand, if it is beyond this range, the layer formation by the solution application might become difficult.

In the fourth element, one or more kinds of the PTAZ are used as a hole-transport material to form a hole-transport layer primarily composed of the PTAZ.

In the fifth element, one or more kinds of the PTAZ are used, as a resin binder, and a low-molecular hole-transport material is molecularly dispersed in the resin binder to form a hole-transport layer. The TPD is suitable for the low-molecular hole-transport material.

Both hole-transport layers may contain other ingredients such as various additives which do not inhibit the function of the PTAZ and the TPD.

The film thickness of the hole-transport layer is not specifically limited in the present invention, and it can be set to the optimum range depending upon the structure characteristics, namely, to which type it belongs.

The hole-transport layer can be formed by the aforesaid solution application.

In both elements, it is essential to have a hole-transport layer containing the PTAZ. No other particular restrictions are imposed thereon. There can employ either a conventional two-layer structure or a multi-layer structure comprising three or more layers. In short, the construction of both elements are applicable to any elements of various layer structures.

The layer material other than the hole-transport layer, which constitutes the element of the two-layer structure or the multi-layer structure, is not specifically limited in the present invention. There can employ various conventional materials used for the respective layers. Also, the film thickness of the respective layers constituting the element is not specifically limited in the present invention. The respective layers can be formed by the aforesaid solution application and vapor phase deposition, likewise in the hole-transport layer. Each layer may contain other ingredients such as resin binders and various additives which are not directly related to the layers' functions.

In every organic electroluminescent element of the present invention, a protective layer may be coated to shield the element against transmission of water or oxygen in air, or an element coated with the protective layer may be further sealed with a glass or a polymer, in order to improve storage stability in air or to extend the lifetime at the time of a continuous light emission.

Savant Technologies LLC - 1004.620

FIELD OF INDUSTRIAL APPLICABILITY

As described above, every organic electroluminescent element of the present invention drives at a lower voltage, and is valid for producing a large-area luminescent element having flexibility because it is composed of organic material. Thus there is a great applicability in the fields of indication, illumination and display.

EXAMPLES

The invention will be better understood by the following Examples and Comparative Examples which show by way of example.

Example 1

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.), the TPD expressed by the formula (5) as a hole-transport material, the Alq expressed by the formula (3) as an electron-transport material and the TAZ expressed by the formula (1) as a 1,2,4-triazole derivative were deposited in this order by vacuum deposition to form a TPD layer, an Alq layer and a TAZ layer, respectively. The luminescent region was expressed by a square being 0.5 cm in side.

The deposition conditions for each layer:

Ultimate vacuum degree: 2×10^{-5} Torr;

Temperature of substitute: Room temperature; and

Deposition rate: 2 to 4Å/sec.

Each film thickness:

TPD layer (a hole-transport layer): 500Å;

Alq layer (an electron-transport layer): 200Å; and

TAZ layer: 300Å.

Then, on the TAZ layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element. The deposition rate of the electrode layer was 11Å/sec. and that of the protective layer was 10Å/sec.

The ITO film and the Mg/Ag electrode layer thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to allow the luminescent layer to emit light. Its luminance was measured using a luminance meter (Model No. LS-100, available from Minolta Co., Ltd.).

There observed green light emission of 5800 cd/m^2 in luminance at a drive voltage of a maximum 14 V (145 mA/cm^2) as shown in Fig. **7**. This emission color proved that light emission originated from the Alq layer.

Example 2

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.), the PVK expressed by the formula (2) as a hole-transport luminescent material was coated by a dip coating using dichloroethane as a solvent to form a PVK layer, on which the TAZ expressed by the formula (1) as a 1,2,4-triazole derivative and the Alq expressed by the formula (3) as an electron-transport material were deposited in this order by vacuum deposition to form a TAZ layer and an Alq layer, respectively. The luminescent region was expressed by a square being 0.5 cm in side. The deposition conditions were the same as in Example 1.

Each film thickness was:

PVK layer (a hole-transport luminescent layer); 400Å;

TAZ layer: 200Å; and

Alq layer (an electron-transport layer): 300Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element of the layer structure shown in Fig. **1(a)**. The deposition rates for the electrode layer and protective layer were the same as in Example 1.

Savant Technologies LLC - 1004.621

The ITO film and the Mg/Ag electrode layer of the organic electroluminescence thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to allow the luminescent layer to emit light. Its luminance was measured using the aforesaid luminance meter.

As a result, light emission was initiated from 4 V and there observed blue light emission of 700 cd/m^2 in luminance at a drive voltage of a maximum 14 V (220 mA/cm^2) as shown in Fig. **8**. It showed that blue light emission of the element has outstanding high luminance in view of the CRT display's luminance at the blue color region being about 20 to 30 cd/m^2.

The blue light emission was measured at room temperature using a fluorophotometer (Model No. F4010 available from Hitachi Co, Ltd.).

There observed an emission spectrum having a peak at a wavelength of 410 nm as shown by a solid line in Fig. **9**. The emission spectrum nearly corresponded to an emission spectrum of the PVK itself shown by a broken line in Fig. **9**. This proved that light emission originated from the PVK layer of Example 2.

Even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 3

In the same manner as in Example 2 except that the Alq layer was omitted, an organic electroluminescent element was prepared and its characteristics was examined.

A voltage for initiating light emission became slightly large and a maximum current became small, but there obtained blue light emission with high luminance similar to Example 2.

Even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Comparative Example 1

In the same manner as in Example 2 except that the TAZ layer was omitted, an organic electroluminescent element was prepared and its characteristics was examined.

This element exhibited green light emission whose peak is at a wavelength of 530 nm. This emission color proved that the light emission originated from the Alq layer, not the PVK layer. This finding showed that the combination of the PVK layer and the TAZ layer is essential to allow the PVK layer to emit blue light.

Comparative Example 2

There prepared an organic electroluminescent element composed of the PVK layer alone wherein the TAZ layer and the Alq layer were omitted. The luminance of light emission was too weak to evaluate its luminance.

Example 4

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.), the TPD, the TAD and the Alq were deposited in this order by vacuum deposition to form a TPD layer, a TAD layer and an Alq layer, respectively. The luminescent region was expressed by a square being 0.5 cm in side. The deposition conditions were the same as in Example 1.

Each film thickness was as follows:

TPD layer (a hole-transport layer): 400Å;

TAZ layer (a carrier-transport control layer): 150Å; and

Alq layer (an electron-transport layer): 450Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element of the layer structure shown in Fig. **1(b)**. The deposition rates for the electrode layer and the protective layer were the same as in Example 1.

The ITO film and the Mg/Ag electrode layer thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to

Savant Technologies LLC - 1004.622

allow the luminescent layer to emit light. Its luminance was measured using the aforesaid luminance meter.

There observed blue light emission of 3700 cd/m^2 in luminance at a drive voltage of a maximum 16 V (145 mA/cm^2) as shown in Fig. **10**.

Further, the blue light emission was measured at room temperature using the aforesaid fluorophotometer. There observed an emission spectrum having a peak at a wavelength of 464 nm, as shown by a solid line in Fig. **11**. The emission spectrum nearly corresponded to the emission spectrum of the vapor deposited film composed of the TPD alone, shown by a short broken line in Fig. **11**. This proved that the light emission originated from the TPD layer of Example 4.

Examples 5 and 6

There employed an organic electroluminescent element having the same layer structure as in Example 4, but the film thickness of the TAZ layer as a carrier-transport control layer was changed to 50Å (Example 5) or 100Å (Example 6) to measure each emission spectrum in the same manner as in Example 4.

As a result, Example 5 exhibited a green emission spectrum being luminescent color of the Alq layer, as shown by a chain line in Fig. **11**.

In Example 6, such a green light emission became remarkably small and, at the same time, blue light emission being the emission color of the TPD layer became large, as shown by a long broken line in Fig. **11**, resulting in blue-green light emission of both color emissions being mixed.

Examples 7 and 8

In the same manner as in Example 4 except that the PBD expressed by the formula (4), as a material constituting the carrier-transport control layer, was used instead of the TAZ, an organic electroluminescent element of the structure shown in Fig. **1(b)** was prepared and its emission spectrum was measured.

The element whose PBD layer had a film thickness of 100Å (Example 7) exhibited a green spectrum being the emission color of the Alq layer, as shown by a solid line in Fig. **12**.

In the element whose TAZ layer had a film thickness of 300Å (Example 8), as shown by a broken line in Fig. **12**, there observed light emission of blue-green wherein green light emission being the luminescent color of the Alq layer was mixed with blue light emission being the luminescent color of the TPD layer.

Example 9

The PVK expressed by the formula (2), 5 molar % (for PVK) of the TPB expressed by the formula (7), 0.3 molar % (for PVK) of coumarine 6 expressed by the formula (8) and 0.3 molar % (for PVK) of the DCM expressed by the formula (10) were dissolved in dichloromethane to prepare an application solution. The application solution was applied on an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.) by dip coating, followed by drying to form a hole-transport luminescent layer.

Then, on the hole-transport luminescent layer, the TAZ expressed by the formula (1) and the Alq expressed by the formula (3) as an electron-transport material were deposited in this order by vacuum deposition to form an electron-transport layer of a two-layer structure. The luminescent region was expressed by a square being 0.5 cm in side. The deposition conditions for the TAZ layer and Alq layer were as follows:

Ultimate vacuum degree: 1 to 2 x 10^{-5} Torr;

Temperature of substrate: Room temperature; and

Deposition rate: 2 to 4Å/second.

Each film thickness was:

Hole-transport luminescent layer: 400 to 500Å;

TAZ layer: 200Å; and

Alq layer: 300Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element of the layer structure shown in Fig. **6(a)**. The deposition rate for the electrode layer and that of the protective layer were 11Å/sec. and 10Å/sec., respectively.

The ITO film and the Mg/Ag electrode layer thus prepared were employed as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to

Savant Technologies LLC - 1004.623

allow the luminescent layer to emit light. Its luminance was measured using the aforesaid luminance meter.

There observed white light emission of 3352 cd/m^2 in luminance at a drive voltage of 16 V and a current density of 250 mA/cm^2.

Further, the white light emission was measured at room temperature using the aforesaid fluorophotometer. There obtained an emission spectrum that extended over a range of visible light having a wavelength of 400-700 nm, as shown in Fig. **13**.

Still further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 10

In the same manner as in Example 9 except that an application solution was prepared by dissolving the PVK and 5 molar % (for PVK) of the TPB in dichloromethane, an organic electroluminescent element was prepared and its characteristics were examined.

There observed blue light emission with a luminance of 1500 cd/m^2 at a drive voltage of 16 V and a current density of 220 mA/cm^2.

Further, the blue light emission was measured using the aforesaid fluorophotometer. There obtained an emission spectrum having a peak at a wavelength of 450 nm, as shown in Fig. **14**. This proved that blue light emission originated from the TPB.

Still further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 11

In the same manner as in Example 9 except that an application solution was prepared by dissolving the PVK and 1 molar % (for PVK) of the coumarine 6 in dichloromethane, an organic electroluminescent element was prepared and its characteristics was examined.

There observed green light emission with a luminance of 2200 cd/m^2 at a drive voltage of 16 V and a current density of 340 mA/cm^2.

Further, the green light emission was measured using the aforesaid fluorophoto meter. There obtained an emission spectrum having a peak at a wavelength of 510 nm, as shown in Fig. **15**. This proved that green light emission originated from the coumarine 6.

Still further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 12

In the same manner as in Example 9 except that an application solution was prepared by dissolving the PVK and 0.1 molar % (for PVK) of the DCM in dichloromethane, an organic electroluminescent element was prepared and its characteristics was examined.

There observed white light emission with a luminance of 1100 cd/m^2 at a drive voltage of 16 V and a current density of 210 mA/cm^2.

Further, the white light emission was measured using the aforesaid fluorophotometer. As a result, it was confirmed that the white light emission originated from the light emission of the PVK whose wavelength is 410 nm and light emission of the DCM whose wavelength is 550 nm.

Thereafter, in the same manner in the foregoing except that the DCM concentration for the PVK was changed to 2 molar %, an organic electroluminescent element was prepared and its characteristics was examined.

There observed that a peak value at a wavelength of 550 nm became larger than that in at a wavelength of 410 nm, resulting in orange light emission.

Still further, even if the elements were preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 13

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.), the PTAZ-1 expressed by the formula (6a) as a hole-transport material was coated by dip coating using dichloromethane as a solvent to form a

Savant Technologies LLC - 1004.624

PTAZ-1 layer. Then, the Alq expressed by the formula (3) as an electron-transport material was applied vacuum deposition the PTAZ-1 layer to form a Alq layer. The luminescent region was represented by a square being 0.5 cm in side.

The deposition conditions were:

Ultimate vacuum degree: 1 to 2 x 10^{-5} Torr;

Temperature substrate: Room temperature; and

Deposition rate: 2 to 4Å/sec.

Each film thickness was:

PTAZ-1 layer (a hole-transport layer): 400Å; and

Alq layer (an electron-transport layer): 600Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element. The deposition rate for the electrode layer and the protective layer were 11 Å/sec. and 10Å/sec., respectively.

The ITO film and the Mg/Ag electrode layer thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to allow the luminescent layer to emit light. Its luminance was measured using the aforesaid luminance meter. There obtained light emission of 1200 cd/m^2 in luminance at a drive voltage of a maximum 16 V (180mA/cm^2).

Still further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 14

In the same manner as in Example 13 except that the PTAZ-2 expressed by the formula (6b) as a material of constituting a hole-transport layer was used in place of the PTAZ-1, an organic electroluminescent was prepared and its luminance was measured.

There observed light emission of 370 cd/m^2 in luminance at a drive voltage of a maximum 16 V (730 mA/cm^2).

Further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Example 15

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.,), a PTAZ-2 wherein 30 % by weight of the TPD expressed by the formula (5), as a hole-transport material, was molecularly dispersed was coated by dip coating using dichloromethane as a solvent to form a PTAZ-2:TPD layer, on which the Alq was deposited by vacuum deposition to form an Alq layer. Its luminescent region was represented by a square being 0.5 cm in side. The deposition conditions were the same as in Example 13. Each film thickness was:

PTAZ-2:TPD layer (a hole-transport layer): 400Å; and

Alq layer (an electron-transport layer): 800Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element. The deposition rates for the electrode layer and the protective layer were the same as in Example 13.

The ITO film and the Mg/Ag electrode layer thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air to allow the luminescent layer to emit light. Its luminance was measured using the aforesaid luminance meter.

There observed light emission of 4500 cd/m^2 in luminance at a drive voltage of a maximum 14 V (250 mA/cm^2).

Further, even if the element was preserved at room temperature for several days, there observed no change in appearance, and the element emitted light at luminance similar to that before preservation.

Savant Technologies LLC - 1004.625

Comparative Example 3

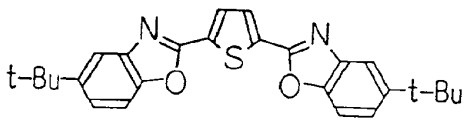
In the same manner as in Example 15 except that a hole-transport layer composed of the TPD alone was formed by vacuum deposition in place of the PTAZ-2:TPD layer, an organic electroluminescent element was prepared [a TPD layer (a hole-transport layer): 500Å, an Alq layer (an electron-transport layer): 500Å], and its luminance was measured in the aforesaid manner.

There observed light emission of 10000 cd/m^2 in high luminance at a drive voltage of 14 V.

Further, the element was preserved at room temperature for several days. As a result, it was confirmed that black points occurred on the luminescent surface and that the TPD was crystallized.

Example 16

On an ITO (indium-tin-oxide) coated glass substrate having a sheet resistance of 15 Ω/□ (ITO film thickness: 1500 to 1600Å, manufactured by Asahi Glass Co., Ltd.,), a PTAZ-2 wherein 30 % by weight of the TPD was molecularly dispersed was coated by dip coating using dichloromethane as a solvent to form a PTAZ-2:TPD layer, on which a 2,5-bis(5-tert-butyl-2-benzooxazolyl)-thiophene (hereinafter referred to as "BBOT") expressed by the formula:



(11)

as a luminescent material and the TAZ expressed by the formula (1) as an electron-transport material were deposited in this order by vacuum deposition method to form a BBOT layer and a TAZ layer. The luminescent region was represented by a square being 0.5 cm in side. The deposition conditions were the same as in Example 13. Each film thickness was:

PTAZ-2:TPD layer (a hole-transport layer): 400Å;

BBOT layer (a luminescent layer): 700Å; and

TAZ layer (an electron-transport layer): 400Å.

Then, on the Alq layer, magnesium was codeposited with silver to form a Mg/Ag electrode layer having a film thickness of 2000Å [Mg/Ag = 10/1 (molar ratio)], on which silver was deposited alone to form a protective layer having a film thickness of 1000Å, thus obtaining an organic electroluminescent element. The deposition rates for the electrode layer and protective layer were the same as in Example 13.

The ITO film and the Mg/Ag electrode layer of the organic electroluminescence thus prepared were used as an anode and a cathode, respectively, and a bias voltage was applied between a couple of electrodes at room temperature in air. As a result, blue light emission with good efficiency was obtained.

The luminance was measured in the same manner as in Examples 13 to 15. There observed light emission of 100 cd/m^2 in luminance at a drive voltage of a maximum 18 V (8 mA/cm^2), as shown in Fig. **17** (wherein a plot O-O denotes the relation between an applied voltage and luminance, and another plot Δ-Δ denotes the relation between an applied voltage and a current density).

Further, the light emission was measured at room temperature using the aforesaid fluorophotometer. There obtained an emission spectrum having a peak at a wavelength of 443 nm, as shown in Fig. **18.** The emission spectrum corresponded to that of the BBOT. This proved that light emission originated from the BBOT layer of Example 16.

Comparative Example 4

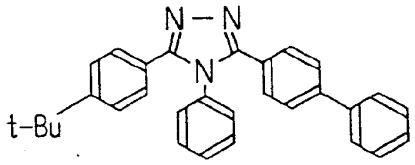
In the same manner as in Example 16 except that a hole-transport layer composed of the TPD alone was prepared by vacuum deposition in place of the PTAZ-2:TPD layer, thus obtaining an organic electroluminescent element comprising a TPD layer (a hole-transport layer): 400Å; a BBOT layer (a luminescent layer): 700Å and a TAZ layer (an electron-transport layer): 400Å. This element, however, emitted light with poor luminance efficiency.

Savant Technologies LLC - 1004.626

Claims

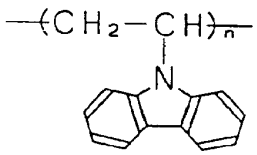
1. An organic electroluminescent element comprising at least a layer of a 1,2,4-triazole derivative.

2. An organic electroluminescent element according to claim 1, wherein the 1,2,4-triazole derivative is 3-(4-biphenylyl)-4-phenyl-5-(4-tert-butylphenyl)-1,2,4-triazole expressed by the formula:



(1)

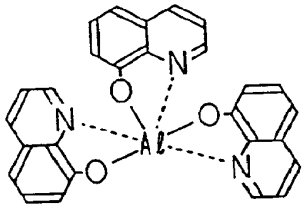
3. An organic electroluminescent element according to claim 1, which comprises, as a hole-transport luminescent layer, a layer of poly-N-vinylcarbazole expressed by the formula:



(2)

wherein **n** denotes a polymerization degree.

4. An organic electroluminescent element according to claim 3, which comprises, as an electron-transport layer, a layer of a tris(8-quinolinolato)aluminum (III) complex of the formula :

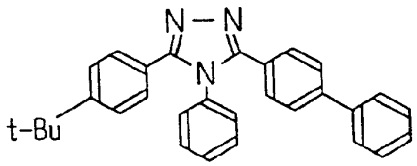


(3)

5. An electroluminescent element comprising a carrier-transport control layer for selectively transporting holes and/or electrons, which is interposed between a hole-transport layer and an electron-transport layer.

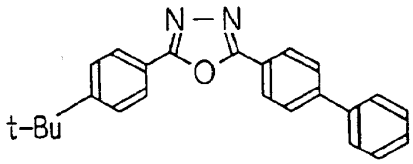
6. An electroluminescent element according to claim 5, wherein the carrier-transport control layer is a layer of 3-(4-biphenylyl)-4-phenyl-5-(4-tert-butylphenyl)-1,2,4-triazole expressed by the formula:

Savant Technologies LLC - 1004.627



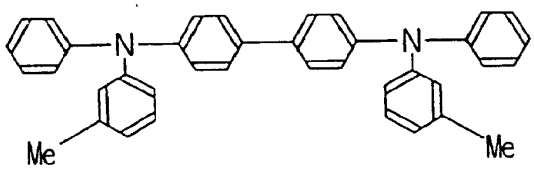
(1)

7. An organic electroluminescent element according to claim 5, wherein the carrier-transport control layer is a layer of 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole expressed by the formula:



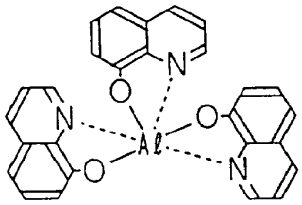
(4)

8. An organic electroluminescent element according to claim 5, wherein the hole-transport layer is a layer of N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4-diamine expressed by the formula:



(5)

and the electron-transport layer is a layer of a tris(8-quinolinolato)aluminum (III) complex of the formula:

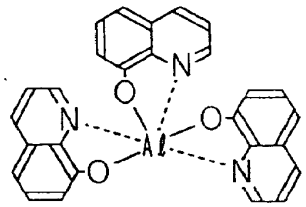


(3)

9. An organic electroluminescent element comprising at least one electron-transport layer and at least one hole-transport luminescent layer, said hole-transport luminescent layer being composed of a polymer and at least one kind of dye which is molecularly dispersed in the polymer.

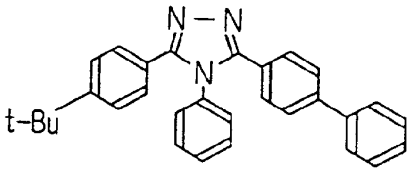
10. An organic electroluminescent element according to claim 9, wherein the electron-transport layer is composed of a single layer of a 1,2,4-triazole derivative, or two layers consisting of the layer of the 1,2,4-triazole derivative and a layer of a tris(8-quinolinolato)aluminum (III) complex expressed by the formula:

Savant Technologies LLC - 1004.628



(3)

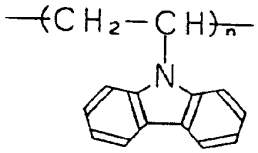
11. An organic electroluminescent element according to claim 10, wherein the 1,2,4-triazole derivative is 3-(4-biphenylyl)-4-phenyl-5-(4-tert-butylphenyl)-1,2,4-triazole expressed by the formula:



(1)

12. An organic electroluminescent element according to claim 9, wherein the hole-transport luminescent layer is composed of a polymer having carrier-transport properties and a dye which is molecularly dispersed in the polymer.

13. An organic electroluminescent element according to claim 12, wherein the polymer having carrier-transport properties is a poly-N-vinylcarbazole expressed by the formula:



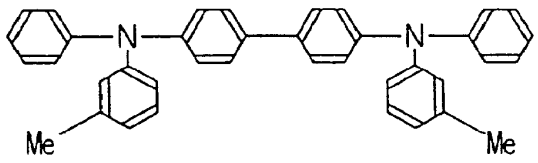
(2)

wherein **n** denotes a polymerization degree.

14. An organic electroluminescent element according to claim 9, wherein the hole-transport luminescent layer is composed of a polymer having no carrier-transport properties and a dye and a low-molecular hole-transport material which are molecularly dispersed in the polymer.

15. An organic electroluminescent element according to claim 14, wherein the low-molecular hole-transport material, which is molecularly dispersed in the polymer having no carrier-transport properties along with the dye, is N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4-diamine expressed by the formula:

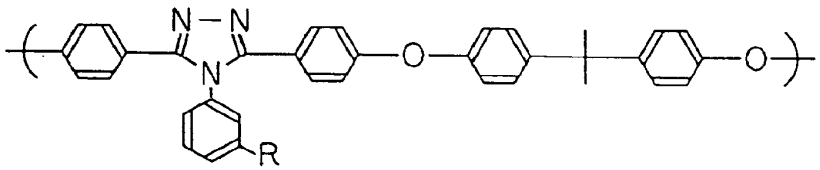
Savant Technologies LLC - 1004.629



(5)

16. An organic electroluminescent element according to claim 9, wherein a plurality of dyes to be molecularly dispersed in the hole-transport luminescent layer, are combined such that an emission spectrum of the hole- transport luminescent layer extends over the whole range of visible light region having a wavelength of 400 too 700 nm.

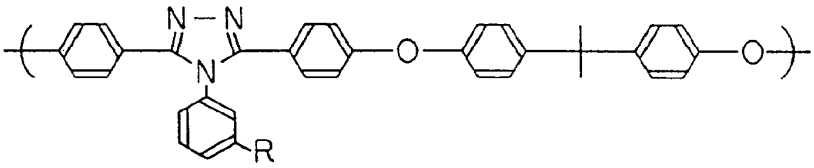
17. An organic electroluminescent element comprising a hole-transport layer which contains, as a hole-transport material, a high-molecular 1,2,4-triazole derivative of a repeating unit expressed by the general formula:



(6)

wherein R denotes at least one member selected from the group consisting of: a hydrogen atom, a methyl group and an ethyl group.

18. An organic electroluminescent element comprising a hole-transport layer which is formed by molecularly dispersing a low-molecular hole-transport material in a high-molecular 1,2,4-triazole derivative of a repeating unit expressed by the general formula:

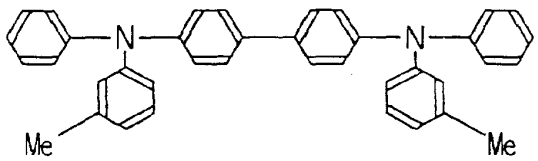


(6)

wherein R denotes at least one member selected from the group consisting of: a hydrogen atom, a methyl group and an ethyl group, as a resin binder.

19. An organic electroluminescent element according to claim 18, wherein the lower-molecular weight hole-transport material, which is molecularly dispersed in the 1,2,4-triazole derivative as a resin binder, is a N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4-diamine expressed by the formula:

Savant Technologies LLC - 1004.630



(5)

Savant Technologies LLC - 1004.631

FIG. 1 (a)

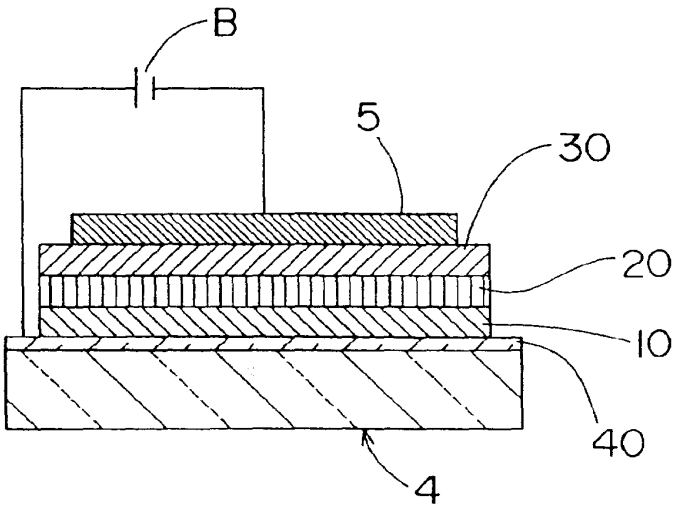
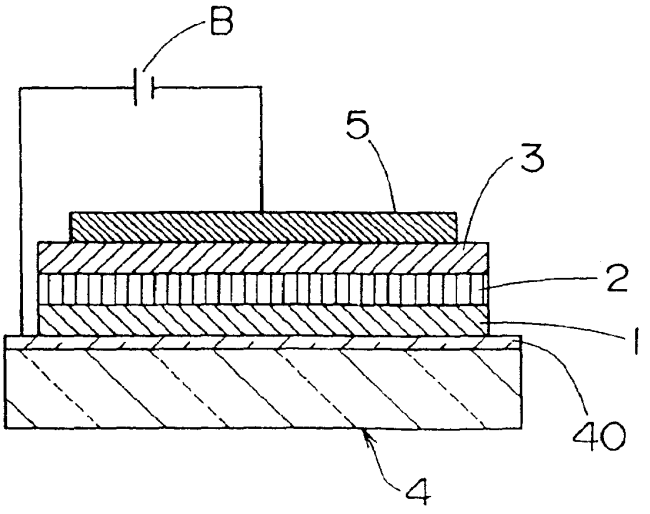


FIG. 1 (b)



Savant Technologies LLC - 1004.632

FIG. 2(a)

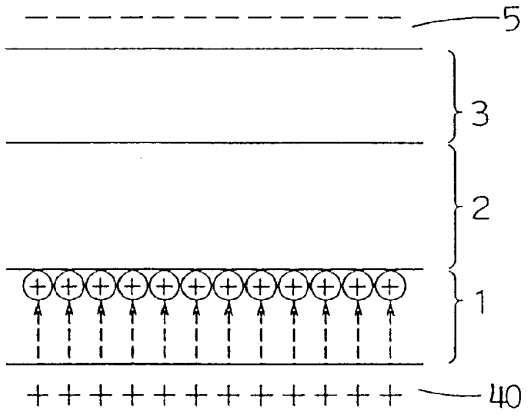


FIG. 2(b)

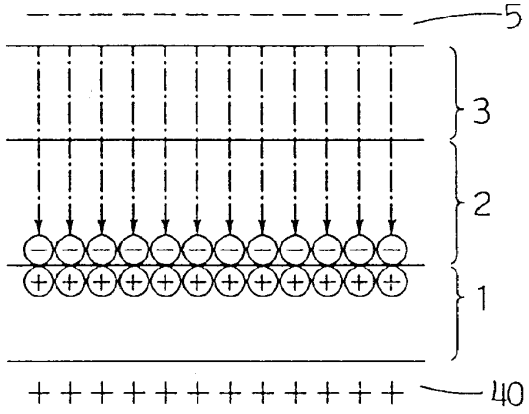
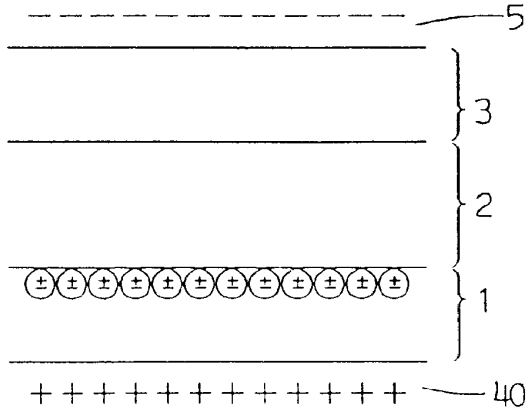


FIG. 2(c)



Savant Technologies LLC - 1004.633

FIG. 3(a)

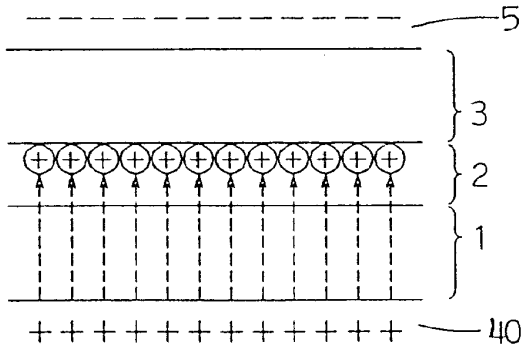


FIG. 3(b)

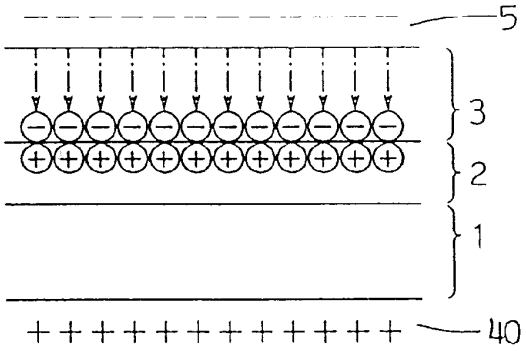
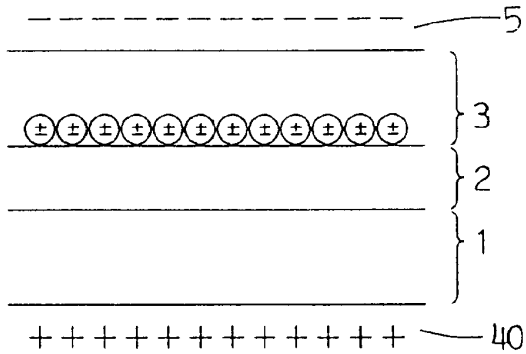


FIG. 3(c)



Savant Technologies LLC - 1004.634

FIG. 4(a)

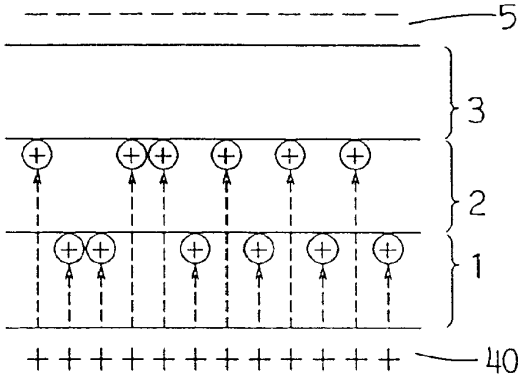


FIG. 4(b)

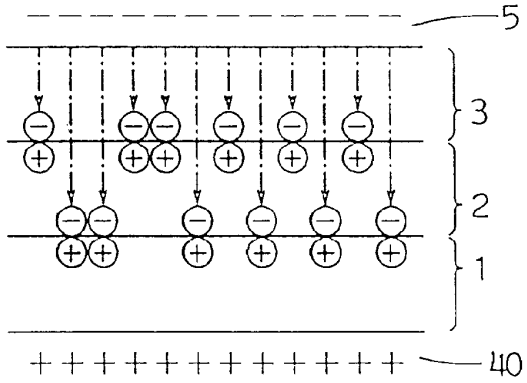
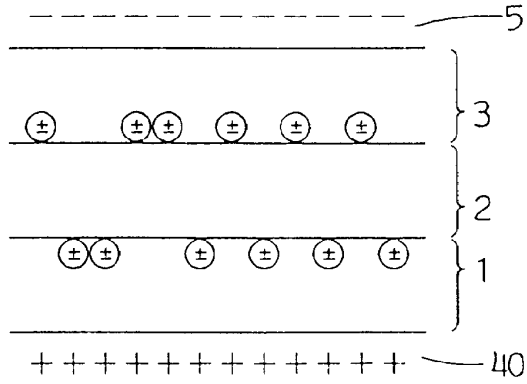


FIG. 4(c)



Savant Technologies LLC - 1004.635

FIG. 5(a)

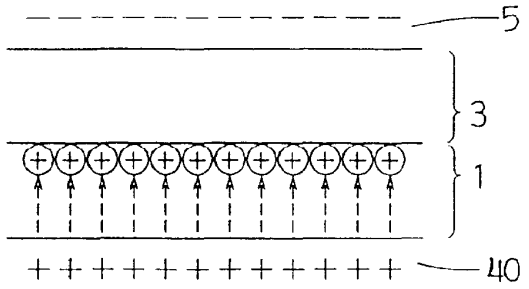


FIG. 5(b)

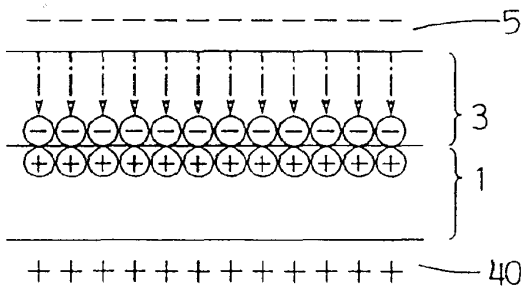
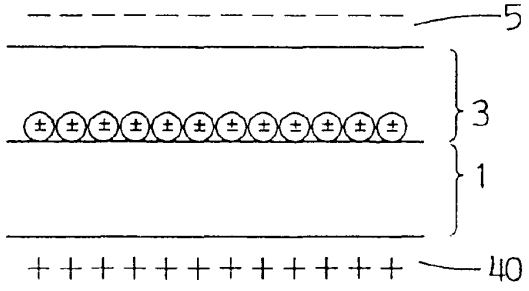


FIG. 5(c)



Savant Technologies LLC - 1004.636

FIG. 6 (a)

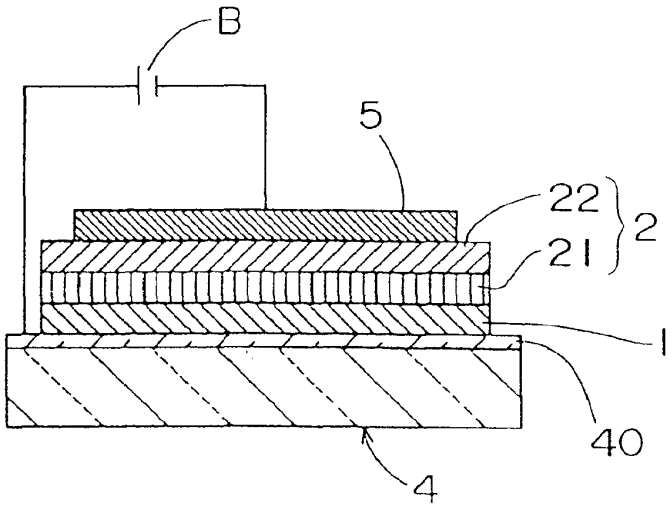
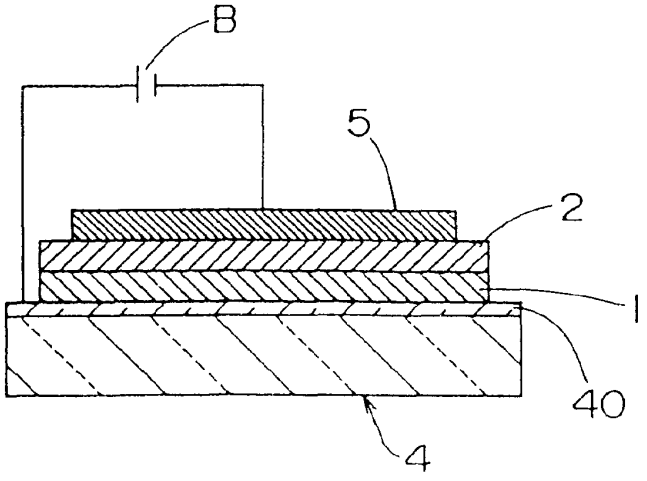
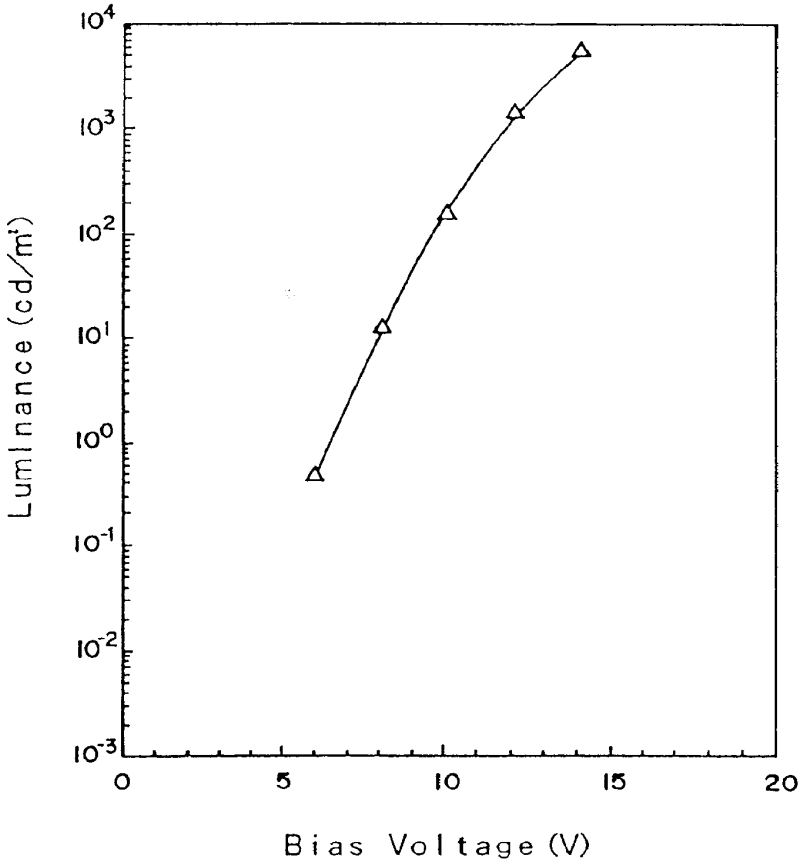


FIG. 6 (b)



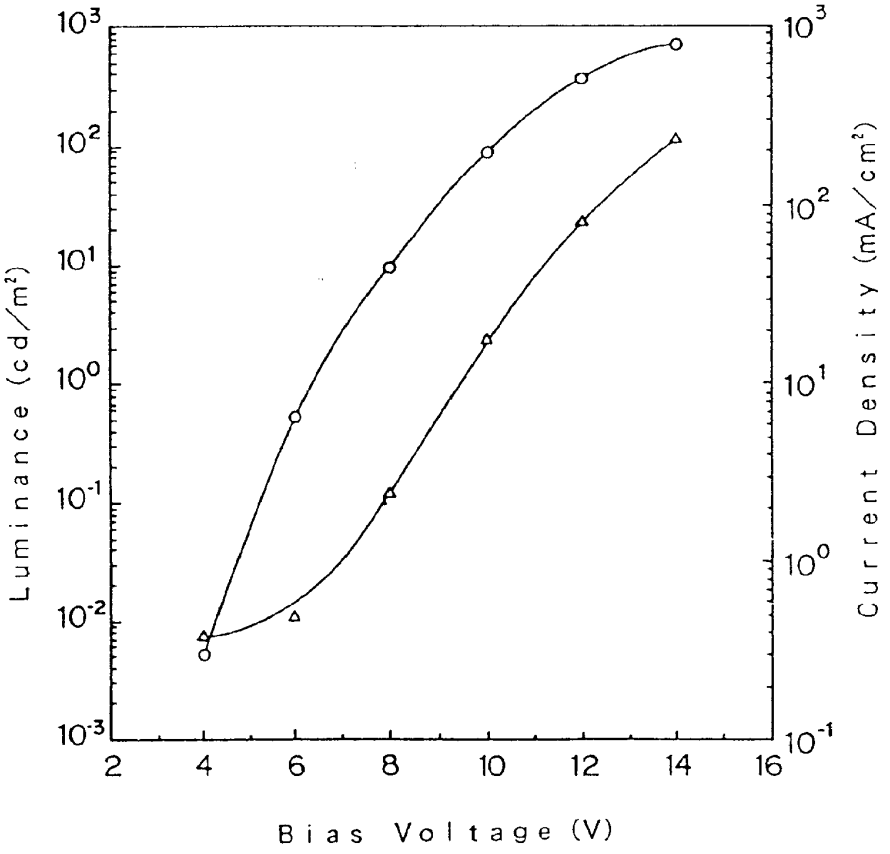
Savant Technologies LLC - 1004.637

FIG. 7



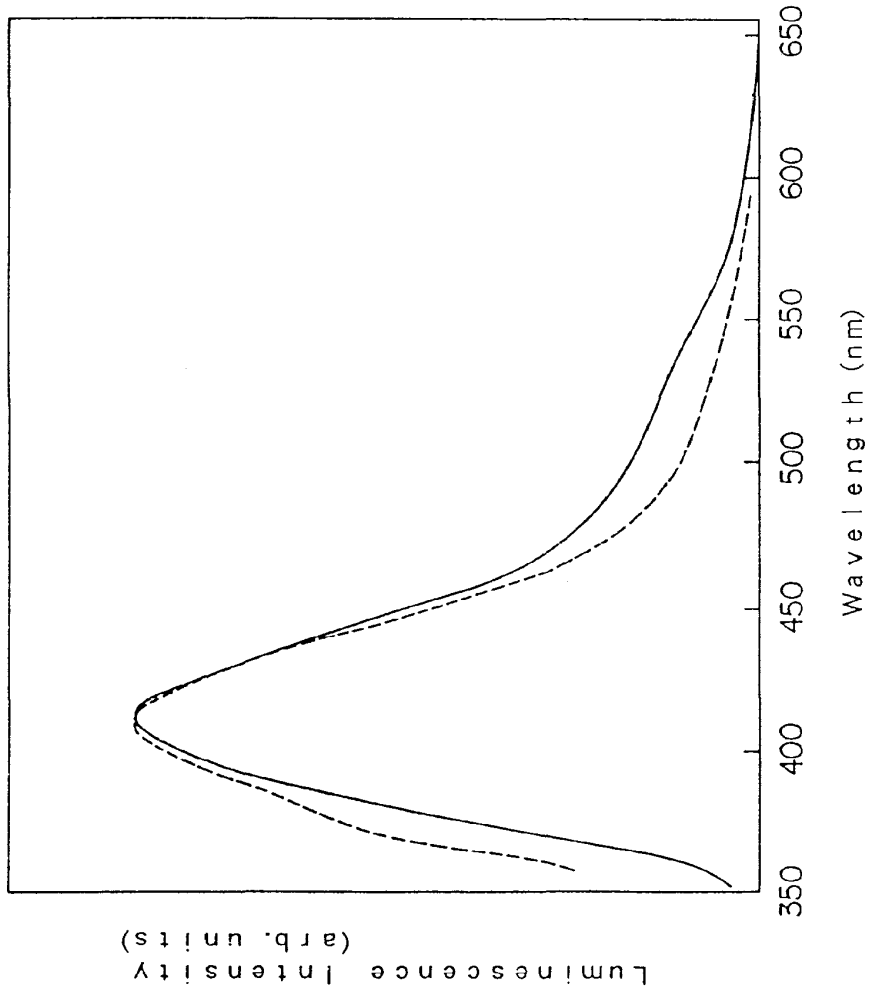
Savant Technologies LLC - 1004.638

FIG. 8



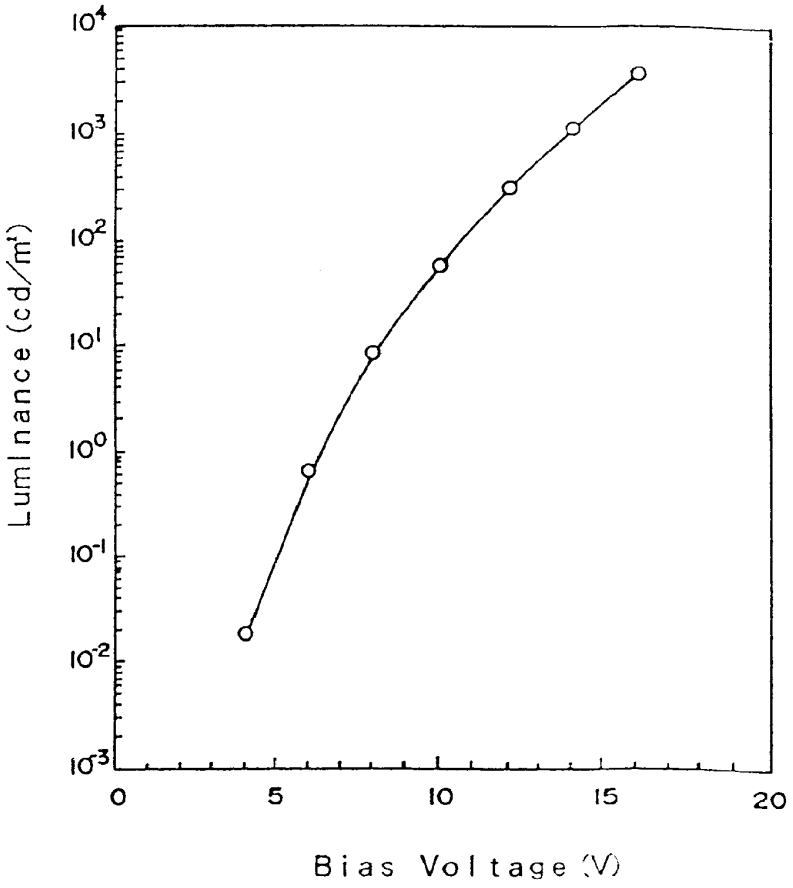
Savant Technologies LLC - 1004.639

FIG. 9



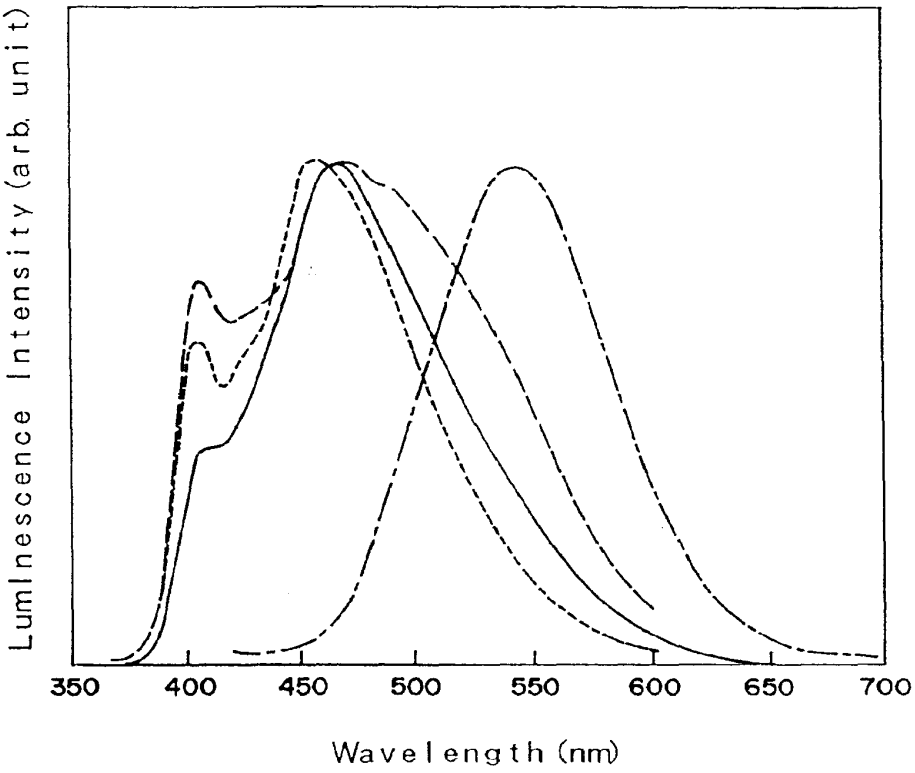
Savant Technologies LLC - 1004.640

FIG. 10



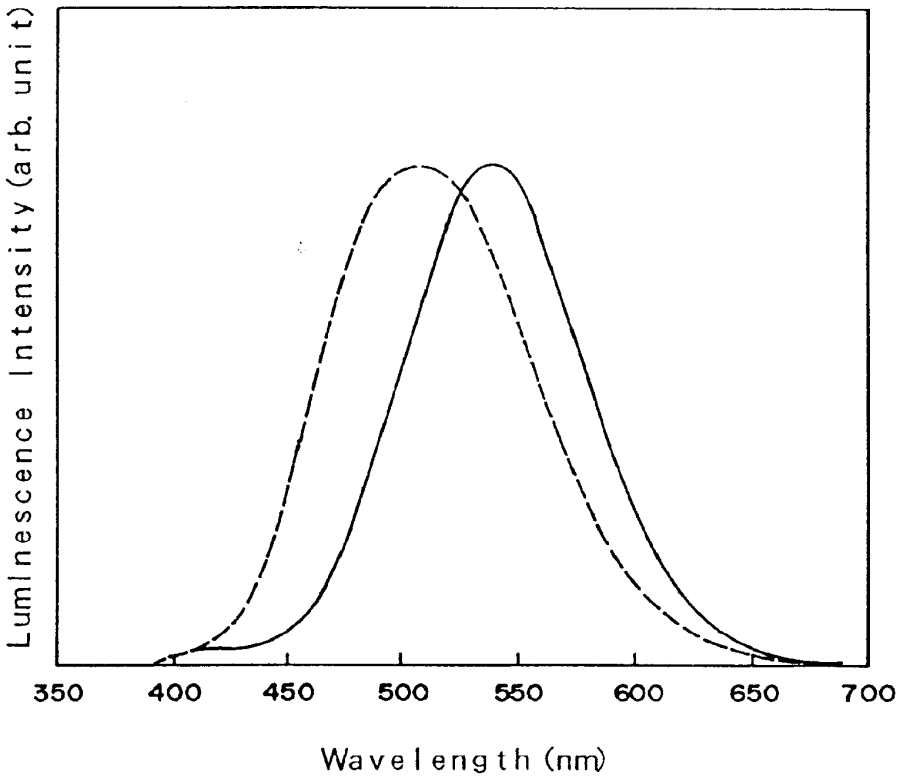
Savant Technologies LLC - 1004.641

FIG. 11



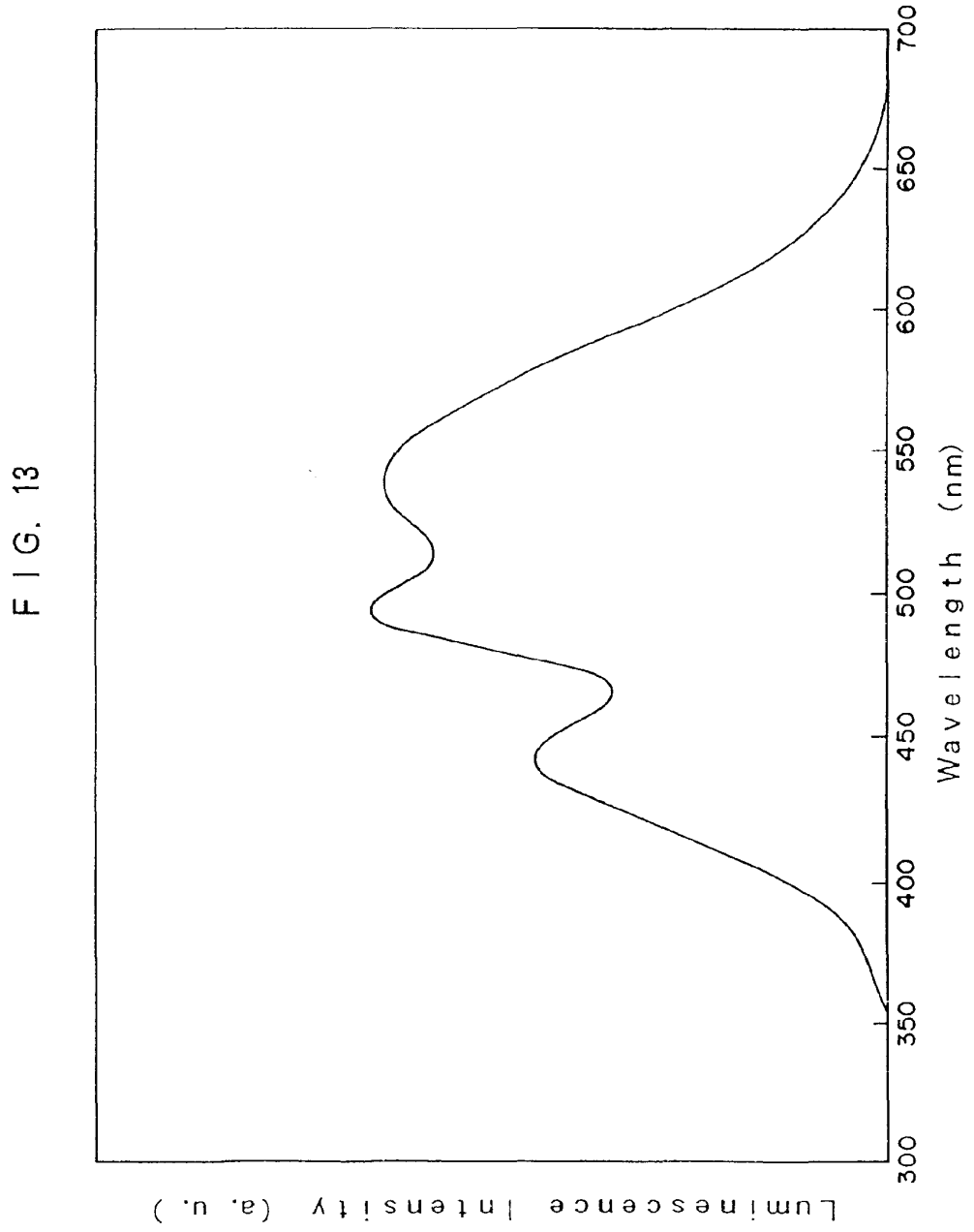
Savant Technologies LLC - 1004.642

FIG. 12



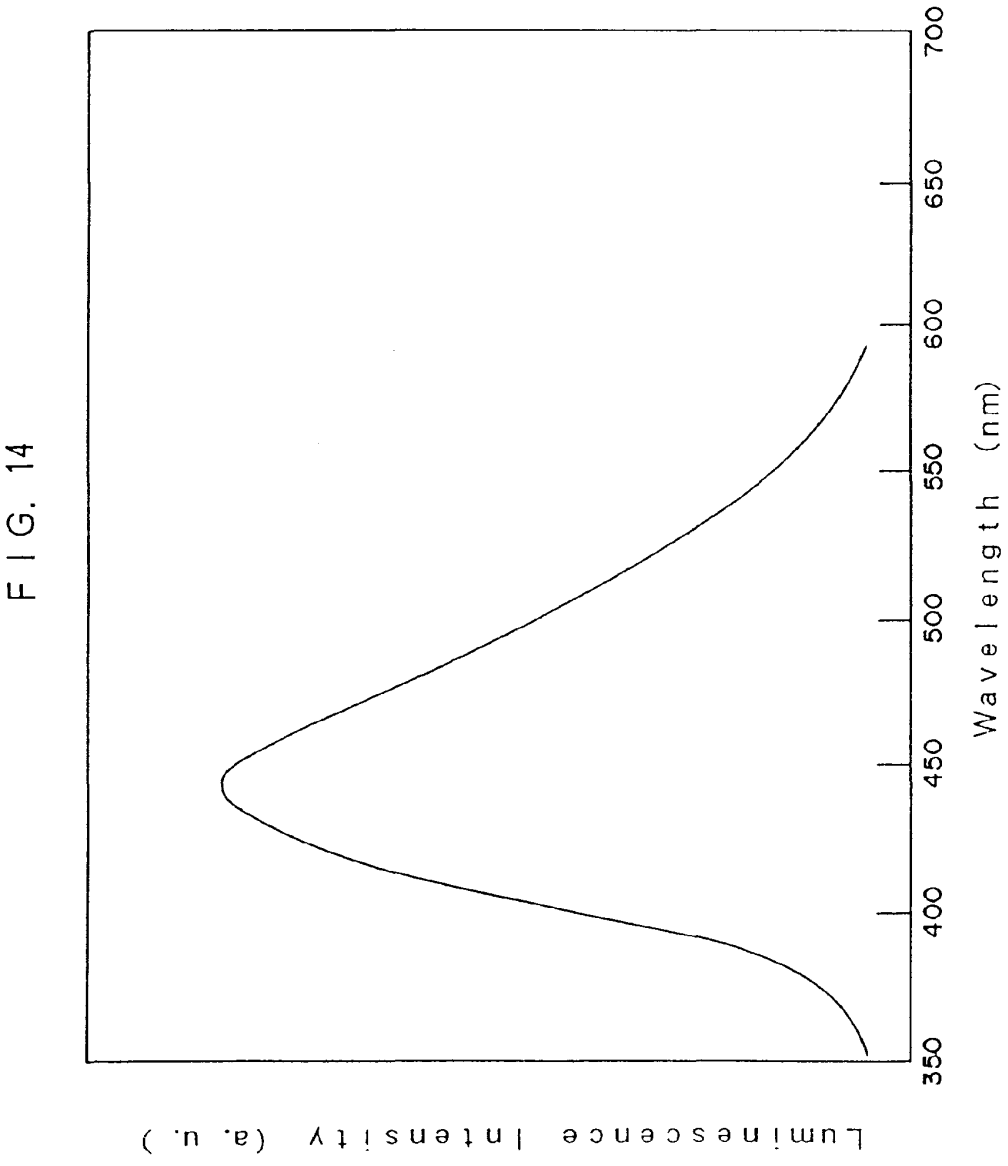
Savant Technologies LLC - 1004.643

FIG. 13



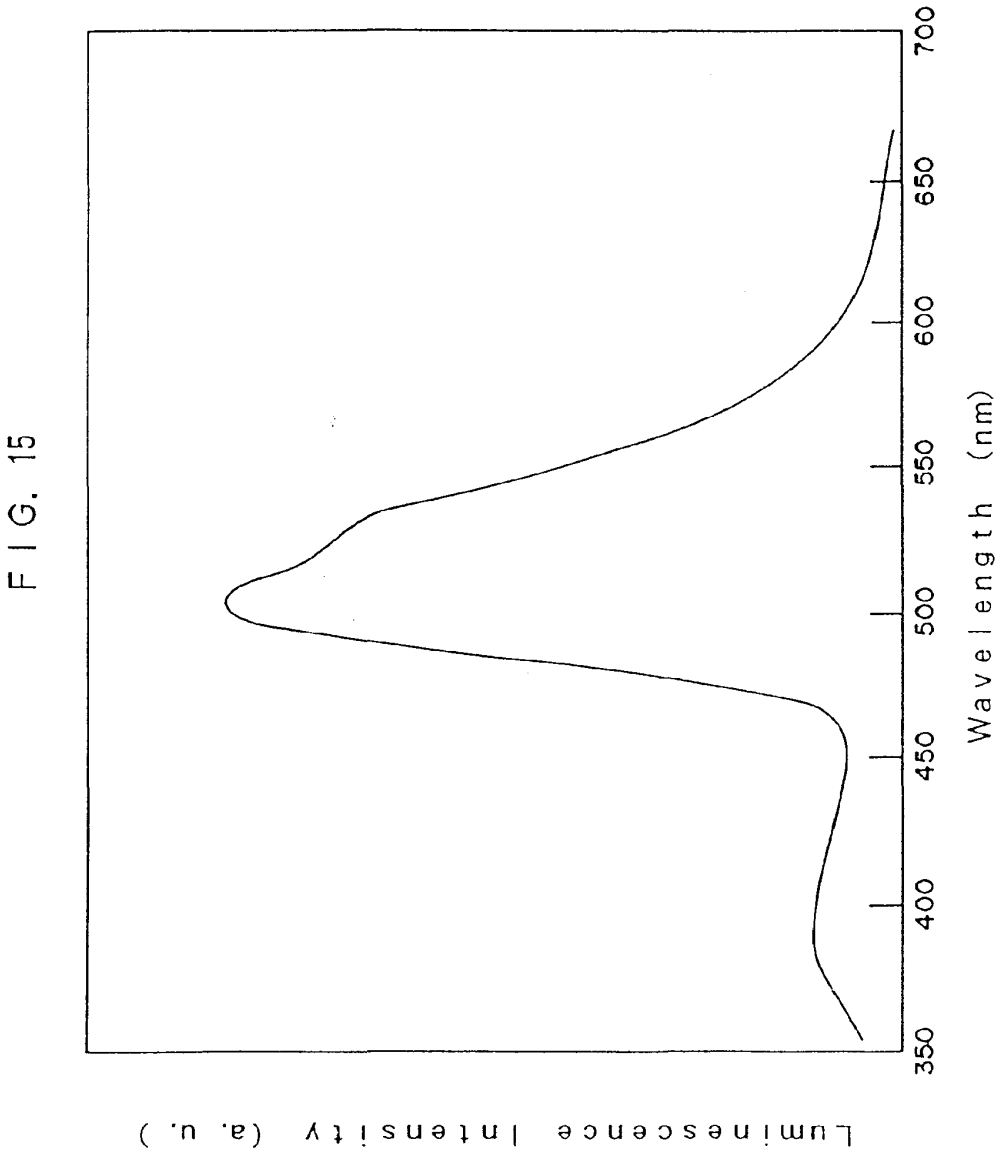
Savant Technologies LLC - 1004.644

FIG. 14



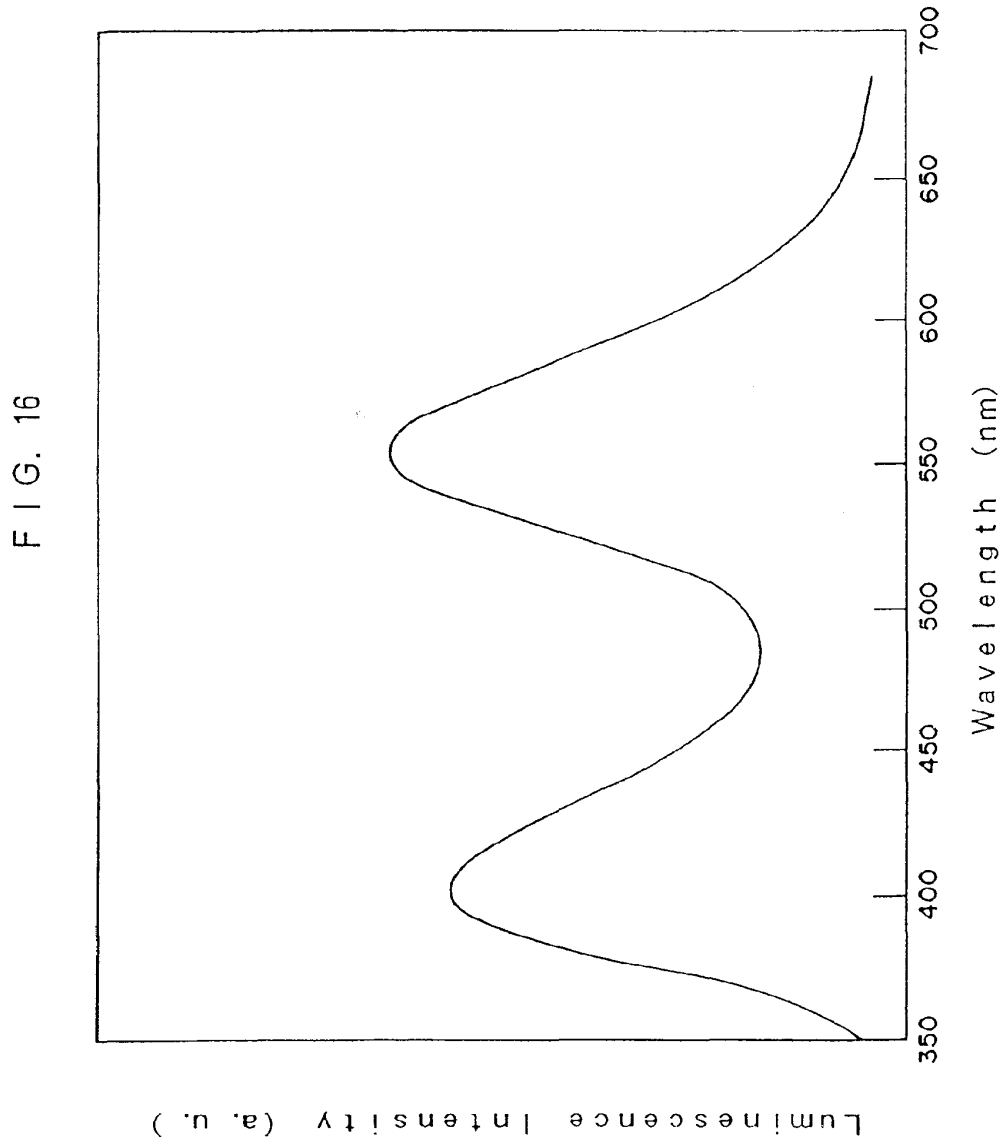
Savant Technologies LLC - 1004.645

FIG. 15



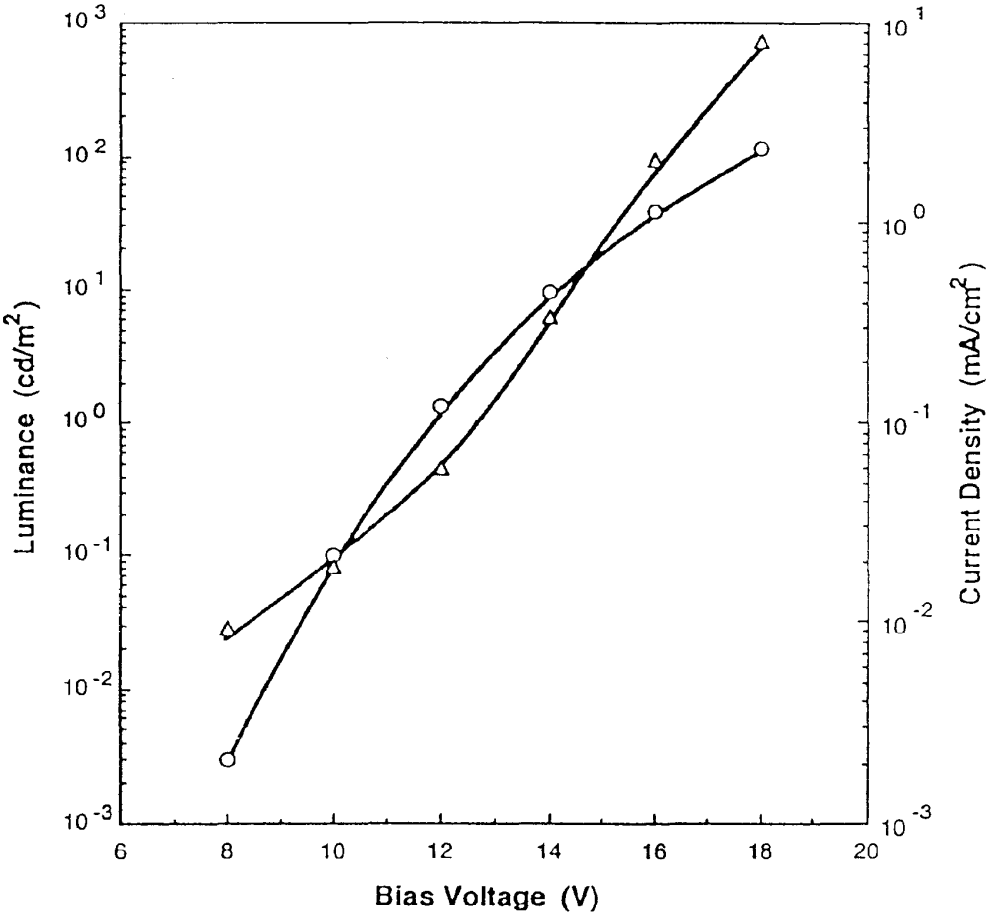
Savant Technologies LLC - 1004.646

FIG. 16



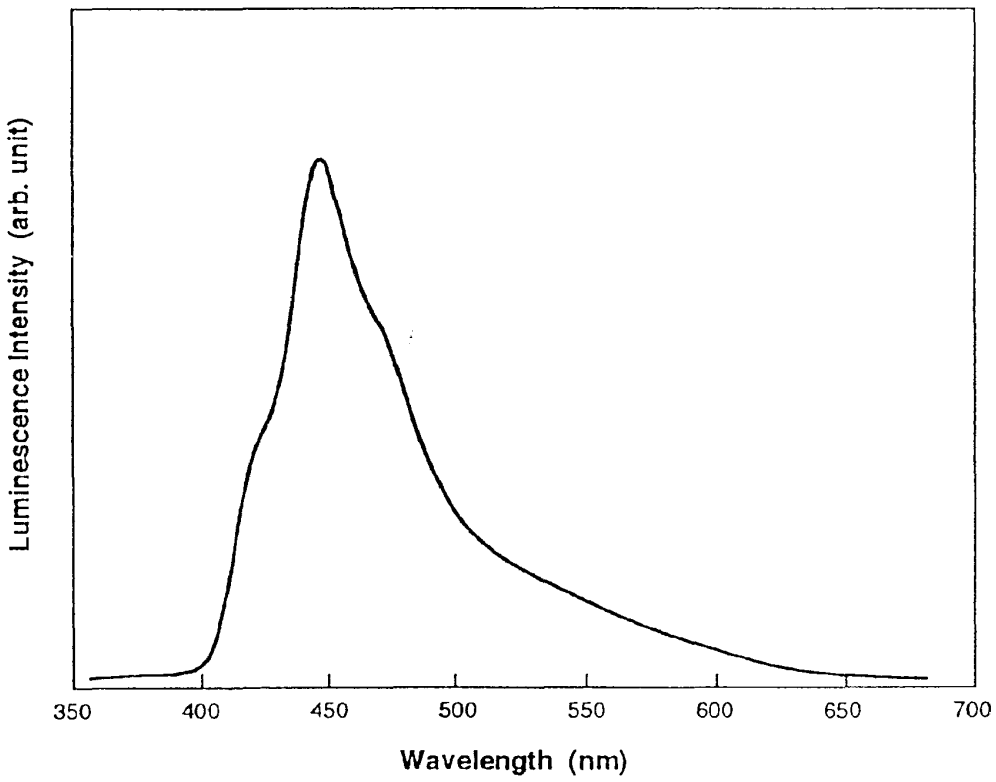
Savant Technologies LLC - 1004.647

FIG. 17



Savant Technologies LLC - 1004.648

FIG. 18



Savant Technologies LLC - 1004.649

FIG. 19(a)

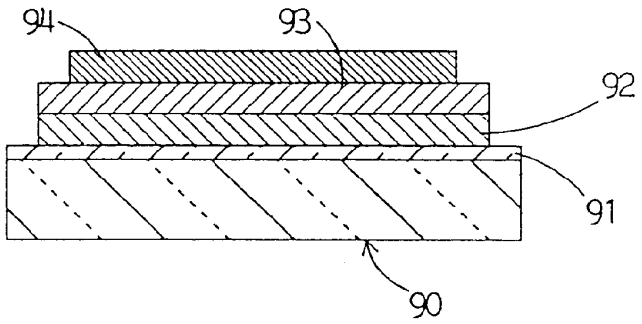


FIG. 19(b)

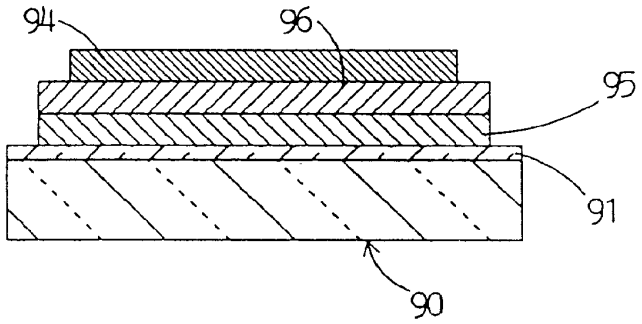
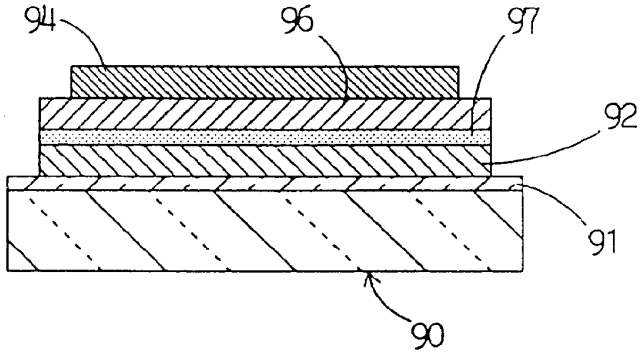


FIG. 19(c)



Savant Technologies LLC - 1004.650

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP94/00435

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^5 C09K11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^5 C09K11/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP, A, 4-308689 (Mitsubishi Kasei Corp.), October 30, 1992 (30. 10. 92), (Family: none)	1 4, 7, 8, 10, 15, 19 2, 6, 11, 17, 18
Y	WO, A1, 92/00515 (Fiber Chem Inc.), May 15, 1992 (15. 05. 92) & US, A, 5107133 & EP, A1, 536283 & JP, A, 6-500627	1
X A	GB, A1, 1393750 (HOECHST AKTIENGES-ELLSCHAFT), May 14, 1975 (14. 05. 75) & DE, A1, 785794 & FR, A1, 2145216	1 2, 6, 11, 17, 18
Y	JP, A, 4-298989 (Ricoh Co., Ltd.), October 22, 1992 (22. 10. 92), (Family: none)	3, 4, 7-9, 12-14, 16

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
May 25, 1994 (25. 05. 94)	June 14, 1994 (14. 06. 94)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

Savant Technologies LLC - 1004.651

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP94/00435

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, A, 4-212286 (Asahi Chemical Industry Co., Ltd.), August 3, 1992 (03. 08. 92), (Family: none)	3, 5, 7-9 12-14, 16
Y	JP, A, 4-237993 (Idemitsu Kosan Co., Ltd.), August 26, 1992 (26. 08. 92), (Family: none)	4, 5, 7-9, 12-14, 16
Y	JP, A, 4-363894 (Ricoh Co., Ltd.), December 16, 1992 (16. 12. 92), (Family: none)	5, 7, 8

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

Savant Technologies LLC - 1004.652

(12)UK Patent Application (19)GB (11) 2 017 409 A

(21) Application No **7913930**
(22) Date of filing
20 Apr 1979
(23) Claims filed
20 Apr 1979
(30) Priority data
(31) **11422/78**
(32) **22 Mar 1978**
(33) **United Kingdom (GB)**
(43) Application published
3 Oct 1979
(51) **INT CL² H01L 33/00 // H05B 33/20**
(52) Domestic classification
H1K 1EA 2R3A 2R3E 2S16 2S17 2S1C 2S1D 2S20 2S2D 4C14 4C2A 4C2D 5B2 5B5 5B9 9E 9L 9N1A EAX
C4S 66Y 68X 68Y 708 713 714 731 733
(56) Documents cited
GB 1036040
GB 1022808
GB 1022725
GB 1014041
(58) Field of search
C4S
H1K
(71) Applicants
Burhan Bayraktaroglu
120 Glen Street
Apartment 2
Yellow Springs
Ohio 45387
USA
Hans Ludwig Hartnagel
An Der Ziegelhutte 1
Ernsthofen (Odenwald)
6101 Modautal
West Germany
(72) Inventors
Burhan Bayraktaroglu
Hans Ludwig Hartnagel
(74) Agents
Mr P W Neville

(54) **Light-emitting diode**

(57) A diode which emits white light when reverse-biassed consists of a semiconductor bearing a thick layer of semiconductor oxide (e.g. gallium arsenide oxide and/or alumina). On top of that is a metal (e.g. indium) contact pad. The light appears as a halo around the contact. A second contact on the oxide layer may be used in place of a direct connection to the semiconductor body.

Savant Technologies LLC - 1004.653

SPECIFICATION

Light-emitting diode

This invention relates to a light-emitting diode, and to a method of producing white light.

Light-emitting diodes have been developed which give red or green light, but white light has hitherto been unobtainable.

The present invention is a light-emitting diode comprising a semiconductor bearing a layer of semiconductor oxide, the oxide layer bearing a metal pad, the diode under reverse bias emitting white light. The invention also provides a method of producing white light, comprising reverse-biassing a diode comprising a semiconductor bearing a layer of semiconductor oxide, the oxide layer bearing a metal pad. The light appears as a halo around the edge of the metal pad, and typically is a continuous spectrum over the visible range (wavelengths 420–700nm approximately) and continuing, as might be expected, well into the infra-red.

The semiconductor may be silicon, preferably with an ample superficial trap density, or a III/V semiconductor such as gallium arsenide, which may be bulk grown or epitaxially grown, or a II/VI semiconductor. The gallium arsenide may be p-type or n-type, the latter being preferred. The gallium arsenide has preferred dopant concentration of 10^{16} to 5×10^{17} per ml, but such pre-injected holes are not essential; they do, however, lower the voltage of operation. Excessive doping will eliminate the necessary Schottky barrier.

The oxide layer may be produced as desired, for example by leaving the semiconductor in air, by thermal growth, by depositing a reactive oxide such as Al_2O_3 or silicon nitride or (preferably, for the best reproducibility) by anodising. The oxide layer may be as thin as 10 Å or 20 Å, but in such cases the light-emitting diode might have only a short life. The oxide layer is preferably at least 50 Å thick for reasonable durability, more preferably at least 100 Å thick. For normal conditions, the oxide layer need not exceed 300 Å in thickness, but thicker layers may be advisable for high-temperature operation.

The oxide may be Al_2O_3 or may be a composite oxide, produced for example by plating Al on to GaAs and anodising the whole.

In a transistor having this surface oxide structure, operation would be under forward biassing, not under the reverse bias used for this light-emitting diode. In a transistor operated under reverse bias, the oxide, far from being present to, say, 100 Å or more thickness, would be prevented by all possible means from forming.

The metal, in the case of n-type gallium arsenide, is preferably one with a low work function. Therefore indium is preferred. Gold will work but is not usually preferred, and aluminium is midway between indium and gold. Gold is preferred in the unusual case where a guard ring is provided around the metal pad to prevent high fields at the perimeter of the pad; under reverse bias, light is then emitted from the whole area of oxide underlying the pad, but is only visible to the extent that it can shine through the metal pad. In that case, the pad is preferably gold, which can be applied in very thin (translucent) layers.

The metal may be evaporated on to the oxide, or applied patternwise by photoresist techniques, or in any suitable way.

If it is desired to make an artefact which is luminescent over an area, rather than punctiformly or linearly, the above guard ring technique is possible but, more preferably, the metal pad would be applied as a grid extending over the desired area.

Using n-type GaAs, doped at 10^{16}/ml, with indium as the metal, light is emitted at a current of 10mA. With p-type GaAs, the current might have to be over 100mA. Although the power consumptions may be similar, the larger current makes the p-type less stable.

The diode may be annealed before use; this will usually change the trap level distribution and hence the spectrum produced. Increasing the voltage increases the brightness but does not alter the spectrum, this being in passing a demonstration that the light emitted is not due to thermal radiation following breakdown of some layer. Nor is the emission due to plasmon excitation, since that requires a rough metal pad surface (such as indium offers), while the present diode will work with aluminium pads, which are smooth.

The temperature range of operation is at least from 77K to 393K for n-type GaAs/GaAs oxide/In, the lower temperatures favouring efficiency.

The invention also includes a triode, comprising the diode set forth above, wherein the metal pad has associated with it but spaced from it a second metal pad borne on the oxide layer. The second metal pad may be an annulus surrounding the first metal pad, or the first and second metal pads may be in the form of alternating aligned or criss-crossing (non-contacting) strips.

The second metal pad may be spaced a clear 10^2 to 10^4 Å from the first metal pad. The metals may be the same, which makes for ease of fabrication, or different, such as to induce more holes in the semiconductor. In operation, the second metal pad is raised to a potential positive with respect to the first metal pad. The semiconductor, on its face opposite the metal pads, may be earthed, but need not be if the second and first pads are respectively forward and reverse biassed.

The smaller the clear spacing between the

Savant Technologies LLC - 1004.654

pads, the lower the voltage at onset of luminescence, and thus the greater the efficiency. Using n-type GaAs, doped at 10^{16}/ml, with a 20 Å layer of oxide, and the pads a clear 1000 Å apart, luminescence may be expected at an applied potential of 2V; current consumption might be around 20mA.

Under forward biassing of the second metal pad, positive holes are formed in the n-type GaAs, giving rise at will to an inversion layer, which migrates under the electric field to the first metal pad, at the edge of which the field is strong enough to cause electrons from the reverse-biassed first metal pad to annihilate the holes with emission of energies in the visible range. In this way, light is produced without having to rely on avalanching.

The invention also provides a double-oxide light-emitting diode, being layers successively of a metal, alumina, metal-oxide and semiconductor, both the alumina and oxide being from 20 Å to 70 Å thick (thinner than for charge-storage devices). Light intensity may be improved by this structure.

The choice of metal for that pad which is to be reverse biassed is governed by the requirement that the difference in Fermi levels (volts) between the metal and the semiconductor must be too small to break down the oxide layer. As the oxide layer will withstand voltages in direct proportion to the thickness of the layer, that layer can be made as thick as necessary, at the cost of efficiency. The Fermi level difference between gold and gallium arsenide is about 1.3 volts, which would break down a thin oxide layer. The Fermi level difference between the metal indium and the semiconductor gallium arsenide is very small, making those an ideal pair. Aluminium in this respect is intermediate between indium and gold.

Diodes were made up using n-type GaAs differing in dopant (pre-injected hole) concentration, and differing in choice of metal pad. The diodes required the following approximate reverse biassing to start passing current.

Dopant	Metal	Bias	Current
10^{16}/ml	Al	− 19V	5mA
10^{16}/ml	In	− 15V	10mA
10^{17}/ml	Al	− 9V	20mA

The above values for 'current' are the approximate currents passed at a given intensity of light emission by each diode. The structure with the lowest voltage of operation is thus not necessarily the most efficient.

An exemplary light-emitting diode was constructed as follows:

A sample of n-type gallium arsenide (hole density 10^{16}/ml) was etched in a solvent containing 2 weight percent NaOH and 4 volume percent H_2O_2—which at room temperature dissolves gallium arsenide at about 1000 Å/minute.

The sample was anodised as described in British Patent Specification 1503411, to give a native oxide thickness of 100 Å. A spot of indium was evaporated on to the oxide, and a pin was rested on the spot. The sample was resting on a conductive grid. A bias of − 15V was applied between the pin and the conductive grid. A current of 10mA flowed, and white light was emitted around the edge of the spot.

CLAIMS

1. A light-emitting diode comprising a semiconductor bearing a layer of semiconductor oxide, the oxide layer bearing a metal pad, the diode being such as to emit white light when reverse-biassed.

2. A light-emitting diode according to Claim 1, wherein the semiconductor is silicon having a substantial superficial trap density.

3. A light-emitting diode according to Claim 1, wherein the semiconductor is a III/V or a II/VI semiconductor.

4. A light-emitting diode according to Claim 3, wherein the semiconductor is a gallium arsenide.

5. A light-emitting diode according to Claim 4, wherein the gallium arsenide is n-type.

6. A light-emitting diode according to any of Claims 2 to 5, wherein the semiconductor has a dopant concentration of 10^{16} to 5×10^{17}/ml.

7. A light-emitting diode according to any preceding claim, wherein the layer of semiconductor oxide is at least 50 Å thick.

8. A light-emitting diode according to Claim 7, wherein the layer of semiconductor oxide is from 100 to 300 Å thick.

9. A light-emitting diode according to any preceding claim, wherein the semiconductor oxide is Al_2O_3 or contains Al_2O_3.

10. A double-oxide light-emitting diode, comprising a light-emitting diode according to Claim 9 wherein the Al_2O_3 is in the form of a layer interposed between the metal pad and the oxide of the semiconductor, both the Al_2O_3 and the oxide of the semi-conductor being from 20 Å to 70 Å thick.

11. A light-emitting diode according to Claim 4 or any claim dependent thereon, wherein the metal pad is of indium.

12. A light-emitting diode according to any preceding claim, wherein the metal pad has the form of a grid extending over that area of the oxide layer which is to emit light.

13. A light-emitting diode according to any of Claims 1 to 10, wherein the metal pad is of translucently thin gold and further comprising a guard ring around the pad.

14. A light-emitting diode according to Claim 1 and substantially as hereinbefore de-

Savant Technologies LLC - 1004.655

scribed.

15. A light-emitting triode comprising a light-emitting diode according to any preceding claim further comprising a second metal pad spaced from the (first) metal pad and also in contact with the semiconductor oxide.

16. A light-emitting triode according to Claim 15, wherein the second metal pad is an annulus surrounding the first metal pad.

17. A light-emitting triode according to Claim 15, wherein the first and second metal pads are in the form of alternating aligned or criss-crossing (non-contacting) strips.

18. A method of producing white light, comprising reverse-biassing a diode or triode according to any preceding claim.

19. A method according to Claim 18, wherein the reverse-biassing is arranged to produce a current flow of at least 10mA.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1979.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

Savant Technologies LLC - 1004.656

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **01-260707**

(43)Date of publication of application : **18.10.1989**

(51)Int.CI. **F21V 9/10**

F21V 5/00

H01L 33/00

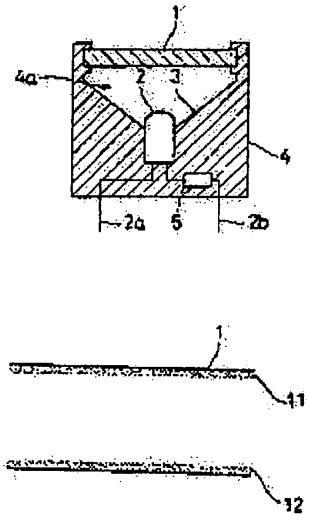
(21)Application number : **63-088445**

(22)Date of filing : **11.04.1988**

(71)Applicant : **IDEC IZUMI CORP**
MITSUI PETROCHEM IND LTD

(72)Inventor : **USUDA SHOJI**
GANAI KAKUTARO

(54) DEVICE FOR EMITTING WHITE LIGHT



(57)Abstract:

PURPOSE: To enable pure white light to be obtained by transparent light by means of color mixing by letting a device be composed of LED, a transparent glass body which is dyeing agent penetrating and is high in transparency wherein each of dyeing agents of two color composing three primary colors formed by color mixing of luminous color from LED is penetrated into the respective front and rear surfaces of the glass body, and of a case which supports the glass body while letting it be faced with the luminous section of LED.

CONSTITUTION: In a case 4 made of an insulating resin raw material formed into a box shape, the inner circumferential surface of a recessed section 4a wherein a red color LED 2 is embedded, is composed of an inclined surface the face of which is covered with a reflective film so as to be used as a reflector 3. The glass body 1 is composed of polymerizable fluid polymer including monomer, or oligomer, or mixture thereof which includes compound in a bisallyle family as an essential ingredient so as to be formed into a plane shape. In addition, a blue dyeing agent 11 and a green dyeing

BEST AVAILABLE COPY

Savant Technologies LLC - 1004.657

agent 12 are penetrated into the front and the rear surfaces of the glass body 1 respectively over an appropriate range. This constitution thereby permits the three primary colors by color mixing to be formed so that pure white light can be obtained.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2003 Japan Patent Office

⑲日本国特許庁(JP)　⑪特許出願公開

⑫公開特許公報(A)　平1−260707

⑤1Int.Cl.⁴	識別記号	庁内整理番号	⑷3公開　平成1年(1989)10月18日
F 21 V 9/10		6908−3K	
5/00		6908−3K	
H 01 L 33/00		M−7733−5F	審査請求　未請求　請求項の数 4　(全11頁)

⑤4発明の名称　白色発光装置

⑵1特　願　昭63−88445
⑵2出　願　昭63(1988)4月11日

⑦2発明者　白田　昭司　大阪府大阪市淀川区三国本町1丁目10番40号　和泉電気株式会社内
⑦2発明者　賀内　覚太郎　千葉県君津郡袖ケ浦町長浦字拓2号　三井石油化学工業株式会社内
⑦1出願人　和泉電気株式会社　大阪府大阪市淀川区三国本町1丁目10番40号
⑦1出願人　三井石油化学工業株式会社　東京都千代田区霞が関3丁目2番5号
⑦4代理人　弁理士　小森　久夫

明細書

1.発明の名称

白色発光装置

2.特許請求の範囲

(1) ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透させた染料浸透性かつ高透光性の透明ガラス体と、このガラス体をＬＥＤの発光部に対向させて保持するケースと、により構成したことを特徴とする白色発光装置。

(2) ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透させた染料浸透性かつ高透光性の透明ガラス体の中空封止体と、から構成したことを特徴とする白色発光装置。

(3) 加色混合の三原色のうちの二色のそれぞれに発色する積層配置された二つのＬＥＤと、加色混合の三原色の残る一色の染料を表面から浸透させた染料浸透性かつ高透光性の透明ガラス体の封止体と、から構成したことを特徴とする白色発光装置。

(4) 前記染料が、蛍光染料である請求項1～3のいずれかに記載の白色発光装置。

3.発明の詳細な説明

(a)産業上の利用分野

この発明は、ＬＥＤを用いた表示装置に関し、特に白色発光して表示を行う白色発光装置に関する。

(b)従来の技術

操作パネルにおいて動作状態を表示する表示ランプが多数になると、互いを区別するために多数色の表示ランプが必要になり、白色発光する表示ランプが必要となる場合がある。そこで従来の表示ランプではフィラメントランプの前面に不透明乳白色の樹脂板などの拡散板を備えたものがあった。これによってフィラメントランプの発光を拡散板において拡散し、白色光を得るようにしている。

(c)発明が解決しようとする課題

Savant Technologies LLC - 1004.659

しかしながら、上記従来の表示ランプでは、光源にフィラメントランプを用いていたため、消費電力が大きく、また発熱も著しいため、フィラメントランプが切れやすくランプの交換作業が煩雑になる欠点があった。また、拡散板による光の拡散によって白色光を得ていたため、赤，緑，青の三原色の加色混合によって得られる白色光と異なり、黄色味がかった不鮮明な白色しか得られなかった。

この発明の目的は、ＬＥＤの発光色と染料浸透性および高透光性を有する透明ガラス体の表裏面の染料色とで加色混合の白色を得るようにし、消費電力を低下するとともに発熱を軽減し、さらに交換作業を不要にするとともに、透過光によって加色混合の純粋な白色を得ることができる白色発光装置を提供することにある。

(d)課題を解決するための手段

この発明の白色発光装置は、ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透させた染料浸透性かつ高透光性の透明ガラス体と、このガラス体をＬＥＤの発光部に対向させて保持するケースと、により構成したことを特徴とする。

また、上記透明ガラス体を上記ＬＥＤの中空封止体としても良い。

さらに、加色混合の原色のうちの二色のそれぞれに発光する二つのＬＥＤを積層して配置し、上記透明ガラス体により構成した封止体の表面に三原色のうちの残る一色の染料を浸透させても良い。

また、上記染料として蛍光染料を用いても良い。

(e)作用

この発明においては、ＬＥＤの白色は高透光性のガラス体を透過して外部に配光される。このガラス体は染料浸透性の透明ガラス体であり、表裏面のそれぞれから二色の染料が浸透されている。この二色の染料はＬＥＤの発光色とともに加色混合の三原色を構成する。ガラス体に浸透した染料は外部光を反射し、その光の反射方向はＬＥＤの白色光の配光方向に等しい。したがって、外部からガラス体を見ると、ＬＥＤの発光色と二色の染料色との三色が混合して白色光に見える。

以上の作用は、上記の二色の染料を浸透した透明ガラス体をＬＥＤの中空封止体とした場合にも同様である。

また、加色混合の三原色のうちの二色のそれぞれに発光する二つのＬＥＤを積層配置すると、それらの上方に二色の混合した光が配光される。この２つのＬＥＤを染料浸透性および高透光性を有する透明ガラス体で封止すると、上記２色の混合光が透明ガラス体を透過する。このとき、透明ガラス体に加色混合の三原色の残りの一色の染料を浸透させておくと、透明ガラス体の外側には加色混合の三原色の光が混合して配光され、白色光に見える。

透明ガラス体に浸透させる染料を蛍光染料とすると、光の混合状態がより良好になる。

(f)実施例

第１図は、この発明の実施例である白色発光装置の側面断面図である。

絶縁性樹脂素材により箱型形状に成型されたケース４の内部に赤色ＬＥＤ２が埋めこまれている。この赤色ＬＥＤ２はケース４の凹部４ａに露出している。この凹部４ａの外縁部には平板状のガラス体１が固定されている。また、凹部４ａの内周面は表面を反射被膜により被覆された傾斜面によって構成されており、リフレクタ３にされている。また、赤色ＬＥＤ２のリード線２ａ，２ｂは抵抗５を介して外部に露出している。

第２図は、上記白色発光装置の一部を構成する透明ガラス体の側面断面図である。

ガラス体１は、ビスアリル系化合物を必須成分として含むモノマーまたはオリゴマーまたはこれらの混合物を含む重合可能な液状物の重合体を平板状に形成したものである。ビスアリル系化合物を必須成分として含むモノマーまたはオリゴマーまたはこれらの混合物を含む重合可能な液状物は、好ましくは脂肪族、脂環式または芳香族二価ア

Savant Technologies LLC - 1004.660

ルコールのビス（アリルカーボネート）のモノマーまたはオリゴマーまたはこれらの混合物と、重合開始剤とを含有する組成物である。この一例としては、

特開昭59－45312号記載の、核ハロゲン置換ベンゼンジカルボン酸のジアリレングリコールジアリルカーボネートとの共重合体、

特開昭59－8709号記載の、核ハロゲン置換ベンゼンジカルボン酸のエステル類（例えば2，4－ジクロロテレフタル酸ビスアリルエステルなど）の一種以上と、単独重合体としての屈折率が1．55以上であるラジカル重合可能で芳香環含有の単官能性単量体（例えばフェニルメタクリレートなど）の一種以上との共重合体、

特開昭59－8710号記載の、特定のビスアリルカーボネートまたはビスβ－メチルアリルカーボネート（例えば1，4－ビス（ヒドロキシエトキシ）ベンゼンビスアリルカーボネートなど）の一種以上と、単独重合体としての屈折率が1．55以上であるラジカル重合可能で芳香環含有の単官能性単量体（例えばフェニルメタクリレートなど）の一種以上との共重合体、

特開昭59－96109号記載の、モノオール（例えば4－ベンジルーフェノール）と不飽和カルボン酸（クロライド）（例えばアクリル酸（クロライド））とを反応させたモノマーと、単独重合体の屈折率が1．55以上のラジカル重合可能なモノマー（例えばスチレン）との共重合体、

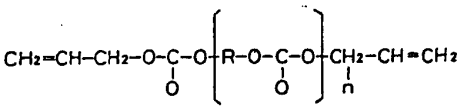
特開昭59－96113号記載の、クロロ安息香酸のアリルエステル（例えば2，3－ジクロロ安息香酸ジアリルエステル）と、2官能性単量体（例えばテトラブロモフタル酸のジアリルエステル）との共重合体、

特開昭59－184210号記載の共重合体、

ジエチレングリコールビスアリルカーボネート

および

一般式



（式中、Rは2価アルコールの残基であり、nの値またはnの平均値は1～10、好ましくは2～10である）で表される脂肪族、脂環式または芳香族二価アルコールのビス（アリルカーボネート）のモノマーまたはオリゴマーまたはこれらの混合物aを含有する。　成分aは、好ましくは、ジアリルカーボネートと二価アルコールとのモル比4：1以下、より好ましくは、モル比2：1における反応生成物であるのがよい。

二価アルコールは、好ましくは、エチレングリコール、1，3－プロパンジオール、1，4－ブタンジオール、1，6－ヘキサンジオール、ジエチレングリコール、ポリエチレングリコール、ジプロピレングリコール、プロピレングリコール、ネオペンチルグリコール、トリメチルペンタンジオール、シクロヘキサンジメタノール、ビス（ヒドロキシメチル）トリシクロデカン、2，7－ノルボルナンジオール、α，α′－キシレンジオール、1，4－ビス（ヒドロキシエトキシベンゼン）および2，2－ビス（4－（ヒドロキシエトキシ）フェニル）プロパンの一種または二種以上を用いる。

重合開始剤は、光重合開始剤、熱重合開始剤、光・熱併用重合開始剤またはこれらの組み合わせなどいかなるものを用いてもよい。

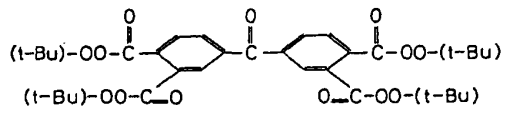
光重合開始剤には光重合開始剤の他、電子線、放射線重合開始剤などがある。

光重合開始剤としては、たとえば2－ヒドロキシ－2－メチル－1－フェニル－プロパン－1－オンが挙げられる。

熱重合開始剤としては、ジイソプロピルパーオキシジカーボネート、ジセカンダリブチルパーオキシジカーボネート、ジシクロヘキシルパーオキシジカーボネート、過安息香酸第3ブチルなどのパーオキシジカーボネート類、ベンゾイルパーオキシド、アセチルパーオキシドなどのジアシルパーオキシド類などの有機過酸化物および、アゾビスイソブチロニトリルなどのラジカル開始剤が挙げられる。

光・熱併用重合開始剤としては、例えば下記式

Savant Technologies LLC - 1004.661



の化合物が挙げられる。

重合開始剤の使用量は、封止剤に対して、0.1～10wt%、好ましくは1～6wt%とする。

上記の組成を有する透明ガラス体1は染料浸透性を備え、ガラス体1の温度を上昇すると、ガラス体1を構成する分子の間隔が広がり、染料の染色剤が分子間に浸透する。こののち温度を常温まで冷却すると分子間隔が再び狭まり、ガラス体1の内部に染色剤が封じこめられる。ガラス体1は上記染料浸透性の特性により表裏両面の近傍を青色および緑色に染色している。すなわち、青色および緑色の染色剤をそれぞれ2g／ℓの割合で水中に溶かして青色および緑色の染色液を作成し、これを83℃程度まで昇温する。このようにして作成した青色および緑色の染色液中にガラス体1の表裏それぞれの面を適当な時間浸漬する。これによってガラス体1の表裏面には第2図の断面図に示すように青色染色剤11および緑色染色剤12がそれぞれ適当な範囲に浸透する。また、上記組成を有するガラス体は、98%程度の高い透光性を備えている。

以上のように構成された白色発光装置の赤色LED2を駆動すると、赤色LED2の赤色光は、充分な透光性を有するガラス体1を通過し外部に配光される。また、ガラス体1の内部に浸透した青色および緑色の染料は外部光を反射し、この反射光がLED2の赤色光と同方向に配光される。これによって白色発光装置の外側では加色混合の三原色を構成する赤、緑および青の三色が混合し、白色光として認知される。

なお、本実施例では染料浸透性の透明ガラス体を平板状に形成したが、この透明ガラス体を第3図に示すようにLEDの中空封止体としてもよい。この場合において同図に示す中空封止体31は、前記組成のガラス体を中空形状に成型した後、その外側面および内側面に加色混合の三原色のうちの二色のそれぞれを浸透させる。この中空封止体31により、三原色のうちの残りの一色に発光するLED32をカバーすれば、LED32の発光が中空封止体31を浸透する際に加色混合の三原色が混合し、中空封止体31の外部に白色光を得る。例えば赤色LEDを用いた場合には中空封止体31の表裏面にそれぞれ青色および緑色の染料を浸透させる。また、赤色LEDの代わりに緑色LEDを使用した場合には、中空封止体31の表裏面にそれぞれ青色および赤色の染料を浸透させることにより同様の効果を得ることができる。

さらに、第5図に示すように加色混合の三原色のうちの二色のそれぞれに発光するLED42a，42bを積層して配置し、このLED42a，42bを前記組成のガラス体で封止して封止体41を形成した後、この封止体41に三原色の残る一色の染料を浸透させて白色発光装置を構成しても良い。この場合第5図に示すように、GaP緑色LED41aとGaAsP赤色LED41bとを電極51，52を銀ペースト53を用いて接合する。この接合面において電極51，52は部分的に配置されており、赤色LED41bの光は緑色LED41aを透過し、緑色LED41aの光とともに上方に配光される。このとき、封止体41の表面に青色染料を浸透させておくことにより、加色混合の三原色を混合して白色光を得ることができる。LED41a，41bにおいてその発光の一部は水平方向に配光されるが、約70%程度は上方に配光され、これにより白色光を得ることができる。

なお、透明ガラス体1、中空封止体31および封止体41に浸透させる染料を螢光染料とすると加色混合状態がより良好になり、白色光の視認性が高くなる。

(6)発明の効果

請求項1および2に記載した発明によれば、ガラス体の表裏面または中空封止体の内外側面に浸透した二色の染料とLEDの発光とにより、加色

Savant Technologies LLC - 1004.662

混合の三原色を構成して白色光を得ることができる。この白色光はＬＥＤの透明ガラス体を透過した光によって得られる鮮明な白色光である。また、ＬＥＤの使用によって消費電力を低減するとともにフィラメント切れなどによるランプの交換作業を排除することができる。

また、請求項３に記載した発明によれば、積層配置された二色のＬＥＤの発光と封止体に浸透した染料とにより加色混合の三原色を構成して白色光を得ることができる。この場合において二色のＬＥＤを封止後に封止体を染料中に浸漬して白色発光装置を得ることができ、その製造工程が簡略化できる。

さらに、請求項４に記載した発明によれば、蛍光染料を用いることによってＬＥＤの発光色との混合状態をより良好にできる。

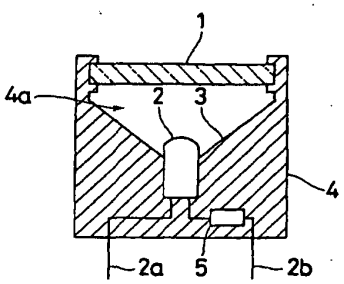
4.図面の簡単な説明

第１図は請求項１記載の発明の実施例である白色発光装置の側面断面図、第２図は同白色発光装置の一部を構成する透明ガラス体の断面図である。また、第３図は請求項２記載の発明の実施例である白色発光装置を示す側面断面図である。さらに、第４図は請求項３記載の発明の実施例である白色発光装置を示す側面図、第５図は同白色発光装置のＬＥＤの構成を示す図である。

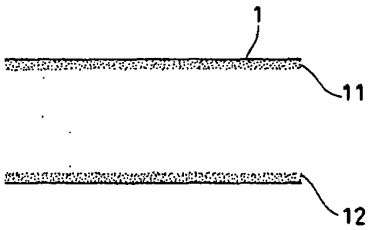
１－透明ガラス体、
２－赤色ＬＥＤ、
４－ケース、
１１－青色染料、
１２－緑色染料、
３１－中空封止体、
４１－封止体。

出願人　和泉電気株式会社
　　三井石油化学工業株式会社
代理人　弁理士　小森久夫

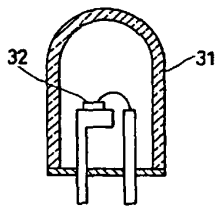
第1図



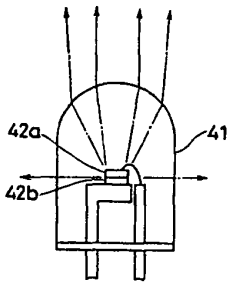
第2図



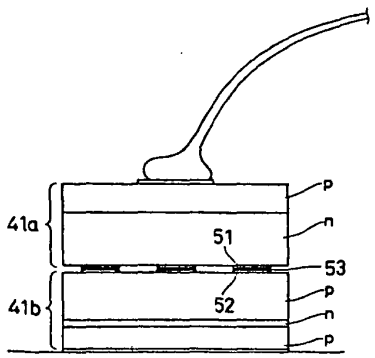
第3図



第4図



第5図



BEST AVAILABLE COPY

Savant Technologies LLC - 1004.663

手 続 補 正 書 (自発)

昭和 63 年 9月 22日

特許庁長官 殿

1 事件の表示
特願昭 63-088445 号

2 発明の名称
白色発光装置

3 補正をする者
事件との関係 特許出願人
住所 大阪市淀川区三国本町１丁目１０番４０号
名称(氏名) (030) 和泉電気株式会社
4 代理人 代表者 藤田 貞三
住所 大阪市東区谷町2-27 ビジョンビル
Tel. 06-941-3982 Fax. 06-941-3983
氏名 弁理士 (8454) 小森 久夫

5 補正命令の日付(発送日) 昭和 年 月 日 (自発)

6 補正により増加する発明の数 なし

7 補正の対象
(1) 発明の詳細な説明
(2)
(3)
(4)
(5)

63. 9. 24

8 補正の内容
(1) 発明の詳細な説明を次の通りに補正する.
(a) 明細書の第8頁を別紙の通りに補正する.

単官能性単量体（例えばフェニルメタクリレートなど）の一種以上との共重合体、

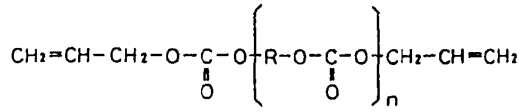
特開昭５９－９６１０９号記載の、モノオール（例えば４－ベンジルーフェノール）と不飽和カルボン酸（クロライド）（例えばアクリル酸（クロライド））とを反応させたモノマーと、単独重合体の屈折率が１．５５以上のラジカル重合可能なモノマー（例えばスチレン）との共重合体、

特開昭５９－９６１１３号記載の、クロロ安息香酸のアリルエステル（例えば２，３－ジクロロ安息香酸ジアリルエステル）と、２官能性単量体（例えばテトラブロモフタル酸のジアリルエステル）との共重合体、

特開昭５９－１８４２１０号記載の共重合体、

ジエチレングリコールビスアリルカーボネート、および

一般式



手 続 補 正 書(自発)

平成 1 年 4月 28日

特許庁長官 殿

1 事件の表示
特願昭 63-088445 号

2 発明の名称
白色発光装置

3 補正をする者
事件との関係 特許出願人
住所 大阪市淀川区三国本町1丁目10番40号
名称(氏名) (030) 和泉電気株式会社
代表者 藤田 貞三
4 代理人
住所 大阪市中央区谷町2丁目3番8号
ピジョンビル
Tel. 06-941-3982 Fax. 06-941-3983
氏名 弁理士 (8454) 小森 久夫

5 補正命令の日付(発送日)(自発)平成 年 月 日

6 補正により増加する発明(または請求項)の数 なし

7 補正の対象
(1) 発明の詳細な説明
(2)
(3)
(4)
(5)

1. 5. 1

BEST AVAILABLE COPY

Savant Technologies LLC - 1004.664

8　補正の内容
(1)明細書全文を別紙の通りに補正する。
（但し、補正の対象の個に記載した以外は変更なし）

明　細　書

1.発明の名称

白色発光装置

2.特許請求の範囲

(1)　ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透させた染料浸透性かつ高透光性の透明ガラス体と、このガラス体をＬＥＤの発光部に対向させて保持するケースと、により構成したことを特徴とする白色発光装置。

(2)　ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透させた染料浸透性かつ高透光性の透明ガラス体の中空封止体と、から構成したことを特徴とする白色発光装置。

(3)　加色混合の三原色のうちの二色のそれぞれに発色する積層配置された二つのＬＥＤと、加色混合の三原色の残る一色の染料を表面から浸透させた染料浸透性かつ高透光性の透明ガラス体の封止体と、から構成したことを特徴とする白色発光装置。

(4)　前記染料が、蛍光染料である請求項１～３のいずれかに記載の白色発光装置。

3.発明の詳細な説明

(a)産業上の利用分野

この発明は、ＬＥＤを用いた表示装置に関し、特に白色発光して表示を行う白色発光装置に関する。

(b)従来の技術

操作パネルにおいて動作状態を表示する表示ランプが多数になると、互いを区別するために多数色の表示ランプが必要になり、白色発光する表示ランプが必要となる場合がある。そこで従来の表示ランプではフィラメントランプの前面に不透明乳白色の樹脂板などの拡散板を備えたものがあった。これによってフィラメントランプの発光を拡散板において拡散し、白色光を得るようにしている。

(c)発明が解決しようとする課題

しかしながら、上記従来の表示ランプでは、光源にフィラメントランプを用いていたため、消費電力が大きく、また発熱も著しいため、フィラメントランプが切れやすくランプの交換作業が煩雑になる欠点があった。また、拡散板による光の拡散によって白色光を得ていたため、赤，緑，青の三原色の加色混合によって得られる白色光と異なり、黄色味がかった不鮮明な白色しか得られなかった。

この発明の目的は、ＬＥＤの発光色と染料浸透性および高透光性を有する透明ガラス体の表裏面の染料色とで加色混合の白色を得るようにし、消費電力を低下するとともに発熱を軽減し、さらに交換作業を不要にするとともに、透過光によって加色混合の純粋な白色を得ることができる白色発光装置を提供することにある。

(d)課題を解決するための手段

この発明の白色発光装置は、ＬＥＤと、このＬＥＤの発光色とで加色混合の三原色を構成する二色の染料のそれぞれを表裏面のそれぞれから浸透

Savant Technologies LLC - 1004.665

させた染料浸透性かつ高透光性の透明ガラス体と、このガラス体をＬＥＤの発光部に対向させて保持するケースと、により構成したことを特徴とする。

また、上記透明ガラス体を上記ＬＥＤの中空封止体としても良い。

さらに、加色混合の原色のうちの二色のそれぞれに発光する二つのＬＥＤを積層して配置し、上記透明ガラス体により構成した封止体の表面に三原色のうちの残る一色の染料を浸透させても良い。

また、上記染料として蛍光染料を用いても良い。

(e)作用

この発明においては、ＬＥＤの白色は高透光性のガラス体を透過して外部に配光される。このガラス体は染料浸透性の透明ガラス体であり、表裏面のそれぞれから二色の染料が浸透されている。この二色の染料はＬＥＤの発光色とともに加色混合の三原色を構成する。ガラス体に浸透した染料は外部光を反射し、その光の反射方向はＬＥＤの白色光の配光方向に等しい。したがって、外部からガラス体を見ると、ＬＥＤの発光色と二色の染料色との三色が混合して白色光に見える。

以上の作用は、上記の二色の染料を浸透した透明ガラス体をＬＥＤの中空封止体とした場合にも同様である。

また、加色混合の三原色のうちの二色のそれぞれに発光する二つのＬＥＤを積層配置すると、それらの上方に二色の混合した光が配光される。この２つのＬＥＤを染料浸透性および高透光性を有する透明ガラス体で封止すると、上記２色の混合光が透明ガラス体を透過する。このとき、透明ガラス体に加色混合の三原色の残りの一色の染料を浸透させておくと、透明ガラス体の外側には加色混合の三原色の光が混合して配光され、白色光に見える。

透明ガラス体に浸透させる染料を蛍光染料とすると、光の混合状態がより良好になる。

(f)実施例

第１図は、この発明の実施例である白色発光装置の側面断面図である。

絶縁性樹脂素材により箱型形状に成型されたケース４の内部に赤色ＬＥＤ２が埋めこまれている。この赤色ＬＥＤ２はケース４の凹部４ａに露出している。この凹部４ａの外縁部には平板状のガラス体１が固定されている。また、凹部４ａの内周面は表面を反射被膜により被覆された傾斜面によって構成されており、リフレクタ３にされている。また、赤色ＬＥＤ２のリード線２ａ，２ｂは抵抗５を介して外部に露出している。

第２図は、上記白色発光装置の一部を構成する透明ガラス体の側面断面図である。

ガラス体１は、ビスアリル系化合物を必須成分として含むモノマーまたはオリゴマーまたはこれらの混合物を含む重合可能な液状物の重合体を平板状に形成したものである。ビスアリル系化合物を必須成分として含むモノマーまたはオリゴマーまたはこれらの混合物を含む重合可能な液状物は、好ましくは脂肪族、脂環式または芳香族二価アルコールのビス（アリルカーボネート）のモノマーまたはオリゴマーまたはこれらの混合物と、重合開始剤とを含有する組成物である。この一例としては、

特開昭５９－４５３１２号記載の、核ハロゲン置換ベンゼンジカルボン酸のジアリルエステルと、ジエチレングリコールジアリルカーボネートとの共重合体、

特開昭５９－８７０９号記載の、核ハロゲン置換ベンゼンジカルボン酸のエステル類（例えば２，４－ジクロロテレフタル酸ビスアリルエステルなど）の一種以上と、単独重合体としての屈折率が１．５５以上であるラジカル重合可能で芳香環含有の単官能性単量体（例えばフェニルメタクリレートなど）の一種以上との共重合体、

特開昭５９－８７１０号記載の、特定のビスアリルカーボネートまたはビスβ－メチルアリルカーボネート（例えば１，４－ビス（ヒドロキシエトキシ）ベンゼンビスアリルカーボネートなど）の一種以上と、単独重合体としての屈折率が１．

Savant Technologies LLC - 1004.666

５５以上であるラジカル重合可能で芳香環含有の単官能性単量体（例えばフェニルメタクリレートなど）の一種以上との共重合体、

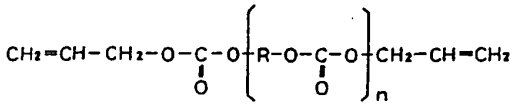
特開昭５９－９６１０９号記載の、モノオール（例えば４－ベンジルーフェノール）と不飽和カルボン酸（クロライド）（例えばアクリル酸（クロライド））とを反応させたモノマーと、単独重合体の屈折率が１．５５以上のラジカル重合可能なモノマー（例えばスチレン）との共重合体、

特開昭５９－９６１１３号記載の、クロロ安息香酸のアリルエステル（例えば２，３－ジクロロ安息香酸ジアリルエステル）と、２官能性単量体（例えばテトラブロモフタル酸のジアリルエステル）との共重合体、

特開昭５９－１８４２１０号記載の共重合体、

ジエチレングリコールビスアリルカーボネートの共重合体、および

一般式



（式中、Ｒは２価アルコールの残基であり、ｎの値またはｎの平均値は１～１０、好ましくは２～１０である）で表される脂肪族、脂環式または芳香族二価アルコールのビス（アリルカーボネート）のモノマーまたはオリゴマーまたはこれらの混合物ａを含有する組成物の共重合体がある。成分ａは、好ましくは、ジアリルカーボネートと二価アルコールとのモル比４：１以下、より好ましくは、モル比２：１における反応生成物であるのがよい。

二価アルコールは、好ましくは、エチレングリコール、１，３－プロパンジオール、１，４－ブタンジオール、１，６－ヘキサンジオール、ジエチレングリコール、ポリエチレングリコール、ジプロピレングリコール、プロピレングリコール、ネオペンチルグリコール、トリメチルペンタンジオール、シクロヘキサンジメタノール、ビス（ヒドロキシメチル）トリシクロデカン、２，７－ノルボルナンジオール、α，α′－キシレンジオール、１，４－ビス（ヒドロキシエトキシベンゼン）および２，２－ビス（４－（ヒドロキシエトキシ）フェニル）プロパンの一種または二種以上を用いる。

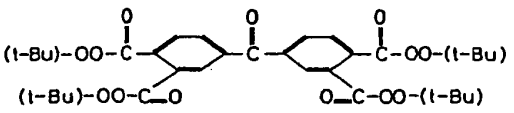
重合開始剤は、光重合開始剤、熱重合開始剤、光・熱併用重合開始剤またはこれらの組み合わせなどいかなるものを用いてもよい。

光重合開始剤には光重合開始剤の他、電子線、放射線重合開始剤などがある。

光重合開始剤としては、たとえば２－ヒドロキシ－２－メチル－１－フェニループロパン－１－オンが挙げられる。

熱重合開始剤としては、ジイソプロピルパーオキシジカーボネート、ジセカンダリブチルパーオキシジカーボネート、ジシクロヘキシルパーオキシジカーボネート、過安息香酸第３ブチルなどのパーオキシジカーボネート類、ベンゾイルパーオキシド、アセチルパーオキシドなどのジアシルパーオキシド類などの有機過酸化物および、アゾビスイソブチロニトリルなどのラジカル開始剤が挙げられる。

光・熱併用重合開始剤としては、例えば下記式



の化合物が挙げられる。

重合開始剤の使用量は、ビスアリル系化合物を必須成分として含むモノマーまたはオリゴマーまたはこれらの混合物を含む重合可能な液状物である封止剤に対して、０．１～１０ｗｔ％、好ましくは１～６ｗｔ％とする。

上記の組成を有する透明ガラス体１は染料浸透性を備え、ガラス体１の温度を上昇すると、ガラス体１を構成する分子の間隔が広がり、染料の染色剤が分子間に浸透する。こののち温度を常温まで冷却すると分子間隔が再び狭まり、ガラス体１の内部に染色剤が封じこめられる。ガラス体１は上記染料浸透性の特性により表裏両面の近傍を青色および緑色に染色している。すなわち、青色および緑色の染色剤をそれぞれ２ｇ／ℓの割合で水

Savant Technologies LLC - 1004.667

中に溶かして青色および緑色の染色液を作成し、これを８３℃程度まで昇温する。このようにして作成した青色および緑色の染色液中にガラス体１の表裏それぞれの面を適当な時間浸漬する。これによってガラス体１の表裏面には第２図の断面図に示すように青色染色剤１１および緑色染色剤１２がそれぞれ適当な範囲に浸透する。また、上記組成を有するガラス体は、９８％程度の高い透光性を備えている。

以上のように構成された白色発光装置の赤色ＬＥＤ２を駆動すると、赤色ＬＥＤ２の赤色光は、充分な透光性を有するガラス体１を通過し外部に配光される。また、ガラス体１の内部に浸透した青色および緑色の染料は外部光を反射し、この反射光がＬＥＤ２の赤色光と同方向に配光される。これによって白色発光装置の外側では加色混合の三原色を構成する赤、緑および青の三色が混合し、白色光として認知される。

なお、本実施例では染料浸透性の透明ガラス体を平板状に形成したが、この透明ガラス体を第３図に示すようにＬＥＤの中空封止体としてもよい。この場合において同図に示す中空封止体３１は、前記組成のガラス体を中空形状に成型した後、その外側面および内側面に加色混合の三原色のうちの二色のそれぞれを浸透させる。この中空封止体３１により、三原色のうちの残りの一色に発光するＬＥＤ３２をカバーすれば、ＬＥＤ３２の発光が中空封止体３１を浸透する際に加色混合の三原色が混合し、中空封止体３１の外部に白色光を得る。例えば赤色ＬＥＤを用いた場合には中空封止体３１の表裏面にそれぞれ青色および緑色の染料を浸透させる。また、赤色ＬＥＤの代わりに緑色ＬＥＤを使用した場合には、中空封止体３１の表裏面にそれぞれ青色および赤色の染料を浸透させることにより同様の効果を得ることができる。

さらに、第５図に示すように加色混合の三原色のうちの二色のそれぞれに発光するＬＥＤ４２ａ，４２ｂを積層して配置し、このＬＥＤ４２ａ，４２ｂを前記組成のガラス体で封止して封止体４１を形成した後、この封止体４１に三原色の残る一色の染料を浸透させて白色発光装置を構成しても良い。この場合第５図に示すように、ＧａＰ緑色ＬＥＤ４１ａとＧａＡｓＰ赤色ＬＥＤ４１ｂとを電極５１，５２を銀ペースト５３を用いて接合する。この接合面において電極５１，５２は部分的に配置されており、赤色ＬＥＤ４１ｂの光は緑色ＬＥＤ４１ａを透過し、緑色ＬＥＤ４１ａの光とともに上方に配光される。このとき、封止体４１の表面に青色染料を浸透させておくことにより、加色混合の三原色を混合して白色光を得ることができる。ＬＥＤ４１ａ，４１ｂにおいてその発光の一部は水平方向に配光されるが、約７０％程度は上方に配光され、これにより白色光を得ることができる。

なお、透明ガラス体１、中空封止体３１および封止体４１に浸透させる染料を蛍光染料とすると加色混合状態がより良好になり、白色光の視認性が高くなる。

⑹発明の効果

請求項１および２に記載した発明によれば、ガラス体の表裏面または中空封止体の内外側面に浸透した二色の染料とＬＥＤの発光とにより、加色混合の三原色を構成して白色光を得ることができる。この白色光はＬＥＤの透明ガラス体を透過した光によって得られる鮮明な白色光である。また、ＬＥＤの使用によって消費電力を低減するとともにフィラメント切れなどによるランプの交換作業を排除することができる。

また、請求項３に記載した発明によれば、積層配置された二色のＬＥＤの発光と封止体に浸透した染料とにより加色混合の三原色を構成して白色光を得ることができる。この場合において二色のＬＥＤを封止後に封止体を染料中に浸漬して白色発光装置を得ることができ、その製造工程が簡略化できる。

さらに、請求項４に記載した発明によれば、蛍光染料を用いることによってＬＥＤの発光色との混合状態をより良好いにできる。

4.図面の簡単な説明

Savant Technologies LLC - 1004.668

第1図は請求項1記載の発明の実施例である白色発光装置の側面断面図、第2図は同白色発光装置の一部を構成する透明ガラス体の断面図である。また、第3図は請求項2記載の発明の実施例である白色発光装置を示す側面断面図である。さらに、第4図は請求項3記載の発明の実施例である白色発光装置を示す側面図、第5図は同白色発光装置のＬＥＤの構成を示す図である。

1－透明ガラス体、
2－赤色ＬＥＤ、
4－ケース、
11－青色染料、
12－緑色染料、
31－中空封止体、
41－封止体。

出願人　和泉電気株式会社
　　三井石油化学工業株式会社
代理人　弁理士　小森久夫

Savant Technologies LLC - 1004.669

(19) Japanese Patent Office (JP)

(11) Patent No. 2900928

(12) **Examined Patent Publication (B2)**

(45) Publication Date: June 2, 1999

(24) Registration Date: March 19, 1999

(51) Int. Cl.[5]	Identification Symbols	FI	
H01L 33/00		H01L 33/00	N
			C

Number of Claims: 1 (Total of 3 pages)

(21) Patent Application No.: H9-306393

(62) Indication of Division: Division of H3-336011

(22) Application Date: November 25, 1991

(65) Application Publication No.: H10-93146

(43) Application Publication Date: April 10, 1998

Examination Request Date: January 16, 1998

(73) Patent Right Holder: 000226057
Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Yoshiaki Tadatsu
c/o Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Shuji Nakamura
c/o Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(74) Agent: Patent Attorney: Yasuhiro Toyosu

Examiner Mitsuhiro Yoshino

Continued to the last page

(54) [Invention Title] Light Emitting Diode

(57) [What is Claimed is:]

[Claim 1] A light emitting diode with a light emitting device (11) on a metal piece, whereas a fluorescent dye or pigment, which is excited with light from the light emitting device (11) and which emits fluorescent light

Savant Technologies LLC - 1004.670

with wavelengths different from those of the excitation light, is added to a resin mold which surrounds the entirety of the light emitting device (11),

wherein

said fluorescent dye or pigment (5) is excited with the visible light from the light emitting device, and emits visible light with a longer wavelength that that of the excitation light;

said light emitting device is equipped with n-type and p-type gallium nitride related compound semiconductor layers which are stacked on a sapphire substrate and which emit blue visible light and;

the light emitting device (11) which is made of gallium nitride related compound semiconductors is equipped with a pair of electrodes on the same surface of the device which is located on an opposite side of a surface of the device which comes in contact with the metal piece, the electrodes being wire-bonded with gold wires, whereas one of the electrodes is an ohmic electrode which is connected to a section where a surface of the n-type gallium nitride related compound semiconductor is exposed.

[Detailed Explanation of Invention]

[Technological Field]

[0001]

The present invention relates to a light emitting diode (hereafter referred to as an LED) in which a light emitting device is surrounded with a resin mold.

[0002]

[Conventional Technologies]

In general, an LED has a structure as illustrated in Figure 1. The numeral designator 1 represents a light emitting device which is cut to a piece of 1mm square or smaller and which is made of materials such as GaAlAs and GaP, the numeral designator 2 represents a metal stem, the numeral designator 3 represents a metal post and the numeral designator 4 represents a resin mold which surrounds the light emitting device. The back surface electrode of the light emitting device 1 is attached on the metal stem 2 using a material such as silver paste, thereby electrically connecting it thereto. A gold wire coming from the metal post 3, which is the other electrode, is bonded to the surface of the front surface electrode of the light emitting device 1. Further, the light emitting device 1 is molded using the transparent resin mold 4.

[0003]

Ordinarily, a resin with a large index of refraction and a high transparency is selected for the resin mold 4, so that the emission light from the light emitting device is efficiently emitted to the air. In other cases, an inorganic or organic pigment is mixed as a coloring agent in the resin mold 4 in order to convert or correct the emission color of the light emitting device.

Savant Technologies LLC - 1004.671

[0004]

[Issues to be Resolved by Invention]

Conventionally, however, most of technologies to convert the wavelength by adding a coloring agent to a resin mold are not put into practical use and only handful technologies to employ a coloring agent for color correction are utilized. This is because adding an enough amount of a coloring agent, which is a non-light-emission material, to realize the wavelength conversion greatly reduces the brightness of an LED.

[0005]

In addition, currently realized LED's are infrared, red, yellow and green light emitting ones. Blue and ultraviolet LED's are not yet realized. Research is being conducting with semiconductors such as ZnSe which is a II-VI group material, SiC which is a IV-IV group material, and GaN which is a III-V group material. Recently, among these materials, gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$) are attracting attentions because it was found that they exhibit relatively superior light emission at normal temperatures. Moreover, LED's employing gallium nitride related compound semiconductors in which a pn junction was realized for the first time were reported (Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991). According to this publication, LED's employing gallium nitride related compound semiconductors have a main emission peak at around 430nm and also have another emission peak in the ultraviolet range of around 370nm. These wavelengths are the shortest among those for the above semiconductor materials. Such LED's, however, have a disadvantage in that their luminosity factor is poor because the emission color is close to violet, as their emission wavelength indicates.

[0006]

The present invention was conceived with considerations being given to such circumstances. Its purpose is to improve the luminosity factor and brightness of LED's having a light emission device which is made of gallium nitride related compound semiconductors.

[Means to Resolve Issues]

[0007]

A light emitting diode of the present invention has a light emitting device 11 and a fluorescent dye or pigment 5 which is excited with light from the light emitting device 11 and which emits fluorescent light with wavelengths longer than those of the excitation light. Further, in the light emitting diode of the present invention, the fluorescent dye or pigment 5 is arranged so as to surround the light emitting device 11 on a metal piece, and the light emitting device is equipped with stacked n-type and p-type gallium nitride related compound semiconductors which emit blue visible light. The light emitting device 11 which is made of gallium nitride related compound semiconductors is equipped with a pair of electrodes on the same surface of the device which is located on an opposite side of a surface of the device which comes in contact with the metal piece, the

Savant Technologies LLC - 1004.672

electrodes being wire-bonded with gold wires. One of the electrodes is an ohmic electrode which is connected to a section where a surface of the n-type gallium nitride related compound semiconductor is exposed.

[0008]

[Embodiment to Implement Invention]

Figure 2 illustrate an example to depict the structure of an LED according to the present invention. The numeral designator 11 represents a blue light emitting device in which n-type and p-type GaAlN layers are stacked on a sapphire substrate, the numeral designators 2 and 3 represent a metal stem and a metal post, respectively, in the same manner as in Figure 1, and the numeral designator 4 represents a resin mold surrounding the light emitting device. There is the sapphire insulating substrate on the back surface of the light emitting device 11 and an electrode can not be made on the back surface. Therefore, in order to electrically connect an n-electrode on the GaAlN layer to the metal stem 2, a method is employed in which the GaAlN layers are etched to expose the surface of the n-type layer, upon which an ohmic electrode is attached. The ohmic electrode and the metal stem 2 are electrically connected using a gold wire. Moreover, the other electrode is wire-bonded to the surface of the p-type layer using a gold wire coming from the metal post 3 in the same manner as in Figure 1. Further, a fluorescent dye 5 which is excited with light with a wavelength near 420 to 440nm and which emits light with an emission peak near 480nm is added to the resin mold 4.

[0009]

[Advantages of Invention]

A fluorescent dye or pigment in a light emitting diode of the present invention is excited with visible light and emits light with a longer wavelength than that of the excitation light. Contrarily, there are fluorescent pigments which are excited with a long-wavelength light and which emit light with a shorter wavelength than that of the excitation light. Such materials, however, have a very poor energy efficiency and provides a very week emission light. As discussed above, gallium nitride related compound semiconductors have emission peaks in the shortest wavelength range among semiconductor materials which are employed for LED's. Moreover, they have an emission peak in the ultraviolet range. Therefore, when they are employed as materials for a light emitting device and when a fluorescent dye or pigment is added to a resin mold surrounding the light emitting device, the fluorescent material can be most optimally excited. Therefore, different types of a fluorescent dye or pigment can not only correct color of blue LED's but also convert light into a variety of wavelengths. Further, visible light is converted to one with a longer wavelength with a good energy efficiency and hence, the amount of a fluorescent dye or pigment can be small and the invention is very excellent from the view point of reducing the degradation of luminosity factor.

[Brief Explanation of Figures]

[Figure 1] A schematic cross section to illustrate the structure of a conventional LED.

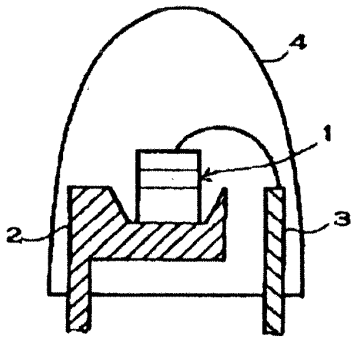
Savant Technologies LLC - 1004.673

[Figure 2] A schematic cross section to illustrate the structure of an example of an LED according to the present invention.

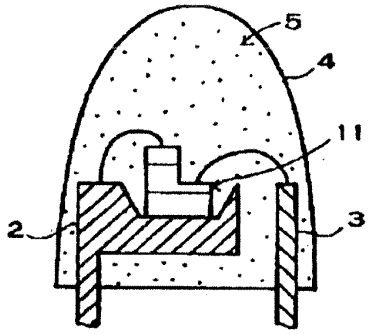
[Explanation of Numeral Designators]

11 Light emitting device
2 Metal stem
3 Metal post
4 Resin mold
5 Fluorescent dye

[Figure 1]



[Figure 2]



Continued from the first page

(56) References: Patent Application Publication H01-179471 (JP, A)
Utility Model Patent Application Publication H03-24692 (JP, U)
Utility Model Patent Publication S54-41660 (JP, Y1)
Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991

(58) Searched Fields (Int. Cl.[6], Name of Data Base)
H01L 33/00

Savant Technologies LLC - 1004.674

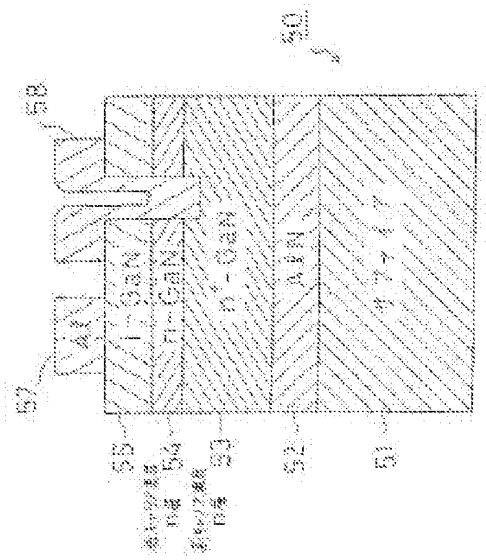
LIGHT-EMITTING ELEMENT OF GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR

Publication number: JP4010665 (A)
Publication date: 1992-01-14
Inventor(s): MANABE KATSUHIDE; MABUCHI AKIRA; SASA MICHINARI; YAMAZAKI SHIRO +
Applicant(s): TOYODA GOSEI KK; JAPAN RES DEV CORP +
Classification:
- international: ***H01L21/205; H01L33/12; H01L33/32; H01L33/38; H01L33/40;*** **H01L21/02; H01L33/00;** (IPC1-7): H01L33/00
- European:
Application number: JP19900114191 19900427
Priority number(s): JP19900114191 19900427

Also published as:
JP2623464 (B2)

Abstract of **JP 4010665 (A)**

PURPOSE:To change an emitted light color to a blue color, a white color and a red color by a method wherein zinc(Zn) and silicon(Si) are used as elements to be doped for an i-layer.
CONSTITUTION:A gallium nitride-based compound semiconductor light-emitting element is provided with the following: an n-layer composed of an n-type gallium nitride-based compound semiconductor (Al1Ga1-xN; including X=0); and an i-layer composed of an i-type gallium nitride-based compound semiconductor (AlxGa1-xN; including X=0). At the light-emitting element, zinc(Zn) and silicon(Si) are used as elements to be doped for the i-layer. When the i-layer 55 is doped with only zinc, the emitted light color of a light-emitting diode is a blue color.; When the layer is doped with zinc and silicon and the doping amount of silicon is comparatively small at a ratio of 1/200 to 1/1000 to a zinc density, the emitted light color of the light-emitting diode is a red color. When the ratio is comparatively large at 1/100 to 1/200, the color is a white color.



Data supplied from the ***espacenet*** database — Worldwide

Savant Technologies LLC - 1004.675

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　平4－10665

⑤Int. Cl.⁵	識別記号	庁内整理番号	㊸公開　平成4年(1992)1月14日
H 01 L 33/00		C 8934－4M	
21/205		7739－4M	

審査請求　未請求　請求項の数 1（全10頁）

㊹発明の名称　窒化ガリウム系化合物半導体発光素子

㉑特　願　平2－114191

㉒出　願　平2(1990)4月27日

㉒発明者　真部　勝英　愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

㉒発明者　馬淵　彰　愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

㉒発明者　佐々　道成　愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

㉒発明者　山崎　史郎　愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内

㉑出願人　豊田合成株式会社　愛知県西春日井郡春日町大字落合字長畑1番地

㉑出願人　新技術事業団　東京都千代田区永田町2丁目5番2号

㉔代理人　弁理士　藤谷　修

明　細　書

1. 発明の名称

窒化ガリウム系化合物半導体発光素子

2. 特許請求の範囲

n型の窒化ガリウム系化合物半導体（$A\ell_xGa_{1-x}N$;X=0を含む）からなるn層と、i型の窒化ガリウム系化合物半導体（$A\ell_xGa_{1-x}N$;X=0を含む）からなるi層とを有する窒化ガリウム系化合物半導体発光素子において、

前記i層のドーピング元素は、亜鉛(Zn)とシリコン(Si)であることを特徴とする発光素子。

3. 発明の詳細な説明

【産業上の利用分野】

本発明は窒化ガリウム系化合物半導体発光素子に関する。

【従来技術】

従来、青色の発光ダイオードとしてGaN系の化合物半導体を用いたものが知られている。そのGaN系の化合物半導体は直接遷移であることから発光効率が高いこと、光の3原色の1つである青色を発光色とすること等から注目されている。

このようなGaN系の化合物半導体を用いた発光ダイオードは、サファイア基板上に直接又は窒化アルミニウムから成るバッファ層を介在させて、n型GaN系の化合物半導体から成るn層を成長させ、そのn層の上にi型GaN系の化合物半導体から成るi層を成長させた構造をとっている（特開昭62-119196号公報、特開昭63-188977号公報）。

【発明が解決しようとする課題】

しかし、上記構造の発光ダイオードにおけるi層のドーピング元素には、亜鉛が用いられている。このため、発光色が青色に固定されてしまい他の例えば白色を発光させることは出来なかった。

そこで、本発明の目的は、GaN系の化合物半導体の発光ダイオードの発光色を変えることである。

【課題を解決するための手段】

本発明は、n型の窒化ガリウム系化合物半導体（$A\ell_xGa_{1-x}N$;X=0を含む）からなるn層と、i型の窒化ガリウム系化合物半導体（$A\ell_xGa_{1-x}N$;

Savant Technologies LLC - 1004.676

X=0 を含む）からなるｉ層とを有する窒化ガリウム系化合物半導体発光素子において、

前記ｉ層のドーピング元素は、亜鉛(Zn)とシリコン(Si)であることを特徴とする。

【発明の作用及び効果】

本発明は、ｉ層のドーピング元素に亜鉛(Zn)とシリコン(Si)とを用いたために、発光色が可変できた。

即ち、亜鉛に対してシリコンのドーピング割合を変化させることで、青色、白色、赤色と変化させることができた。

【実施例】

以下、本発明を具体的な実施例に基づいて説明する。

まず、本実施例に係る発光ダイオードの製造装置について説明する。

第２図は本発明の窒化ガリウム発光ダイオードを製造する気相成長装置の断面図である。

石英管１０はその左端でＯリング１５でシールされてフランジ１４に当接し、緩衝材３８と固定

具３９を用い、ボルト４６，４７とナット４８，４９等により数箇所にてフランジ１４に固定されている。又、石英管１０の右端はＯリング４０でシールされてフランジ２７に螺子締固定具４１，４２により固定されている。

石英管１０で囲われた内室１１には、反応ガスを導くライナー管１２が配設されている。そのライナー管１２の一端１３はフランジ１４に固設された保持プレート１７で保持され、その他端１６の底部１８は保持脚１９で石英管１０に保持されている。

ライナー管１２の平面形状は第７図に示すように、下流程拡がっており、石英管１０の長軸（Ｘ軸）に垂直なライナー管１２の断面は、第３図～第６図に示すように、Ｘ軸方向での位置によって異なる。即ち、反応ガスはＸ軸方向に流れるが、ガス流の上流側では第２図に示すように円形であり、下流側（Ｘ軸正方向）に進むに従って、Ｙ軸方向を長軸とし、長軸方向に拡大され、短軸方向に縮小された楕円形状となり、サセプタ２０を載

置するやや上流側のＡ位置では第５図に示すように上下方向（Ｚ軸）方向に薄くＹ軸方向に長い偏平楕円形状となっている。Ａ位置における第５図に示すⅣ－Ⅳ矢視方向断面図における開口部のＹ軸方向の長さは７㎝であり、Ｚ軸方向の長さは1.2 ㎝である。

ライナー管１２の下流側には、サセプタ２０を載置するＸ軸に垂直な断面形状が長方形の試料載置室２１が一体的に連設されている。その試料載置室２１の底部２２にサセプタ２０が載置される。そのサセプタ２０はＸ軸に垂直な断面は長方形であるが、その上面２３はＸ軸に対して緩やかにＺ軸正方向に傾斜している。そのサセプタ２０の上面２３に試料、即ち、長方形のサファイア基板５１が載置されるが、そのサファイア基板５１とそれに面するライナー管１２の上部管壁２４との間隙は、上流部で12mm，下流部４㎜である。

サセプタ２０には操作棒２６が接続されており、フランジ２７を取り外してその操作棒２６により、サファイア基板５１を載置したサセプタ２０を試

料載置室２１へ設置したり、結晶成長の終わった時に、試料載置室２１からサセプタ２０を取り出せるようになっている。

又、ライナー管１２の上流側には、第１ガス管２８と第２ガス管２９とが開口している。第１ガス管２８は第２ガス管２９の内部にあり、それらの両管２８，２９は同軸状に２重管構造をしている。第１ガス管２８の第２ガス管２９から突出した部分の周辺部には多数の穴３０が開けられており、又第２ガス管２９にも多数の穴３０が開けられている。そして、第１ガス管２８により導入された反応ガスはライナー管１２内へ吹出し、その場所で、第２ガス管２９により導入されたガスと初めて混合される。

その第１ガス管２８は第１マニホールド３１に接続され、第２ガス管２９は第２マニホールド３２に接続されている。そして、第１マニホールド３１にはキャリアガスの供給系統Ｉとトリメチルガリウム（以下「ＴＭＧ」と記す）の供給系統Ｊとトリメチルアルミニウム（以下「ＴＭＡ」と記

Savant Technologies LLC - 1004.677

ず）の供給系統Kとジエチル亜鉛（以下「ＤＥＺ」と記す）の供給系統Ｌとシラン（SiH_4）の供給系統Ｍが接続されている。第２マニホールド３２にはＮＨ₃の供給系統Ｈとキャリアガスの供給系統Ｉとが接続されている。

又、石英管１０の外周部には冷却水を循環させる冷却管３３が形成され、その外周部には高周波電界を印加するための高周波コイル３４が配設されている。

又、ライナー管１２はフランジ１４を介して外部管３５と接続されており、その外部管３５からはキャリアガスが導入されるようになっている。

又、試料載置室２１には、側方から導入管３６がフランジ１４を通過して外部から伸びており、その導入管３６内に試料の温度を測定する熱電対４３とその導線４４，４５が配設されており、試料温度を外部から測定できるように構成されている。

このような装置構成により、第１ガス管２８で導かれたＴＭＧとＴＭＡとH_2とＤＥＺとシラン

との混合ガスと、第２ガス管２９で導かれたＮＨ₃とH_2との混合ガスがそれらの管の出口付近で混合され、その混合反応ガスはライナー管１２により試料載置室２１へ導かれ、サファイア基板５１とライナー管１２の上部管壁２４との間で形成された間隙を通過する。この時、サファイア基板５１上の反応ガスの流れが均一となり、場所依存性の少ない良質な結晶が成長する。

ｎ型の$A\ell_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランの供給を停止して第１ガス管２８と第２ガス管２９とから混合ガスを流出させれば良く、ｉ型の$A\ell_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランとを供給して第１ガス管２８と第２ガス管２９とからそれぞれの混合ガスを流出させれば良い。ｉ型の$A\ell_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランはサファイア基板５１に吹き付けられ熱分解し、ドーパント元素は成長する$A\ell_xGa_{1-x}N$にドーピングされて、ｉ型の$A\ell_xGa_{1-x}N$が得られる。

次に本装置を用いて、第１図に示す構成の発光

ダイオード５０を製造する方法について説明する。

まず、有機洗浄及び熱処理により洗浄したａ面を主面とする単結晶のサファイア基板５１をサセプタ２０に装着する。次に、反応室１１の圧力を1×10^{-5}Torrに減圧した後、H_2を２ℓ／分で、第１ガス管２８及び第２ガス管２９及び外部管３５を介してライナー管１２に流しながら、温度1100℃でサファイア基板５１を気相エッチングした。

次に温度を400 ℃まで低下させて、第１ガス管２８からH_2を10ℓ／分、15℃のＴＭＡ中をバブリングしたH_2を50mℓ／分、第２ガス管２９からH_2を10ℓ／分、ＮＨ₃を10ℓ／分で２分間供給した。この成長工程で、ＡｌＮのバッファ層５２が約500 Åの厚さに形成された。

次に、２分経過した時にＴＭＡの供給を停止して、サファイア基板５１の温度を1150℃に保持し、第１ガス管２８からH_2を10ℓ／分、－15℃のＴＭＧ中をバブリングしたH_2を200mℓ／分、H_2で1ppmに希釈したシラン(SiH_4)を200 mℓ／分、第２ガス管２９からH_2を10ℓ分、ＮＨ₃を10 ℓ

／分で15分間供給して、膜厚約 2.5μm、キャリア濃度 2×10^{18}/ cm³のGaN から成る高キャリア濃度ｎ層５３を形成した。

続いて、サファイア基板５１の温度を1150℃に保持し、同様に、第１ガス管２８、第２ガス管２９から、H_2を20ℓ／分、 -15℃のTMG 中をバブリングしたH_2を100mℓ／分、NH_3を10ℓ／分の割合で20分間供給し、膜厚約 1.5μm、キャリア濃度 1×10^{18}/ cm³のGaN から成る低キャリア濃度ｎ層５４を形成した。

次に、サファイア基板５１を 900℃にして、同様に、第１ガス管２８、第２ガス管２９から、それぞれ、H_2を10ℓ／分、 -15℃のTMG 中をバブリングしたH_2を100mℓ／分、 5℃のDEZ 中をバブリングしたH_2 500mℓ／分、H_2で1ppmに希釈したシラン(SiH_4)を 100mℓ／分、NH_3を10ℓ／分の割合で 1分間供給して、膜厚 750ÅのGaN から成るｉ層５５を形成した。この時、ｉ層５５における亜鉛の密度は1×10^{20}/ cm³で、シリコンの密度は 1×10^{18}/ cm³であった。

Savant Technologies LLC - 1004.678

このようにして、第８図に示すような多層構造が得られた。

次に、第９図に示すように、ｉ層５５の上に、スパッタリングによりSiO_2層６１を2000Åの厚さに形成した。次に、そのSiO_2層６１上にフォトレジスト６２を塗布して、フォトリソグラフにより、そのフォトレジスト６２を高キャリア濃度ｎ層５３に対する電極形成部位のフォトレジストを除去したパターンに形成した。

次に、第１０図に示すように、フォトレジスト６２によって覆われていないSiO_2層６１をフッ化水素酸系エッチング液で除去した。

次に、第１１図に示すように、フォトレジスト６２及びSiO_2層６１によって覆われていない部位のｉ層５５とその下の低キャリア濃度ｎ層５４と高キャリア濃度ｎ層５３の上面一部を、真空度0.04Torr、高周波電力0.44W/㎠、流速10cc/分のCCℓ_2F_2ガスでエッチングした後、Arでドライエッチングした。

次に、第１２図に示すように、ｉ層５５上に残っているSiO_2層６１をフッ化水素酸で除去した。

次に、第１３図に示すように、試料の上全面に、Aℓ層６３を蒸着により形成した。そして、そのAℓ層６３の上にフォトレジスト６４を塗布して、フォトリソグラフにより、そのフォトレジスト６４が高キャリア濃度ｎ層５３及びｉ層５５に対する電極部が残るように、所定形状にパターン形成した。

次に、第１３図に示すようにそのフォトレジスト６４をマスクとして下層のAℓ層６３の露出部を硝酸系エッチング液でエッチングし、フォトレジスト６４をアセトンで除去し、高キャリア濃度ｎ層５３の電極８、ｉ層５５の電極７を形成した。

このようにして、第１図に示すMIS(Metal-Insulater-Semiconductor)構造の窒化ガリウム系発光素を製造することができる。

このようにして製造された発光ダイオード１０の発光強度を測定したところ、0.1mcdであった。

又、このｉ層５５のエレクトロルミネッセンス強度を測定した。その結果を第１４図において曲

線Ａで示す。

波長480nm(青色)のピークが現れる他、長波長側にスペクトルが広がっているのが理解される。即ち、波長550nm(緑色)と波長700nm(赤色)も発光しており、この結果、人間の目で視認される色は白色となる。

次に、ｉ層５５をSIMSより分析した。その結果を第１５図に示す。ｉ層５５における亜鉛とシリコンの分布が理解される。

又、ｉ層５５におけるシリコンの密度を、亜鉛密度1×10^{20}/㎤に対して、1/100～1/200の割合で変化させて、同様に発光ダイオードを製造した。

ｉ層５５のエレクトロルミネッセンス強度を測定したが、第１４図の曲線Ａと同様になった。又、発光ダイオードの発光色は、白色であった。

又、ｉ層５５における亜鉛密度を5×10^{19}/㎤～3×10^{21}/㎤とし、その亜鉛密度に対して、シリコンを1/100～1/200の割合で変化させて、同様に発光ダイオードを製造した。ｉ層５５のエレ

クトロルミネッセンス強度を測定したが、第１４図の曲線Ａとほぼ同様な曲線が得られた。又、それらの発光ダイオードの発光色は、白色であった。

又、ｉ層５５における亜鉛密度を2×10^{20}/㎤シリコン密度を2×10^{18}/㎤とする発光ダイオードを上記の方法で同様に製造した。そして、その発光ダイオードのｉ層５５のエレクトロルミネッセンス強度を測定した。第１４図の曲線Ｂに示す特性が得られた。即ち、曲線Ａに比べて、波長480nm(青色)のEL強度は減少し、波長550nm(緑色)のEL強度は同じ位に現れ、逆に、波長700nm(赤色)のEL強度は遙かに大きくなっている。この結果、人間の目で視認される色は赤色となる。又、これらの発光ダイオードの発光色は、赤色であった。

又、ｉ層５５における亜鉛密度を5×10^{19}/㎤～3×10^{21}/㎤とし、その範囲の亜鉛密度に対するシリコン密度の割合を1/200～1/1000とする発光ダイオードを複数製造した。そして、その発光ダイオードのｉ層５５のエレクトロルミネッセン

Savant Technologies LLC - 1004.679

ス強度を測定した。その測定結果は、第１４図の曲線Ｂとほぼ同様な曲線となった。又、それらの発光ダイオードの人間によって判断される色は赤色であった。

又、比較のために、亜鉛密度を１×10^{20}/ cmとし、シリコンをドープしない発光ダイオードを製造した。そして、その発光ダイオードのｉ層５５のエレクトロルミネッセンス強度を測定した。第１４図の曲線Ｃに示す特性が得られた。即ち、曲線Ａに比べて、波長480nm(青色）のEL強度は遙かに大きく、波長550nm(緑色）のEL強度は同じ位に現れ、逆に、波長700nm(赤色）のEL強度は遙かに小さくなっている。これらの発光ダイオードの人間によって認識される発光色は、青色であった。

以上のことから、次のことが結論される。

(1) ｉ層５５に亜鉛だけドープした場合の発光ダイオードの発光色は、青色である。

(2) ｉ層５５に亜鉛とシリコンとをドープし、シリコンのドープ量が、その亜鉛密度に対する割合が1/200 ～1/1000で比較的少ない場合には、発光

ダイオードの発光色は赤色となる。

(3) ｉ層５５に亜鉛とシリコンとをドープし、シリコンのドープ量が、その亜鉛密度に対する割合が1/100 ～1/200 で比較的多い場合には、発光ダイオードの発光色は白色となる。

尚、上記実施例では、シリコンの原料にシランを用いたがテトラエチルシラン（$(C_2H_5)_4Si$:TESi）を用いても良い。

4.図面の簡単な説明

第１図は本発明の具体的な一実施例に係る発光ダイオードの構成を示した構成図、第２図はその発光ダイオードを製造する装置を示した構成図、第３図乃至第６図はその装置で使用されたライナー管の断面図、第７図はそのライナー管の平面図、第８図乃至第１３図は発光ダイオードの製造工程を示した断面図、第１４図はその発光ダイオードのｉ層のエレクトロルミネッセンスによる測定結果を示した測定図、第１５図はｉ層のSIMSによる分析結果を示した測定図である。

１０……発光ダイオード　１……サファイア基板

２……バッファ層　３……高キャリア濃度ｎ層

４……低キャリア濃度ｎ層　５……ｉ層

７，８……電極

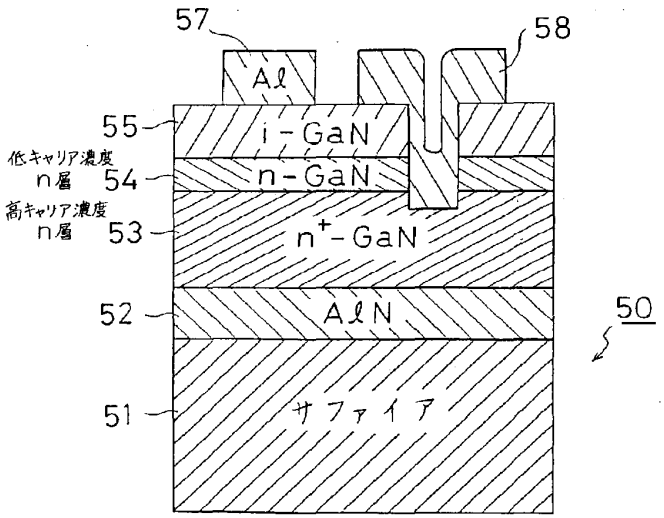
特許出願人　豊田合成株式会社

特許出願人　新技術事業団

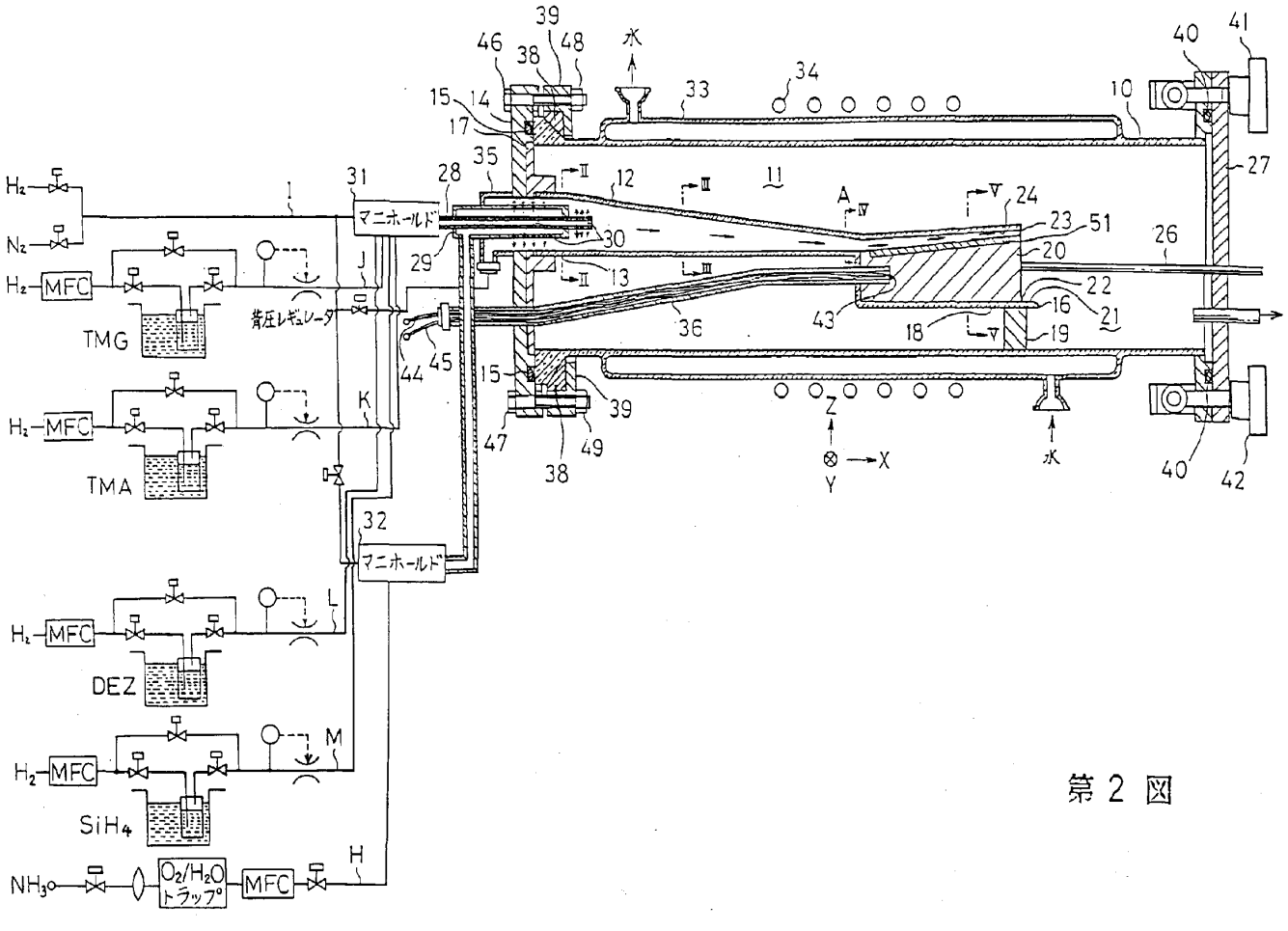
代理人　弁理士　藤谷修

Savant Technologies LLC - 1004.680

第 1 図



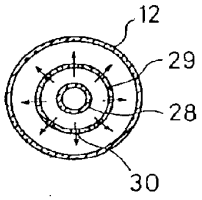
Savant Technologies LLC - 1004.681



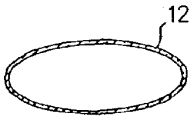
第 2 図

Savant Technologies LLC - 1004.682

第３図

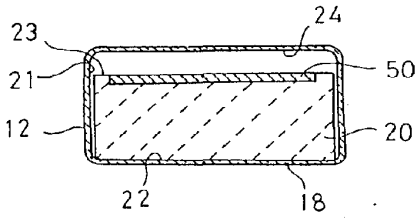


第４図

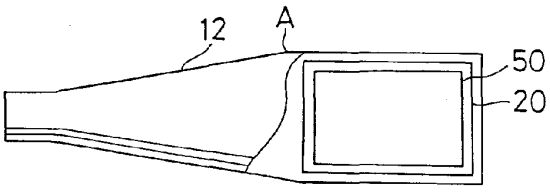


第５図

第６図

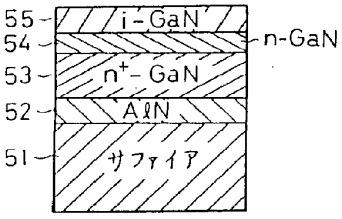


第７図

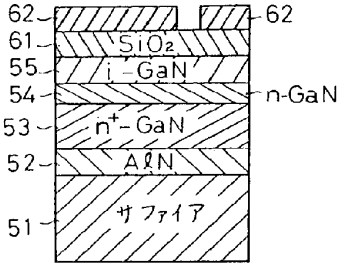


Savant Technologies LLC - 1004.683

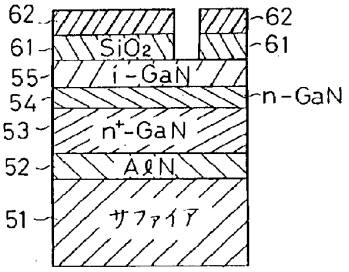
第 8 図



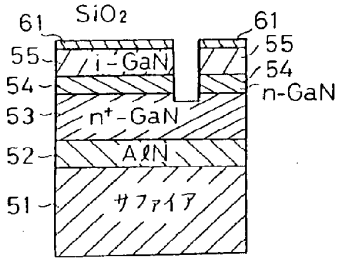
第 9 図



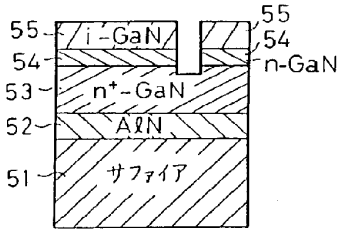
第10図



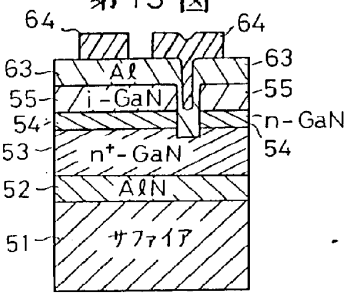
第11図



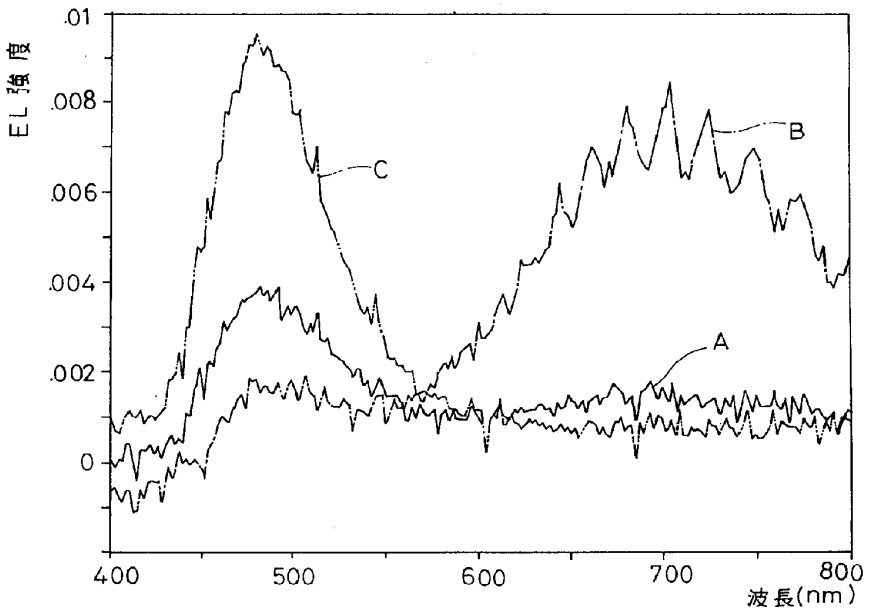
第12図



第13図

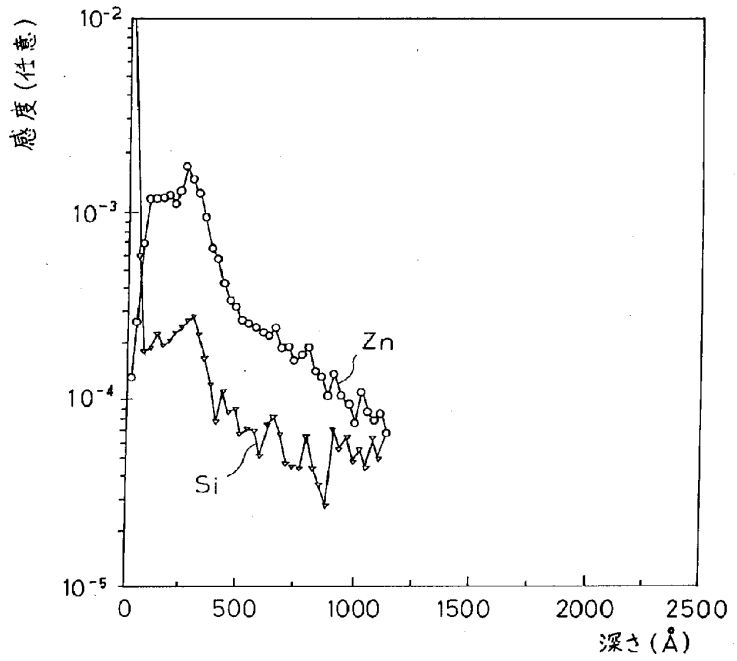


第 14 図



Savant Technologies LLC - 1004.684

第 15 図



Savant Technologies LLC - 1004.685

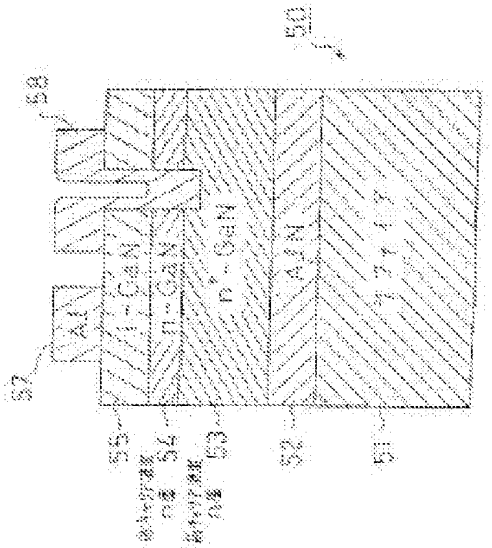
LIGHT-EMITTING ELEMENT OF GALLIUM NITRIDE-BASED COMPOUND SEMICONDUCTOR

Publication number: JP4010666 (A)
Publication date: 1992-01-14
Inventor(s): MANABE KATSUHIDE; KATO HISAYOSHI; MABUCHI AKIRA; KOIDE NORIKATSU +
Applicant(s): TOYODA GOSEI KK; JAPAN RES DEV CORP +
Classification:
- international: ***H01L21/205; H01L33/32; H01L33/38; H01L33/40;*** **H01L21/02; H01L33/00;** (IPC1-7): H01L33/00
- European:
Application number: JP19900114192 19900427
Priority number(s): JP19900114192 19900427

Also published as:
JP3184202 (B2)

Abstract of **JP 4010666 (A)**

PURPOSE:To obtain light to be emitted in a white color by a method wherein zinc(Zn) and silicon(Si) are used as elements to be doped for an i-layer and the ratio of silicon to zinc is specified.
CONSTITUTION:A gallium nitride-based compound semiconductor light-emitting element is provided with the following: an n-layer composed of an n-type gallium nitride-based compound semiconductor (AlxGa1-xN; including X=0); and an i-layer composed of an i-type gallium nitride-based compound semiconductor (AlxGa1-xN; including X=0). At the light-emitting element, elements to be doped for the i-layer are zinc(Zn) and silicon(Si), and the ratio of the doping density of silicon to the doping density of zinc is set at 1/100 to 1/200.



Savant Technologies LLC - 1004.686

⑲日本国特許庁(JP)　⑪特許出願公開

⑫公開特許公報(A)　平4−10666

⑤1Int.Cl.⁵	識別記号	庁内整理番号	㊸公開　平成4年(1992)1月14日
H 01 L 33/00	C	8934−4M	
21/205		7739−4M	

審査請求　未請求　請求項の数 1 (全10頁)

㊹発明の名称　窒化ガリウム系化合物半導体発光素子

㉑特　願　平2−114192

㉒出　願　平2(1990)4月27日

⑦2発明者	真部　勝英	愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内
⑦2発明者	加藤　久喜	愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内
⑦2発明者	馬淵　彰	愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内
⑦2発明者	小出　典克	愛知県西春日井郡春日町大字落合字長畑1番地　豊田合成株式会社内
⑦1出願人	豊田合成株式会社	愛知県西春日井郡春日町大字落合字長畑1番地
⑦1出願人	新技術事業団	東京都千代田区永田町2丁目5番2号
⑦4代理人	弁理士　藤谷　修	

明　細　書

1.発明の名称

窒化ガリウム系化合物半導体発光素子

2.特許請求の範囲

n型の窒化ガリウム系化合物半導体($A\ell_XGa_{1-X}N;X=0$ を含む)からなるn層と、i型の窒化ガリウム系化合物半導体($A\ell_XGa_{1-X}N;X=0$を含む)からなるi層とを有する窒化ガリウム系化合物半導体発光素子において、

前記i層のドーピング元素は、亜鉛(Zn)とシリコン(Si)から成り、シリコンのドーピング密度の亜鉛のドーピング密度に対する割合は、1/100 ～ 1/200 であることを特徴とする発光素子。

3.発明の詳細な説明

【産業上の利用分野】

本発明は、白色発光の窒化ガリウム系化合物半導体発光素子に関する。

【従来技術】

従来、青色の発光ダイオードとしてGaN 系の化合物半導体を用いたものが知られている。そのGaN 系の化合物半導体は直接遷移であることから発光効率が高いこと、光の3原色の1つである青色を発光色とすること等から注目されている。

このようなGaN 系の化合物半導体を用いた発光ダイオードは、サファイア基板上に直接又は窒化アルミニウムから成るバッファ層を介在させて、n型のGaN 系の化合物半導体から成るn層を成長させ、そのn層の上にi型のGaN 系の化合物半導体から成るi層を成長させた構造をとっている(特開昭62-119196 号公報、特開昭63-188977 号公報)。

【発明が解決しようとする課題】

しかし、上記構造の発光ダイオードにおけるi層のドーピング元素には、亜鉛が用いられている。このため、発光色が青色に固定されてしまい他の例えば白色を発光させることは出来なかった。又、1チップで白色を発光する発光ダイオードは、知られていない。従って、白色発光を得るためには、青、緑、赤の発光ダイオードをチップを集合させて、1つのランプとすることが行われていた。

Savant Technologies LLC - 1004.687

このようなランプは、製造工程が複雑となるという問題がある。

そこで、本発明の目的は、GaN 系の化合物半導体を用いて、1チップで白色発光を得ることである。

【課題を解決するための手段】

本発明は、n型の窒化ガリウム系化合物半導体($A\ell_xGa_{1-x}N$;X=0 を含む）からなるn層と、i型の窒化ガリウム系化合物半導体($A\ell_xGa_{1-x}N$;X=0 を含む）からなるi層とを有する窒化ガリウム系化合物半導体発光素子において、

i層のドーピング元素は、亜鉛(Zn)とシリコン(Si)から成り、シリコンのドーピング密度の亜鉛のドーピング密度に対する割合は、1/100 ～1/200 であることを特徴とする。

【発明の作用及び効果】

本発明は、i層のドーピング元素に亜鉛(Zn)とシリコン(Si)とを用い、亜鉛に対するシリコンの割合を1/100 ～1/200 とすることで、白色発光を得ることができた。

【実施例】

以下、本発明を具体的な実施例に基づいて説明する。

まず、本実施例に係る発光ダイオードの製造装置について説明する。

第2図は本発明の窒化ガリウム発光ダイオードを製造する気相成長装置の断面図である。

石英管10はその左端でOリング15でシールされてフランジ14に当接し、緩衝材38と固定具39を用い、ボルト46，47とナット48，49等により数箇所にてフランジ14に固定されている。又、石英管10の右端はOリング40でシールされてフランジ27に螺子締固定具41，42により固定されている。

石英管10で囲われた内室11には、反応ガスを導くライナー管12が配設されている。そのライナー管12の一端13はフランジ14に固設された保持プレート17で保持され、その他端16の底部18は保持脚19で石英管10に保持されている。

ライナー管12の平面形状は第7図に示すように、下流程拡がっており、石英管10の長軸（X軸）に垂直なライナー管12の断面は、第3図～第6図に示すように、X軸方向での位置によって異なる。即ち、反応ガスはX軸方向に流れるが、ガス流の上流側では第2図に示すように円形であり、下流側（X軸正方向）に進むに従って、Y軸方向を長軸とし、長軸方向に拡大され、短軸方向に縮小された楕円形状となり、サセプタ20を載置するやや上流側のA位置では第5図に示すように上下方向（Z軸）方向に薄くY軸方向に長い偏平楕円形状となっている。A位置における第5図に示すIV－IV矢視方向断面図における開口部のY軸方向の長さは7cmであり、Z軸方向の長さは1.2 cmである。

ライナー管12の下流側には、サセプタ20を載置するX軸に垂直な断面形状が長方形の試料載置室21が一体的に連設されている。その試料載置室21の底部22にサセプタ20が載置される。そのサセプタ20はX軸に垂直な断面は長方形であるが、その上面23はX軸に対して緩やかにZ軸正方向に傾斜している。そのサセプタ20の上面23に試料、即ち、長方形のサファイア基板51が載置されるが、そのサファイア基板51とそれに面するライナー管12の上部管壁24との間隙は、上流部で12mm，下流部4mmである。

サセプタ20には操作棒26が接続されており、フランジ27を取り外してその操作棒26により、サファイア基板51を載置したサセプタ20を試料載置室21へ設置したり、結晶成長の終わった時に、試料載置室21からサセプタ20を取り出せるようになっている。

又、ライナー管12の上流側には、第1ガス管28と第2ガス管29とが開口している。第1ガス管28は第2ガス管29の内部にあり、それらの両管28，29は同軸状に2重管構造をしている。第1ガス管28の第2ガス管29から突出した部分の周辺部には多数の穴30が開けられており、又第2ガス管29にも多数の穴30が開けられている。そして、第1ガス管28により導入さ

Savant Technologies LLC - 1004.688

れた反応ガスはライナー管１２内へ吹出し、その場所で、第２ガス管２９により導入されたガスと初めて混合される。

その第１ガス管２８は第１マニホールド３１に接続され、第２ガス管２９は第２マニホールド３２に接続されている。そして、第１マニホールド３１にはキャリアガスの供給系統Ｉとトリメチルガリウム（以下「ＴＭＧ」と記す）の供給系統Ｊとトリメチルアルミニウム（以下「ＴＭＡ」と記す）の供給系統Ｋとジエチル亜鉛（以下「ＤＥＺ」と記す）の供給系統Ｌとシラン（SiH_4）の供給系統Ｍが接続されている。第２マニホールド３２にはNH_3の供給系統Ｈとキャリアガスの供給系統Ｉとが接続されている。

又、石英管１０の外周部には冷却水を循環させる冷却管３３が形成され、その外周部には高周波電界を印加するための高周波コイル３４が配設されている。

又、ライナー管１２はフランジ１４を介して外部管３５と接続されており、その外部管３５から

はキャリアガスが導入されるようになっている。

又、試料載置室２１には、側方から導入管３６がフランジ１４を通過して外部から伸びており、その導入管３６内に試料の温度を測定する熱電対４３とその導線４４，４５が配設されており、試料温度を外部から測定できるように構成されている。

このような装置構成により、第１ガス管２８で導かれたＴＭＧとＴＭＡとH_2とＤＥＺとシランとの混合ガスと、第２ガス管２９で導かれたNH_3とH_2との混合ガスがそれらの管の出口付近で混合され、その混合反応ガスはライナー管１２により試料載置室２１へ導かれ、サファイア基板５１とライナー管１２の上部管壁２４との間で形成された間隙を通過する。この時、サファイア基板５１上の反応ガスの流れが均一となり、場所依存性の少ない良質な結晶が成長する。

ｎ型の$Al_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランの供給を停止して第１ガス管２８と第２ガス管２９とから混合ガスを流出させれば

良く、ｉ型の$Al_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランとを供給して第１ガス管２８と第２ガス管２９とからそれぞれの混合ガスを流出させれば良い。ｉ型の$Al_xGa_{1-x}N$薄膜を形成する場合には、ＤＥＺとシランはサファイア基板５１に吹き付けられ熱分解し、ドーパント元素は成長する$Al_xGa_{1-x}N$にドーピングされて、ｉ型の$Al_xGa_{1-x}N$が得られる。

次に本装置を用いて、第１図に示す構成の発光ダイオード５０を製造する方法について説明する。

まず、有機洗浄及び熱処理により洗浄したａ面を主面とする単結晶のサファイア基板５１をサセプタ２０に装着する。次に、反応室１１の圧力を1×10^{-5}Torrに減圧した後、H_2を２ℓ／分で、第１ガス管２８及び第２ガス管２９及び外部管３５を介してライナー管１２に流しながら、温度1100℃でサファイア基板５１を気相エッチングした。

次に温度を400 ℃まで低下させて、第１ガス管２８からH_2を10ℓ／分、15℃のＴＭＡ中をバブリングしたH_2を 50mℓ／分、第２ガス管２９か

らＨ₂を10ℓ分、ＮＨ₃を10ℓ／分で 2分間供給した。この成長工程で、ＡℓＮのバッファ層５２が約500 Åの厚さに形成された。

次に、 2分経過した時にＴＭＡの供給を停止して、サファイア基板５１の温度を1150℃に保持し、第１ガス管２８からＨ₂を10ℓ／分、－15℃のＴＭＧ中をバブリングしたＨ₂を200mℓ／分、Ｈ₂で1ppmに希釈したシラン(SiH_4)を200 mℓ／分、第２ガス管２９からＨ₂を10ℓ／分、ＮＨ₃を 10ℓ／分で15分間供給して、膜厚約 2.5㎛、キャリア濃度 2×10^{18}/ ㎤のGaN から成る高キャリア濃度ｎ層５３を形成した。

続いて、サファイア基板５１の温度を1150℃に保持し、同様に、第１ガス管２８、第２ガス管２９から、H_2を20ℓ／分、 -15℃のTMG 中をバブリングしたＨ₂を100mℓ／分、NH_3を10ℓ／分の割合で20分間供給し、膜厚約 1.5㎛、キャリア濃度 1×10^{18}/ ㎤のGaN から成る低キャリア濃度ｎ層５４を形成した。

次に、サファイア基板５１を 900℃にして、同

Savant Technologies LLC - 1004.689

様に、第１ガス管２８、第２ガス管２９から、それぞれ、H_2を10ℓ／分、-15℃のTMG中をバブリングしたH_2を100mℓ／分、5℃のDBZ中をバブリングしたH_2 500mℓ／分、H_2で1ppmに希釈したシラン(SiH_4)を100mℓ／分、NH_3を10ℓ／分の割合で1分間供給して、膜厚750ÅのGaNから成るｉ層５５を形成した。この時、ｉ層５５における亜鉛の密度は1×10^{20}/cm³で、シリコンの密度は1×10^{19}/cm³であった。

このようにして、第８図に示すような多層構造が得られた。

次に、第９図に示すように、ｉ層５５の上に、スパッタリングによりSiO_2層６１を2000Åの厚さに形成した。次に、そのSiO_2層６１上にフォトレジスト６２を塗布して、フォトリソグラフにより、そのフォトレジスト６２を高キャリア濃度ｎ層５３に対する電極形成部位のフォトレジストを除去したパターンに形成した。

次に、第１０図に示すように、フォトレジスト６２によって覆われていないSiO_2層６１をフッ化水素酸系エッチング液で除去した。

次に、第１１図に示すように、フォトレジスト６２及びSiO_2層６１によって覆われていない部位のｉ層５５とその下の低キャリア濃度ｎ層５４と高キャリア濃度ｎ層５３の上面一部を、真空度0.04Torr、高周波電力0.44W/cm²、流速10cc/分のCCℓ₂F₂ガスでエッチングした後、Arでドライエッチングした。

次に、第１２図に示すように、ｉ層５５上に残っているSiO_2層６１をフッ化水素酸で除去した。

次に、第１３図に示すように、試料の上全面に、Aℓ層６３を蒸着により形成した。そして、そのAℓ層６３の上にフォトレジスト６４を塗布して、フォトリソグラフにより、そのフォトレジスト６４が高キャリア濃度ｎ層５３及びｉ層５５に対する電極部が残るように、所定形状にパターン形成した。

次に、第１３図に示すようにそのフォトレジスト６４をマスクとして下層のAℓ層６３の露出部を硝酸系エッチング液でエッチングし、フォトレジ

スト６４をアセトンで除去し、高キャリア濃度ｎ層５３の電極８、ｉ層５５の電極７を形成した。

このようにして、第１図に示すMIS(Metal-Insulater-Semiconductor)構造の窒化ガリウム系発光素を製造することができる。

このようにして製造された発光ダイオード１０の発光強度を測定したところ、0.1mcdであった。

又、このｉ層５５のエレクトロルミネッセンス強度を測定した。その結果を第１４図において曲線Ａで示す。

波長480nm(青色)のピークが現れる他、長波長側にスペクトルが広がっているのが理解される。即ち、波長550nm(緑色)と波長700nm(赤色)も発光しており、この結果、人間の目で視認される色は白色となる。

次に、ｉ層５５をSIMSより分析した。その結果を第１５図に示す。ｉ層５５における亜鉛とシリコンの分布が理解される。

又、ｉ層５５におけるシリコンの密度を、亜鉛密度1×10^{20}/cm³に対して、1/100～1/200の割

合で変化させて、同様に発光ダイオードを製造した。

ｉ層５５のエレクトロルミネッセンス強度を測定したが、第１４図の曲線Ａと同様になった。又、発光ダイオードの発光色は、白色であった。

又、ｉ層５５における亜鉛密度を5×10^{19}/cm³～3×10^{21}/cm³とし、その亜鉛密度に対して、シリコンを1/100～1/200の割合で変化させて、同様に発光ダイオードを製造した。ｉ層５５のエレクトロルミネッセンス強度を測定したが、第１４図の曲線Ａとほぼ同様な曲線が得られた。又、それらの発光ダイオードの発光色は、白色であった。

又、ｉ層５５における亜鉛密度を2×10^{20}/cm³シリコン密度を2×10^{19}/cm³とする発光ダイオードを上記の方法で同様に製造した。そして、その発光ダイオードのｉ層５５のエレクトロルミネッセンス強度を測定した。第１４図の曲線Ｂに示す特性が得られた。即ち、曲線Ａに比べて、波長480nm(青色)のEL強度は減少し、波長550nm(緑色)のEL強度は同じ位に現れ、逆に、波長700nm

Savant Technologies LLC - 1004.690

（赤色）のEL強度は遙かに大きくなっている。この結果、人間の目で視認される色は赤色となる。又、これらの発光ダイオードの発光色は、赤色であった。

又、i層55における亜鉛密度を 5×10^{19}/cm³～3×10^{21}/cm³とし、その範囲の亜鉛密度に対するシリコン密度の割合を1/200～1/1000とする発光ダイオードを複数製造した。そして、その発光ダイオードのi層55のエレクトロルミネッセンス強度を測定した。その測定結果は、第14図の曲線Bとほぼ同様な曲線となった。又、それらの発光ダイオードの人間によって判断される色は赤色であった。

又、比較のために、亜鉛密度を1×10^{20}/cm³とし、シリコンをドープしない発光ダイオードを製造した。そして、その発光ダイオードのi層55のエレクトロルミネッセンス強度を測定した。第14図の曲線Cに示す特性が得られた。即ち、曲線Aに比べて、波長480nm(青色）のEL強度は遙かに大きく、波長550nm(緑色）のEL強度は同じ位に

現れ、逆に、波長700nm(赤色）のEL強度は遙かに小さくなっている。これらの発光ダイオードの人間によって認識される発光色は、青色であった。

以上のことから、次のことが結論される。

(1) i層55に亜鉛だけドープした場合の発光ダイオードの発光色は、青色である。

(2) i層55に亜鉛とシリコンとをドープし、シリコンのドープ量が、その亜鉛密度に対する割合が1/200～1/1000で比較的少ない場合には、発光ダイオードの発光色は赤色となる。

(3) i層55に亜鉛とシリコンとをドープし、シリコンのドープ量が、その亜鉛密度に対する割合が1/100～1/200で比較的多い場合には、発光ダイオードの発光色は白色となる。

尚、上記実施例では、シリコンの原料にシランを用いたがテトラエチルシラン（$(C_2H_5)_4Si$:TESi）を用いても良い。

4.図面の簡単な説明

第1図は本発明の具体的な一実施例に係る発光ダイオードの構成を示した構成図、第2図はその

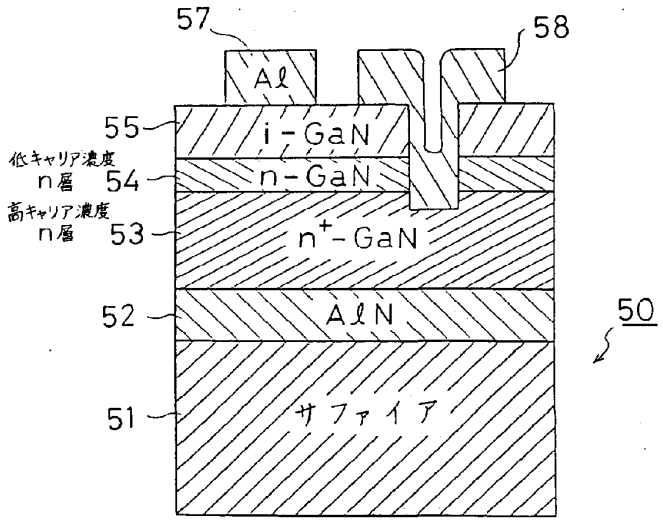
発光ダイオードを製造する装置を示した構成図、第3図乃至第6図はその装置で使用されたライナー管の断面図、第7図はそのライナー管の平面図、第8図乃至第13図は発光ダイオードの製造工程を示した断面図、第14図はその発光ダイオードのi層のエレクトロルミネッセンスによる測定結果を示した測定図、第15図はi層のSIMSによる分析結果を示した測定図である。

10…発光ダイオード　1…サファイア基板
2…バッファ層　3…高キャリア濃度n層
4…低キャリア濃度n層　5…i層
7，8…電極

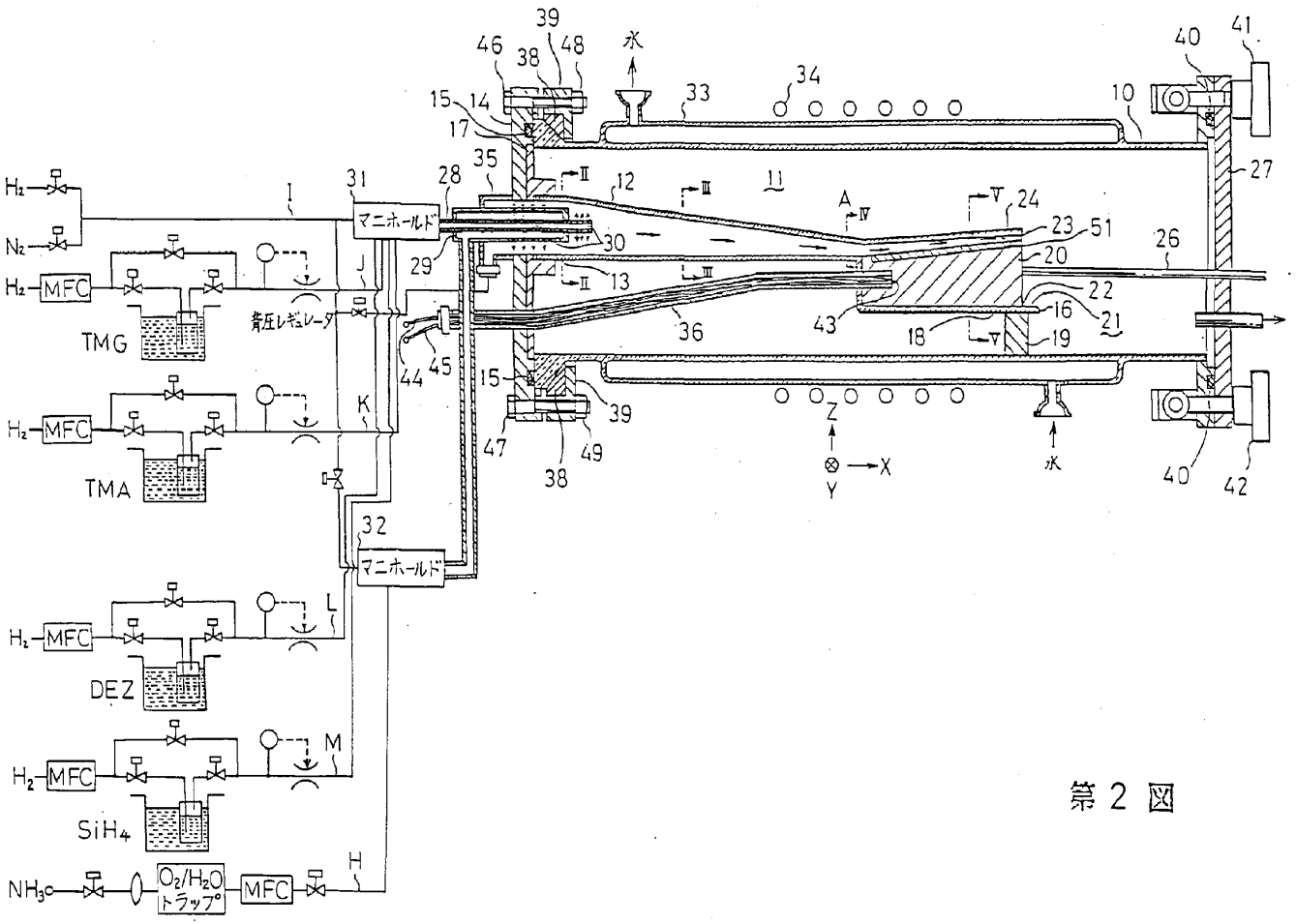
特許出願人　豊田合成株式会社
特許出願人　新技術事業団
代理人　弁理士　藤谷修

Savant Technologies LLC - 1004.691

第 1 図



Savant Technologies LLC - 1004.692

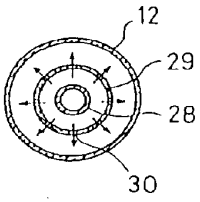


第 2 図

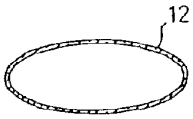
特開平 4－10666(7)

Savant Technologies LLC - 1004.693

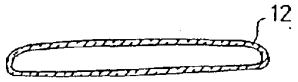
第 3 図



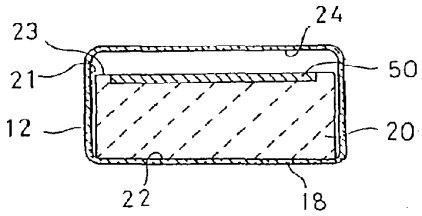
第 4 図



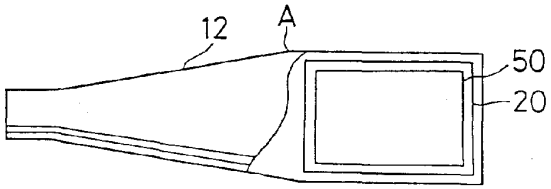
第 5 図



第 6 図

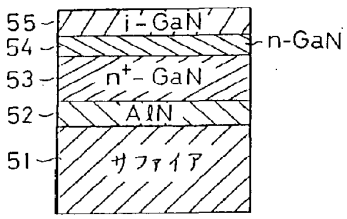


第 7 図

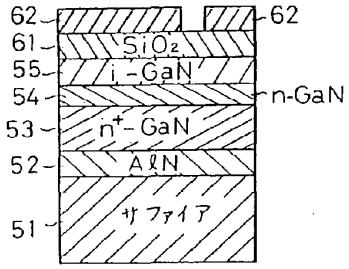


Savant Technologies LLC - 1004.694

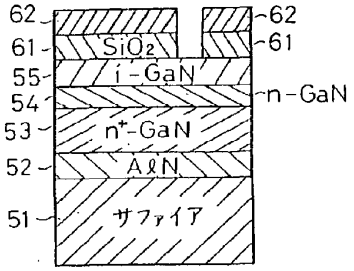
第 8 図



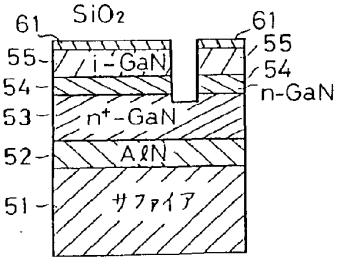
第 9 図



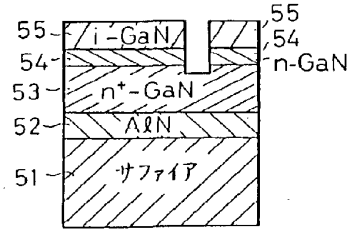
第10図



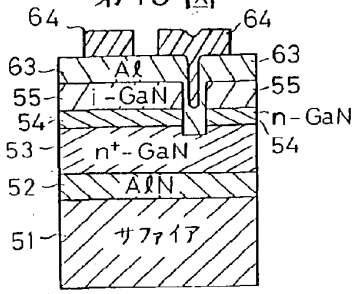
第11図



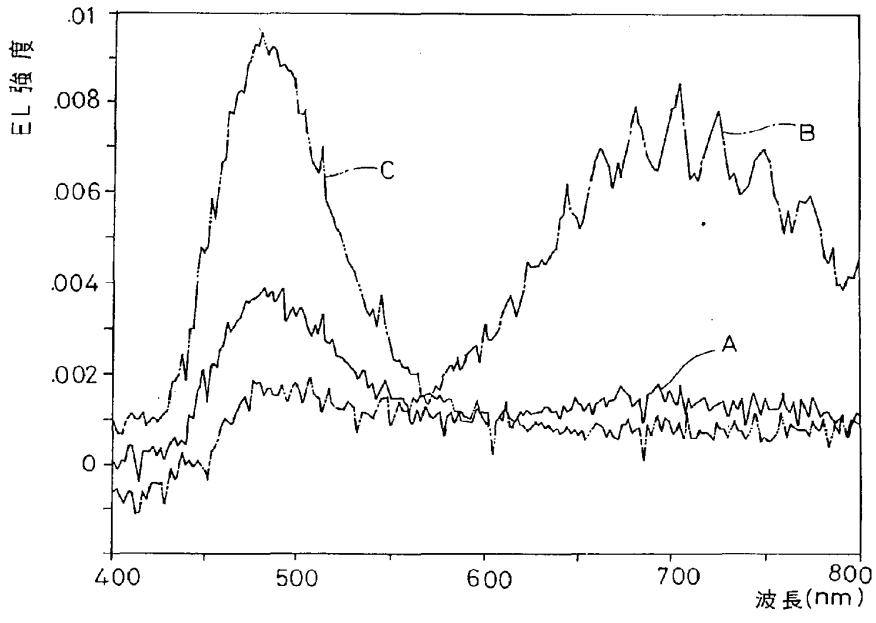
第12図



第13図

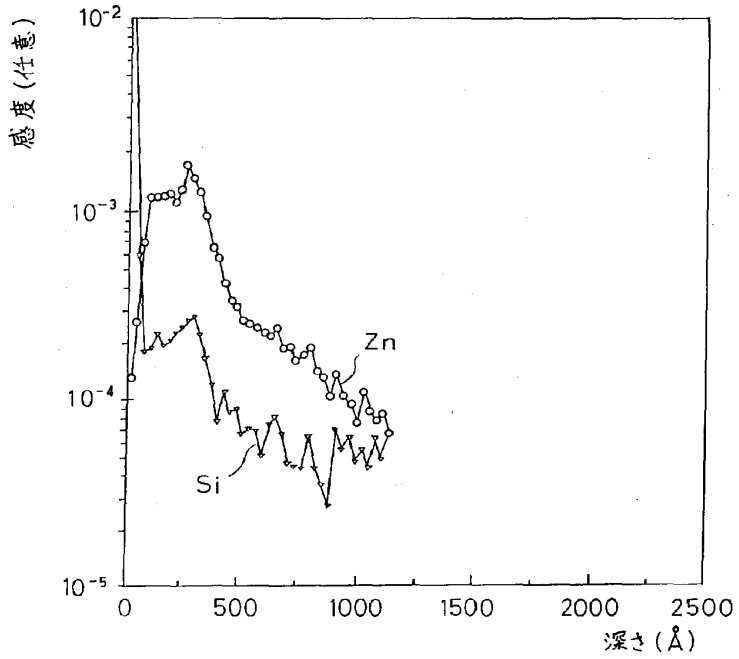


第 14 図



Savant Technologies LLC - 1004.695

第 15 図



Savant Technologies LLC - 1004.696

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **04-289691**

(43)Date of publication of application : **14.10.1992**

(51)Int.Cl. **H05B 33/22**
H05B 33/14

(21)Application number : **02-407300**

(22)Date of filing : **07.12.1990**

(71)Applicant : **MITSUBISHI CABLE IND LTD**

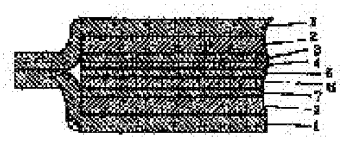
(72)Inventor : **BABA TOSHIYUKI**

(54) EL ILLUMINANT

(57)Abstract:

PURPOSE: To change a luminance color of an EL illuminant having a luminous layer formed by a sol.gel method.

CONSTITUTION: A luminous layer 5 having a diffused phosphor formed by a sol.gel method has a transparent electrode layer 4 on one side while having a rear electrode layer 7 on the other side. Moreover, an EL illuminant having an SiO2 layer 3 having a solidified phosphor dye is provided on the outside of aforesaid transparent electrode layer. The EL illuminant is excellent in luminance uniformity, brightness and a life. The EL illuminant excellent in water resistance can be formed due to an excellent water shielding property of the SiO2 layer. Further, various kinds of phosphor dyes can be used so as to obtain many kinds of luminance.



Savant Technologies LLC - 1004.697

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平4－289691

(43)公開日　平成４年(1992)10月14日

(51)Int.Cl.[5]	識別記号	庁内整理番号	Ｆ１	技術表示箇所
Ｈ０５Ｂ　33/22		8815－3K		
33/14		8815－3K		

審査請求　未請求　請求項の数１(全　４　頁)

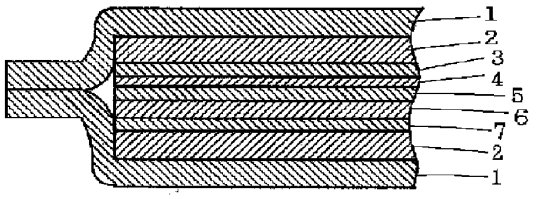
(21)出願番号　特願平2－407300

(22)出願日　平成２年(1990)12月７日

(71)出願人　000003263
三菱電線工業株式会社
兵庫県尼崎市東向島西之町８番地
(72)発明者　馬場　俊之
兵庫県伊丹市池尻４丁目３番地　三菱電線工業株式会社伊丹製作所内
(74)代理人　弁理士　藤本　勉

(54)【発明の名称】　ＥＬ発光体

(57)【要約】
【目的】ゾル・ゲル法で形成した発光層を有するＥＬ発光体の発光色を変化させること。
【構成】ゾル・ゲル法で形成した、蛍光体を分散含有する発光層（５）の片側に透明電極層（４）を有し、他方の側に背面電極層（７）を有する。かつ前記の透明電極層の外側に、蛍光染料を固定化したSiO_2層（３）を有するＥＬ発光体。
【効果】発光の均一性、輝度、寿命に優れる。SiO_2層が遮水性に優れることより耐水性に優れるＥＬ発光体を形成することができる。また、種々の蛍光染料の使用が可能で多種類の発光を得ることができる。



Savant Technologies LLC - 1004.698

1

【特許請求の範囲】

【請求項１】　ゾル・ゲル法で形成した、蛍光体を分散含有する発光層の片側に透明電極層を有し、他方の側に背面電極層を有すると共に、前記の透明電極層の外側に、蛍光染料を固定化したSiO_2層を有することを特徴とするＥＬ発光体。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、ゾル・ゲル法で形成した発光層の発光色を制御した、発光の均一性に優れるＥＬ発光体に関する。

【０００２】

【従来の技術】従来、蛍光体を分散含有する発光層の片側に透明電極層を有し、他方の側に背面電極層を有すると共に、その発光層がゾル・ゲル法で形成されてなるＥＬ発光体が知られていた（特開平２－３３８８８号公報）。

【０００３】しかしながら、ゾル・ゲル法による発光層の形成時における加熱処理で有機物からなる蛍光顔料が熱分解する問題があるため、発光層に蛍光顔料を添加することができず、発光色を白色等に変化させることができない問題点があった。

【０００４】

【発明が解決しようとする課題】本発明は、ゾル・ゲル法で発光層を形成したＥＬ発光体において、その発光色を変化させることを課題とする。

【０００５】

【課題を解決するための手段】本発明は、ゾル・ゲル法で形成した、蛍光体を分散含有する発光層の片側に透明電極層を有し、他方の側に背面電極層を有すると共に、前記の透明電極層の外側に、蛍光染料を固定化したSiO_2層を有することを特徴とするＥＬ発光体を提供するものである。

【０００６】

【作用】透明電極層の外側に、蛍光染料を固定化したSiO_2層を設けることにより、発光色を変化させることができる。またかかる方式とすることにより、蛍光染料を均一な分散状態に含有させることができると共に、緻密なSiO_2層を形成でき、防湿性や耐候性等の耐久性に優れるものとすることができる。

【０００７】また、種々の蛍光染料を固定化できて、同じ構成の発光層に基づく光を多種類に変化させることができる。

【０００８】

【実施例】本発明のＥＬ発光体を図１に例示した。３が蛍光染料を固定化したSiO_2層、４が透明電極層、５が発光層、７が背面電極層である。なお、１は防湿層、２は捕水層、６は絶縁層である。

【０００９】蛍光染料を固定化したSiO_2層の形成は、ＬＰＤ（液相析出）法により行うことができる。すなわち例えば、シリカを飽和させたケイフッ化水素酸の水溶液に蛍光染料を添加し、これにホウ酸水溶液などからなる開始剤を添加して基板を浸漬し、室温等で基板上に蛍光染料を含むSiO_2層を析出成長させる方法などにより行うことができる。

2

【００１０】前記において、基板として例えば透明導電フィルムの如きＥＬ発光体を構成する部材、ないし部品を用いることにより、当該SiO_2層を導入するための、フィルムなどからなる別個の基板の付加を回避することができ、ＥＬ発光体の薄型化に有利である。

【００１１】SiO_2層の厚さは適宜に決定してよいが、一般には１００μm以下、就中５～６０μmとされる。蛍光染料としては、例えばローダミン６Ｇ、オーラミン、ロケットレッドなどの、目的とする発光色に変化せしめうるものが用いられる。蛍光染料を固定化したSiO_2層は、透明電極層の外側に設けられるが、透明電極層の直上にある必要はない。

【００１２】透明電極層の形成は、例えばインジウムないし錫の酸化物の如き透明導電性付与剤を、発光層の上に蒸着法等で設ける方法や、フィルム上に蒸着等してなる透明導電フィルムを用いる方法、透明導電性付与剤を樹脂バインダに添加してなる透明導電塗料等を塗布する方法などにより行うことができる。

【００１３】透明導電塗料等の塗布は例えば、スクリーン印刷法、流延法、ドクターブレード法、ロールコーティング法などの適宜な方法で行ってよい。

【００１４】透明導電塗料等における樹脂バインダとしては、例えばシアノエチルセルロース、シアノエチルサッカロース、シアノエチルプルラン、シアノエチルポリビニルアルコール、ポリフッ化ビニリデン、ポリテトラフルオロエチレン、ポリクロロトリフルオロエチレン、テトラフルオロエチレン・ヘキサフルオロプロピレン共重合体、フッ化ビニリデン系共重合体などが好ましく用いられる。

【００１５】前記のフッ化ビニリデン系共重合体におけるフッ化ビニリデンとの共重合体成分としては、テトラフルオロエチレン、トリフルオロエチレン、クロロトリフルオロエチレン、ヘキサフルオロプロピレンなどの１種又は２種以上が用いられる。塗布液の調製には、酢酸セロソルブ、ジメチルホルムアミド、メチルエチルケトンの如き適宜な有機溶媒を用いてよい。

【００１６】透明電極層に対しては必要に応じ、銀粉やカーボン等の導電性粉末を含有する樹脂ペースト等の塗布層からなる集電帯が設けられる。集電帯は、ターミナル方式のリード電極を介して透明電極層に印加する電圧の偏りを抑制するためのものである。集電帯は、透明電極層の一部に帯状に設ける方式が通例である。

【００１７】蛍光体を分散含有する発光層は、ゾル・ゲル法で形成される。その例としては、テトラエトキシシランの如き金属アルコキシド等の有機金属化合物をエタ

Savant Technologies LLC - 1004.699

3

ノールやイソプロパノール等に溶解させ、その溶液に酢酸水溶液等の触媒を添加し、必要に応じ加熱して加水分解反応や重縮合反応等により高分子量化ゾルを生成させる。

【００１８】次に、前記の高分子量化ゾルにおけるアルコール等の溶媒を炭酸プロピレン等に置換してゾル・ゲル反応を停止させた後、その高分子量化ゾルをバインダーとしてそれに蛍光体を添加し、その分散液を透明電極層や背面電極層等に塗布して、加熱処理する方法などがあげられる。

【００１９】前記において、蛍光体としては適宜なものを用いてよい。一般には例えば、硫化亜鉛又は硫化カドミウム亜鉛を銅、マンガン、アルミニウム、銀、塩素、ホウ素などで活性化したものや、希土類賦活酸化イットリウム等の酸化物が用いられる。蛍光体の平均粒径は、１０μm以上、就中１５～４０μmが適当である。また、発光層における蛍光体の体積占有率は３０～８０％が一般的である。

【００２０】背面電極層は例えば、導電性塗料を塗布する方法や、アルミニウム箔などの適宜な金属箔を用いる方法などにより形成することができる。

【００２１】防湿層は、ＥＬ発光体の外側を包囲して水分の侵入を防止するためのものである。本発明では、発光層がゾル・ゲル法で形成されて耐水性に優れ、かつ蛍光染料を固定化したSiO_2層が遮水性に優れることに基づいて、防湿層は必要に応じて設けられる。防湿層の厚さは適宜に決定してよいが、ＥＬ発光体の薄型化の点よりは５０～５００μmが適当である。防湿層の形成には適宜なプラスチックフィルムを用いてよい。好ましくは、吸水率や透湿度の小さいプラスチックフィルムが用いられる。

【００２２】好ましく用いうるプラスチックフィルムの例としては、ポリクロロトリフルオロエチレン、ないしその共重合体、ポリ塩化ビニリデン、塩化ビニル・塩化ビニリデン共重合体、延伸ポリプロピレン、高密度ポリエチレン、四フッ化エチレン・六フッ化エチレン共重合体、フッ化エチレン・プロピレン共重合体、ポリエチレンテレフタレート、エチレン・テトラフルオロエチレン共重合体などからなるフィルムがあげられる。

【００２３】捕水層は、発光層への水分の侵入を防止するためのものであるが、防湿層の場合と同様、必要に応じて設けられる。捕水層は、防湿層の内側に設ける方式が一般的である。

【００２４】捕水層の形成には、水に不溶であるが、水分を吸収捕獲して膨潤する性質を示す吸水性プラスチックが好ましく用いられる。就中、水分の吸収能が自重の５倍以上、特に１０倍以上のものが好ましい。

【００２５】吸水性プラスチックの例としては、カルボキシル基、スルホン基、リン酸基、第四級アンモニウム塩、アミノ基、イミノ基、ピリジウム基の如きイオン化

4

性基、ないしその塩及び／又はヒドロキシル基、エーテル基、鎖状ないし環状のアミド基、ニトリル基の如きノニオン性親水性基等を有する天然、ないし合成の親水性で水不溶性のポリマなどがあげられる。

【００２６】吸水性プラスチックの具体例としては、ポリアクリルアミド、ポリアクリルアミドとポリオレフィンとのブレンドポリマー、アクリル酸ないしその塩とジビニルベンゼンとの共重合体、アクリロニトリルと塩化ビニルとエチレン系単量体との共重合体のアルカリ加水分解物、アクリロニトリルと塩化ビニリデンとエチレン系単量体との共重合体のアルカリ加水分解物などがあげられる。

【００２７】さらに、アクリルアミド系共重合体のホルムアルデヒド架橋体、ポリアクリル酸とポリビニルアルコールとの酸縮合物、ポリビニルアルコールのエピクロルヒドリン架橋体、アクリロニトリル系重合体をアルカリで加水分解した重合体のホルムアルデヒド架橋体、ポリビニルアルコールのリン酸縮合体、２－ヒドロキシエチルメタクリレートとエチレングリコールジメタクリレートとの共重合体などもあげられる。

【００２８】またさらに、２－メチル－５－ビニルピリジンとＮ，Ｎ’－メチレンビスアクリルアミドとの共重合体、Ｎ，Ｎ’－ジメチルアミノエチルメタクリレートとＮ，Ｎ’－メチレンビスアクリルアミドとの共重合体、Ｎ－ビニル－２－ピロリドンとエチレングリコールジメタクリレートとの共重合体、ポリオキシエチレンの放射線照射による架橋体、でん粉の酸性下加熱縮合物、でん粉－アクリロニトリルグラフト共重合体のケン化物、ビニルエステルとエステル系不飽和カルボン酸、ないしその誘導体との共重合体の乾燥体、イソブチレン－マレイン酸共重合体などもあげられる。

【００２９】捕水層の形成は、吸水性プラスチック溶液を塗布する方法や、吸水性プラスチックからなるフィルムをラミネートする方法などがあげられる。捕水層の厚さは２０～３００μmが一般的であるが、これに限定されない。

【００３０】必要に応じて設けられる絶縁層は、絶縁性樹脂の塗布方法や、絶縁フィルムのラミネート法などにより形成することができる。絶縁層には、発光層と同様に、例えばチタン酸バリウム、チタン酸鉛、チタン酸ジルコニウム、酸化チタン、硫化亜鉛、炭化ケイ素の如き高誘電率微粒子を配合してもよい。

【００３１】なお本発明においては、ゾル・ゲル法で形成した発光層による発光色を変化させるべく、蛍光染料を固定化したSiO_2層を透明導電層の外側に設ける点を除き、例えば防湿層、捕水層、透明電極層、背面電極層、集電帯、絶縁層、リード電極などの形成手段については任意であり、従来に準じることができる。

【００３２】ちなみに、厚さ２０μmのアルミニウム箔からなる背面電極層の上に、リード電極の付設下、チタ

Savant Technologies LLC - 1004.700

5

ン酸バリウム含有のフッ化ビリニデン系共重合体の酢酸セロソルブ溶液を塗布して厚さ約１５μmの絶縁層を形成した後、その上にゾル・ゲル法で、銅とアルミニウムで活性化した硫化亜鉛からなる蛍光体を分散含有する厚さ約５０μmの発光層を形成した。

【００３３】次に、前記の発光層の上にＩＴＯからなる厚さ約５μmの透明電極層をスパッタリング法で形成した後、その上に銀粉含有の樹脂ペーストを部分塗布して幅２mmの集電帯を形成し、リード電極を設けると共に、ＬＰＤ法でローダミン６Ｇを固定化した厚さ１０μmのSiO_2層を形成して、ＥＬ発光体を得た。

【００３４】前記において、SiO_2層を設けない場合の発光色は青緑色であったが、SiO_2層の付設により白色光に変化させることができた。また、その発光色の変化において輝度の実質的な低下は認められず、発光の均一性にも優れていた。

【００３５】

【発明の効果】本発明のＥＬ発光体は、蛍光染料を固定

6

化したSiO_2層を介在させたので、ゾル・ゲル法で形成した発光層の発光色を変化させることができる。かつ、種々の蛍光染料の使用が可能であり、同じ構成の発光層に基づいて多種類の発光を得ることができ、白色光も得ることができる。また発光の均一性、輝度、耐候性等の寿命に優れており、SiO_2層が遮水性に優れることより耐水性にも優れている。

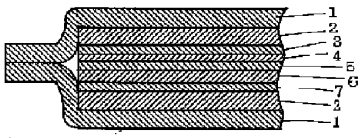
【図面の簡単な説明】

【図１】実施例の断面図である。

【符号の説明】

１：防湿層
２：捕水層
３：SiO_2層
４：透明電極層
５：発光層
６：絶縁層
７：背面電極層

【図１】



Savant Technologies LLC - 1004.701

Espacenet
Bibliographic data: JP4321280 (A) — 1992-11-11

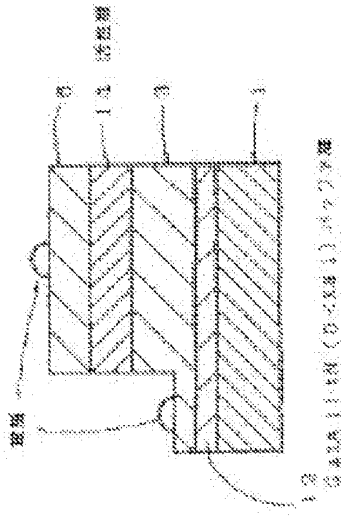
BLUE COLOR LIGHT-EMITTING DIODE

Inventor(s):	NAKAMURA SHUJI +
Applicant(s):	NICHIA KAGAKU KOGYO KK +

Classification:	**- international:**	***H01L21/20; H01L21/86; H01L33/12; H01L33/32;*** (IPC1-7): H01L21/20; H01L21/86; H01L33/00
	- European:	
Application number:	JP19910116912 19910419	
Priority number (s):	JP19910116912 19910419	
Also published as:	JP2791448 (B2)	

Abstract of JP4321280 (A)

PURPOSE:To provide the title blue color light-emitting diode in high efficiency and brightness having excellent light-emitting characteristics such as color purity. CONSTITUTION:The title blue color light-emitting diode is composed of a buffer layer 2 comprising GaxAl1-xN (where 0<X<=1), an Si doped n type clad layer 3, a Zn doped light-emitting active layer 14 and an Mg doped p type clad layer 5 laminated on a sapphire substrate 1.



Savant Technologies LLC - 1004.702

Last updated: 5.12.2011 Worldwide Database 5.7.31; 92p

Savant Technologies LLC - 1004.703

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平4－321280

(43)公開日　平成４年(1992)11月11日

(51)Int.Cl.[5]	識別記号	庁内整理番号	Ｆ１	技術表示箇所
Ｈ０１Ｌ　33/00	Ｃ	8934－4M		
21/20		9171－4M		
21/86		7739－4M		

審査請求　未請求　請求項の数１(全　3　頁)

(21)出願番号　特願平3－116912

(22)出願日　平成３年(1991)４月19日

(71)出願人　000226057
日亜化学工業株式会社
徳島県阿南市上中町岡491番地100

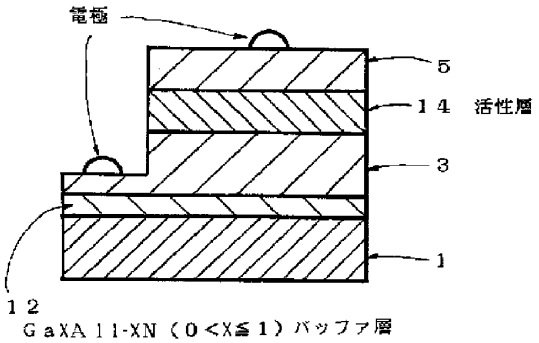
(72)発明者　中村　修二
徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

(54)【発明の名称】　青色発光ダイオード

(57)【要約】

【目的】　高効率で、高輝度かつ色純度等の発光特性に優れた青色発光ダイオードを提供する。

【構成】　サファイア基板上に、$Ga_xAl_{1-x}N$（但しXは０＜X≦１の範囲にある。）よりなるバッファ層と、Ｓｉがドープされたｎ型のクラッド層と、Ｚｎがドープされた発光する活性層と、さらに、Ｍｇがドープされたｐ型のクラッド層とが積層されている青色発光ダイオード。



Savant Technologies LLC - 1004.704

1

【特許請求の範囲】

【請求項１】　$Ga_xAl_{1-x}N$（但しXは０＜X≦１の範囲にある。）よりなるバッファ層と、Ｚｎがドープされた発光する活性層と、Ｓｉがドープされたｎ型のクラッド層と、さらに、Ｍｇがドープされたｐ型のクラッド層とを具備していることを特徴とする青色発光ダイオード。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、一般式が$Ga_xAl_{1-x}N$（０≦X≦１）で表される窒化ガリウム系化合物半導体よりなる青色発光ダイオードに係り、特に発光効率が高く、高輝度、かつ色純度の良い、青色発光ダイオードに関するものである。

【０００２】

【従来の技術】現在、窒化ガリウム系化合物半導体を使用した青色発光ダイオードは、図２に示すＭＩＳ構造のものがよく知られている。

【０００３】一般にＭＩＳ構造の青色発光ダイオードは、基本的に、サファイア基板１上に、ＡｌＮよりなるバッファ層２、Ｓｉドープｎ型$Ga_xAl_{1-x}N$層３、Ｚｎドープｉ型$Ga_xAl_{1-x}N$層４が順に積層され、３および４から電極が取り出された構造となっている。このようなＭＩＳ構造の窒化ガリウム系化合物半導体を有する青色発光ダイオードは、他のｐ－ｎ接合を有する半導体材料、例えばＧａＡｌＡｓ、ＧａＰ等よりなる赤色発光ダイオード、緑色発光ダイオードに比較して発光効率が低く、また輝度が低いために、実用化するには未だ不十分であった。

【０００４】

【発明が解決しようとする課題】なぜ、上記ＭＩＳ構造の青色発光ダイオードしか実用化できないかというと、発光する活性層を得るため、ｐ型ドーパントとしてのＺｎを窒化ガリウム系化合物半導体にドープしても、ｐ型にはならず、高抵抗のｉ型にしかならないからである。なおここでいう高抵抗のｉ型とは抵抗率$10^8\Omega\cdot cm$以上をいう。

【０００５】またｐ型ドーパントとしてＺｎの代わりに、Ｍｇをドープしてｐ型層を得ようとする試みもあり、一応、Ｍｇをドープすると低抵抗のｐ型層は得られる。しかしながら、そのｐ型層の発光波長は、青色より短波長の紫色であるため、Ｍｇが発光中心となる構造のｐ－ｎ接合では色純度の良い青色発光ダイオードを得ることは不可能であった。

【０００６】以上述べたように、窒化ガリウム系化合物半導体を使用してｐ－ｎ接合の青色発光ダイオードを得ることは非常に困難であるため、現在ではＭＩＳ構造の青色発光ダイオードしかできていないのが実状である。

【０００７】周知のように、発光出力に代表される発光特性、信頼性等を考慮するとＭＩＳ構造よりも、ｐ－ｎ

2

接合が有利であるのは常識であり、一刻も早く、ｐ－ｎ接合青色発光ダイオードの実現が強く望まれている。

【０００８】従って、本発明は上記事情を鑑みて成されたものであり、上記ｉ型層をｐ型層とｎ型層ではさむ構造の青色発光ダイオードを実現することにより、高効率で、高輝度かつ色純度等の発光特性に優れた青色発光ダイオードを提供することを目的とする。

【０００９】

【課題を解決するための手段】本発明は、サファイア基板上に、一般式が$Ga_xAl_{1-x}N$（０≦X≦１）で表される窒化ガリウム系化合物半導体が積層された構造を有する青色発光ダイオードにおいて、$Ga_xAl_{1-x}N$（但しXは０＜X≦１の範囲にある。）よりなるバッファ層と、Ｚｎがドープされた発光する活性層と、Ｓｉがドープされたｎ型のクラッド層と、さらに、Ｍｇがドープされたｐ型のクラッド層とを具備していることを特徴とするものである。

【００１０】その構造の一例を図１にしめす。本発明の青色発光ダイオードは、サファイア基板１上に、$Ga_xAl_{1-x}N$（０＜X≦１）よりなるバッファ層１２、Ｓｉがドープされたｎ型のクラッド層であるＳｉドープｎ型$Ga_xAl_{1-x}N$層３（以下ｎ型クラッド層という。）、Ｚｎがドープされた発光する活性層であるＺｎドープ$Ga_xAl_{1-x}N$層１４（以下活性層という。）、Ｍｇがドープされたｐ型のクラッド層であるＭｇドープｐ型$Ga_xAl_{1-x}N$層５（以下ｐ型クラッド層という。）が順に積層され、さらに、３および５から電極が取り出された構造となっている。

【００１１】バッファ層１２は、その上に積層する窒化ガリウム系化合物半導体層の結晶性を向上させるために必要なものであり、通常数ｎｍ～数百ｎｍ以下の厚さで形成する。またバッファ層１２はサファイア基板の他に、ｎ型クラッド層３、活性層１４の上に形成しても良い。

【００１２】活性層１４は、Ｚｎを発光中心とし、発光波長のピークはおよそ４７０～４８０ｎｍにある。

【００１３】

【作用】本発明の青色発光ダイオードにおいて、バッファ層１２の作用は、本発明者が先に出願した特願平３－３２２５９号において詳しく述べている。簡単にいうとバッファ層の材料を、従来のＡｌＮとするよりも、$Ga_xAl_{1-x}N$（０＜X≦１）とする方が、その上に成長させる窒化ガリウム系化合物半導体の結晶性が格段に向上し、その上に成長させるＭｇドープの$Ga_xAl_{1-x}N$層が容易にｐ型化するということである。

【００１４】またバッファ層１２の材料を$Ga_xAl_{1-x}N$（０＜X≦１）とすることにより、活性層１４においても、ＡｌＮをバッファ層とした従来のｉ型$Ga_xAl_{1-x}N$層４に比べ、格段に結晶性が向上するため、抵抗率も$10^5\Omega\cdot cm$以下となる。

Savant Technologies LLC - 1004.705

3

【００１５】従って、発光ダイオードを上記のような構造とすると、いちばん上にあるｐ型クラッド層５が容易にｐ型となるため、例えば、ｐ型クラッド層５を＋（プラス）側にして、ｎ型クラッド層３を－（マイナス）側にして電流を流すと、ｐ型クラッド層５からは活性層４にホールが注入され、同時にｎ型クラッド層３からは電子が注入され、発光層である活性層４でホールと電子が再結合し、Ｚｎを発光中心として色純度の良い青色の発光を示す。

【００１６】上記のように、このバッファ層１２なしでは、ｐ型層が得られず、本発明の構造の青色発光ダイオードを得ることは不可能である。

【００１７】

【発明の効果】以上述べたように、本発明の青色発光ダイオードは、ｐ型およびｎ型の窒化ガリウム系化合物半導体層で発光する活性層をはさみ、電子とホールとを活性層に注入して発光させる、例えばダブルヘテロ構造の発光ダイオードの発光メカニズムと同一であり、それはＭＩＳ構造の青色発光ダイオードに比べ、高効率、かつ高輝度で、色純度の良い青色発光ダイオードを実現することができる。

【００１８】さらに本発明の青色発光ダイオードはバッファ層に$Ga_xAl_{1-x}N$（$0<X\leqq 1$）を有しているため、サファイア基板上に積層した化合物半導体の結晶性が非常に良くなる。そのため、ＡｌＮバッファ層の上に積層したｐ型クラッド層５と、本発明の構成要件である$Ga_xAl_{1-x}N$（$0<X\leqq 1$）バッファ層の上に形成したｐ型クラッド層５とでは、その結晶性が格段に異なるのである。従って優れた結晶性を有する本発明の青色発光ダイオードが当然輝度が高くなる。

4

【図面の簡単な説明】

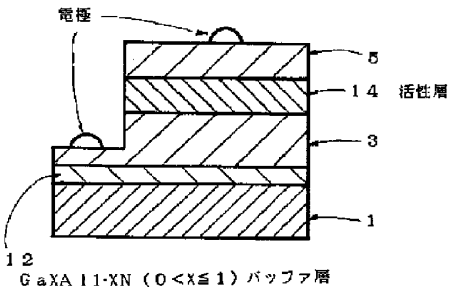
【図１】　本発明の青色発光ダイオードの構造を示す断面図。

【図２】　従来の青色発光ダイオードの構造を示す断面図。

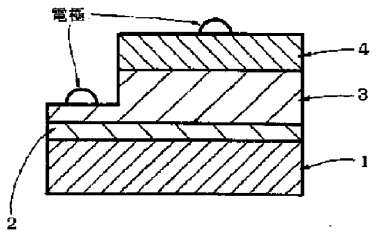
【符号の説明】

１・・・サファイア基板
２・・・ＡｌＮバッファ層
３・・・ｎ型クラッド層
４・・・ｉ型$Ga_xAl_{1-x}N$層
５・・・ｐ型クラッド層
１２・・・$Ga_xAl_{1-x}N$（$0<X\leqq 1$）バッファ層
１４・・・活性層

【図１】



【図２】



Savant Technologies LLC - 1004.706

(19) Japanese Patent Office (JP) (11) Laid Open Patent Application Publication No.

(12) **Laid Open Patent Application Publication (A)** H05-152609

(43) Publication Date: June 18, 1993

(51) Int. Cl.[5]	Identification Symbol	Internal Reference No.	FI	Technical Display Location
H01L 33/00	N	8934-4M		

Examination Request: Not Requested

Number of Claims: 1 (Total of 3 pages)

(21) Patent Application No.: H3-336011

(22) Application Date: November 25, 1991

(71) Applicant: 000226057
Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Yoshiaki Tadatsu
c/o Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Shuji Nakamura
c/o Nichia Corporation
491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

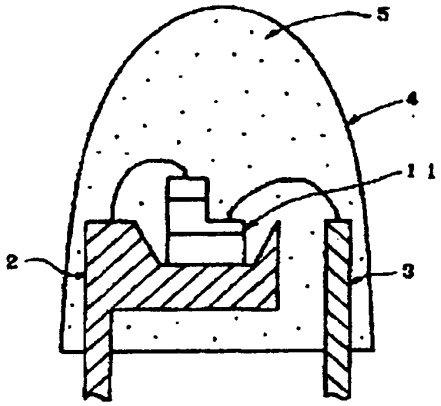
(54) [Invention Title] Light Emitting Diode

(57) [Abstract]

[Purpose] To improve the luminosity factor and brightness of an LED having a light emission device which is made of gallium nitride related compound semiconductor materials whose emission peaks are in the vicinities of 430nm and 370nm.

[Constitution] A light emitting diode having a light emitting device on a stem, the light emitting device being surrounded with a resin mold, wherein said light emitting device is made of gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$), and further wherein a fluorescent dye or pigment, which is excited with emission light from said gallium nitride related compound semiconductors and which emits fluorescent light, is added to said resin mold.

Savant Technologies LLC - 1004.707



Savant Technologies LLC - 1004.708

[What is Claimed is:]

[Claim 1] A light emitting diode having a light emitting device on a stem, the light emitting device being surrounded with a resin mold, wherein said light emitting device is made of gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$), and further wherein a fluorescent dye or pigment, which is excited with emission light from said gallium nitride related compound semiconductors and which emits fluorescent light, is added to said resin mold.

[Detailed Explanation of Invention]

[0001]

[Field of Industrial Application]

The present conception relates to a light emitting diode (hereafter referred to as an LED) in which a light emitting device is surrounded with a resin mold. In particular, the present invention relates to a light emitting diode which can emit a variety of light emissions using one type of light emitting device, further which is bright, and which can vary the emission wavelength.

[0002]

[Conventional Technologies]

In general, an LED has a structure as illustrated in Figure 1. The numeral designator 1 represents a light emitting device which is cut to a piece of 1mm square or smaller and which is made of materials such as GaAlAs and GaP, the numeral designator 2 represents a metal stem, the numeral designator 3 represents a metal post and the numeral designator 4 represents a resin mold which surrounds the light emitting device. The back surface electrode of the light emitting device 1 is attached on the metal stem 2 using a material such as silver paste, thereby electrically connecting it thereto. A gold wire coming from the metal post 3, which is the other electrode, is bonded to the surface of the front surface electrode of the light emitting device 1. Further, the light emitting device 1 is molded using the transparent resin mold 4.

[0003]

Ordinarily, a resin with a large index of refraction and a high transparency is selected for the resin mold 4, so that the emission light from the light emitting device is efficiently emitted to the air. In other cases, an inorganic or organic pigment is mixed as a coloring agent in the resin mold 4 in order to convert or correct the emission color of the light emitting device. For instance, when a red pigment is added to a resin mold around a green light emitting device having GaP semiconductor materials, its emission color turns into white.

[0004]

Savant Technologies LLC - 1004.709

[Issues to be Resolved by Invention]

Conventionally, however, most of technologies to convert the wavelength by adding a coloring agent to a resin mold are not put into practical use and only handful technologies to employ a coloring agent for color correction are utilized. This is because adding an enough amount of a coloring agent, which is a non-light-emission material, to realize the wavelength conversion greatly reduces the brightness of an LED.

[0005]

In addition, currently realized LED's are infrared, red, yellow and green light emitting ones. Blue and ultraviolet LED's are not yet realized. Research is being conducting with semiconductors such as ZnSe which is a II-VI group material, SiC which is a IV-IV group material, and GaN which is a III-V group material. Recently, among these materials, gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$) are attracting attentions because it was found that they exhibit relatively superior light emission at normal temperatures. Moreover, LED's employing gallium nitride related compound semiconductors in which a pn junction was realized for the first time were reported (Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991). According to this publication, LED's employing gallium nitride related compound semiconductors have a main emission peak at around 430nm and also have another emission peak in the ultraviolet range of around 370nm. These wavelengths are the shortest among those for the above semiconductor materials. Such LED's, however, have a disadvantage in that their luminosity factor is poor because the emission color is close to violet, as their emission wavelength indicates.

[0006]

The present invention was conceived with considerations being given to such circumstances. Its purpose is to improve the luminosity factor and brightness of LED's having a light emission device which is made of gallium nitride related compound semiconductors whose emission peaks are in the vicinities of 430nm and 370nm.

[0007]

[Means to Resolve Issues]

The present invention provides a light emitting diode having a light emitting device on a stem, the light emitting device being surrounded with a resin mold, wherein said light emitting device is made of gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$), and further wherein a fluorescent dye or pigment, which is excited with emission light from said gallium nitride related compound semiconductors and which emits fluorescent light, is added to said resin mold.

Savant Technologies LLC - 1004.710

[0008]

Figure 2 illustrate an example to depict the structure of an LED according to the present invention. The numeral designator 11 represents a blue light emitting device in which n-type and p-type GaAlN layers are stacked on a sapphire substrate, the numeral designators 2 and 3 represent a metal stem and a metal post, respectively, in the same manner as in Figure 1, and the numeral designator 4 represents a resin mold surrounding the light emitting device. There is the sapphire insulating substrate on the back surface of the light emitting device 11 and an electrode can not be made on the back surface. Therefore, in order to electrically connect an n-electrode on the GaAlN layer to the metal stem 2, a method is employed in which the GaAlN layers are etched to expose the surface of the n-type layer, upon which an ohmic electrode is attached. The ohmic electrode and the metal stem 2 are electrically connected using a gold wire. Moreover, the other electrode is wire-bonded to the surface of the p-type layer using a gold wire coming from the metal post 3 in the same manner as in Figure 1. Further, a fluorescent dye 5 which is excited with light with a wavelength near 420 to 440nm and which emits light with an emission peak near 480nm is added to the resin mold 4.

[0009]

[Advantages of Invention]

A fluorescent dye or pigment is generally excited with a short-wavelength light and emits light with a longer wavelength than that of the excitation light. Contrarily, there are fluorescent pigments which are excited with a long-wavelength light and which emit light with a shorter wavelength than that of the excitation light. Such materials, however, have a very poor energy efficiency and provides a very week emission light. As discussed above, gallium nitride related compound semiconductors have emission peaks in the shortest wavelength range among semiconductor materials which are employed for LED's. Moreover, they have an emission peak in the ultraviolet range. Therefore, when they are employed as materials for a light emitting device and when a fluorescent dye or pigment is added to a resin mold surrounding the light emitting device, the fluorescent material can be most optimally excited. Therefore, different types of a fluorescent dye or pigment can not only correct color of blue LED's but also convert light into a variety of wavelengths. Further, light with a shorter wavelength is converted to one with a longer wavelength with a good energy efficiency and hence, the amount of a fluorescent dye or pigment can be small and the invention is very excellent from the view point of reducing the degradation of luminosity factor.

[Brief Explanation of Figures]

[Figure 1] A schematic cross section to illustrate the structure of a conventional LED.

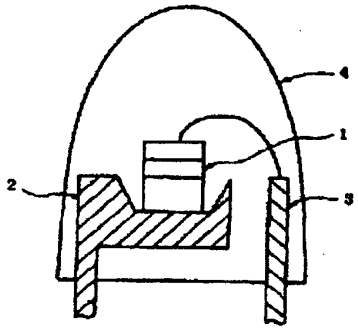
[Figure 2] A schematic cross section to illustrate the structure of an example of an LED according to the present invention.

Savant Technologies LLC - 1004.711

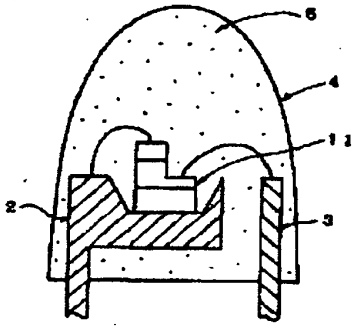
[Explanation of Numeral Designators]

11	Light emitting device
2	Metal stem
3	Metal post
4	Resin mold
5	Fluorescent dye

[Figure 1]



[Figure 2]



Savant Technologies LLC - 1004.712

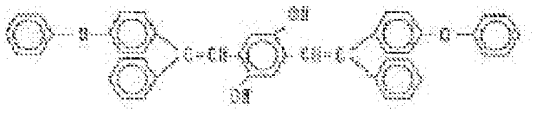
WHITE ORGANIC ELECTROLUMINESCENCE ELEMENT

Publication number: JP6207170 (A)
Publication date: 1994-07-26
Inventor(s): MATSUURA MASAHIDE; SHOJI HIROSHI; AZUMA HISAHIRO; KUSUMOTO TADASHI +
Applicant(s): IDEMITSU KOSAN CO +
Classification:
- international: ***C09K11/06; H01L51/50; H05B33/12; H05B33/14;*** **C09K11/06; H01L51/50; H05B33/12; H05B33/14;** (IPC1-7): C09K11/06; H05B33/14
- European:
Application number: JP19930290207 19931119
Priority number(s): JP19930290207 19931119; JP19920311889 19921120

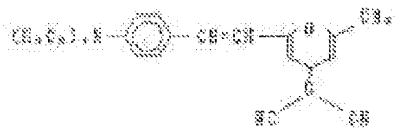
Also published as:
JP3366401 (B2)

Abstract of **JP 6207170 (A)**

PURPOSE:To provide a new white organic electroluminescence element having a specific construction, emitting white luminescence in high luminous efficiency and stability and suitable as a light-emitting element for various displays.
CONSTITUTION:The organic electroluminescence element is produced by sandwiching an organic compound containing luminescent layer between a pair of electrodes. At least one of the electrode is (semi)transparent. The luminescent layer has a laminated structure consisting of the 1st luminescent layer containing an organic compound having fluorescence peak wavelength of 380-480nm in solid state (e.g. the compound of formula I) and the 2nd luminescent layer containing an organic compound having a fluorescence peak wavelength of 480-580nm in solid state (preferably 8-hydroxyquinoline, etc.) laminated on the transparent electrode or anode in the order.; At least one of the 1st luminescent layer, the 2nd luminescent layer and the other organic compound is incorporated with 0.1-10mol% (based on the organic compound constituting the layer) of an organic compound having fluorescence peak wavelength of 580-680nm in solution state (e.g. dicyanomethylenepyrane of formula II).



I



II

Savant Technologies LLC - 1004.713

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平6－207170

(43)公開日　平成６年(1994)７月26日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｃ０９Ｋ　11/06		Ｚ　9159－4Ｈ		
Ｈ０５Ｂ　33/14				

審査請求　未請求　請求項の数10　ＯＬ　（全 48 頁）

(21)出願番号　特願平5－290207

(22)出願日　平成５年(1993)11月19日

(31)優先権主張番号　特願平4－311889

(32)優先日　平４(1992)11月20日

(33)優先権主張国　日本（ＪＰ）

(71)出願人　000183646
出光興産株式会社
東京都千代田区丸の内３丁目１番１号

(72)発明者　松浦　正英
千葉県袖ケ浦市上泉1280番地　出光興産株式会社内

(72)発明者　東海林　弘
千葉県袖ケ浦市上泉1280番地　出光興産株式会社内

(72)発明者　東　久洋
千葉県袖ケ浦市上泉1280番地　出光興産株式会社内

(74)代理人　弁理士　大谷　保

最終頁に続く

(54)【発明の名称】　白色有機エレクトロルミネッセンス素子

(57)【要約】
【目的】　発光効率が高く、かつ発光安定性に優れる白色有機エレクトロルミネッセンス素子を提供すること。
【構成】　発光層が固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物を含有する第一発光層と、固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満である有機化合物を含有する第二発光層とが透明電極又は陽極側から順次積層された積層構造からなり、かつ溶液状態での蛍光ピーク波長が５８０ｎｍ以上６５０ｎｍ以下である有機化合物を、有機化合物層の少なくとも一層に、その層を形成する有機化合物に対して0.１～１０モル％の割合で含有させた白色有機エレクトロルミネッセンス素子である。

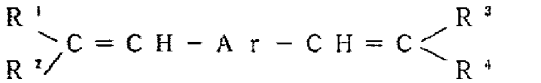
Savant Technologies LLC - 1004.714

【特許請求の範囲】

【請求項１】　少なくとも一方が透明もしくは半透明な一対の電極間に発光層を少なくとも含む有機化合物層を挟持してなる有機エレクトロルミネッセンス素子において、該発光層は固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物を含有する第一発光層と、固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満である有機化合物を含有する第二発光層とが透明電極又は陽極側から順次積層された積層構造からなり、かつ溶液状態での蛍光ピーク波長が５８０ｎｍ以上６５０ｎｍ以下である有機化合物を、上記第一発光層、第二発光層及びその他の有機化合物層の中から選ばれた少なくとも一層に、その層を形成する有機化合物に対し、０.１～１０モル％の割合で含有させたことを特徴とする白色有機エレクトロルミネッセンス素子。

【請求項２】　固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物が、一般式（Ｉ）

【化１】



・・・（Ｉ）

〔式中、R^1 ～R^4 は、それぞれ水素原子，炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，置換もしくは無置換の炭素数６～１８のアリール基，置換もしくは無置換の芳香族複素環式基，置換もしくは無置換のシクロヘキシル基，置換もしくは無置換の炭素数６～１８のアリールオキシ基を示す。ここで、置換基は炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，炭素数６～１８のアリールオキシ基，炭素数１～６のアシル基，炭素数１～６のアシルオキシ基，カルボキシル基，スチリル基，炭素数６～２０のアリールカルボニル基，炭素数６～２０のアリールオキシカルボニル基，炭素数１～６のアルコキシカルボニル基，ビニル基，アニリノカルボニル基，カルバモイル基，フェニル基，ニトロ基，水酸基あるいはハロゲン原子を示す。これらの置換基は単一でも複数でもよい。また、R^1 ～R^4 は同一でも、また互いに異なっていてもよく、R^1 とR^2 及びR^3 とR^4 は互いに置換している基と結合して、置換もしくは無置換の飽和又は不飽和の五員環あるいは置換もしくは無置換の飽和又は不飽和の六員環を形成してもよい。Ａｒは置換もしくは無置換の炭素数６～２０のアリーレン基を表わし、単一置換されていても、複数置換されていてもよく、また結合部位は、オルト，パラ，メタいずれでもよい。なお、置換基は前記と同じである。また、アリーレン基の置換基同士が結合して、置換もしくは無置換の飽和又は不飽和の五員環あるいは置換もしくは無置換の飽和又は不飽和の六員環を形成してもよい。但し、Ａｒが無置換フェニレンの場合、R^1 ～R^4 はそれぞれ炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，置換もしくは無置換のナフチル基，ビフェニル基，シクロヘキシル基，アリールオキシ基より選ばれたものである。〕で表される芳香族メチリディン化合物である請求項１記載の白色有機エレクトロルミネッセンス素子。

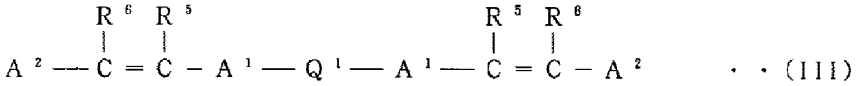
【請求項３】　固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物が、一般式（II）

Ａ－Ｑ－Ｂ　　・・・（II）

〔式中、Ａ及びＢは、それぞれ上記一般式（Ｉ）で表される化合物から１つの水素原子を除いた一価基を示し、同一であっても異なってもよい。また、Ｑは共役系を切る二価基を示す。〕で表される芳香族メチリディン化合物である請求項１記載の白色有機エレクトロルミネッセンス素子。

【請求項４】　固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物が、一般式（III）

【化２】



・・（III）

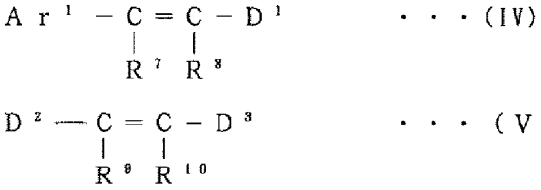
〔式中、A^1 は置換もしくは無置換の炭素数６～２０のアリーレン基又は二価の芳香族複素環式基を示す。結合位置はオルト，メタ，パラのいずれでもよい。A^2 は置換もしくは無置換の炭素数６～２０のアリール基又は一価の芳香族複素環式基を示す。R^5 及びR^6 は、それぞれ水素原子，置換もしくは無置換の炭素数６～２０のアリール基，シクロヘキシル基，一価の芳香族複素環式基，炭素数１～１０のアルキル基，炭素数７～２０のアラルキル基又は炭素数１～１０のアルコキシ基を示す。なお、R^5 ，R^6 は同一でも異なってもよい。ここで、置換基とは、アルキル基，アリールオキシ基，アミノ基又はこれらの基を有するもしくは有しないフェニル基であり、該置換基は単一でも複数でもよい。また、R^5 の各置換基はA^1 と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよく、同様にR^6 の各置換基はA^2 と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよい。また、Q^1 は、共役を切る二価基を表す。〕で表される芳香族メチリディン化合物である請求項１記載の白色有機エレクトロルミネッセンス素子。

【請求項５】　固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満である有機化合物が、８－ヒドロキシキノリンまたはその誘導体の金属錯体である請求項１記載の白色有機エレクトロルミネッセンス素子。

Savant Technologies LLC - 1004.715

【請求項６】　第一発光層及び／又は第二発光層に、一般式（IV）及び（Ｖ）

【化３】



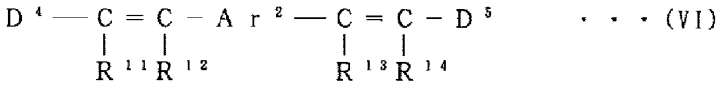
・・・（IV）

・・・（Ｖ）

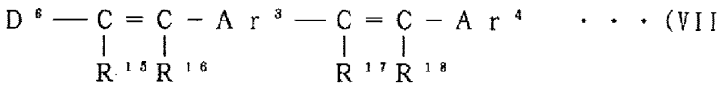
〔式中、Ar^1 は炭素数６～２０のアリール基を示す。R^7 ～R^{10}は、それぞれ独立に水素原子又は炭素数６～２０のアリール基を示す。D^1 ～D^3 は、それぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。ここで、Ar^1 ，R^7 ～R^{10}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基，炭素数６～１０のアラルキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。〕で表されるスチルベン誘導体の中から選ばれた少なくとも一種を含有させてなる請求項１記載の白色有機エレクトロルミネッセンス素子。

【請求項７】　第一発光層及び／又は第二発光層に、一般式（VI）及び(VII)

【化４】



・・・(VI)



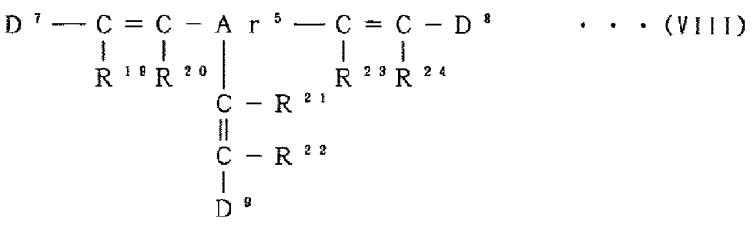
・・・(VII)

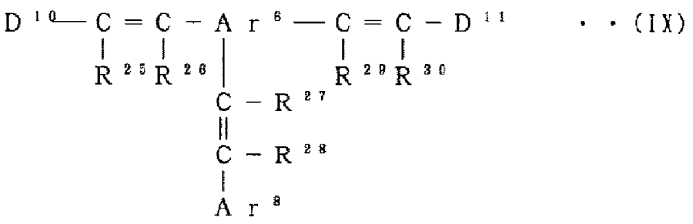
〔式中、Ar^2 及びAr^3 は、それぞれ独立に炭素数６～２０のアリーレン基を示し、Ar^4 は炭素数６～２０のアリール基を示す。R^{11}～R^{18}は、それぞれ独立に水素原子又は炭素数６～２０のアリール基を示す。ここで、Ar^2 ～Ar^4，R^{11}～R^{18}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基，炭素数６～１０のアラリキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。D^4 ～D^6 は、それぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。〕で表されるジスチルアリーレン誘導体の中から選ばれた少なくとも一種を含有させてなる請求項１記載の白色有機エレクトロルミネッセンス素子。

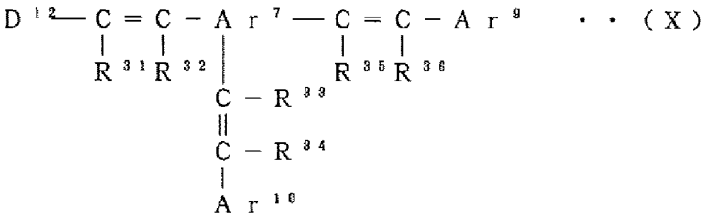
【請求項８】　第一発光層及び／又は第二発光層に、一般式（VIII）～（Ｘ）

【化５】

Savant Technologies LLC - 1004.716







〔式中、Ar^5 ～Ar^7 は、それぞれ独立に炭素数６～２４の３価の芳香族環基を示し、Ar^8 ～Ar^{10}は、それぞれ独立に炭素数６～２０のアリール基を示す。R^{19}～R^{36}は、それぞれ独立に水素原子又は炭素数６～２０のアリール基を示す。D^7 ～D^{12}はそれぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。ここで、Ar^5 ～Ar^7，R^{19}～R^{36}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基，炭素数６～１０のアラルキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。〕で表されるトリススチリルアリーレン誘導体の中から選ばれた少なくとも一種を含有させてなる請求項１記載の白色有機エレクトロルミネッセンス素子。

【請求項９】　第一発光層と第二発光層において、陰極側に近い発光層の方が、電子輸送能力が大である請求項１記載の白色有機エレクトロルミネッセンス素子。

【請求項１０】　第二発光層の膜厚が、第一発光層の膜厚以上である請求項１記載の白色有機エレクトロルミネッセンス素子。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は新規な白色有機エレクトロルミネッセンス素子に関し、さらに詳しくは、発光効率が高く、かつ発光安定性に優れた白色発光を呈する有機エレクトロルミネッセンス素子に関するものである。

【０００２】

【従来の技術】エレクトロルミネッセンス素子（ＥＬ素子）は、自己発光のため視認性が高く、かつ完全固体素子であるため、耐衝撃性に優れるという特徴を有している。そのため、現在、無機又は有機化合物を用いた様々なＥＬ素子が提案され、かつ、実用化が試みられている。これらの素子のうち、有機ＥＬ素子は印加電圧を大幅に低下させることができるので、各種材料・素子の開発が進められている。さらに、現在用いられているバックライトやディスプレイなどの表示素子の軽量化にも有効である。白色発光する有機ＥＬ素子については、従来、次のような技術の開示がなされているが、以下のような問題点が多々あった。例えば、ヨーロッパ公開特許第０３９０５５１号公報では、キャリアをキャリア界面の蓄積によるトンネリング注入によって取り込むため白色発光するための域値電圧が存在し、その域値以下においては白色ではないため階調表示ができない。特開平３－２３０５８４号公報では、二色の蛍光物の混合発光であるため良好な白色にはならない。特開平２－２２０３９０号公報では、白色発光を呈するが、印加電圧３０Ｖで輝度１１０ｃｄ／m^2 であり、駆動電圧が高い割りには発光効率が低い。特開平４－５１４９１号公報では、端面発光構造であり面全体としての用途には不適である。

【０００３】

【発明が解決しようとする課題】本発明は、このような事情のもとで、従来の有機ＥＬ素子の特性を維持すると

Savant Technologies LLC - 1004.717

ともに、発光効率が高く、かつ発光安定性に優れた白色発光を呈する有機ＥＬ素子を提供することを目的としてなされたものである。

【０００４】

【課題を解決するための手段】本発明者らは、高い発光効率及び発光安定性を有する白色有機ＥＬ素子を開発すべく鋭意研究を重ねた結果、正孔と電子との再結合領域を第一発光層と第二発光層との界面領域として、第一発光層及び第二発光層それぞれに、固体状態の蛍光ピーク波長が異なる特定の範囲にある有機化合物を含有させ、かつ第一発光層、第二発光層及びその他の有機化合物層の中から選ばれた少なくとも一層に、溶液状態での蛍光ピーク波長が特定の範囲にある有機化合物を含有させることにより、従来の有機ＥＬ素子の特性を維持するとともに、発光効率が高く、かつ発光安定性に優れた白色発光を呈する有機ＥＬ素子が得られることを見出した。本発明は、かかる知見に基づいて完成したものである。すなわち、本発明は、少なくとも一方が透明もしくは半透明な一対の電極間に発光層を少なくとも含む有機化合物層を挟持してなる有機エレクトロルミネッセンス素子において、該発光層は固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満である有機化合物を含有する第一発光層と、固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満である有機化合物を含有する第二発光層とが透明電極又は陽極側から順次積層された積層構造からなり、かつ溶液状態での蛍光ピーク波長が５８０ｎｍ以上６５０ｎｍ以下である有機化合物を、上記第一発光層、第二発光層及びその他の有機化合物層の中から選ばれた少なくとも一層に、その層を形成する有機化合物に対し、0.１～１０モル％の割合で含有させたことを特徴とする白色有機エレクトロルミネッセンス素子を提供するものである。

【０００５】本発明の白色有機ＥＬ素子は、第一発光層と第二発光層の２層の発光層に特徴がある。この第一発光層には、固体状態の蛍光ピーク波長が３８０ｎｍ以上４８０ｎｍ未満（青色系）、好ましくは４２０ｎｍ以上４７５ｎｍ未満である有機化合物が用いられ、第二発光層には、固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満（緑色系）、好ましくは４９０ｎｍ以上５６０ｎｍ未満である有機化合物が用いられる。さらに、上記発光層及び他の有機化合物層の中から選ばれた少なくとも一層に、溶液状態での蛍光ピーク波長が５８０ｎｍ以上６５０ｎｍ以下（赤色系）、好ましくは５８５ｎｍ以上６２０ｎｍ以下である有機化合物を、その層を形成する有機化合物に対して0.１～１０モル％、好ましくは0.５～５モル％の割合で含有させたことを特徴とする。この0.１～１０モル％というのは、濃度消光を生じないための濃度範囲である。なお、蛍光スペクトルにおいて、ピークが複数ある化合物においては、上記のそれぞれの波長全面域に少なくとも一つのピークをもっていればよい。

【０００６】本発明の白色有機ＥＬ素子による白色光は、上記第一発光層及び第二発光層及び混合成分からの発光の重ね合わせ（すなわち、特定の蛍光ピーク波長を有する３種類の上記有機化合物の３原色発光の重ね合わせ）により得ることができる。なお、図１に白色光の定義をＣＩＥ座標にて示した。ここで、第一発光層に用いる有機化合物は、特に限定されず、例えば特開平３－２３１９７０号公報あるいは国際公開特許ＷＯ９２／０５１３１号公報、特願平５－１７０３５４号明細書、特願平５－１２９４３８号明細書に記載されている有機化合物の中で、上記第一発光層の蛍光条件を満足するものが挙げられる。好ましいものとしては、特開平３－２３１９７０号公報、国際公開特許ＷＯ９２／０５１３１号公報、特願平５－１７０３４５号明細書に記載されている上記第一発光層の蛍光条件を満たすものと、特願平５－１２９４３８号明細書に記載されている適当な化合物との組合せ、さらには後述する正孔注入輸送層に用いる化合物のなかで、上記第一発光層の蛍光条件を満足するものを挙げることができる。次に、特開平３－２３１９７０号公報、国際公開特許ＷＯ９２／０５１３１号公報に記載されている上記第一発光層の蛍光条件を満たす化合物としては、一般式（Ｉ）

【０００７】

【化６】

$$\begin{matrix} R^1 \\ R^2 \end{matrix}\!\!>C=CH-Ar-CH=C<\!\!\begin{matrix} R^3 \\ R^4 \end{matrix} \qquad \cdots (I)$$

【０００８】〔式中、R^1 ～R^4 は、それぞれ水素原子，炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，置換もしくは無置換の炭素数６～１８のアリール基，置換もしくは無置換の芳香族複素環式基，置換もしくは無置換のシクロヘキシル基，置換もしくは無置換の炭素数６～１８のアリールオキシ基，置換もしくは無置換のピリジル基を示す。ここで、置換基は炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，炭素数６～１８のアリールオキシ基，炭素数１～６のアシル基，炭素数１～６のアシルオキシ基，カルボキシル基，スチリル基，炭素数６～２０のアリールカルボニル基，炭素数６～２０のアリールオキシカルボニル基，炭素数１～６のアルコキシカルボニル基，ビニル基，アニリノカルボニル基，カルバモイル基，フェニル基，ニトロ基，水酸基あるいはハロゲン原子を示す。これらの置換基は単一でも複数でもよい。また、R^1 ～R^4 は同一でも、また互いに異なっていてもよく、R^1 と

Savant Technologies LLC - 1004.718

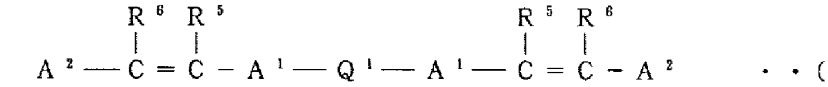
R^2 及びR^3 とR^4 は互いに置換している基と結合して、置換もしくは無置換の飽和又は不飽和の五員環あるいは置換もしくは無置換の飽和又は不飽和の六員環を形成してもよい。Ａｒは置換もしくは無置換の炭素数６～２０のアリーレン基を表わし、単一置換されていても、複数置換されていてもよく、また結合部位は、オルト，パラ，メタいずれでもよい。なお、置換基は前記と同じである。また、アリーレン基の置換基同士が結合して、置換もしくは無置換の飽和又は不飽和の五員環あるいは置換もしくは無置換の飽和又は不飽和の六員環を形成してもよい。但し、Ａｒが無置換フェニレンの場合、R^1 ～R^4 は、それぞれ炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，置換もしくは無置換のナフチル基，ビフェニル基，シクロヘキシル基，アリールオキシ基より選ばれたものである。〕で表される芳香族メチリディン化合物，一般式（II）

Ａ－Ｑ－Ｂ　　・・・　（II）

〔式中、Ａ及びＢは、それぞれ上記一般式（Ｉ）で表される化合物から１つの水素原子を除いた一価基を示し、同一であっても異なってもよい。また、Ｑは共役系を切る二価基を示す。〕で表される芳香族メチリディン化合物及び一般式（III）

【０００９】

【化７】



【０００１０】〔式中、A^1 は置換もしくは無置換の炭素数６～２０のアリーレン基又は二価の芳香族複素環式基を示す。結合位置はオルト，メタ，パラのいずれでもよい。A^2 は置換もしくは無置換の炭素数６～２０のアリール基又は一価の芳香族複素環式基を示す。R^5 及びR^6 は、それぞれ水素原子，置換もしくは無置換の炭素数６～２０のアリール基，シクロヘキシル基，一価の芳香族複素環式基，炭素数１～１０のアルキル基，炭素数７～２０のアラルキル基又は炭素数１～１０のアルコキシ基を示す。なお、R^5 ，R^6 は同一でも異なってもよい。ここで、置換基とは、アルキル基，アリールオキシ基，アミノ基又はこれらの基を有するもしくは有しないフェニル基であり、該置換基は単一でも複数でもよい。R^5 の各置換基はA^1 と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよく、同様にR^6 の各置換基はA^2 と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよい。また、Q^1 は前記と同じである。〕で表される芳香族メチリディン化合物が挙げられる。

【０００１１】ここで、一般式（Ｉ）中のR^1 ～R^4 は、前述の如く同一でも異なってもよく、それぞれ水素原子，炭素数１～６のアルキル基（メチル基，エチル基，ｎ－プロピル基，イソプロピル基，ｎ－ブチル基，イソブチル基，sec －ブチル基，tert－ブチル基，イソペンチル基，t-ペンチル基，ネオペンチル基，イソヘキシル基），炭素数１～６のアルコキシ基（メトキシ基，エトキシ基，プロポキシ基，ブトキシ基等），炭素数７～１８のアラルキル基（ベンジル基，フェネチル基等），炭素数６～１８のアリール基（フェニル基，ビフェニル基，ナフチル基等），シクロヘキシル基，芳香族複素環式基（ピリジル基，キノリル基），炭素数６～１８のアリールオキシ基（フェノキシ基，ビフェニルオキシ基，ナフチルオキシ基等）を示す。

【０００１２】また、R^1 ～R^4 は、これらに置換基の結合したものでもよい。即ち、R^1 ～R^4 は、それぞれ置換基含有フェニル基，置換基含有アラルキル基，置換基含有シクロヘキシル基，置換基含有ビフェニル基，置換基含有ナフチル基を示す。ここで、置換基は炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，炭素数６～１８のアリールオキシ基，炭素数１～６のアシル基，炭素数１～６のアシルオキシ基，カルボキシル基，スチリル基，炭素数６～２０のアリールカルボニル基，炭素数６～２０のアリールオキシカルボニル基，炭素数１～６のアルコキシカルボニル基，ビニル基，アニリノカルボニル基，カルバモイル基，フェニル基，ニトロ基，水酸基あるいはハロゲン原子であり、複数置換されていてもよい。したがって、例えば、置換基含有アラルキル基は、アルキル基置換アラルキル基（メチルベンジル基，メチルフェネチル基等），アルコキシ基置換アラルキル基（メトキシベンジル基，エトキシフェネチル基等），アリールオキシ基置換アラルキル基（フェノキシベンジル基，ナフチルオキシフェネチル基等），フェニル基置換アラルキル基（フェニルフェネチル基等）、上記置換基含有フェニル基は、アルキル基置換フェニル基（トリル基，ジメチルフェニル基，エチルフェニル基など），アルコキシ基置換フェニル基（メトキシフェニル基，エトキシフェニル基など）アリールオキシ基置換フェニル基（フェノキシフェニル基，ナフチルオキシフェニル基等）あるいはフェニル基置換フェニル基（つまり、ビフェニリル基）である。また、置換基含有シクロヘキシル基は、アルキル基置換シクロヘキシル基（メチルシクロヘキシル基，ジメチルシクロヘキシル基，エチルシクロヘキシル基等），アルコキシ基置換シクロヘキシル基（メトキシシクロヘキシル基，エトキシシクロヘキシル基等）あるいはアリールオキシ基置換シクロヘキシル基（フェノキシシクロヘキシル基，ナフチルオキシシクロヘキシル基），フェニル基置換シクロヘキシル基（フェニルシクロヘキシル基）である。置換基含有ナフチル基は、アルキル基置換ナフチル基（メチルナフチル基，ジメチルナ

Savant Technologies LLC - 1004.719

フチル基等），アルコキシ基置換ナフチル基（メトキシナフチル基，エトキシナフチル基等）あるいはアリールオキシ基置換ナフチル基（フェノキシナフチル基，ナフチルオキシナフチル基），フェニル基置換ナフチル基（フェニルナフチル基）である。

【００１３】上記R^1～R^4としては、上述したもののうち、それぞれ炭素数１～６のアルキル基，アリールオキシ基，フェニル基，ナフチル基，ビフェニル基，シクロヘキシル基が好ましい。これらは置換あるいは無置換のいずれでもよい。また、R^1～R^4は同一でも、また互いに異なっていてもよく、R^1とR^2及びR^3とR^4は互いに置換している基と結合して、置換もしくは無置換の飽和又は不飽和の五員環あるいは置換もしくは無置換の飽和又は不飽和の六員環を形成してもよい。

【００１４】一方、一般式（Ｉ）中のＡｒは置換もしくは無置換の炭素数６～２０のアリーレン基を表わし、置換もしくは無置換のフェニレン基，ビフェニレン基，ｐ－テルフェニレン基，ナフチレン基，ターフェニレン基，ナフタレンジイル基，アントラセンジイル基，フェナントレンジイル基，フェナレンジイル基等のアリーレン基であり、無置換でも置換されていてもよい。又、メチリディン（＝Ｃ＝ＣＨ－）の結合位置はオルト，メタ，パラ等どこでもよい。但し、Ａｒが無置換フェニレンの場合、R^1～R^4は炭素数１～６のアルコキシ基，炭素数７～１８のアラルキル基，置換あるいは無置換のナフチル基，ビフェニル基，シクロヘキシル基，アリールオキシ基より選ばれたものである。置換基はアルキル基（メチル基，エチル基，ｎ－プロピル基，イソプロピル基，ｎ－ブチル基，イソブチル基，sec －ブチル基，ｔ－ブチル基，イソペンチル基，ｔ－ペンチル基，ネオペンチル基，イソヘキシル基等），アルコキシ基（メトキシ基，エトキシ基，プロポキシ基，イソプロポキシ基，ブチルオキシ基，イソブチルオキシ基，sec －ブチルオキシ基，ｔ－ブチルオキシ基，イソペンチルオキシ基，ｔ－ペンチルオキシ基），アリールオキシ基（フェノキシ基，ナフチルオキシ基等），アシル基（ホルミル基，アセチル基，プロピオニル基，ブチリル基等），アシルオキシ基，アラルキル基（ベンジル基，フェネチル基等），フェニル基，水酸基，カルボキシル基，アニリノカルボニル基，カルバモイル基，アリールオキシカルボニル基，メトキシカルボニル基，エトキシカルボニル基，ブトキシカルボニル基，ニトロ基，ハロゲン原子であり、単一置換でも複数置換されていてもよい。

【００１５】前記一般式（Ｉ）で表わされるメチリディン芳香族化合物は、１分子中に２つのメチリディン（＝Ｃ＝ＣＨ－）基を有し、このメチリディン基の幾何異性によって、４通りの組合わせ、すなわち、シス－シス，トランス－シス，シス－トランス及びトランス－トランスの組合わせがある。本発明のＥＬ素子における第一発光層は、それらのいずれのものであってもよいし、幾何異性体の混合したものでもよい。特に好ましくは、全てトランス体のものである。また、上記置換基は、置換基の間で結合し、置換、無置換の飽和もしくは不飽和の五員環又は六員環を形成してもよい。

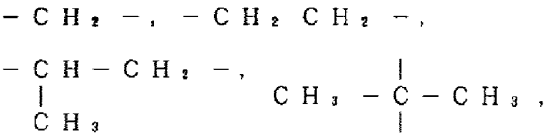
【００１６】一般式（II）におけるＡ及びＢは、それぞれ上記一般式（Ｉ）で表される化合物から１つの水素原子を除いた一価基を示し、同一であっても異なってもよいものである。ここで、一般式（II）におけるＱは共役系を切る二価基を示す。ここで、共役とは、π電子の非極在性によるもので、共役二重結合あるいは不対電子又は孤立電子対によるものも含む。Ｑの具体例としては、

【００１７】

【化８】

Savant Technologies LLC - 1004.720

－ＣＨ₂－，－ＣＨ₂ＣＨ₂－，



－ＣＨ₂ＣＨ₂ＣＨ₂－，

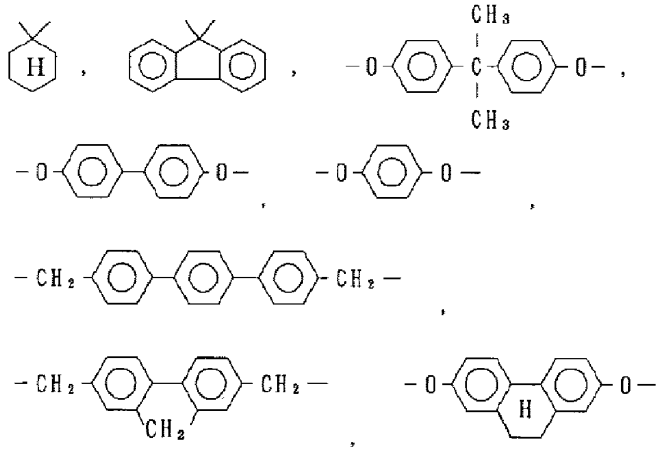
－Ｏ－，－Ｏ－ＣＯ－Ｏ－，

－ＯＣＨ₂ＣＨ₂Ｏ－　，

－ＣＯ－ＣＯ－，

－ＣＯＣＨ₂ＣＯ－，

－ＣＯ（ＣＨ₂）₂ＣＯ－，



【００１８】が挙げられる。このように共役系を切る二価の基を用いる理由は、上記で示されるＡあるいはＢ（即ち、一般式（Ｉ）の化合物）を、単独で本発明の有機ＥＬ素子として用いた場合に得られるＥＬ発光色と、一般式（II）で表わされる化合物を本発明の有機ＥＬ素子として用いた場合に得られるＥＬ発光色とが変わらぬようにするためである。つまり、一般式（Ｉ）又は一般式（II）で表わされる第一発光層が、短波長化あるいは長波長化したりすることはないようにするためである。また、共役系を切る二価基で接続するとガラス転移温度（Ｔｇ）は、上昇することが確認でき、均一なピンホールフリーの微結晶あるいはアモルファス性薄膜が得られることができ、発光均一性を向上させている。更に、共役系を切る二価基で結合していることにより、ＥＬ発光が長波長化することなく、また、合成あるいは精製が容易にできる長所を備えている。

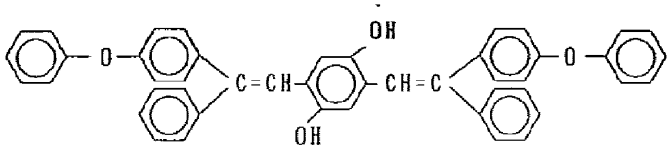
【００１９】また、一般式（III）中のA^1は置換もしくは無置換の炭素数６～２０のアリーレン基又は二価の芳香族複素環式基、A^2は置換もしくは無置換の炭素数６～２０のアリール基（フェニル基，ビフェニル基，ナフチル基等）又は一価の芳香族複素環式基を示す。R^5及びR^6は、それぞれ水素原子，置換もしくは無置換の炭素数６～２０のアリール基，シクロヘキシル基，一価の芳香族複素環式基，炭素数１～１０のアルキル基（メチル基，エチル基，ｎ－プロピル基，イソプロピル基，ｎ－ブチル基，イソブチル基，sec －ブチル基，tert－ブチル基，イソペンチル基，t-ペンチル基，ネオペンチル基，イソヘキシル基等），炭素数７～２０のアラルキル基（ベンジル基，フェネチル基等）又は炭素数１～１０のアルコキシ基（メトキシ基，エトキシ基，プロポキシ基，ブトキシ基等）を示す。なお、R^5，R^6は同一でも異なってもよい。ここで、置換基とは、アルキル基，アリールオキシ基，アミノ基又はこれらの基を有するもしくは有しないフェニル基であり、該置換基は単一でも複数でもよい。R^5の各置換基はA^1と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよく、同様にR^6の各置換基はA^2と結合して、飽和もしくは不飽和の五員環又は六員環を形成してもよい。また、Ｑは、上記と同様に共役を切る二価基を表す。さらに、該A^1の結合はオルト，メタ，パラのいずれでもよい。さ

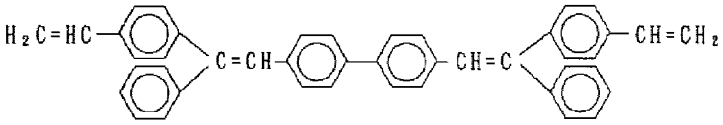
Savant Technologies LLC - 1004.721

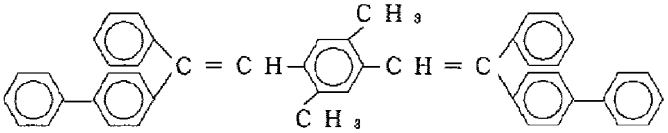
らに、本発明において、上記の一般式（Ｉ），一般式（II）又は一般式（III)で表される有機化合物は、ＣＩＥ色度座標における青紫，紫青，青，緑青もしくは青緑の発光を呈する化合物であることが必要である。具体的には、

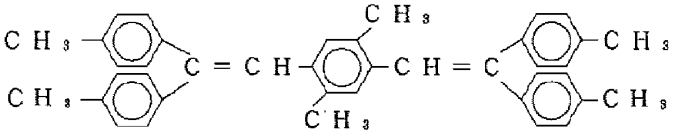
【００２０】

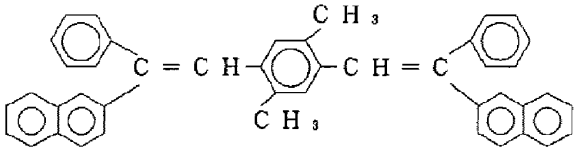
【化９】

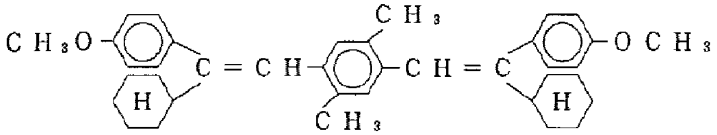






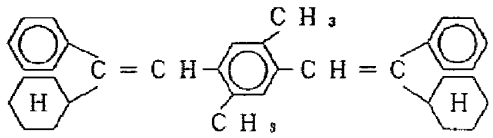


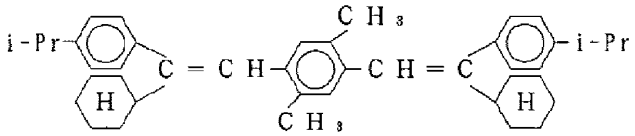




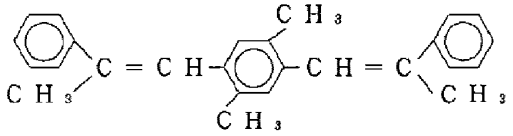
【００２１】

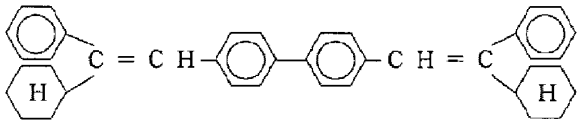
【化１０】

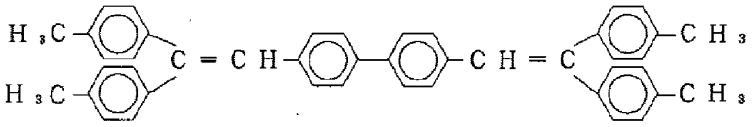


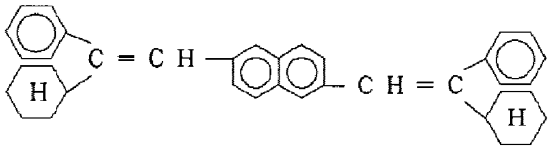


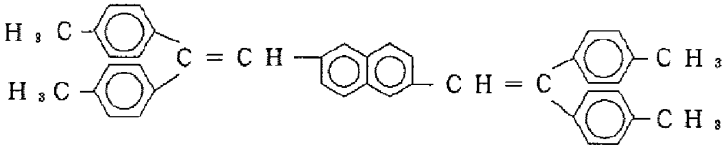
i-Pr　：イソプロピル基，以下同様





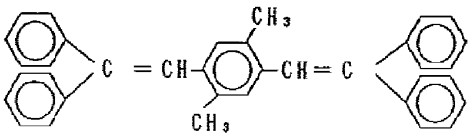


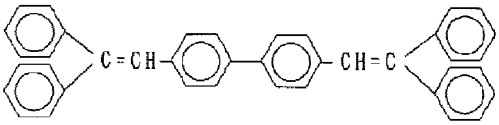


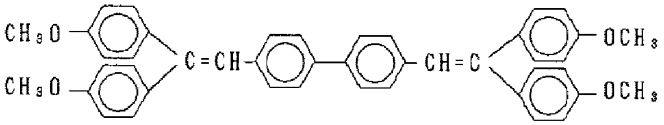


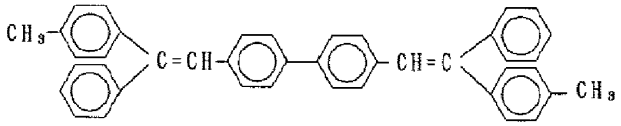
【0022】　　【化11】

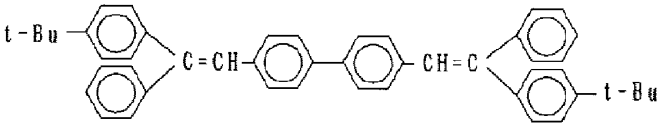
Savant Technologies LLC - 1004.723



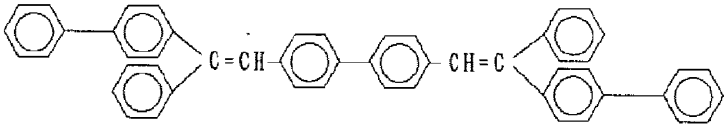






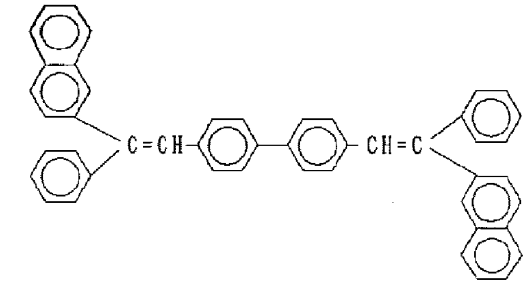


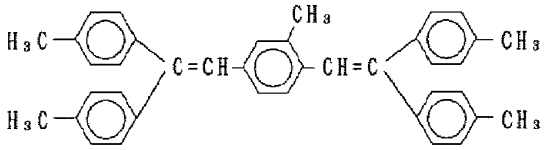
t-Bu：ｔ－ブチル基，以下同様

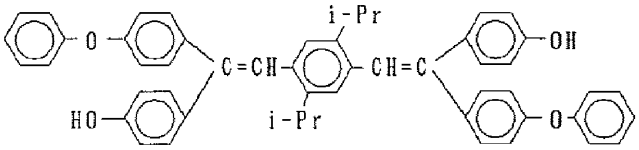


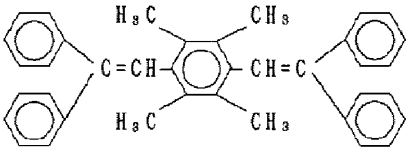
【0023】

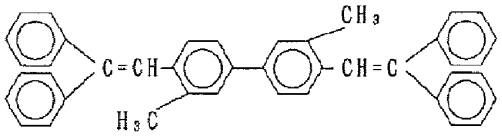
【化12】



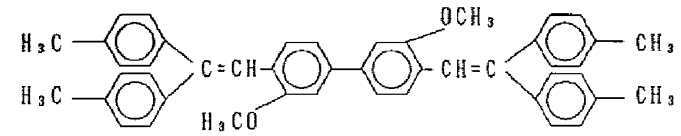


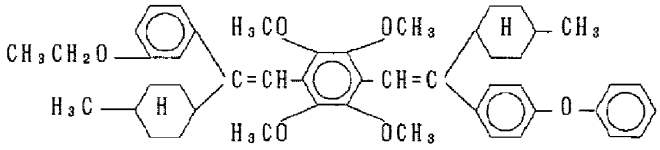


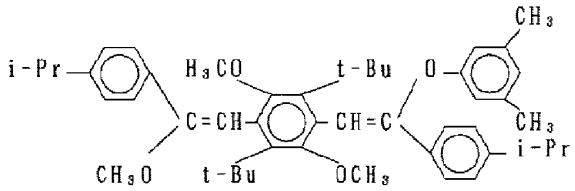


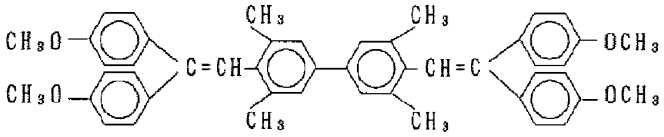


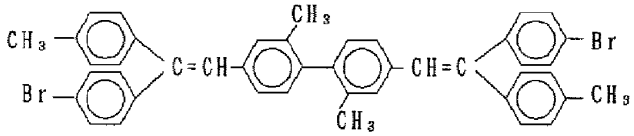
【００２４】　　【化１３】



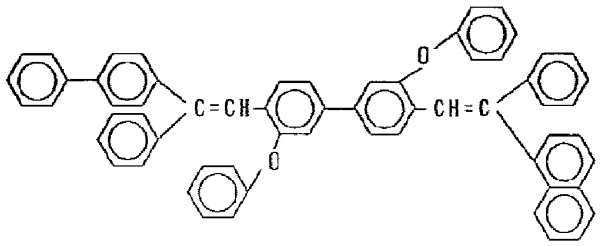


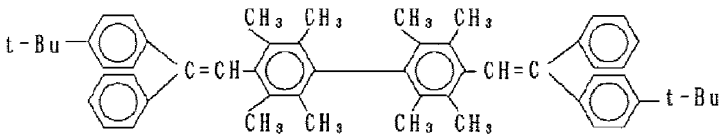


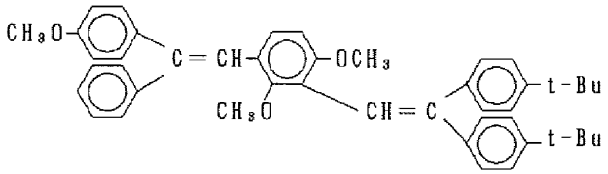


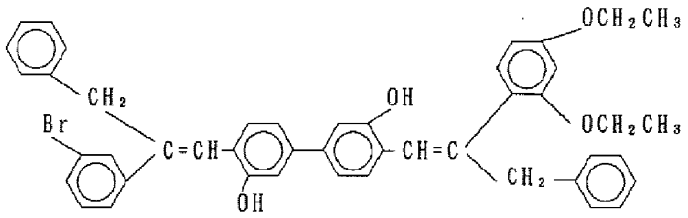


【0025】　　【化14】



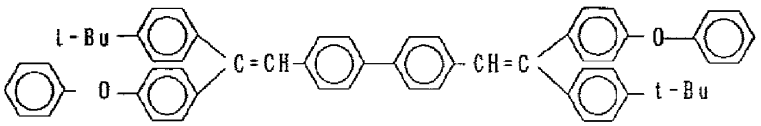


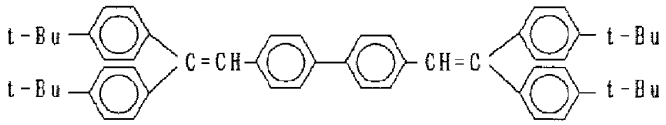


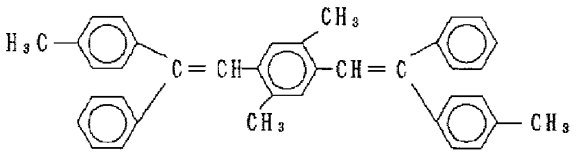


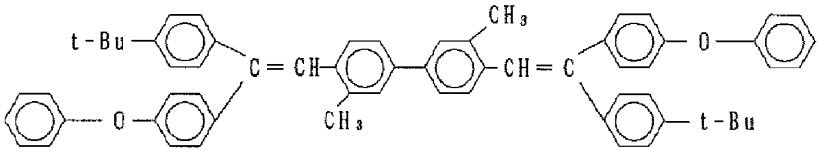
【0026】　　【化15】

Savant Technologies LLC - 1004.727



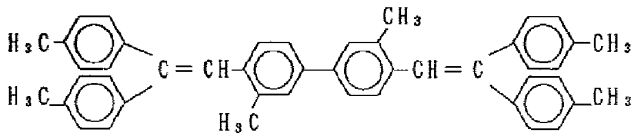


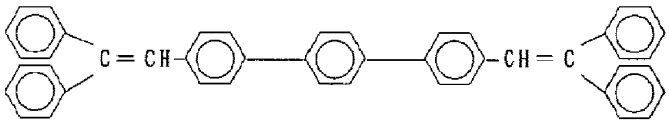


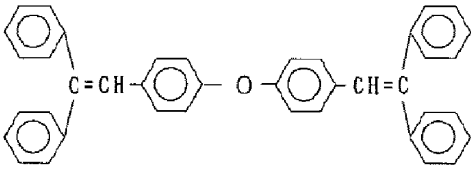


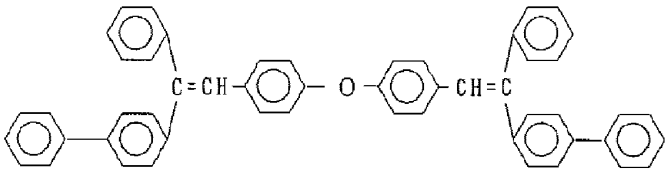
【0027】　　【化16】

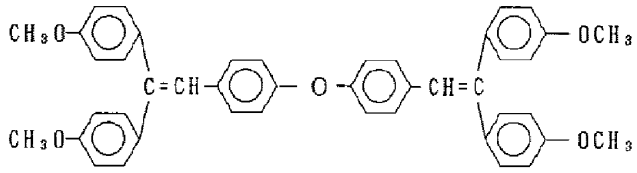
Savant Technologies LLC - 1004.728







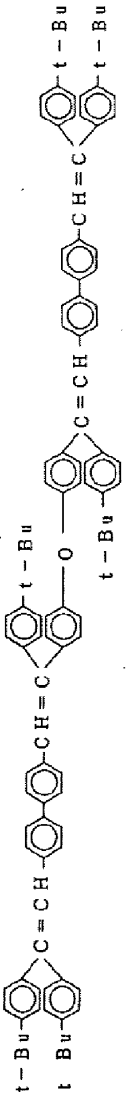


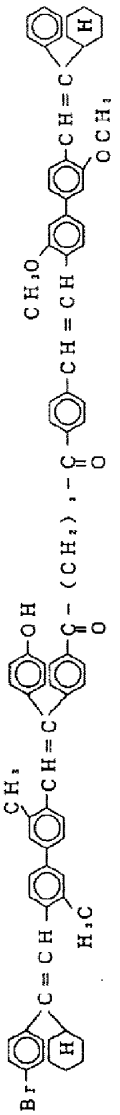


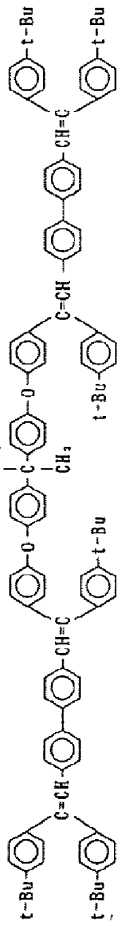
【0028】

【化17】

Savant Technologies LLC - 1004.729







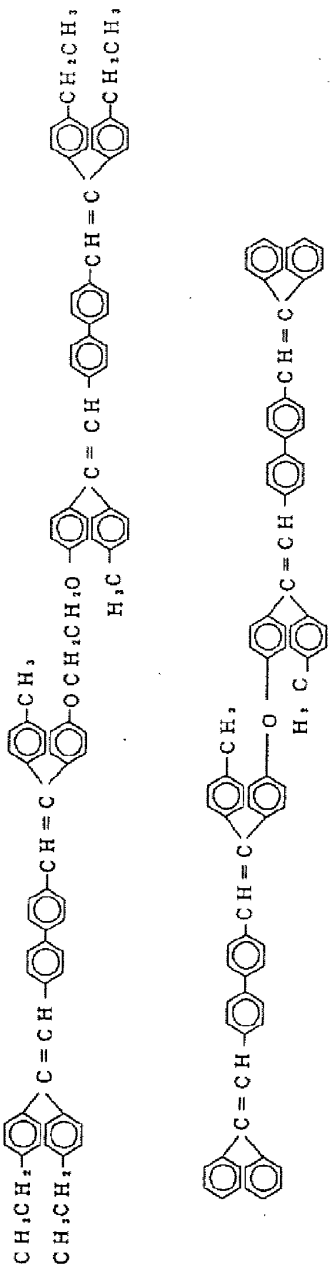
【0029】
【化18】

Savant Technologies LLC - 1004.730

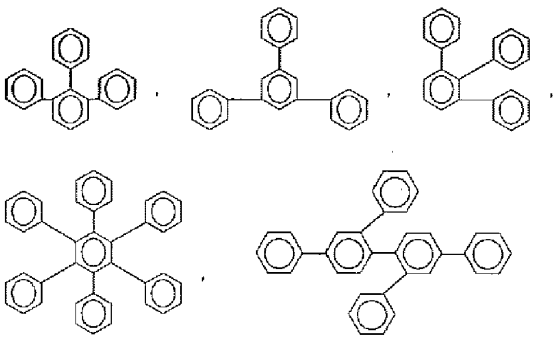
【0030】などである。他の有機化合物としては、

【0031】

【化19】



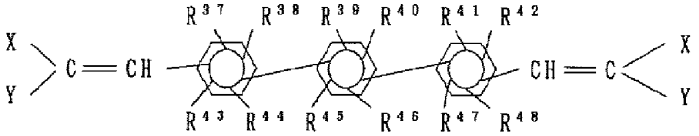
Savant Technologies LLC - 1004.731



【００３２】なども挙げられる。また、特願平５－１７０３５４号明細書に記載されている上記第一発光層の蛍光条件を満たす化合物としては、一般式（XI）

【００３３】

【化２０】

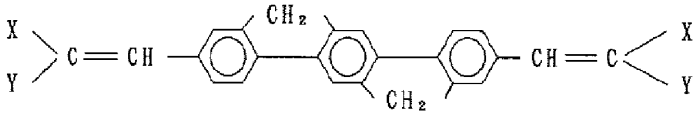


【００３４】〔式中、R^{37}～R^{48}は、それぞれ独立に水素原子又は炭素数１～６のアルキル基を示す。但し、R^{37}～R^{48}のうち少なくとも１つは炭素数１～６のアルキル基である。また、R^{38}とR^{39}，R^{40}とR^{41}，R^{44}とR^{45}，R^{46}とR^{47}は、互いに結合して飽和もしくは不飽和の五員環又は六員環を形成してもよい。X及びYはそれぞれ独立に置換又は無置換の炭素数６～２０のアリール基を示す。XとYは置換基と結合して置換もしくは無置換の飽和又は不飽和の五員環あるいは六員環を形成してもよい。ここで、置換基としては炭素数１～６のアルキル基，炭素数１～６のアルコキシ基，炭素数６～１８のアリールオキシ基，フェニル基，アミノ基，シアノ基，ニトロ基，水酸基あるいはハロゲン原子を示す。これらの置換基は単一でも複数置換されていてもよい。〕で表されるターフェニレン誘導体のスチリル化合物を挙げることができる。

【００３５】ここで、一般式（XI）において、R^{37}～R^{48}は、それぞれ独立に水素原子あるいはメチル基，エチル基，ｎ－プロピル基，イソプロピル基，ｎ－ブチル基，イソブチル基，ｓｅｃ－ブチル基，ｔ－ブチル基，イソペンチル基，ｔ－ペンチル基，ネオペンチル基，ｎ－ヘキシル基，イソヘキシル基などの炭素数１～６のアルキル基を示す。但し、R^{37}～R^{48}のうち少なくとも１つは炭素数１～６のアルキル基であり、特にメチル基又はエチル基が好ましい。また、R^{38}とR^{39}，R^{40}とR^{41}，R^{44}とR^{45}，R^{46}とR^{47}は、互いに結合して飽和もしくは不飽和の五員環又は飽和もしくは不飽和の六員環を形成してもよい。飽和もしくは不飽和の五員環又は六員環を有するスチリル化合物の例としては、R^{38}とR^{39}，及びR^{46}とR^{47}が飽和五員環を形成する場合は、

【００３６】

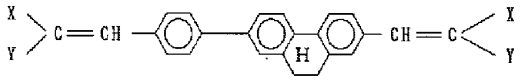
【化２１】



【００３７】などが挙げられ、R^{46}とR^{47}で飽和六員環を形成する場合には、

【００３８】

【化２２】



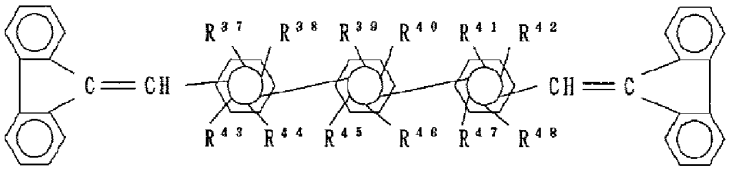
【００３９】などが挙げられる。X及びYは、それぞれ独立に置換または無置換のフェニル基，ナフチル基，ビフェニル基，ターフェニル基，アントラリル基，フェナントリル基，ピレニル基，ペリレニル基など炭素数６～２０のアリール基を示す。ここで、置換基としては、例えばメチル基，エチル基，ｎ－プロピル基，イソプロピル基，ｎ－ブチル基，イソブチル基，ｓｅｃ－ブチル基，ｔ－ブチル基，イソペンチル基，ｔ－ペンチル基，ネオペンチル基，ｎ－ヘキシル基，イソヘキシル基などの炭素数１～６のアルキル基、メトキシ基，エトキシ基，ｎ－プロポキシ基，イソプロポキシ基，ｎ－ブチルオキシ基，イソブチルオキシ基，ｓｅｃ－ブチルオキシ

Savant Technologies LLC - 1004.732

基，イソペンチルオキシ基，ｔ－ペンチルオキシ基，ｎ－ヘキシルオキシ基などの炭素数１～６のアルコキシ基、フェノキシ基，ナフチルオキシ基など炭素数６～１８のアリールオキシ基、フェニル基、アミノ基、シアノ基、ニトロ基、水酸基あるいはハロゲン原子が挙げられる。これらの置換基は単一でも複数置換されていてもよい。また、ＸとＹは置換基と結合して置換もしくは無置換の飽和又は不飽和の五員環あるいは飽和又は不飽和の六員環を形成してもよい。飽和もしくは不飽和の五員環又は六員環を有するスチリル化合物の例としては、ＸとＹが飽和五員環を形成する場合は、

【００４０】

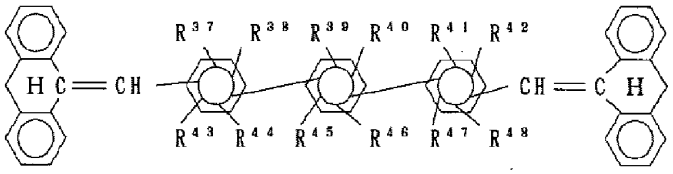
【化２３】



【００４１】などが挙げられ、ＸとＹが飽和六員環形成する場合は、

【００４２】

【化２４】



【００４３】などが挙げられる。

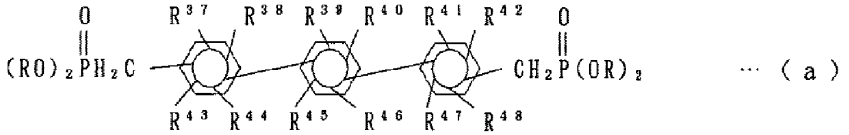
【００４４】上記一般式（ＸＩ）で表されるスチリル化合物は、種々の公知の方法によって製造することができる。具体的には、次の２つの方法が挙げられる。

方法１

一般式（ａ）

【００４５】

【化２５】

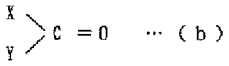


…（ａ）

【００４６】〔式中、Ｒは炭素数１～４のアルキル基又はフェニル基を示し、R^{37}～R^{48}は前記と同じである。〕で表されるホスホン酸エステルと、一般式（ｂ）

【００４７】

【化２６】



…（ｂ）

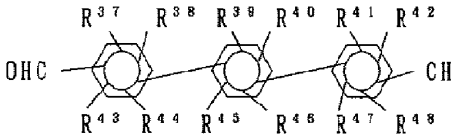
【００４８】〔式中、Ｘ，Ｙは前記と同じである。〕で表されるカルボニル化合物を塩基存在下で縮合する方法（Ｗｉｔｔｉｇ反応又はＷｉｔｔｉｇ－Ｈｏｒｎｅｒ反応）により合成することができる。

方法２

一般式（ｃ）

【００４９】

【化２７】

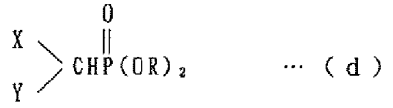


…（ｃ）

【００５０】〔式中、R^{37}～R^{48}は前記と同じである。〕で表されるジアルデヒド化合物と一般式（ｄ）

【００５１】

【化２８】



…（ｄ）

【００５２】〔式中、Ｒ，Ｘ，Ｙは前記と同じである。〕で表されるホスホン酸エステルを塩基存在下で縮合する方法（Ｗｉｔｔｉｇ反応又はＷｉｔｔｉｇ－Ｈｏ

Savant Technologies LLC - 1004.733

ｒｎｅｒ反応）により合成することができる。

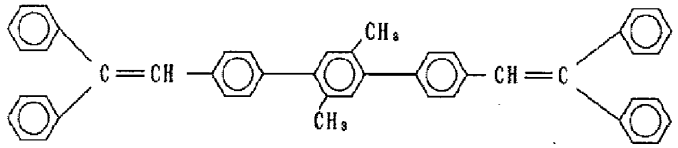
【００５３】この合成で用いる反応溶媒としては、炭化水素，アルコール類，エーテル類が好ましい。具体的には、メタノール；エタノール；イソプロパノール；ブタノール；２－メトキシエタノール；１，２－ジメトキシエタン；ビス（２－メトキシエチル）エーテル；ジオキサン；テトラヒドロフラン；トルエン；キシレン；ジメチルスルホキシド；Ｎ，Ｎ－ジメチルホルムアミド；Ｎ－メチルピロリドン；１，３－ジメチル－２－イミダゾリジノンなどが挙げられる。特に、テトラヒドロフラン，ジメチルスルホキシドが好適である。また、縮合剤としては、水酸化ナトリウム，水酸化カリウム，ナトリウムアミド，水素化ナトリウム，ｎ－ブチルリチウム，ナトリウムメチラート，カリウム－ｔ－ブトキシドなどが好ましく、特にｎ－ブチルリチウム，カリウム－ｔ－ブトキシドが好ましい。反応温度は、用いる反応原料の種類などにより異なり、一義的に定めることはできないが、通常は０℃～約１００℃までの広範囲を指定できる。特に好ましくは０℃～室温の範囲である。

【００５４】以下に、本発明で用いられる上記スチリル化合物の具体例（１）～（２６）を挙げるが、本発明はそれらに限定されるものではない。

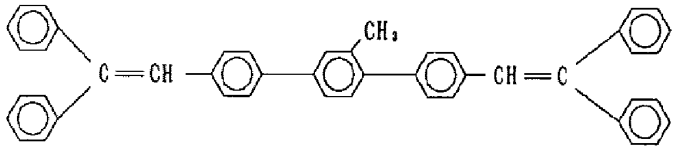
【００５５】

【化２９】

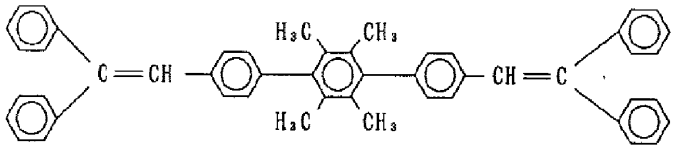
（１）



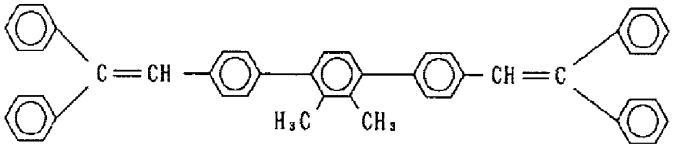
（２）



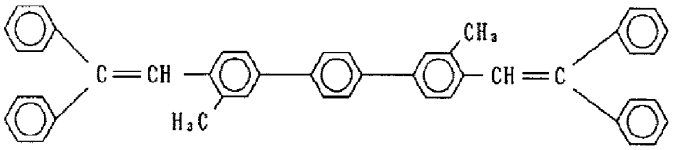
（３）



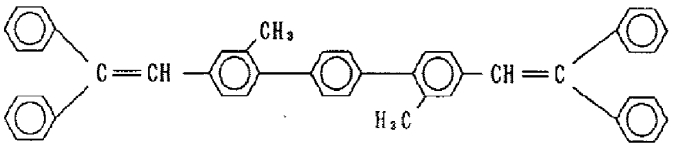
（４）



（５）



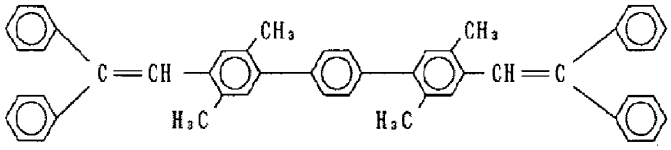
（６）



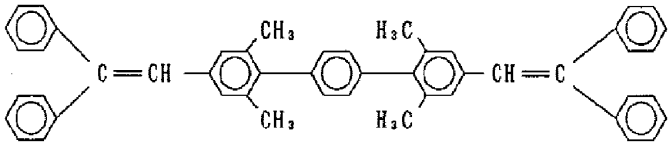
Savant Technologies LLC - 1004.734

【0056】　　【化30】

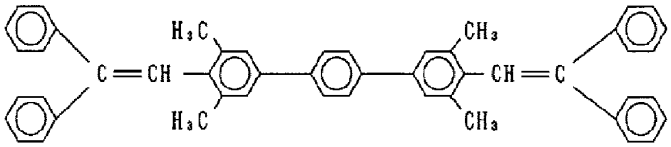
（7）



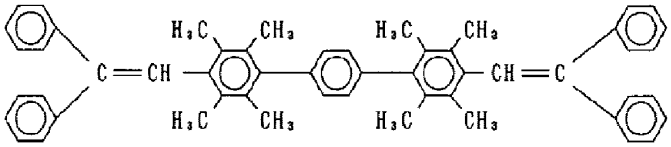
（8）



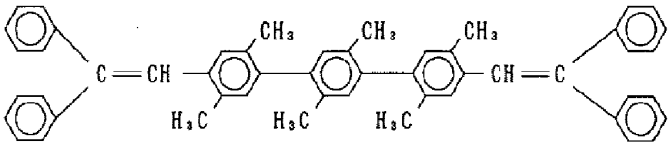
（9）



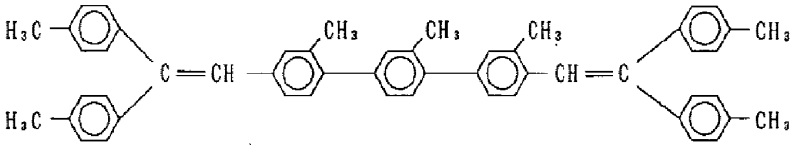
（10）



（11）



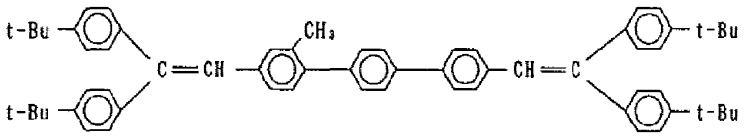
（12）



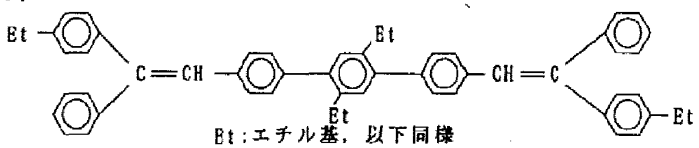
【0057】　　【化31】

Savant Technologies LLC - 1004.735

(13)

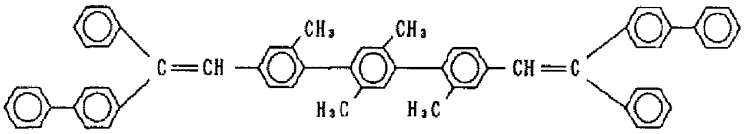


(14)

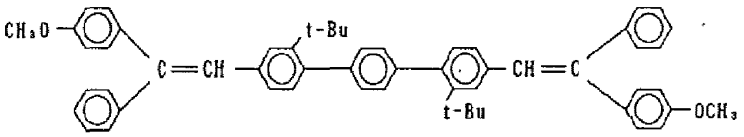


Bt：エチル基，以下同様

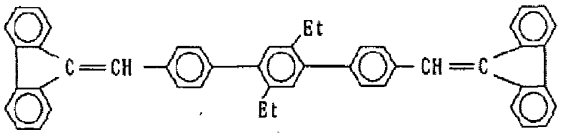
(15)



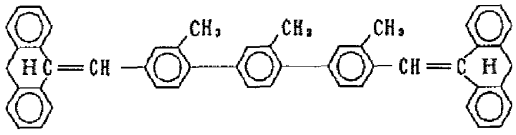
(16)



(17)



(18)

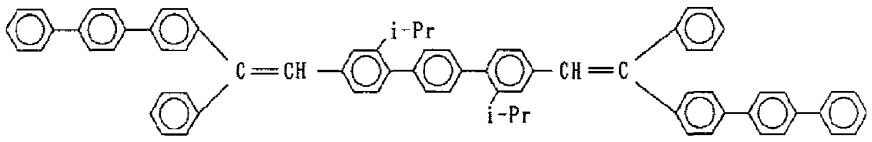


【0058】

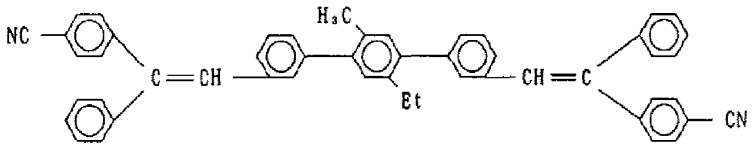
【化32】

Savant Technologies LLC - 1004.736

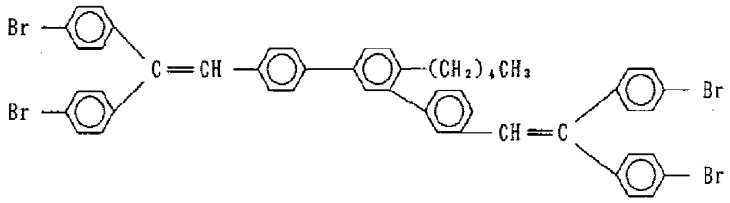
（19）



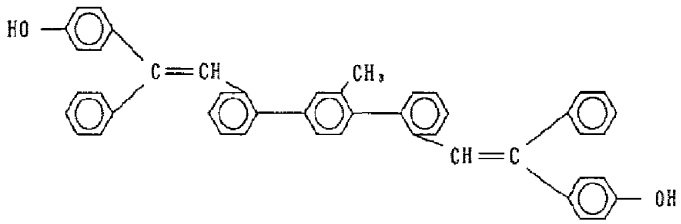
（20）



（21）



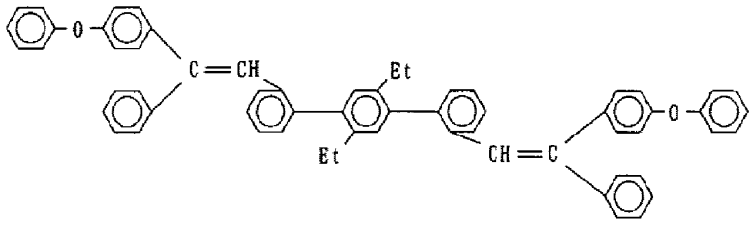
（22）



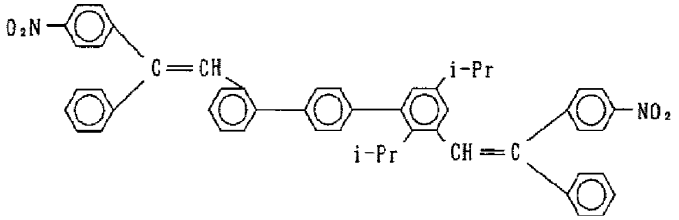
【0059】　　【化33】

Savant Technologies LLC - 1004.737

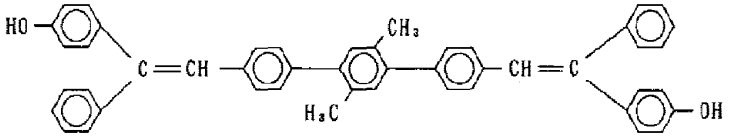
（２３）



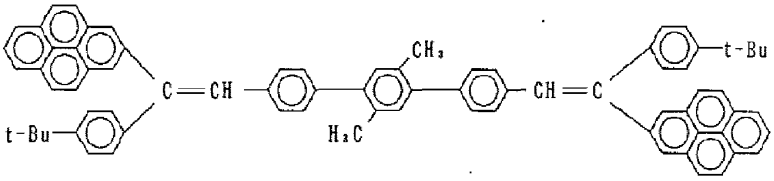
（２４）



（２５）



（２６）

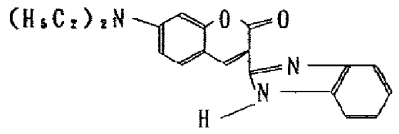


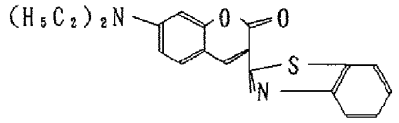
【００６０】一方、第二発光層に用いられる、固体状態の蛍光ピーク波長が４８０ｎｍ以上５８０ｎｍ未満である有機化合物については、特に制限はなく、例えばヨーロッパ公開特許第０２８１３８１号公報に記載されているレーザー色素として用いられるクマリン誘導体が挙げられる。具体的には、

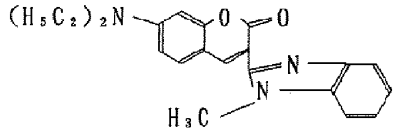
【００６１】

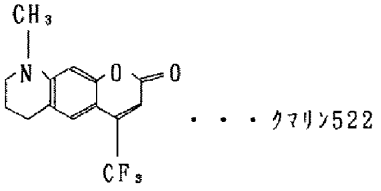
【化３４】

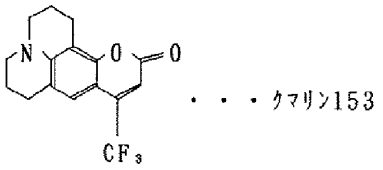
Savant Technologies LLC - 1004.738


・・・クマリン７


・・・クマリン６


・・・クマリン３０

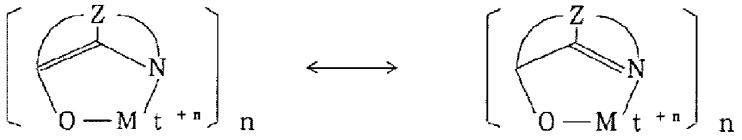

・・・クマリン522


・・・クマリン153

【００６２】などである。さらに、特開平３－２３１９７０号公報あるいは特願平２－２７９３０４号明細書に記載されている有機化合物中で上記第二発光層の蛍光条件を満足するものが挙げられる。さらに、好ましいものとして、８－ヒドロキシキノリン又はその誘導体の金属錯体を挙げることができる。具体的には、オキシン（一般に８－キノリノールまたは８－ヒドロキシキノリン）のキレートを含む金属キレートオキシノイド化合物である。このような化合物は高水準の性能を示し、容易に薄膜形態に成形される。オキシノイド化合物の例は下記構造式を満たすものである。

【００６３】

【化３５】



【００６４】〔式中、Ｍｔは金属を表し、ｎは１～３の整数であり、且つ、Ｚはその各々の位置が独立であって、少なくとも２以上の縮合芳香族環を完成させるために必要な原子を示す。〕ここで、Ｍｔで表される金属は、一価，二価又は三価の金属とすることができるものであり、例えばリチウム，ナトリウムまたはカリウム等のアルカリ金属、マグネシウム又はカルシウム等のアルカリ土類金属、ホウ素又はアルミニウム等の土類金属である。一般に有用なキレート化合物であると知られている一価，二価または三価の金属はいずれも使用することができる。

【００６５】また、Ｚは、少なくとも２以上の縮合芳香族環の一方がアゾールまたはアジンからなる複素環を形成させる原子を示す。ここで、もし必要であれば、上記縮合芳香族環に他の異なる環を付加することが可能である。また、機能上の改善が無いまま嵩ばった分子を付加することを回避するため、Ｚで示される原子の数は１８以下に維持することが好ましい。

【００６６】さらに、具体的にキレート化オキシノイド化合物を例示すると、トリス（８－キノリノール）アルミニウム，ビス（８－キノリノール）マグネシウム，ビス（８－キノリノール）亜鉛，ビス（２－メチル－８－キノリノール）亜鉛，ビス（ベンゾ－８－キノリノール）亜鉛，ビス（２－メチル－８－キノリラート）アルミニウムオキシド，トリス（８－キノリノール）インジウム，トリス（５－メチル－８－キノリノール）アルミニウム，８－キノリノールリチウム，トリス（５－クロロ－８－キノリノール）ガリウム，トリス（２－メチル－８－キノリノール）ガリウム，ビス（５－クロロ－８－キノリノール）カルシウム，５，７－ジクロル－８－キノリノールアルミニウム，トリス（５，７－ジブロモ－８－ヒドロキシキノリノール）アルミニウム，トリス

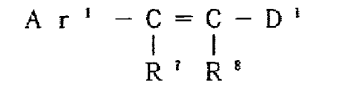
Savant Technologies LLC - 1004.739

（７－プロピル－８－キノリノール）アルミニウム，ビス（８－キノリノール）ベリリウム，ビス（２－メチル－８－キノリノール）ベリリウムなどがある。

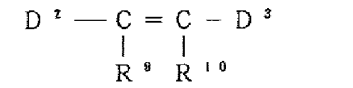
【００６７】本発明の白色有機ＥＬ素子においては、前記第一発光層及び／又は第二発光層に、特願平５－１２９４３８号明細書に記載されているスチルベン誘導体，ジスチリルアリーレン誘導体及びトリススチリルアリーレン誘導体の中から選ばれた少なくとも一種を含有させるのが好ましい。該スチルベン誘導体とは、少なくとも２つの芳香族環を有し、これら芳香族環をビニル基又は置換されたビニル基により結合して構成され、かつ上記芳香族環又はビニル基のいずれかに電子供与性基を有する化合物である。ジスチリルアリーレン誘導体とは、１つのアリーレン基に２つの芳香族環がビニル基又は置換ビニル基を介して結合し、かつ電子供与性基を有する化合物である。トリススチリルアリーレン誘導体とは、１つの３価の芳香族環基に３つの芳香族環がビニル基または置換ビニル基を介して結合し、かつ電子供与性基を有する化合物である。電子供与性基を分子骨格に有する前記誘導体において該電子供与性基とは、好ましくは炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基および炭素数１～３０の炭化水素基を有するアミノ基を示す。上記誘導体において、特に好ましいものは下記一般式（IV）～（X）で表される化合物であり、（IV）及び（Ｖ）はスチルベン誘導体，（VI）及び（VII)はジスチリルアリーレン誘導体，（VIII）～（Ｘ）はトリススチリルアリーレン誘導体を表す。

【００６８】

【化３６】



・・・（IV）

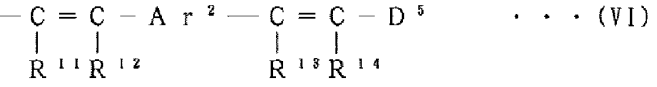


・・・（Ｖ）

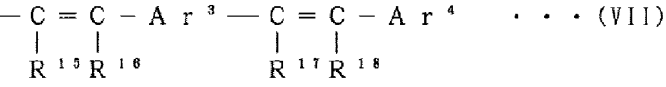
【００６９】〔式中、Ar^1 は炭素数６～２０のアリール基を示す。R^7 ～R^{10}は、それぞれ独立に水素原子又は炭素数６～２０のアリール基を示す。D^1 ～D^3 は、それぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。ここで、Ar^1 ，R^7 ～R^{10}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基，炭素数６～１０のアラルキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。また、この置換基が互いに結合し飽和もしくは不飽和の五員環ないし六員環を形成してもよい。〕

【００７０】

【化３７】



・・・（VI）



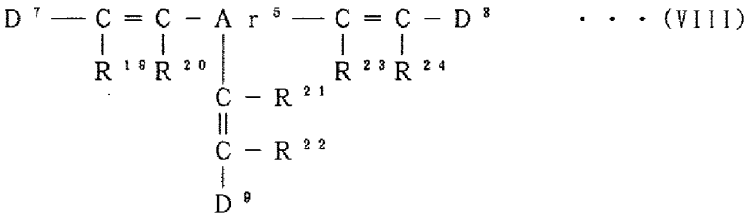
・・・（VII）

【００７１】〔式中、Ar^2 およびAr^3 は、それぞれ独立に炭素数６～２０のアリーレン基を示し、Ar^4 は炭素数６～２０のアリール基を示す。R^{11}～R^{18}は、それぞれ独立に水素原子又は炭素数６～２０のアリール基を示す。ここで、Ar^2 ～Ar^4 ，R^{11}～R^{18}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアリールオキシ基，炭素数６～１０のアラルキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。また、これらの置換基が互いに結合して飽和もしくは不飽和の五員環ないし六員環を形成してもよい。D^4 ～D^6 は、それぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。〕

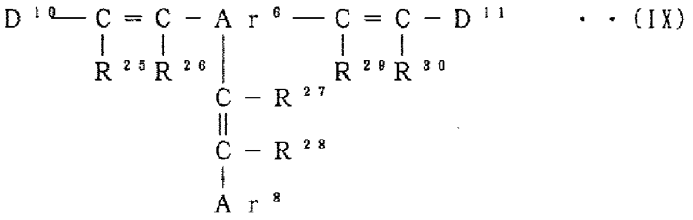
【００７２】

【化３８】

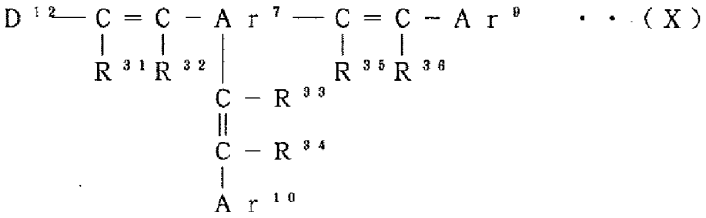
Savant Technologies LLC - 1004.740



・・・（VIII）



・・（IX）

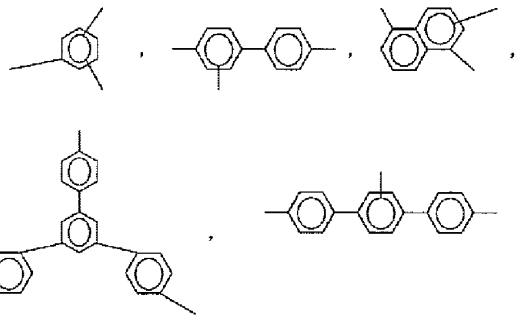


・・（X）

【００７３】〔式中、Ａｒ^{5}～Ａｒ^{7}は、それぞれ独立に炭素数６～２４の３価の芳香族環基を示し、Ａｒ^{8}～Ａｒ^{10}は、それぞれ独立に炭素数６～２０のアリール基を示す。Ｒ^{19}～Ｒ^{36}は、それぞれ独立に水素原子または炭素数６～２０のアリール基を示す。Ｄ^{7}～Ｄ^{12}は、それぞれ独立に電子供与性基で置換された炭素数６～２０のアリール基又は炭素数１０～３０の縮合多環族基を示す。ここで、Ａｒ^{5}～Ａｒ^{7}，Ｒ^{19}～Ｒ^{36}は、それぞれ独立に無置換でもよいし、炭素数１～１０のアルキル基，炭素数１～１０のアルコキシ基，炭素数６～１０のアラルキル基，炭素数６～１０のアリールアルキル基又は炭素数１～２０の炭化水素基を有するアミノ基で置換されていてもよい。また、これらの置換基が互いに結合し飽和もしくは不飽和の五員環ないし六員環を形成してもよい。〕上記一般式（IV）～（X）におけるアリール基としては、好ましくはフェニル基，ビフェニルイル基，ナフチル基，ピレニル基，ターフェニルイル基，アントラニル基，トリル基，キシリル基，スチルベニル基，チエニル基，ビチエニル基，チオフェン基，ビチオフェン基，ターチオフェン基などが挙げられる。アリーレン基としては、好ましくはフェニレン基，ビフェニレン基，ナフチレン基，アントラニレン基，ターフェニレン基，ピレニレン基，スチルベニレン基，チエニレン基，ビチエニレン基などが挙げられる。３価の芳香族環基とは、好ましくは

【００７４】

【化３９】



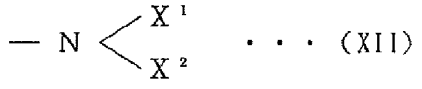
【００７５】が挙げられる。また、上記置換基であるアリールオキシ基としては、フェニルオキシ基，ビフェニルオキシ基，ナフチルオキシ基，アントラニルオキシ基，ターフェニルオキシ基，ピレニルオキシ基などが挙げられ、アルキル基としては、メチル基，エチル基，イソプロピル基，ターシャルブチル基，ペンチル基，ヘキ

Savant Technologies LLC - 1004.741

シル基などが挙げられる。アルコキシ基としては、メトキシ基，エトキシ基，イソプロポキシ基，ターシャルブトキシ基，ペンチルオキシ基などが挙げられ、炭化水素基を有するアミノ基としては、ジメチルアミノ基，ジエチルアミノ基，ジフェニルアミノ基，フェニルエチルアミノ基，フェニルメチルアミノ基，ジトリルアミノ基，エチルフェニルアミノ基，フェニルナフチルアミノ基，フェニルビフェニルアミノ基などが挙げられる。前記一般式（Ⅳ）～（Ｘ）におけるD^{1}～D^{12}は、電子供与性基で置換された炭素数１～２０のアリール基、又は炭素数１０～３０の縮合多環族基である。ここで、電子供与性基とは、好ましくは炭素数１～１０のアルコキシ基，炭素数６～２０のアリールオキシ基，炭素数１～３０の炭化水素基を有するアミノ基が挙げられ、特に好ましくは炭素数１～３０の炭化水素基を有するアミノ基が挙げられる。このアミノ基としては、一般式（XII）

【００７６】

【化４０】



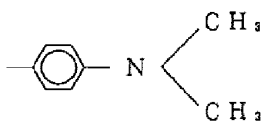
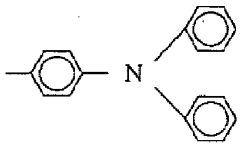
・・・（XII）

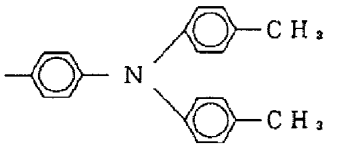
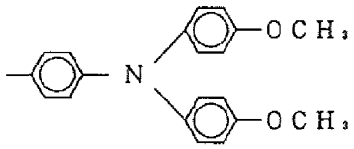
【００７７】〔式中、X^{1} 及びX^{2} は、それぞれ独立に炭素数６～２０のアリール基，炭素数１～１０のアルキル基又は炭素数６～２０のアラルキル基を示し、互いに結合して飽和又は不飽和の環状構造を形成してもよい。また、X^{1} ，X^{2} には、炭素数１～１０のアルキル基，炭素数７～１０のアラルキル基，炭素数６～１０のアリールオキシ基又は炭素数６～１０のアルコキシ基が置換してもよい。さらに、一般式（XII）で表されるアミノ基に置換するアリール基としてのX^{1} とX^{2} が互いに結合した含窒素芳香族環基となってもよい。〕で表されるものが挙げられる。上記電子供与性基としては、例えばフェニルオキシ基，ビフェニルオキシ基，ナフチルオキシ基，アントラニルオキシ基，ターフェニルイルオキシ基などのアリールオキシ基、メトキシ基，エトキシ基，イソプロポキシ基，ターシャルブチルオキシ基，ペンチルオキシ基などのアルコキシ基、ジメチルアミノ基，ジエチルアミノ基，ジフェニルアミノ基，フェニルメチルアミノ基，フェニルエチルアミノ基，フェニルメチルエチルアミノ基，ジトリルアミノ基，エチルフェニルアミノ基，フェニルナフチルアミノ基，フェニルビフェニルイルアミノ基などの炭化水素基を有するアミノ基などが挙げられる。また、D^{1} ～D^{12}の具体例としては、

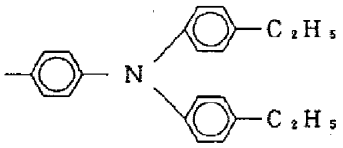
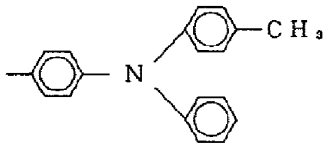
【００７８】

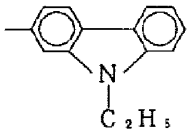
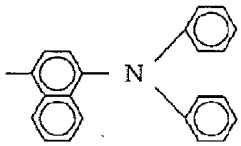
【化４１】

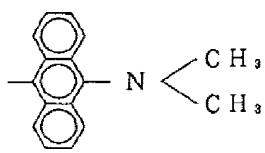
Savant Technologies LLC - 1004.742


,


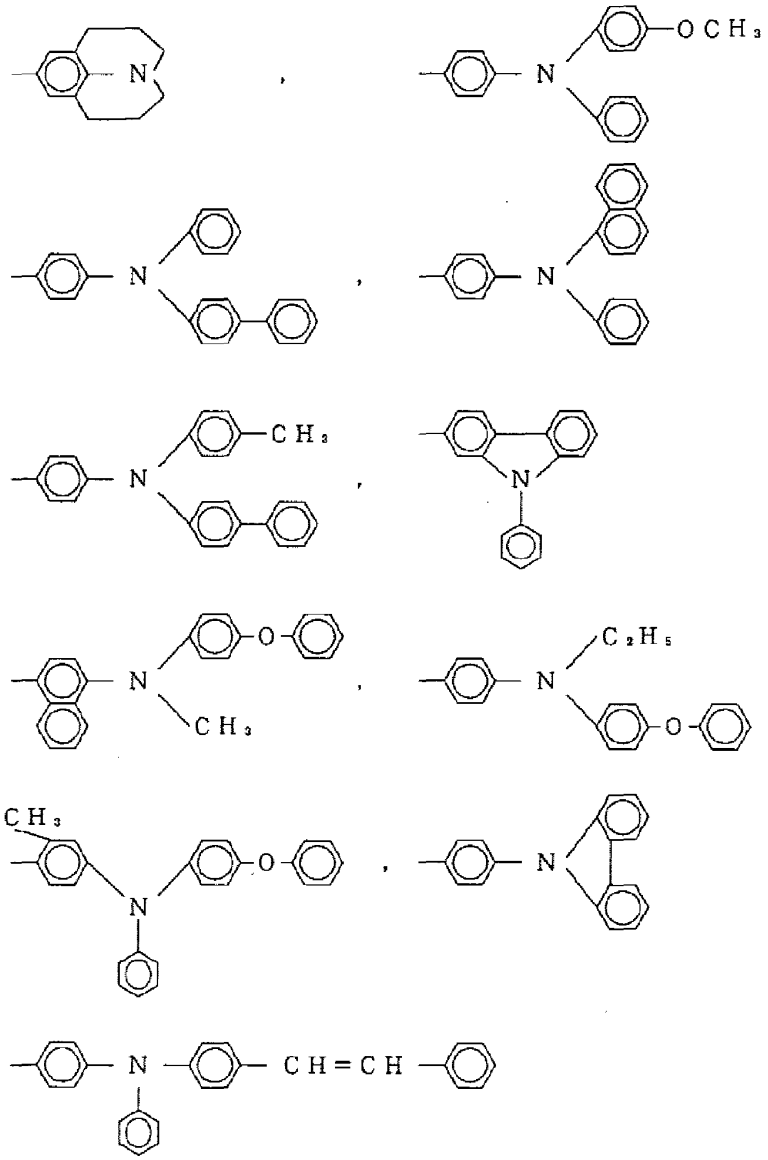

,



,



,


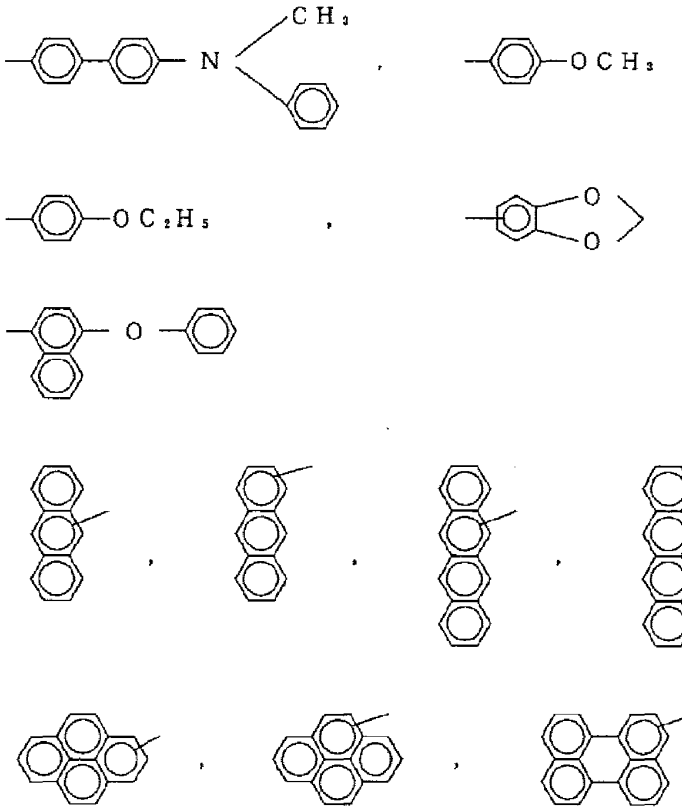

,

【0079】　　【化42】



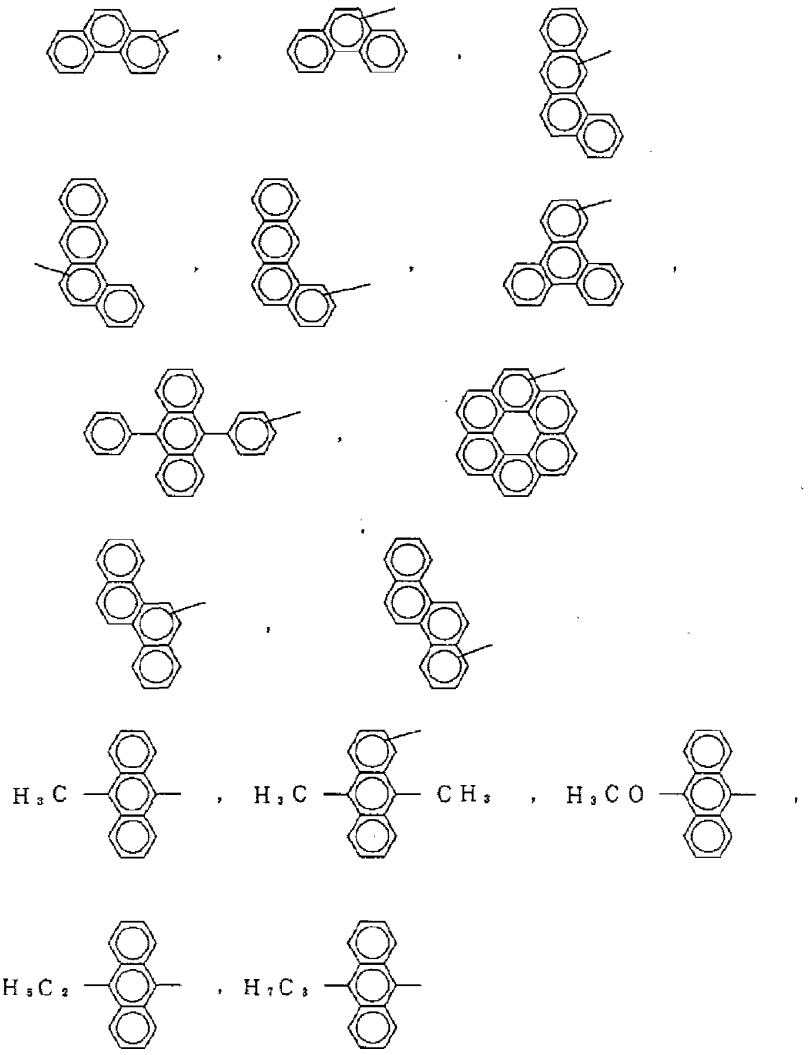
【0080】　　【化43】

Savant Technologies LLC - 1004.744



【0081】　　【化44】

Savant Technologies LLC - 1004.745

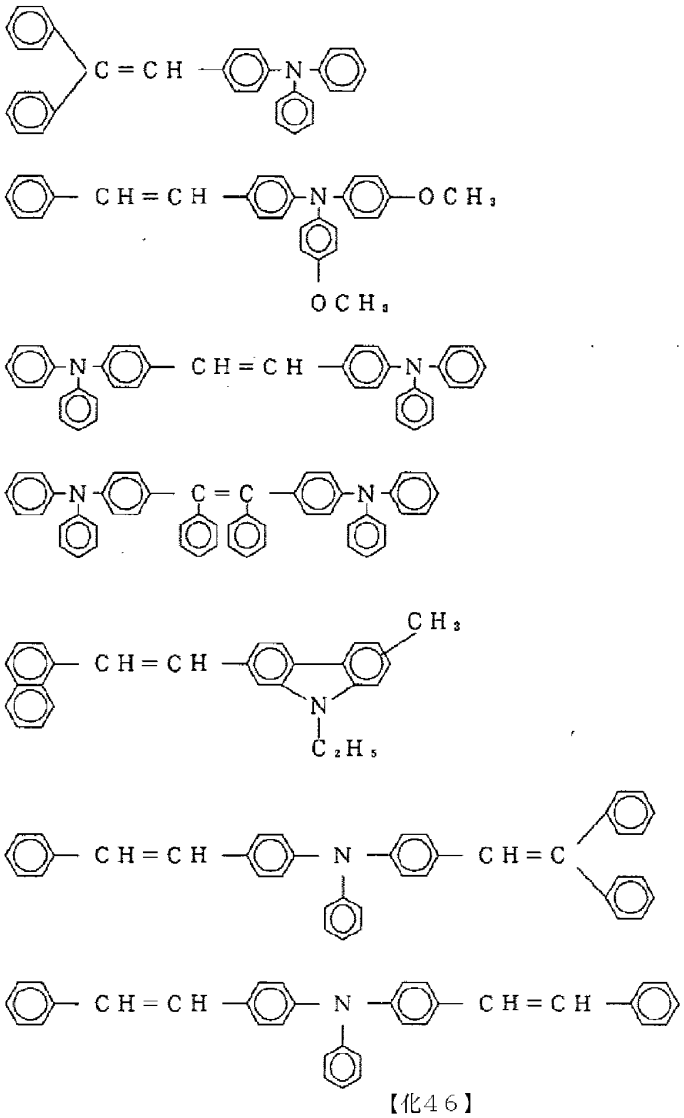


【0082】などが挙げられる。上記一般式（IV）～（X）で表される化合物の具体例としては、

【0083】

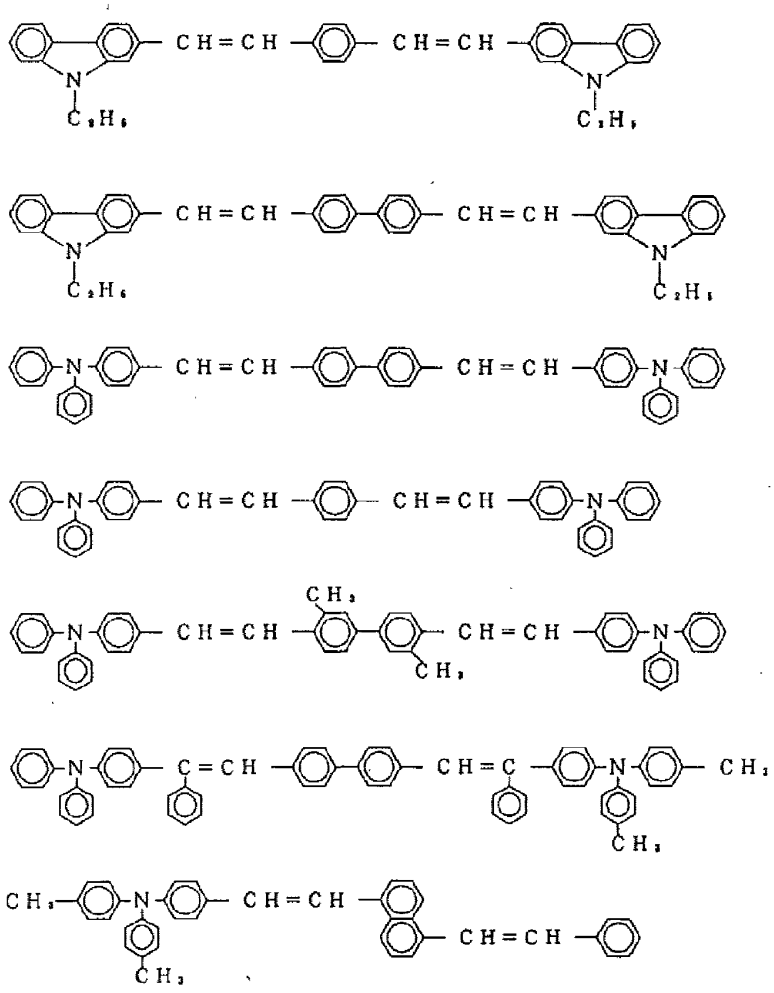
【化45】

Savant Technologies LLC - 1004.746



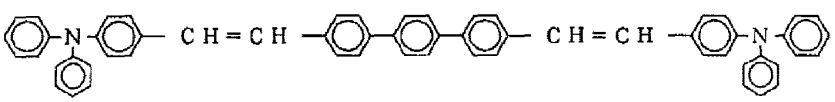
【0084】　　【化46】

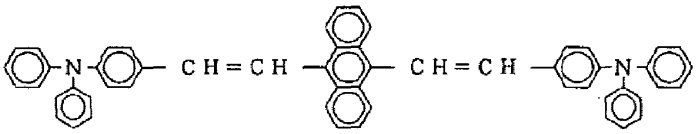
Savant Technologies LLC - 1004.747

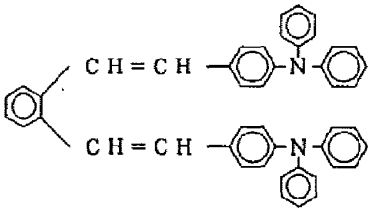


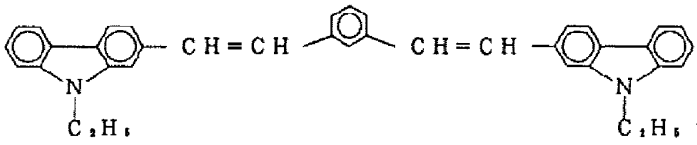
【0085】　　【化47】

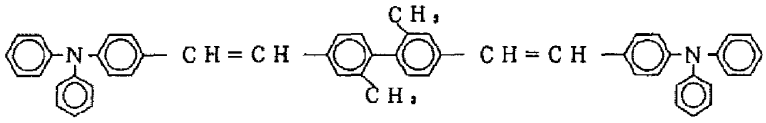
Savant Technologies LLC - 1004.748

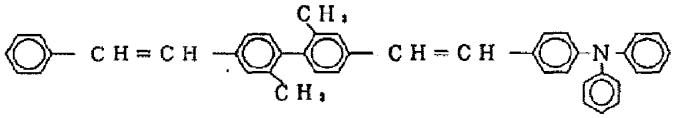






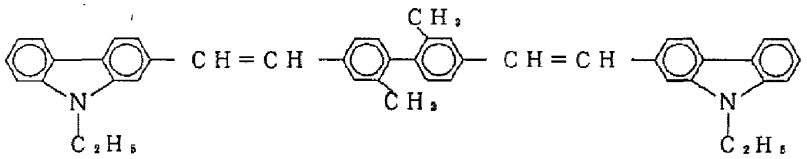


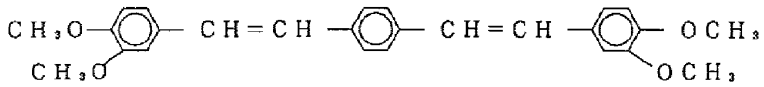


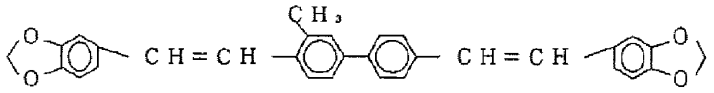


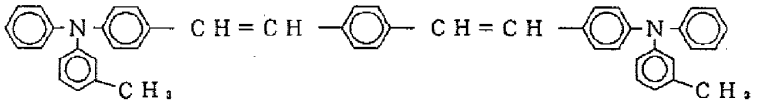
【0086】

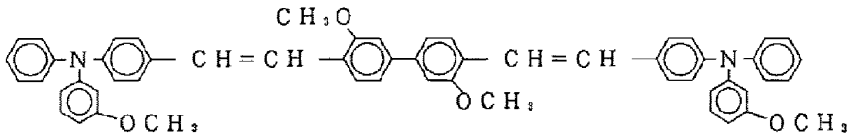
【化48】

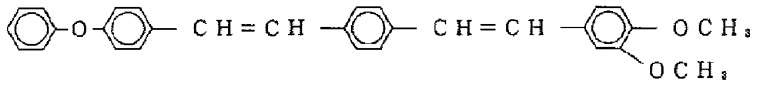


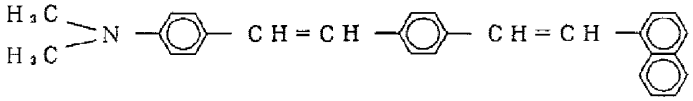






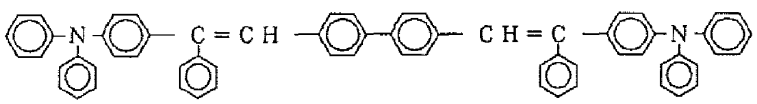


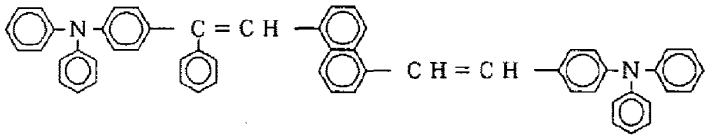


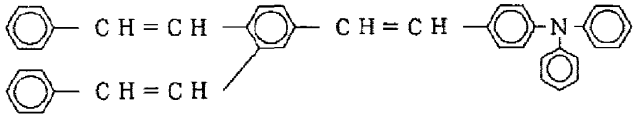


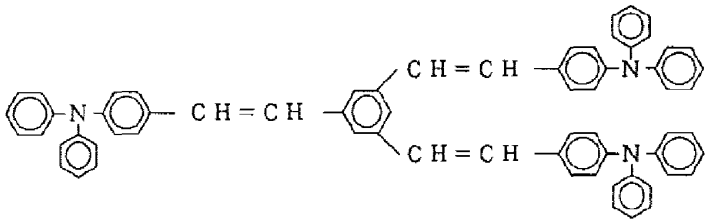
【0087】

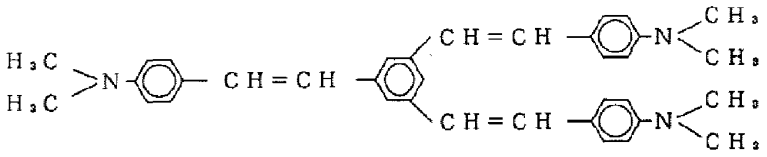
【化49】





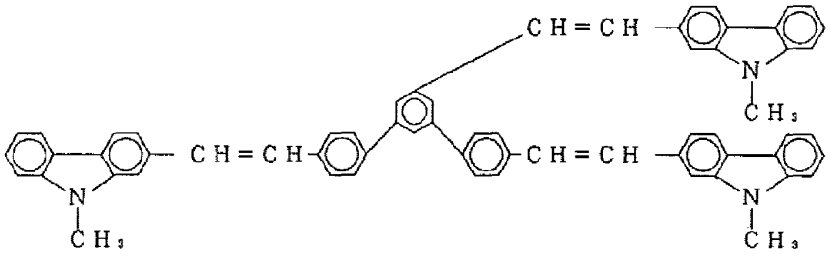


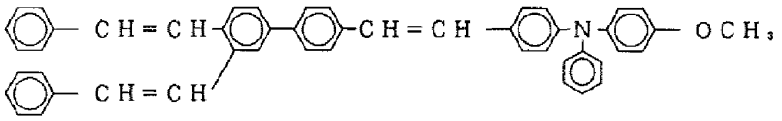


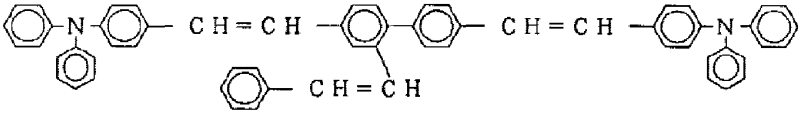


【0088】

【化50】

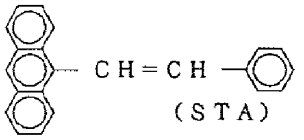


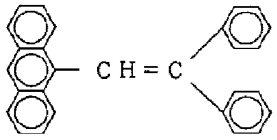


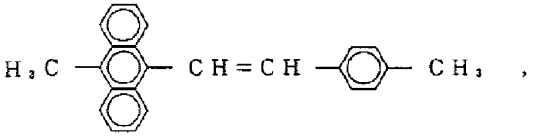


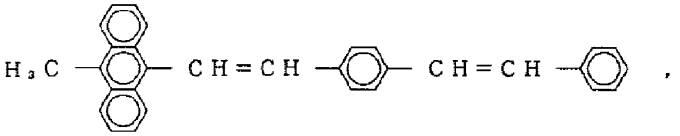
Savant Technologies LLC - 1004.751

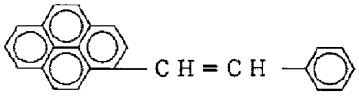
【0089】　　【化51】

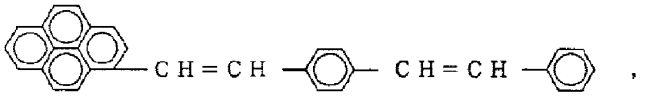

(STA)

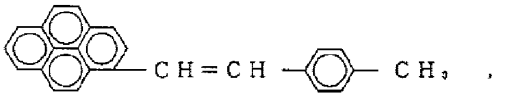


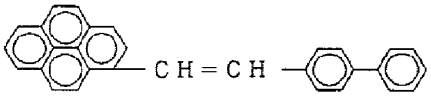





(STPy)

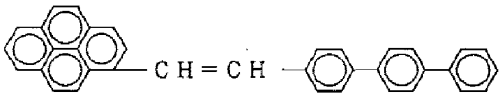

(STSTPy)

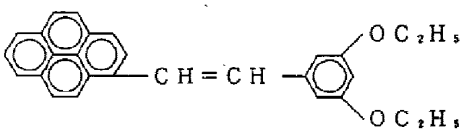

(MeSTPy)

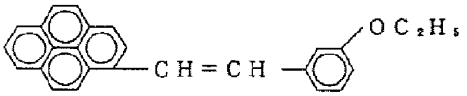


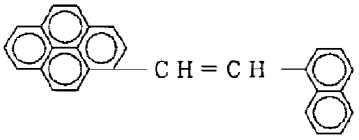
【0090】　　【化52】

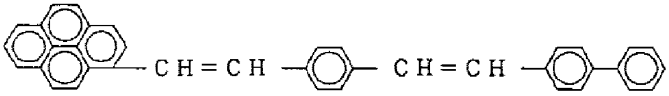
Savant Technologies LLC - 1004.752

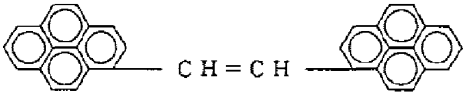

,

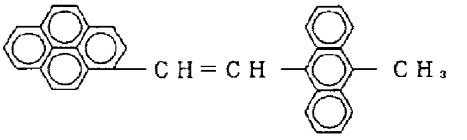

,


,


,

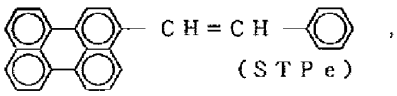

,


,

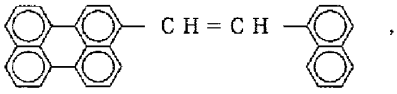

,

【0091】　　【化53】

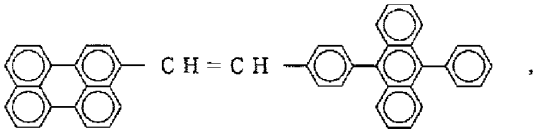
Savant Technologies LLC - 1004.753



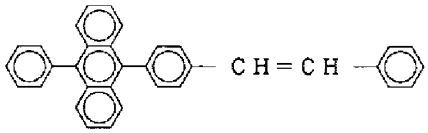
（ＳＴＰｅ），



，



，



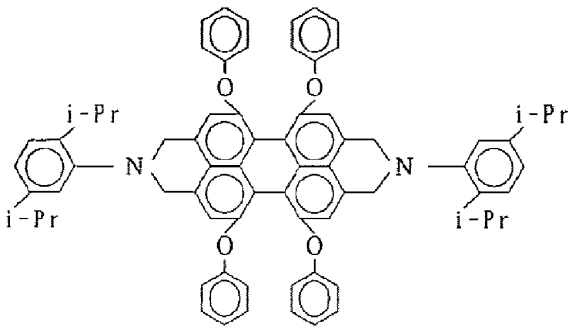
【００９２】などを挙げることができる。

【００９３】本発明の白色有機ＥＬ素子においては、溶液状態での蛍光ピーク波長が５８０ｎｍ以上６５０ｎｍ以下である有機化合物を、前記第一発光層，第二発光層及びその他の有機化合物層の中から選ばれた少なくとも一層に含有させることが必要である。この有機化合物としては、溶液状態でのピーク波長が５８０ｎｍ以上６５０ｎｍ以下であればよく、特に制限はないが、例えばヨーロッパ公開特許第０２８１３８１号公報に記載されている赤色発進レーザー色素として用いられるジシアノメチレンピラン誘導体，ジシアノメチレンチオピラン誘導体，フルオレセイン誘導体，ペリレン誘導体などが挙げられる。具体的には

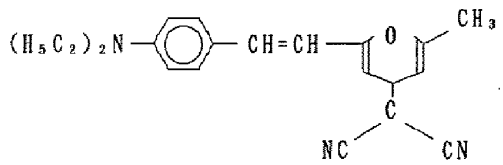
【００９４】

【化５４】

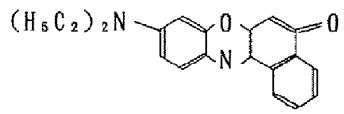
Savant Technologies LLC - 1004.754



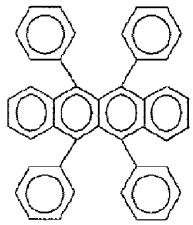
（ルモゲンＦレッド）



（ジシアノメチレンピラン）



（フェノキサゾン）



（ルブレン）

【００９５】などが挙げられる。これらの有機化合物は、層を形成する有機化合物に対して、０．１～１０モル％、好ましくは０．５～５モル％の割合で含有させることが必要である。この０．１～１０％というのは、濃度消光を生じないための濃度範囲である。

【００９６】本発明の白色有機ＥＬ素子の構成は、発光層の構成以外は限定されるものではなく任意の素子構成を採ることができる。具体的に、陽極／正孔注入輸送層／発光層／電子注入輸送層／陰極からなる有機ＥＬ素子の各構成について説明する。

【００９７】本発明の白色有機ＥＬ素子は、支持基板上にて形成することが好ましい。用いられる支持基板は、透明性を有するものが好ましく、一般にガラス，透明プラスチック，石英などである。本発明の白色有機ＥＬ素子における陽極としては、仕事関数の大きい（４ｅＶ以上）金属，合金，電気伝導性化合物及びこれらの混合物を電極物質とするものが好ましく用いられる。このような電極物質の具体例としては、Ａｕなどの金属，ＣｕＩ，ＩＴＯ，SnO_2，ＺｎＯなどの誘電性を有した透明材料又は半透明材料が挙げられる。該陽極は、これらの極物質を蒸着やスパッタリングなどの方法により、薄膜を形成させることにより作製することができる。この電極より発光を取り出す場合には、透過率を１０％より大きくすることが望ましく、また、電極としてのシート抵抗は数百Ω／□以下が好ましい。さらに膜厚は材料にもよるが、通常１０ｎｍ～１μｍ、好ましくは１０～２００ｎｍの範囲で選ばれる。

【００９８】一方、陰極としては、仕事関数の小さい

Savant Technologies LLC - 1004.755

（４ｅＶ以下）金属，合金，電気伝導性化合物及びこれらの混合物を電極物質とするものが用いられる。このような電極物質の具体例としては、ナトリウム，ナトリウム－カリウム合金，マグネシウム，リチウム，マグネシウム／銅混合物，Ａｌ／（Al_2O_3），インジウム，希土類金属などが挙げられる。該陰極は、これらの電極物質を蒸着やスパッタリングなどの方法により、薄膜を形成させることにより、作製することができる。また、電極としてのシート抵抗は数百Ω／□以下が好ましく、膜厚は通常１０ｎｍ～１μｍ、好ましくは５０～２００ｎｍの範囲で選ばれる。なお、このＥＬ素子においては、該陽極又は陰極のいずれか一方が透明又は半透明であることが、発光を透過するため、発光の取出し効率がよく好都合である。

【００９９】このＥＬ素子における発光層は、上記第一発光層と第二発光層からなり、かつ第一発光層、第二発光層の順に透明電極又は陽極側から順次積層された積層構造を有している。特に、陰極側に近い発光層が遠い発光層より電子輸送能力が大であることが好ましい。これは、二つの発光層界面で主たる発光が生じ、ここでの発光もしくは励起状態のエネルギーを利用し、液体状態での蛍光ピークが５８０ｎｍ以上６５０ｎｍ以下である有機化合物が発光し、透明電極から白色発光を取り出させる。第一発光層と第二発光層の積層順が逆になった場合、第一発光層の発光が第二発光層に吸収され、良好な白色が得られなくなる。液体状態での蛍光ピークが５８０ｎｍ以上６５０ｎｍ以下である有機化合物は、発光波長では長波長成分であるので、他の成分により吸収されることはなく、有機化合物層のいかなる層に含有させてもよい。そして、発光層の厚さは、好ましくは第二発光層が第一発光層の膜厚以上であればよく、この範囲で適宜状況に応じて選ぶことができる。上記発光層の形成方法は、限定されることはなく、例えば蒸着法，スピンコート法，キャスト法，ＬＢ法などの公知の方法により薄膜化することにより形成することができるが、特に分子堆積膜であることが好ましい。ここで、分子堆積膜とは、該化合物の気相状態から沈着され形成された薄膜や、該化合物の溶液状態又は液相状態から固体化され形成された膜のことであり、通常この分子堆積膜はＬＢ法により形成された薄膜（分子累積膜）とは、凝集構造，高次構造の相違や、それに起因する機能的な相違により区分することができる。

【０１００】このように本発明における発光層は、電界印加時に、陽極又は正孔注入輸送層より正孔を注入することができ、かつ陰極又は電子注入輸送層より電子を注入することができる注入機能、注入した電荷（電子と正孔）を電界の力で移動させる輸送機能、電子と正孔の再結合の場を提供し、これを発光につなげる発光機能などを有している。本発明の発光層とは、可視光を発光する層のことである。なお、正孔の注入されやすさと、電子の注入されやすさには違いがあっても構わない。また、正孔と電子の移動度で表される輸送機能に大小があってもよいが、どちらか一方を移動することが好ましい。さらに、本発明で用いられる発光材料は、他の有機化合物層内において再結合した電荷による励起状態の供給をうけて発光してもよい。次に、本発明のＥＬ素子における正孔注入輸送層は、必ずしも該素子に必要なものではないが、発光性能の向上のため用いた方が好ましいものである。この正孔注入輸送層としては、より低い電界で正孔を発光層に輸送する材料が好ましく、さらに正孔の移動度が10^4～10^6 ボルト／ｃｍの電場で少なくとも10^{-6}ｃｍ^2／ボルト・秒であれば尚好ましい。例えば、従来、光導伝材料において、正孔の電荷注入輸送材料として慣用されているものやＥＬ素子の正孔注入輸送層に使用される公知のものの中から任意のものを選択して用いることができる。

【０１０１】正孔注入輸送層としては、例えばトリアゾール誘導体（米国特許第3,112,197号明細書等参照），オキサジアゾール誘導体（米国特許第3,189,447 号明細書等参照），イミダゾール誘導体（特公昭３７－１６０９６号公報等参照），ポリアリールアルカン誘導体（米国特許第3,615,402 号明細書，同3,820,989 号明細書，同3,542,544 号明細書，特公昭４５－５５５号公報，同５１－１０９８３号公報，特開昭５１－９３２２４号公報，同５５－１７１０５号公報，同５６－４１４８号公報，同５５－１０８６６７号公報，同５５－１５６９５３号公報，同５６－３６６５６号公報等参照），ピラゾリン誘導体及びピラゾロン誘導体（米国特許第3,180,729 号明細書，同4,278,746 号明細書，特開昭５５－８８０６４号公報，同５５－８８０６５号公報，同４９－１０５５３７号公報，同５５－５１０８６号公報，同５６－８００５１号公報，同５６－８８１４１号公報，同５７－４５５４５号公報，同５４－１１２６３７号公報，同５５－７４５４６号公報等参照），フェニレンジアミン誘導体（米国特許第3,615,404 号明細書，特公昭５１－１０１０５号公報，同４６－３７１２号公報，同４７－２５３３６号公報，特開昭５４－５３４３５号公報，同５４－１１０５３６号公報，同５４－１１９９２５号公報等参照），アリールアミン誘導体（米国特許第3,567,450 号明細書，同3,180,703 号明細書，同3,240,597 号明細書，同3,658,520 号明細書，同4,232,103 号明細書，同4,175,961 号明細書，同4,012,376 号明細書，特公昭４９－３５７０２号公報，同３９－２７５７７号公報，特開昭５５－１４４２５０号公報，同５６－１１９１３２号公報，同５６－２２４３７号公報，西独特許第1,110,518 号明細書等参照），アミノ置換カルコン誘導体（米国特許第3,526,501 号明細書等参照），オキサゾール誘導体（米国特許第3,257,203 号明細書などに記載のもの），スチリルアントラセン誘導体（特開昭５６－４６２３４号公報等参照），フルオレノン誘導体（特開

Savant Technologies LLC - 1004.756

昭５４－１１０８３７号公報等参照），ヒドラゾン誘導体（米国特許第3,717,462 号明細書，特開昭５４－５９１４３号公報，同５５－５２０６３号公報，同５５－５２０６４号公報，同５５－４６７６０号公報，同５５－８５４９５号公報，同５７－１１３５０号公報，同５７－１４８７４９号公報，特開平２－３１１５９１号公報等参照），スチルベン誘導体（特開昭６１－２１０３６３号公報，同６１－２２８４５１号公報，同６１－１４６４２号公報，同６１－７２２５５号公報，同６２－４７６４６号公報，同６２－３６６７４号公報，同６２－１０６５２号公報，同６２－３０２５５号公報，同６０－９３４４５号公報，同６０－９４４６２号公報，同６０－１７４７４９号公報，同６０－１７５０５２号公報等参照）などを挙げることができる。さらに、シラザン誘導体（米国特許第４９５０９５０号明細書），ポリシラン系（特開平２－２０４９９６号公報），アニリン系共重合体（特開平２－２８２２６３号公報）、また特願平１－２１１３９９号明細書で示された導電性高分子オリゴマー、特にチオフェンオリゴマーなどが挙げられる。

【０１０２】本発明においては、これらの化合物を正孔注入輸送層の材料として使用することができるが、次に示すポルフィリン化合物（特開昭６３－２９５６９６５号公報などに記載のもの）及び芳香族第三級アミン化合物及びスチリルアミン化合物（米国特許第4,127,412 号明細書，特開昭５３－２７０３３号公報，同５４－５８４４５号公報，同５４－１４９６３４号公報，同５４－６４２９９号公報，同５５－７９４５０号公報，同５５－１４４２５０号公報，同５６－１１９１３２号公報，同６１－２９５５５８号公報，同６１－９８３５３号公報，同６３－２９５６９５号公報等参照），特に該芳香族第三級アミン化合物を用いることが好ましい。

【０１０３】該ポルフィリン化合物の代表例としては、ポルフィン；１，１０，１５，２０－テトラフェニル－２１Ｈ，２３Ｈ－ポルフィン銅（II）；１，１０，１５，２０－テトラフェニル２１Ｈ，２３Ｈ－ポルフィン亜鉛（II）；５，１０，１５，２０－テトラキス（ペンタフルオロフェニル）－２１Ｈ，２３Ｈ－ポルフィン；シリコンフタロシアニンオキシド；アルミニウムフタロシアニンクロリド；フタロシアニン（無金属）；ジリチウムフタロシアニン；銅テトラメチルフタロシアニン；銅フタロシアニン；クロムフタロシアニン；亜鉛フタロシアニン；鉛フタロシアニン；チタニウムフタロシアニンオキシド；マグネシウムフタロシアニン；銅オクタメチルフタロシアニンなどが挙げられる。また、該芳香族第三級アミン化合物及びスチリルアミン化合物の代表例としては、Ｎ，Ｎ，Ｎ’，Ｎ’－テトラフェニル－４，４’－ジアミノフェニル；Ｎ，Ｎ’－ジフェニル－Ｎ，Ｎ’－ジ（３－メチルフェニル）－４，４’－ジアミノビフェニル（ＴＰＤＡ）；２，２－ビス（４－ジ－ｐ－トリルアミノフェニル）プロパン；１，１－ビス（４－ジ－ｐ－トリルアミノフェニル）シクロヘキサン；Ｎ，Ｎ，Ｎ’，Ｎ’－テトラ－ｐ－トリル－４，４’－ジアミノビフェニル；１，１－ビス（４－ジ－ｐ－トリルアミノフェニル）－４－フェニルシクロヘキサン；ビス（４－ジメチルアミノ－２－メチルフェニル）フェニルメタン；ビス（４－ジ－ｐ－トリルアミノフェニル）フェニルメタン；Ｎ，Ｎ’－ジフェニル－Ｎ，Ｎ’－ジ（４－メトキシフェニル）－４，４’－ジアミノビフェニル；Ｎ，Ｎ，Ｎ’，Ｎ’－テトラフェニル－４，４’－ジアミノジフェニルエーテル；４，４’－ビス（ジフェニルアミノ）クオードリフェニル；Ｎ，Ｎ，Ｎ－トリ（ｐ－トリル）アミン；４－（ジ－ｐ－トリルアミノ）－４’－〔４（ジ－ｐ－トリルアミノ）スチリル〕スチルベン；４－Ｎ，Ｎ－ジフェニルアミノ－（２－ジフェニルビニル）ベンゼン；３－メトキシ－４’－Ｎ，Ｎ－ジフェニルアミノスチルベンゼン；Ｎ－フェニルカルバゾール；芳香族ジメチリディン系化合物などが挙げられる。また、発光層の材料として示した芳香族メチリジン化合物（特願平２－２７９３０４号明細書および特開平３－２３１９７０号公報参照）も、正孔注入輸送層の材料として用いることができる。さらに、ｐ型－Ｓｉ，ｐ型－ＳｉＣなどの無機化合物（国際公開特許ＷＯ９０－０５９９８号公報参照）も、正孔注入輸送層の材料として用いることができる。

【０１０４】本発明のＥＬ素子における正孔注入輸送層は、上記化合物を、例えば真空蒸着法，スピンコート法，キャスト法，ＬＢ法等の公知の薄膜化法により製膜して形成することができる。この正孔注入輸送層としての膜厚は、特に制限はないが、通常は１ｎｍ～１０μｍ、好ましくは５ｎｍ～５μｍである。この正孔注入輸送層は、これらの正孔注入輸送材料一種又は二種以上からなる一層で構成されてもよいし、あるいは、前記正孔注入輸送層とは別種の化合物からなる正孔注入輸送層を積層したものであってもよい。

【０１０５】本発明の白色有機ＥＬ素子においては、発光層と陰極間の付着性を向上させるために、該電子注入輸送層は、発光層及び陰極に対し付着性の高い材料を含有するのが好ましい。この様な付着性の高い材料としては、ニトロ置換フルオレノン誘導体，アントラキノジメタン誘導体，ジフェニルキノン誘導体，チオピランジオキシド誘導体，ナフタレンペリレン誘導体などの複素環テトラカルボン酸無水物，カルボジイミド，フルオレニリデンメタン誘導体，アントラキノジメタン誘導体およびアントロン誘導体，オキサジアゾール誘導体，その他特定の電子伝達性化合物などを挙げることができる。また、８－ヒドロキシキノリン又はその誘導体の金属錯体（Ａｌ，Ｚｎ，Ｌｉ，Ｇａ，Ｂｅ，Ｉｎ，Ｍｇ，Ｃｕ，Ｃａ，ＳｎまたはＰｂ）を挙げることができる。具体的には、オキシン（一般に８－キノリノールまたは８－ヒ

Savant Technologies LLC - 1004.757

ドロキシキノリン）のキレートを含む金属キレートオキシノイド化合物である。このような化合物は高水準の性能を示し、容易に薄膜形態に成形される。

【０１０６】さらに、具体的にキレート化オキシノイド化合物を例示すると、トリス（８－キノリノール）アルミニウム；ビス（８－キノリノール）マグネシウム；ビス（ベンゾ－８－キノリノール）亜鉛；ビス（２－メチル－８－キノリラート）アルミニウムオキシド；トリス（８－キノリノール）インジウム；トリス（５－メチル－８－キノリノール）アルミニウム；８－キノリノールリチウム；トリス（５－クロロ－８－キノリノール）ガリウム；ビス（５－クロロ－８－キノリノール）カルシウム；５，７－ジクロル－８－キノリノールアルミニウム；トリス（５，７－ジブロモ－８－ヒドロキシキノリノール）アルミニウム等がある。その他に、メタルフリーあるいはメタルフタロシアニン、それらの末端がアルキル基またはスルホン基で置換されているものも好ましい。さらに、発光層の材料として前述したジスチリルピラジン誘導体も電子注入輸送層の材料として用いることができる。さらに、ｐ型－Ｓｉ，ｐ型－ＳｉＣなどの無機化合物（国際公開特許ＷＯ９０－０５９９８号公報参照）も、電子注入輸送層の材料として用いることができる。

【０１０７】本発明のＥＬ素子における電子注入輸送層は、上記化合物を、例えば真空蒸着法，スピンコート法，キャスト法，ＬＢ法等の公知の薄膜化法により製膜して形成することができる。この電子注入輸送層としての膜厚は、特に制限はないが、通常は１ｎｍ～１０μｍ、好ましくは５ｎｍ～５μｍである。この電子注入輸送層は、これらの電子注入輸送材料一種又は二種以上からなる一層で構成されてもよいし、あるいは、前記電子注入輸送層とは別種の化合物からなる電子注入輸送層を積層したものであってもよい。

【０１０８】

【実施例】次に、実施例により本発明をさらに詳しく説明するが、本発明はこれらの例によってなんら限定されるものではない。

実施例１～３

２５ｍｍ×７５ｍｍ×1.１ｍｍのガラス基板上にＩＴＯを蒸着法にて１００ｎｍの膜厚で製造したものを透明電極基板とした。この基板をイソプロピルアルコール中にて１０分間超音波洗浄を行い、浸漬した。この基板を乾燥窒素中にて乾燥し、次いで、ＵＶオゾン洗浄を（株）サムコインターナショナル研究所製の装置（ＵＶ－３００）にて行い、透明電極基板とした。この透明電極基板を市販の蒸着装置（日本真空技術（株）製）の基板ホルダーに設置し、モリブデン製抵抗加熱ボートにＮ，Ｎ’－ジフェニル－Ｎ，Ｎ’－ビス（３－メチルフェニル）－〔１，１’－ビフェニル〕－４，４’－ジアミン（ＴＰＤ）を２００ｍｇ入れ、更に、別のモリブデン製抵抗加熱ボートに４，４’－ビス（２，２’－ジフェニルビニル）ビフェニル（ＤＰＶＢｉ）を２００ｍｇ入れ、さらに、別のモリブデン製抵抗加熱ボートに第１表に示す化合物（Ａ）を入れ、真空槽を１×１０$^{-4}$Ｐａまで減圧した。その後、ＴＰＤ入りボートを２１５～２２０℃まで加熱し、ＴＰＤを蒸着速度0.１～0.３ｎｍ／秒で透明支持基板上に蒸着して、膜厚６０ｎｍの正孔注入輸送層を製膜した。このときの基板温度は室温であった。

【０１０９】次に、これを取り出すことなく、この正孔注入輸送層の上に、ＤＰＶＢｉの入ったボートを加熱して第一発光層として４０ｎｍ積層蒸着した。このとき、同時に化合物（Ａ）のボートを加熱し、第一発光層に化合物（Ａ）を第１表に示す（ｂ）モル％の割合で含有させた。その後、真空槽を大気圧に戻し、新たにモリブデン製抵抗加熱ボートに８－ヒドロキシキノリン・アルミニウム錯体（Ａｌｑ）を２００ｍｇ入れ、さらに別のモリブデン製抵抗加熱ボートに第１表に示す化合物（Ｃ）を入れ、再度、真空槽を１×１０$^{-4}$Ｐａまで減圧した。次いでＡｌｑ入りのボートを加熱し、第二発光層として、２０ｎｍ製膜した。このとき、同時に化合物（Ｃ）のボートも加熱し、化合物（Ｃ）を第１表に示す（ｄ）モル％の割合で、第二発光層に含有させた。その後、真空槽を大気圧へ再度戻し、モリブデン製抵抗加熱ボートにマグネシウムリボンを１ｇ入れ、タングステンバスケットに銀ワイヤーを５００ｍｇ入れて、真空槽を１×１０$^{-4}$Ｐａまで減圧した。この後、マグネシウムを蒸着速度1.４ｎｍ／秒、銀を蒸着速度0.１ｎｍ／秒で膜厚１５０ｎｍ同時蒸着し、混合金属からなる陰極とした。

【０１１０】

【表１】

Savant Technologies LLC - 1004.758

第　１　表

	（A） 化合物の種類	（b） （A）の含有量 （モル％）	（C） 化合物の種類	（d） （C）の含有量 （モル％）
実施例１	ＰＡＶＢｉ	3.0	ルブレン*	0.5
実施例２	ＰＡＶＴＰ	3.0	ルブレン	0.5
実施例３	ＰＡＶＢｉ	3.0	ルモルゲンＦ	3.0

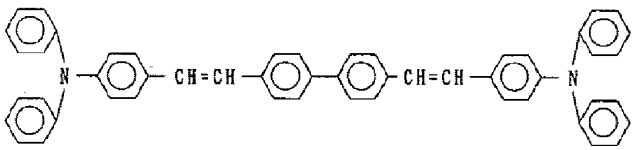
＊：アルドリッチ社製

【０１１１】なお、各有機化合物の蛍光ピーク波長は、ＤＰＶＢｉ（固体）：４６５ｎｍ、ＰＡＶＢｉ（固体）：４６３ｎｍ、ＰＡＶＴＰ（固体）：４５４ｎｍ、Ａｌｑ（固体）：５００ｎｍ、ルブレン（ジメチルホルムアミド0.１重量％溶液）：５８５ｎｍ及びルモゲンＦ（ジメチルホルムアミド0.１重量％溶液）：５９５ｎｍであった。また、ＰＡＶＢｉ及びＰＡＶＴＰの構造式を次に示す。

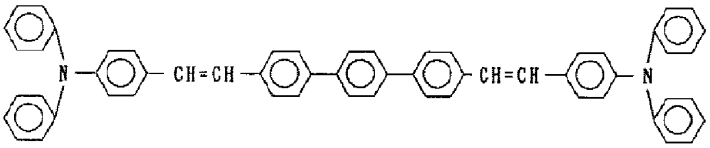
【０１１２】

【化５５】

ＰＡＶＢｉ



ＰＡＶＴＰ



【０１１３】この素子の初期性能の代表値及び半減寿命を求めた。その結果を第２表に示す。なお、半減寿命は、初期輝度：１００ｃｄ／ｍ^2、直流定電流駆動及び駆動環境：乾燥窒素雰囲気の条件で測定を行い、初期輝度の１／２に達した時間で表した。

【０１１４】実施例４

実施例１～３と同じ形状のＩＴＯ付きガラス基板に同じ洗浄工程を施し、透明電極基板とし、真空槽の基板ホルダーに設置した。モリブデン製抵抗加熱ボートにＴＰＤを２００ｍｇ入れ、さらに、別のモリブデン製抵抗加熱ボートにルブレンを入れ、真空槽を１×１０$^{-4}$Ｐａまで減圧した。その後、ＴＰＤ入りボートを加熱し、ＴＰＤを蒸着速度２９～３０ｎｍ／秒で透明支持基板上に蒸着して、膜厚６０ｎｍの正孔注入輸送層を製膜した。これと同時にルブレンの入ったボートを加熱し、0.５モル％の割合で正孔注入輸送層にルブレンを含有させた。このときの基板温度は室温であった。この後、一度大気圧に戻し、別のモリブデン製抵抗加熱ボートにＤＰＶＢｉを２００ｍｇ入れ、さらに、別のモリブデン製ボートに化合物ＰＡＶＢｉを入れ、真空槽を１×１０$^{-4}$Ｐａまで減圧し、該正孔注入輸送層上に、第一発光層としてＤＰＶＢｉを４０ｎｍ積層した。同時に、ＰＡＶＢｉの入ったボートを加熱し、この第一発光層にＰＡＶＢｉを３モル％の割合で含有させた。この後、大気圧に戻し、新たにモリブデン製抵抗加熱ボートにＡｌｑを２００ｍｇ入れ、モリブデン製抵抗加熱ボートにマグネシウムリボンを１ｇ入れ、さらにタングステンバスケットに銀ワイヤーを５００ｍｇ入れて、真空槽を１×１０$^{-4}$Ｐａまで減圧し、Ａｌｑを第二発光層として、４０ｎｍ製膜した。この後、マグネシウムを蒸着速度1.４ｎｍ／秒、銀を蒸

Savant Technologies LLC - 1004.759

着速度0.１ｎｍ／秒で膜厚１５０ｎｍ同時蒸着し、混合金属からなる陰極とした。この素子の初期性能の代表値及び半減寿命を、実施例１～３と同様に求めた。その結果を第２表に示す。

【０１１５】実施例５

実施例１～３と同じ形状のＩＴＯ付きガラス基板に同じ洗浄工程を施し、透明電極基板とし、真空槽の基板ホルダーに設置した。モリブデン製抵抗加熱ボートにＴＰＤを２００ｍｇ入れ、さらに別のモリブデン製抵抗加熱ボートにＤＰＶＢｉを２００ｍｇ入れて真空槽を１×１０$^{-4}$Ｐａまで減圧した。その後、ＴＰＤ入りボートを２１５～２２０℃に加熱し、ＴＰＤを蒸着速度0.１～0.３ｎｍ／秒で透明支持基板上に蒸着して、膜厚６０ｎｍの正孔注入輸送層を製膜させた。この時の基板温度は室温であった。これを真空槽より取り出すことなく、正孔注入輸送層の上に、ＤＰＶＢｉの入ったボートを２４５℃に加熱し、第一発光層として４０ｎｍ積層蒸着した。その後、真空槽を大気圧に戻し、新たにモリブデン製の抵抗加熱ボートにＡｌｑを２００ｍｇ入れて、さらに別のモリブデン製抵抗加熱ボートにルモゲンＦレッド（バフス社製）を入れ、再度真空槽を１×１０$^{-4}$Ｐａまで減圧した。次いで、ルモゲンＦレッド入りのモリブデン製抵抗加熱ボートを３３０℃に加熱し、Ａｌｑ入りのモリブデン製ボートを２５０℃まで加熱し、ルモゲンＦレッドの含有量がＡｌｑに対して３モル％になるように、第二発光層４０ｎｍを製膜した。その後、真空槽を大気圧に戻し、モリブデン製抵抗加熱ボートにマグネシウムを１ｇ入れ、タングステン製バスケットに銀ワイヤーを５００ｍｇ入れ、その後、真空槽を１×１０$^{-4}$Ｐａまで減圧し、マグネシウムを蒸着速度1.４ｎｍ／秒、銀を蒸着速度0.１ｎｍ／秒で膜厚１５０ｎｍ同時蒸着し、混合金属からなる陰極とした。この素子の初期性能の代表値及び半減寿命を実施例１～３と同様に求めた。その結果を第２表に示す。

【０１１６】

【表２】

第　２　表－１

	初期性能			
	電圧（Ｖ）	電流密度（mA/cm^2）	発光輝度（cd/m^2）	発光効率（ルーメン/W）
実施例１	9.5	4.5	１００	0.７
実施例２	9.5	5.０	１００	0.７
実施例３	10.０	7.０	１００	0.４
実施例４	11.０	6.５	１００	0.４
実施例５	9.８	7.５	１００	0.４

【０１１７】

【表３】

第　２　表－２

	ＣＩＢ色度座標（ｘ，ｙ）	半減時間（時間）
実施例１	(0.245，0.278)	1,０００
実施例２	(0.245，0.267)	８００
実施例３	(0.300，0.320)	６００
実施例４	(0.265，0.278)	３００
実施例５	(0.220，0.240)	２００

【０１１８】第２表から分かるように、実施例１～４は、実施例５に比べて発光色の白色化及び量子収率（輝度／電流密度に相当）が向上しており、また発光安定性も向上している。

【０１１９】

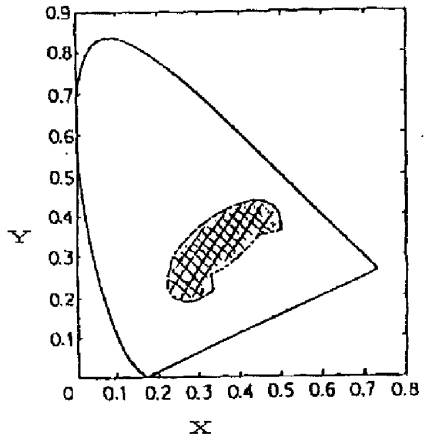
【発明の効果】本発明の白色有機ＥＬ素子は、発光効率が高く、かつ発光安定性に優れた白色発光を呈し、各種表示装置における発光素子として好適に用いられる。

【図面の簡単な説明】

【図１】　図１は、ＣＩＥ色度座標における白色光の定義領域を表したグラフである。

Savant Technologies LLC - 1004.760

【図１】



▨：ＣＩＥ座標における白色発光領域を示す。

フロントページの続き

(72)発明者　楠本　正
千葉県袖ケ浦市上泉1280番地　出光興産株
式会社内

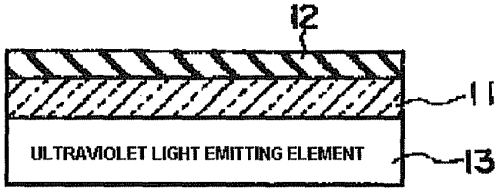
Savant Technologies LLC - 1004.761

Japanese Patent Application Laid-Open No. 267301/1994
Laid-Open Date: September 22, 1994
Application No. 53853/1993
Application Date: March 15, 1993
Inventor: Kazunori Menda
Applicant: OLYMPUS OPTICAL CO., LTD.
Title of the Invention: ORGANIC PHOTOLUMINESCENT ELEMENT

[ABSTRACT]

[PURPOSE] To provide an organic photoluminescent element that can emit desired light without the energization of a luminescent layer doped with an organic coloring matter to avoid a deterioration in the luminescent layer, caused by Joule heat, which is a drawback of an EL element.

[CONSTITUTION] An organic photoluminescent element characterized by comprising: a substrate transparent to ultraviolet light; a luminescent organic material layer provided on a surface of the substrate; and a solid state component that is provided on the backside of the substrate and radiates electromagnetic waves having a larger photon energy than visible light.



Savant Technologies LLC - 1004.762

[CLAIMS]

[Claim 1] An organic photoluminescent element characterized by comprising: a substrate transparent to ultraviolet light; a luminescent organic material layer provided on a surface of the substrate; and a solid state component that is provided on the backside of the substrate and radiates electromagnetic waves having a larger photon energy than visible light.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001] [Field of Industrial Application]

The present invention relates to an improvement in an organic electroluminescent element (hereinafter referred to as organic EL element). More specifically, the present invention relates to a photoluminescent element that can emit desired light without energization.

[0002] [Prior Art]

Organic EL elements has excellent features of thin type, surface emission, and low power consumption drive and can change luminescence wavelength in a visible region by changing coloring matters added. Therefore, organic EL elements have drawn attention as elements particularly having a possibility of realizing full-color flat panel displays, and studies on the organic EL elements have been energetically made.

[0003]

Fig. 5 shows the structure of a conventional low-current injection-type organic EL element (Takeo Wakimoto: Japan Society for the Promotion of Science, Conversion between Light and Electricity 125th Committee, Material for 8th EL Separate Meeting (1992) 26). As shown in the drawing, this element has a structure comprising a glass substrate 1 and a transparent electrode 2 formed of ITO (indium tin oxide), a hole transport layer 3 formed of TPD (a tetraphenyldiamine derivative), a luminescent layer 4 formed of ALQ3 (an aluminum complex) containing an organic coloring matter (a quinacridone derivative) added thereto, and an Mg-Ag back plate 5 stacked in that order on the glass substrate 1 by a vacuum vapor deposition method.

[0004]

When a current of approximately 100 mA/cm^2 (voltage between

Savant Technologies LLC - 1004.763

elements: several V) is injected into the element, a luminescence of approximately 10^4 cd/m^2 at a wavelength of 540 nm (green) can be obtained. Further, the luminescence wavelength can be changed by changing the type of an inductive[#1] coloring matter added to the luminescent layer 4.

#1 Translator's note: "誘起" in the Japanese document which means "inductive" in English deems to be a typographical error and correctly read "有機" which means "organic" in English.

[0005]

On the other hand, Japanese Patent Application Laid-Open No. 312873/1989 discloses an organic EL element comprising a pair of electrodes, one of which is transparent, an organic phosphor thin-film layer and an inorganic semiconductor layer having hole conductivity that are provided between the pair of electrodes. This document describes that green light can be emitted by applying a direct-current voltage across electrodes in the organic EL element.

[0006] [Problems to be Solved by the Invention]

In order to emit light in the conventional organic EL element, the luminescent layer doped with the organic coloring matter should be energized to inject electrons or holes into the luminescent layer. The flow of current, however, causes a rise in temperature due to Joule heat, and, when the luminescent layer is heated to several tens of degrees C, the organic coloring matter is disadvantageously deteriorated (melted). Therefore, in general, the organic EL element has a drawback that the service life is shorter than that of inorganic EL elements using ZnS or the like.

[0007]

As described above, the organic EL element can change the luminescence wavelength in a visible region by changing the coloring matter added and thus is expected to be applied, for example, to color displays, but on the other hand, is sensitive to heat generated by energization. This drawback makes it difficult to put the organic EL element to practical use.

[0008]

In view of the situation, the present invention has been made, and an object of the present invention is to provide an organic photoluminescent element that can emit desired light without the

Savant Technologies LLC - 1004.764

energization of a luminescent layer doped with an organic coloring matter.

[0009] [Means for Solving the Problems and Function]

In order to attain the object, in the present invention, photoluminescence (PL) rather than electroluminescence (EL) is utilized to emit desired light from a luminescent layer doped with an organic coloring matter. Thus, in the present invention, unlike the conventional EL element wherein charges (holes or electrons) are injected, electromagnetic waves having a larger photon energy than visible light (for example, ultraviolet light, X radiation, β radiation, or γ radiation) are applied to excite a luminescent substance and to emit light.

[0010]

Accordingly, the organic PL element according to the present invention is characterized by comprising: a substrate transparent to ultraviolet light; a luminescent organic material layer provided on a surface of the substrate; and a solid state component that is provided on the backside of the substrate and radiates electromagnetic waves having a larger photon energy than visible light.

[0011]

Fig. 1 is a conceptual diagram showing an example of a PL element structure for realizing the above principle according to the present invention. In the drawing, numeral 11 designates a substrate formed of a material transparent to ultraviolet light. A PL luminescent film 12 with an organic coloring matter added thereto is provided on a surface of the substrate 11. A solid luminescent element 13 which emits ultraviolet light is provided on the backside of the substrate 11.

[0012]

In the element structure, ultraviolet light radiated from the solid luminescent element 13 is passed through the transparent substrate 11 and is applied to the PL luminescent film 12 to excite the PL luminescent film. The excited PL luminescent film 12 emits visible light having a wavelength corresponding to the organic coloring matter doped into the PL luminescent film 12.

[0013]

Thus, according to the organic PL element of the present invention, desired light can be emitted without the energization of the PL

Savant Technologies LLC - 1004.765

luminescent film doped with the organic coloring matter. Therefore, the occurrence of Joule heat generated by energization and the deterioration of the organic coloring matter caused by the heat can be avoided, and, thus, an organic luminescent element having a prolonged service life can be provided.

[0014]

In the conceptual diagram of Fig. 1, an ultraviolet light emitting element is used as the solid luminescent element 13. However, if possible, elements that emit radiations such as an X radiation, a β radiation, or a γ radiation may be used. For example, an element into which a radioactive material capable of emitting a β radiation or a γ radiation has been sealed may also be used.

[0015] [Embodiments]

<First Embodiment>

[0016]

Fig. 2 shows a green PL element, which is one embodiment of the present invention, using a ZnO ultraviolet light emitting element. In the drawing, numeral 21 is a transparent glass substrate. A PL luminescent layer 22, which is formed of an ALQ3 material with a quinacridone derivative as an organic coloring matter added thereto and has been formed by a vacuum vapor deposition, is provided on a surface of the glass substrate 21. An ITO transparent electrode 23, a ZnO (zinc oxide) film 24, and an In back plate 25 are stacked in that order by a vapor deposition method on the backside of the glass substrate 21.

[0017]

In the organic PL element, a schottky junction (a barrier) exists at the interface of an ITO electrode 23 and a ZnO film 24. When a forward bias is applied to the junction, ultraviolet light (380 nm) occurs in a depletion layer extended toward ZnO around the junction. The ultraviolet light is passed through the glass substrate 21 and excites the PL luminescent layer 22, and, thus, green (540 nm) visible light is radiated from the PL luminescent layer. Thus, since the PL luminescent layer 22 is excited by ultraviolet light, a deterioration caused by Joule heat experienced in the conventional EL element can be avoided, and a longer service life can be realized.

Savant Technologies LLC - 1004.766

[0018]

In the above embodiment, an organic PL element has been realized using a ZnO ultraviolet light emitting element having a schottky junction structure. Likewise, the green light emitting organic PL element can also be realized by using a solid ultraviolet light emitting element having a structure of a pn junction, MOS junction or the like. Further, light having colors other than green can also be emitted by changing the type of the organic coloring matter doped into the PL luminescent layer 22. Further, the amount of luminescence from the PL luminescent layer 22 can be regulated by regulating the amount of voltage or current applied to the ultraviolet light emitting element.

<Second Embodiment>

[0019]

Fig. 3 shows a structure of a full-color display device using a PL luminescent element according to the present invention. In the drawing, numeral 31 designates a transparent glass substrate. A blue PL luminescent layer (acetolane[#2]) 32, a green PL luminescent layer (ALQ3) 33, and a red PL luminescent layer (a dicyanomethylenepyran derivative) 34 are provided in a matrix form on a surface of a glass substrate 31. On the other hand, ultraviolet light emitting elements 35, 36, 37 are provided on the backside of the substrate 31 in its portions corresponding to respective PL luminescent layers 32 to 34.

#2 Translator's note: "アセトラン" in the Japanese document which means "acetolane" in English deems to be a typographical error and correctly read "アントラセン" which means "anthracene" in English)

[0020]

In the color display device according to the above embodiment, blue, green and/or red lights can be selectively emitted at desired positions by selecting the ultraviolet light emitting elements 35 and 36 (translator's note: "ultraviolet light emitting elements 35 and 36" deems to be a typographical error and correctly read "ultraviolet light emitting elements 35 to 37") and regulating the amount of ultraviolet luminescence. Accordingly, full-color display can be realized. Also in this embodiment, a deterioration in each of the PL luminescent layers 32 to 34 by heat can be avoided, and, thus, a longer service life than that of the conventional EL element can be realized.

Savant Technologies LLC - 1004.767

<Third Embodiment>

[0021]

Fig. 4 shows an example in which a PL element according to the present invention has been applied to a backlight of a liquid crystal display. In the drawing, numeral 41 designates a glass substrate transparent to ultraviolet light. An ultraviolet light emitting element 42 as described in the first embodiment is provided on one side of the glass substrate 41. Further, a blue PL luminescent layer 43, a green PL luminescent layer 44, and a red PL luminescent layer 45 as described in the second embodiment are stacked on the other side of the glass substrate 41.

[0022]

As shown in the drawing, a liquid crystal display device 50 is stacked on the PL luminescent element having the above construction. The liquid crystal display device 50 comprises a first glass substrate 51 and a second glass substrate 52. A polarizing plate 53 is stacked on one side of the glass substrate 51. A transparent electrode 54, a color filter 55, and an aligning film 56 are stacked in that order on the other side of the glass substrate 51. Further, a polarizing plate 57 is stacked on one side of the glass substrate 52, and a transparent electrode 58 and an aligning film 59 are stacked in that order on the other side of the glass substrate 52. A liquid crystal material 60 is filled into the two aligning films 56, 59 to constitute a liquid crystal display cell.

[0023]

In the above embodiment, individual PL luminescent layers 43 to 45 of three primary colors are excited by ultraviolet light emitted from the ultraviolet light emitting element 42 and emit respective lights, and these three primary colors are mixed together to provide a white light. The white light thus obtained is applied as a backlight of the liquid crystal display device 50 through the first glass substrate 51. Also in this embodiment, a deterioration in the PL luminescent layers 43 to 45 can be avoided, and the service life of the PL luminescent layers 43 to 45 can be prolonged.

[0024]

When the PL luminescent element according to the present invention is used as a backlight as in this embodiment, the liquid crystal

Savant Technologies LLC - 1004.768

display device 50 can be always irradiated with white light as a backlight by using, instead of the ultraviolet light emitting element 42, for example, a glass tube into which a radioactive material such as a material that emits a γ radiation has been sealed.

[0025] [Effect of the Invention]

As is apparent from the foregoing detailed description, according to the PL element of the present invention, a deterioration in an organic coloring matter, caused by Joule heat, as experienced in the conventional EL element can be avoided, and, thus, light emitting elements having a prolonged service life can be provided.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] Fig. 1 is a conceptual diagram showing the structure of an organic photoluminescent element according to the present invention,

[Fig. 2] Fig. 2 is a cross-sectional view showing the structure of an organic photoluminescent element according to one embodiment of the present invention.

[Fig. 3] Fig. 3 is a cross-sectional view showing an embodiment in which an organic photoluminescent element according to the present invention has been applied to a full-color display device.

[Fig. 4] Fig. 4 is a cross-sectional view showing an embodiment in which an organic photoluminescent element according to the present invention has been applied to a backlight of a liquid crystal display.

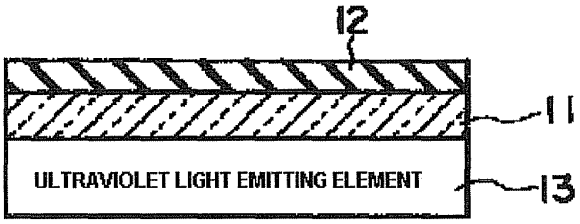
[Fig. 5] Fig. 5 is a cross-sectional view showing the structure of a conventional EL element.

[DESCRIPTION OF REFERENCE CHARACTERS]

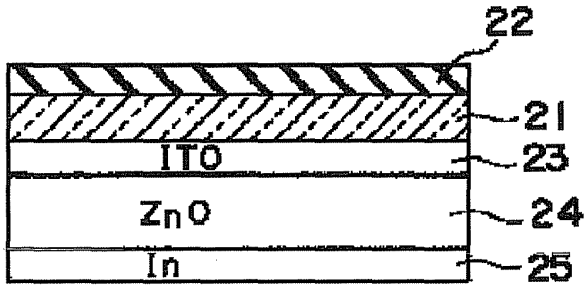
11,21,31,41... transparent glass substrates, 12, 22, 32 to 34... organic PL luminescent layers, 13, 35 to 37, 42... ultraviolet light emitting element, 23... transparent electrode, 24... ZnO ultraviolet luminescent layer, and 25... back plate.

Savant Technologies LLC - 1004.769

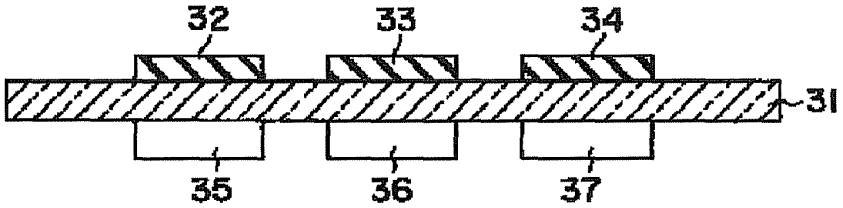
[Fig 1]



[Fig 2]

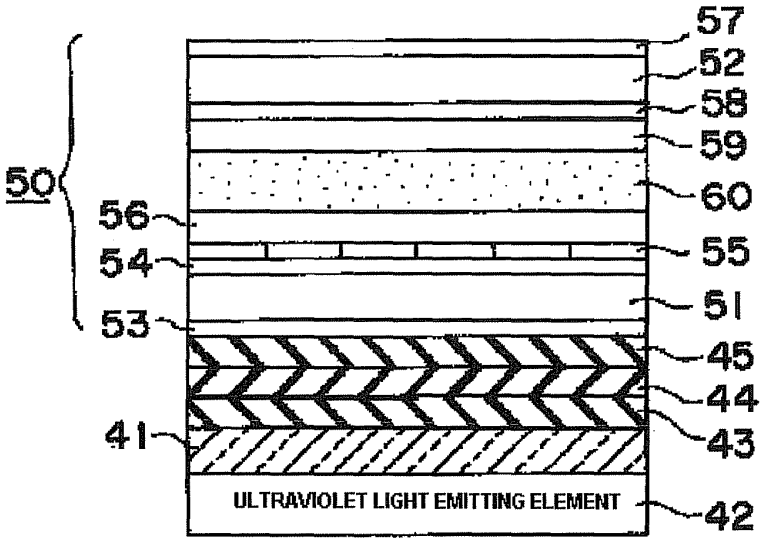


[Fig 3]

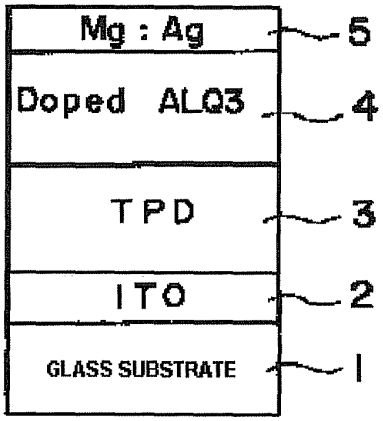


Savant Technologies LLC - 1004.770

[Fig 4]



[Fig 5]



Savant Technologies LLC - 1004.771

D E C L A R A T I O N

In the matter of Patent Application under USPTO in the name of Kazunori MENDA.

I, the undersigned, Makoto ASANO, of Kyowa Patent and Law Office, of 2-3, Marunouchi 3-Chome, Chiyoda-Ku, Tokyo-To, Japan, do hereby declare that I am the translator of the documents attached and certify that the following is a true translation to the best of my knowledge and belief.

Dated this 26th day of February, 2010

M. Asano

Makoto ASANO

Savant Technologies LLC - 1004.772

(19)日本国特許庁（ＪＰ）　(12)**公開特許公報**（Ａ）　(11)特許出願公開番号

特開平6－267301

(43)公開日　平成6年(1994)9月22日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｆ２１Ｋ　2/00		7137－3Ｋ		
Ｃ０９Ｋ　11/06		Ｚ　9159－4Ｈ		
Ｈ０１Ｌ　29/28				
33/00		Ａ　7376－4Ｍ		

審査請求　未請求　請求項の数1　ＯＬ　（全　4　頁）

(21)出願番号　特願平5－53853

(22)出願日　平成5年(1993)3月15日

(71)出願人　000000376
オリンパス光学工業株式会社
東京都渋谷区幡ヶ谷2丁目43番2号

(72)発明者　免田　和典
東京都渋谷区幡ヶ谷2丁目43番2号　オリンパス光学工業株式会社内

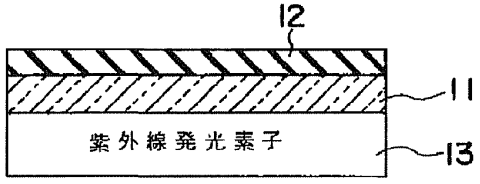
(74)代理人　弁理士　鈴江　武彦

(54)【発明の名称】　有機ホトルミネッセンス素子

(57)【要約】

【目的】ＥＬ素子の欠点であるジュール熱による発光層の劣化を回避するために、有機色素をドープした発光層に通電することなく、所望の発光を得ることができる有機ホトルミネッセンス素子を提供すること。

【構成】紫外線に対して透明な基板と、該基板の表面に設けられた発光性有機材料層と、前記基板の裏面に設けられた可視光よりも光子エネルギーの大きい電磁波を放射する固体素子とを具備したことを特徴とする有機ホトルミネッセンス素子。



Savant Technologies LLC - 1004.773

【特許請求の範囲】
【請求項１】　紫外線に対して透明な基板と、該基板の表面に設けられた発光性有機材料層と、前記基板の裏面に設けられた可視光よりも光子エネルギーの大きい電磁波を放射する固体素子とを具備したことを特徴とする有機ホトルミネッセンス素子。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、有機エレクトロルミネッセンス素子（以下、有機ＥＬ素子という）の改良に関し、より具体的には、通電しなくても所望の発光を得ることができるホトルミネッセンス素子に関する。
【０００２】
【従来の技術】有機ＥＬ素子は、薄型、面発光かつ低電力駆動という優れた特徴を有しており、また添加する色素を変えることによって、発光波長を可視領域で変化させることができる。このため、特にフルカラーのフラットパネルディスプレイを実現できる可能性をもった素子として注目され、活発な研究が行われている。
【０００３】図５は、従来の低電流注入型有機ＥＬ素子の構造を示している（脇本健夫：日本学術新興会、光電相互変換第１２５委員会、第８回ＥＬ分科会資料(1992) 26）。図示のように、この素子では、ガラス基板１上にＩＴＯ（酸化インジウム錫）からなる透明電極２、ＴＰＤ（テトラフェニルジアミン誘電体）からなる正孔輸送層３、有機色素（キナクリドン誘導体）を添加したＡＬＱ3（アルミニウム錯体）からなる発光層４およびＭｇ－Ａｇ背面電極５を、真空蒸着法により順次積層した構造が採用されている。
【０００４】上記のような素子に、100 mA／cm² （素子間電圧：数Ｖ）程度の電流を注入すると、波長 540nm（緑）、10^4 cd／m² 程度の発光を得ることができる。また、発光層４に添加する誘起色素の種類を変えることによって、発光波長を変化させることができる。
【０００５】一方、特開平 1-312873 号には、一方が透明である一対の電極間に、有機蛍光体薄膜層と、正孔伝導性を示す無機半導体層とを設けた有機ＥＬ素子が開示されている。そして、この有機ＥＬ素子の電極間に直流電圧を印加することにより、緑色発光を得ることが記載されている。
【０００６】
【発明が解決しようとする課題】上記従来の有機ＥＬ素子において発光を得るためには、有機色素がドープされた発光層中に電子または正孔を注入するために通電しなければならない。しかし、このように電流を流すとジュール熱により温度が上昇し、数１０℃に加熱されると有機色素は変質（溶解）してしまう。従って、有機ＥＬ素子の寿命は、一般にＺｎＳ等を用いた無機ＥＬ素子よりも短いという欠点がある。
【０００７】上記のように、有機ＥＬ素子は、添加する色素を変えることによって発光波長を可視領域で変化させ得るためカラーディスプレイ等への応用が期待されているが、通電による発熱に弱い欠点があり、この欠点が有機ＥＬ素子の実用化を困難にしている。
【０００８】本発明はかかる事情に鑑みてなされたもので、その課題は、有機色素をドープした発光層に通電することなく、所望の発光を得ることができる有機ホトルミネッセンス素子を提供することである。
【０００９】
【課題を解決するための手段および作用】上記課題を達成するために、本発明では、有機色素をドープした発光層から所望の発光を得るために、エレクトロルミネッセンス（ＥＬ）ではなく、ホトルミネッセンス（ＰＬ）を利用することとした。即ち、本発明においては、従来のＥＬ素子のように電荷（正孔または電子）を注入するのではなく、可視光よりも光子エネルギーの大きい電磁波（例えば紫外線、Ｘ線、β線またはγ線等）を照射して発光物質を励起し、発光させることとした。
【００１０】従って、本発明による有機ＰＬ素子は、紫外線に対して透明な基板と、該基板の表面に設けられた発光性有機材料層と、前記基板の裏面に設けられた可視光よりも光子エネルギーの大きい電磁波を放射する固体素子とを具備したことを特徴とするものである。
【００１１】図１は、本発明の上記原理を実現するためのＰＬ素子構造の一例を概念的に示している。同図において、１１は紫外線に対して透明な材料からなる基板である。該基板１１の表面には、有機色素を添加したＰＬ発光膜１２が形成されている。また、基板１１の裏面には、紫外線を発生する固体発光素子１３が形成されている。
【００１２】かかる素子構造において、固体発光素子１３から放射された紫外線は、透明基板１１を透過してＰＬ発光膜１２に照射され、該ＰＬ発光膜を励起する。励起されたＰＬ発光膜１２は、ドープされている有機色素に対応した波長の可視光を放出する。
【００１３】こうして、本発明の有機ＰＬ素子によれば、有機色素をドープしたＰＬ発光膜に通電することなく、所望の発光を得ることができる。従って、通電によるジュール熱の発生と、これによる有機色素の変質が回避され、寿命の長い有機発光素子を得ることができる。
【００１４】なお、図１の概念図では、固体発光素子１３として紫外線発光素子を用いたが、可能な場合には、Ｘ線、β線、γ線等の放射線を放出する素子を用いてもよい。例えば、β線またはγ線を放出する放射能物質を封入した素子を用いることが可能である。
【００１５】
【実施例】
＜第１実施例＞
【００１６】図２は、ＺｎＯ紫外線発光素子を用いた、本発明の一実施例になる緑色ＰＬ素子を示している。同

Savant Technologies LLC - 1004.774

図において、２１は透明なガラス基板である。該ガラス基板２１の表面には、真空蒸着法を用いて、有機色素としてキナクリドン誘導体を添加したＡＬＱ3 物質からなるＰＬ発光層２２が形成されている。また、ガラス基板２１の裏面には、ＩＴＯ透明電極２３、ＺｎＯ（酸化亜鉛）膜２４及びＩｎ背面電極２５が、真空蒸着法により順次積層されている。

【００１７】上記の有機ＰＬ素子においては、ＩＴＯ電極２３とＺｎＯ膜２４との界面にショットキー接合（障壁）が存在する。該接合に順方向バイアスを印加すると、接合付近のＺｎＯ側に伸びた空乏層中で紫外線（380nm ）が発生する。この紫外線はガラス基板２１を透過してＰＬ発光層２２を励起するため、ＰＬ発光層２２から緑色（540nm ）の可視光が放射される。このように、紫外線でＰＬ発光層２２を励起しているので、従来のＥＬ素子のようなジュール熱による劣化が回避され、より長い寿命を得ることができる。

【００１８】なお、上記実施例においては、ショットキー接合構造を有するＺｎＯ紫外線発光素子をもちいて有機ＰＬ素子を実現したが、例えばｐｎ接合やＭＯＳ接合などの構造を有する固体紫外線発光素子を用いても、同様にして緑色発光の有機ＰＬ素子を実現することができる。また、ＰＬ発光層２２にドープする有機色素の種類を変えることによって、緑色以外の発光を得ることも可能である。更に、紫外線発光素子に印加する電圧或いは電流量を制御するようにすれば、ＰＬ発光層２２からの発光量を制御することも可能である。

＜第２実施例＞

【００１９】図3は、本発明のＰＬ発光素子を用いたフルカラーディスプレイ装置の構造を示している。同図において、３１は透明なガラス基板である。ガラス基板３１の表面には、青色ＰＬ発光層（アセトラン）３２、緑色ＰＬ発光層（ＡＬＱ3 ）３３および赤色ＰＬ発光層（ジシアノメチレンピラン誘導体）３４が、マトリックス状に配置して形成されている。一方、基板３１の裏面には、夫々のＰＬ発光層３２～３４に対応する位置に、紫外線発光素子３５，３６，３７が形成されている。

【００２０】上記実施例のカラーディスプレイ装置では、紫外線発光素子３５～３６を選択し且つその紫外線発光量を制御することにより、任意の位置において、青、緑および／または赤の発光を選択的に得ることができ、従ってフルカラーでの表示が可能となる。この実施例においても、各ＰＬ発光層３２～３４は何れも熱による劣化が回避されるから、従来のＥＬ素子よりも長い寿命を得ることができる。

＜第３実施例＞

【００２１】図4は、本発明のＰＬ素子を液晶ディスプレイのバックライトに応用した例を示している。同図において、４１は紫外線に対して透明なガラス基板である。該ガラス基板４１の片面には、第１実施例におけると同様の紫外線発光素子４２が設けられている。また、ガラス基板４１の他面には、第２実施例で用いたのと同様の、青色ＰＬ発光層４３、緑色ＰＬ発光層４４および赤色ＰＬ発光層４５が積層されている。

【００２２】上記のように構成されたＰＬ発光素子の上には、図示のように、液晶ディスプレイ装置５０が積層されている。液晶ディスプレイ装置５０は、第一のガラス基板５１および第二のガラス基板５２を具備している。ガラス基板５１の片面には偏光板５３が積層され、他面には透明電極５４と、カラーフィルター５５と、配向膜５６が順次積層されている。また、ガラス基板５２の片面には偏光板５７が積層され、他面には透明電極５８および配向膜５９が順次積層されている。そして、二つの配向膜５６，５９の間には液晶物質６０が充填されることにより、液晶表示セルが構成されている。

【００２３】上記実施例においては、三原色のＰＬ発光層４３～４５の夫々が紫外線発光素子４２からの紫外線で励起されて発光し、これら三原色は混ざり合って白色光となる。こうして得られた白色光は、液晶ディスプレイ装置５０のバックライトとして、第一のガラス基板５１を通して照射される。この実施例においても、ＰＬ発光層４３～４５の劣化を回避でき、その寿命を長くすることができる。

【００２４】なお、この実施例のように、本発明のＰＬ発光素子をバックライトとして用いる場合には、紫外線発光素子４２の代わりに、例えばγ線を放射する物質のような放射性物質をガラス管に封入して用いることにより、白色光のバックライトで液晶ディスプレイ装置５０を常時照射することも可能である。

【００２５】

【発明の効果】以上詳述したように、本発明のＰＬ素子によれば、従来のＥＬ素子のようなジュール熱による有機色素の劣化を回避することができ、寿命の長い発光素子を得ることができる。

【図面の簡単な説明】

【図１】本発明による有機ホトルミネッセンス素子の構造を概念的に示す図。

【図２】本発明の一実施例になる有機ホトルミネッセンス素子の構造示す断面図。

【図３】本発明の有機ホトルミネッセンス素子を、フルカラーディスプレイ装置に応用した実施例を示す断面図。

【図４】本発明の有機ホトルミネッセンス素子を、液晶ディスプレイのバックライトに応用した実施例を示す断面図

【図５】従来のＥＬ素子の構造を示す断面図。

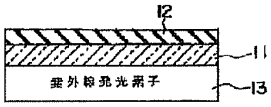
【符号の説明】

１１，２１，３１，４１…透明ガラス基板、１２，２２，３２～３４…有機ＰＬ発光層、１３，３５～３７，４２…紫外線発光素子、２３…透明電極、２４…ＺｎＯ

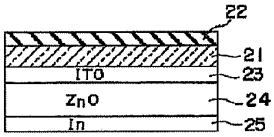
Savant Technologies LLC - 1004.775

紫外線発光層、２５…背面電極

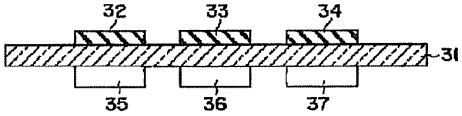
【図１】



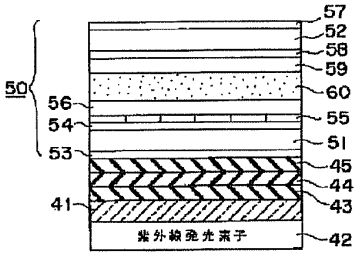
【図２】



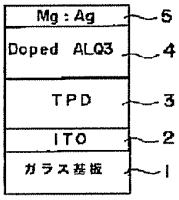
【図３】



【図４】



【図５】



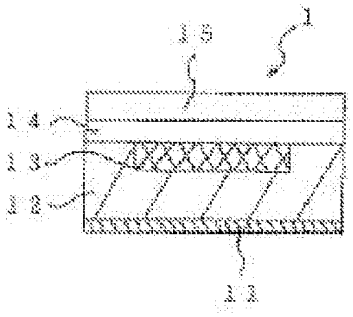
Savant Technologies LLC - 1004.776

LIGHT EMITTING ELEMENT

Publication number: JP6283755 (A)
Publication date: 1994-10-07
Inventor(s): MIMURA SHUSUKE; FUTAKI TOSHIROU; MATSUMOTO TAKAHIRO +
Applicant(s): NIPPON STEEL CORP +
Classification:
- international: ***H01L33/16; H01L33/34; H01L33/42;*** **H01L33/00;** (IPC1-7): H01L33/00
- European:
Application number: JP19930092465 19930325
Priority number(s): JP19930092465 19930325

Abstract of **JP 6283755 (A)**

PURPOSE:To provide a white light emitting element by using a thermally nitrided thermal nitride porous silicon for the porous silicon made on a p-type or n-type single crystalline silicon. CONSTITUTION:For a light emitting element 1, Al 11 is deposited on the rear of a p-type single crystalline silicon substrate 12, and a high-speed thermal nitride porous silicon layer 13 is made on the surface of the p-type single crystalline silicon substrate 12. An amorphous silicon carbon alloy film 14 containing n-type fine crystals is formed on the high-speed thermal nitride porous silicon layer 13, and further ITO 15 is formed as a transparent electrode on the amorphous silicon carbon alloy film 14 containing n-type fine crystals. Hereby, positive holes, from the p-type single crystalline silicon substrate 12, and electrons, from the amorphous silicon carbon alloy film 14 containing n-type fine crystals, can be injected into the high-speed thermal nitride porous silicon layer 13, and a white light can be gotten and also the efficiency of light emission can be prevented from dropping.



Data supplied from the ***espacenet*** database — Worldwide

Savant Technologies LLC - 1004.777

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平6－283755

(43)公開日　平成６年(1994)10月７日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　33/00		Ａ　7376－4M		

審査請求　未請求　請求項の数13　ＦＤ　（全　９　頁）

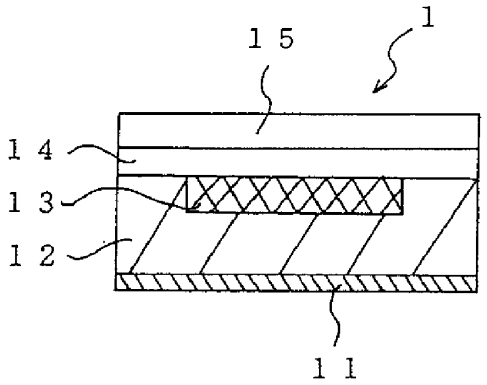
(21)出願番号　特願平5－92465

(22)出願日　平成５年(1993)３月25日

(71)出願人　000006655
新日本製鐵株式会社
東京都千代田区大手町２丁目６番３号
(72)発明者　三村　秀典
神奈川県川崎市中原区井田1618番地　新日本製鐵株式会社先端技術研究所内
(72)発明者　二木　登史郎
神奈川県川崎市中原区井田1618番地　新日本製鐵株式会社先端技術研究所内
(72)発明者　松本　貴裕
神奈川県相模原市淵野辺５丁目10番１号
新日本製鐵株式会社エレクトロニクス研究所内
(74)代理人　弁理士　半田　昌男

(54)【発明の名称】　発光素子

(57)【要約】
【目的】　シリコン用いた発光素子、特にｐｎ接合を用いて電荷を注入し発光させる発光素子を提供することを目的としている。
【構成】　ｐ型単結晶シリコン基板１２上に高速熱窒化多孔質シリコン層１３を作製し、ｎ型の微結晶を含有する非晶質シリコンカーボン合金１４を高速熱窒化多孔質シリコン層１３上へ堆積した。上記の構成とすることによりシリコンを用いたｐｎ接合型の発光素子を実現できた。また、高速熱窒化多孔質シリコンを用いることにより発光効率の低下を防止することのできる発光素子を提供することができる。



Savant Technologies LLC - 1004.778

【特許請求の範囲】
【請求項１】　ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことを特徴とする発光素子。
【請求項２】　ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記熱窒化多孔質シリコンが形成された単結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたことを特徴とする発光素子。
【請求項３】　前記半導体が微結晶を含有する非晶質シリコンカーボン合金からなることを特徴とする請求項２記載の発光素子。
【請求項４】　前記半導体が非晶質シリコンカーボン合金からなることを特徴とする請求項２記載の発光素子。
【請求項５】　前記半導体が微結晶を含有するシリコンからなることを特徴とする請求項２記載の発光素子。
【請求項６】　ｐ型又はｎ型の多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことを特徴とする発光素子。
【請求項７】　ｐ型又はｎ型の多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記熱窒化多孔質シリコンが形成された多結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたことを特徴とする発光素子。
【請求項８】　前記半導体が微結晶を含有する非晶質シリコンカーボン合金からなることを特徴とする請求項７記載の発光素子。
【請求項９】　前記半導体が非晶質シリコンカーボン合金からなることを特徴とする請求項７記載の発光素子。
【請求項１０】　前記半導体が微結晶を含有するシリコンからなることを特徴とする請求項７記載の発光素子。
【請求項１１】　前記熱窒化多孔質シリコン上にインジウムティンオキサイトを形成したことを特徴とする請求項１又は６記載の発光素子。
【請求項１２】　前記熱窒化多孔質シリコン上にＡｕを形成したことを特徴とする請求項１又は６記載の発光素子。
【請求項１３】　前記熱窒化多孔質シリコンは、高速熱窒化した高速熱窒化多孔質シリコンであることを特徴とする請求項１，２，３，４，５，６，７，８，９，１０，１１又は１２記載の発光素子。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、光通信、自発光型ディスプレイ、光源、光集積回路等に用いることのできる発光素子、特にｐｎ接合を用いた発光素子に関するものである。
【０００２】
【従来の技術】シリコン半導体は間接遷移半導体であるため発光素子の作製は実現不可能であると考えられており、そのため従来ｐｎ接合を用いた発光素子はIII －Ｖ属化合物半導体、II－VI属化合物半導体、およびIV－VI属化合物半導体で作製されていた。しかし、シリコン半導体は化合物半導体に比べ、資源が豊富、安価であり、特に多結晶シリコンは、ステンレス基板、石英基板、ガラス基板等種々の基板上に大面積のものを安価に作製することができる。また、デバイス設計・作製技術が高く現状の化合物半導体では実現することが難しい高集積度でかつ高信頼性のある論理、演算、駆動、受光素子等を同一基板上に作り込める等の利点により、シリコンを用いた発光素子、特に最終的にはレーザへの応用が可能なｐｎ接合を用いた発光素子の実現が切望されていた。
【０００３】ところが、１９９０年、Ｌ．Ｔ．Ｃａｎｈａｍにより単結晶シリコンを弗酸溶液中で陽極化成した多孔質シリコンが室温で強いホトルミネッセンスを示すことが示された（Ａｐｐｌｉｅｄ　Ｐｈｙｓｉｃｓ　Ｌｅｔｔｅｒｓ　５７，１９９０，ｐ．１０４６）。このことは、シリコンでも発光素子が実現できる可能性があることを示しており、その後このホトルミネッセンスの発生メカニズムについて盛んに研究が行われていた。
【０００４】
【発明が解決しようとする課題】この多孔質シリコンを用いた発光素子としては、特願平４－３４５０７があるが、従来の多孔質シリコンを用いた発光素子は赤色からオレンジ色までの発光しか示さず、白色に発光するものはなかった。また、従来の発光素子は動作中に発光輝度の低下が見られた。
【０００５】本発明は、上記事情に基づいてなされたものであり、シリコンを用いた発光素子、特に白色発光素子を提供することを目的としたものである。
【０００６】
【課題を解決するための手段】上記課題を解決するために請求項１記載の発明の発光素子は、ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことを特徴とするものである。
【０００７】請求項２記載の発明の発光素子は、ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記熱窒化多孔質シリコンが形成された単結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたことを特徴とするものである。
【０００８】請求項３記載の発明の発光素子は、請求項２記載の発明において、前記半導体が微結晶を含有する非晶質シリコンカーボン合金からなることを特徴とするものである。
【０００９】請求項４記載の発明の発光素子は、請求項２記載の発明において、前記半導体が非晶質シリコンカーボン合金からなることを特徴とするものである。
【００１０】請求項５記載の発明の発光素子は、請求項

Savant Technologies LLC - 1004.779

２記載の発明において、前記半導体が微結晶を含有するシリコンからなることを特徴とするものである。

【００１１】請求項６記載の発明の発光素子は、ｐ型又はｎ型の多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことを特徴とするものである。

【００１２】請求項７記載の発明の発光素子は、ｐ型又はｎ型の多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記熱窒化多孔質シリコンが形成された多結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたことを特徴とするものである。

【００１３】請求項８記載の発明の発光素子は、請求項７記載の発明において、前記半導体が微結晶を含有する非晶質シリコンカーボン合金からなることを特徴とするものである。

【００１４】請求項９記載の発明の発光素子は、請求項７記載の発明において、前記半導体が非晶質シリコンカーボン合金からなることを特徴とするものである。

【００１５】請求項１０記載の発明の発光素子は、請求項７記載の発明において、前記半導体が微結晶を含有するシリコンからなることを特徴とするものである。

【００１６】請求項１１記載の発明の発光素子は、請求項１又は６記載の発明において、前記熱窒化多孔質シリコン上にインジウムティンオキサイトを形成したことを特徴とするものである。

【００１７】請求項１２記載の発明の発光素子は、請求項１又は６記載の発明において、前記熱窒化多孔質シリコン上にＡｕを形成したことを特徴とするものである。

【００１８】請求項１３記載の発明の発光素子は、請求項１，２，３，４，５，６，７，８，９，１０，１１又は１２記載の発明において、前記熱窒化多孔質シリコンは、高速熱窒化した高速熱窒化多孔質シリコンであることを特徴とするものである。

【００１９】

【作用】白色発光素子を作製するためには、その発光層が青色より広いエネルギーバンドギャップ（約２．５ｃＶ以上）を持ち、かつ電子と正孔が発光再結合し、その発光再結合過程のエネルギー差が青から赤まで幅広く有していることが必要である。簡便にこの必要条件を持つことを確認するためには、紫外光励起によるホトルミネッセンスを測定し、白色発光することを確認すればよい。この現象が確認できれば、発光層に電子及び正孔をなんらかの手段で注入し、発光層で再結合を起こさせれば白色発光素子が実現できる。本発明者たちは、多孔質シリコンを熱窒化することにより作製した熱窒化多孔質シリコンが紫外光励起により、白色発光することを見いだした。また、発光層に正孔と電子を注入し発光層で再結合させる手段を見いだした。

【００２０】本発明者等は、ｐ型又はｎ型の単結晶シリコン基板（面方位（１１１）及び（１００）、抵抗率０．０５～５０Ωｃｍ）の上に、陽極化成法（エチルアルコール：弗酸（４８％の水溶液）＝０：１～１０：１の水溶液中で、陽極側に多結晶シリコンを接続し、また陰極側に白金等の電極を接続して電流密度：１ｍＡ／ｃｍ^2 ～２００ｍＡ／ｃｍ^2 の電流を流し、単結晶シリコンを加工する方法）で３０秒～１０分間処理することにより、多孔質シリコン（ｐｏｒｏｕｓ　Ｓｉ）層を作製し、その後前記多孔質シリコン層を高速熱窒化（窒素、アンモニア又は窒素及びアンモニア雰囲気中において、８００℃～１２００℃で１０秒～１２０秒間熱窒化を行う）することにより作製した高速熱窒化多孔質シリコン層が紫外光励起により強い白色ホトルミネッセンスを示すことを見いだした。また、高速熱窒化多孔質シリコン上に、高速熱窒化多孔質シリコンを作製した単結晶シリコン基板と異なる伝導型の広いバンドギャップ（２．０～２．４ｅＶ）と高い導電率（10^{-2}～10^{1} Ｓ／ｃｍ）とを有する微結晶を含有する非晶質シリコンカーボン合金（μｃ－ＳｉＣ）を堆積すると良好なｐｎ接合が得られることを見いだした。また、単結晶シリコン基板のかわりにｐ型又はｎ型の多結晶シリコン基板を用い高速熱窒化多孔質シリコンを作製した場合にも、同様の方法で良好なｐｎ接合が得られることを見いだした。

【００２１】ＬＥＤ発光するような良好なｐｎ接合を作製するためには、高速熱窒化多孔質シリコン層の作製方法（基板の比抵抗、陽極化成の方法、高速熱窒化炉の温度、雰囲気、窒化時間等）はもちろんのこと、特に高速熱窒化多孔質シリコン層と、微結晶を含有する非晶質シリコンカーボン合金膜との界面特性にダメージを与えないように、微結晶を含有する非晶質シリコンカーボン合金の堆積条件を最適化することが非常に重要である。

【００２２】これらについて本発明者等は鋭意研究を行った結果、陽極化成法によりエチルアルコール：弗酸（４８％の水溶液）＝０．１：１～５：１、電流密度５～５０ｍＡ／ｃｍ^2 、陽極化成時間１～５分において面方位（１１１）及び（１００）、抵抗率０．１～４０Ωｃｍのｐ型単結晶シリコン基板の表面に多孔質シリコン層を作製し、さらに５０℃／ｓｅｃ～２５０℃／ｓｅｃの温度上昇を持つ、高速熱窒化炉で８００℃～１２００℃で３０秒から６０秒間熱窒化することにより、ｐ型単結晶シリコン基板から高速熱窒化多孔質シリコン層に正孔が注入できる高速熱窒化多孔質シリコン層の作製条件を見いだした。

【００２３】また、電子サイクロトロン共鳴プラズマＣＶＤ法によりガス圧０．００１～０．００８Ｔｏｒｒ、基板温度１５０～３５０℃、投入電力２００～３５０Ｗ、SiH_4 ：CH_4 ：PH_3 ：H_2 ＝１：１～３：０．００５～０．０３：１００～２００において前記多孔質シリコン層の表面にｎ型の微結晶を含有する非晶質シリコンカーボン合金膜を作製することにより、ｎ型の

Savant Technologies LLC - 1004.780

微結晶を含有する非晶質シリコンカーボン合金膜から高速熱窒化多孔質シリコン層に電子が良好に注入できるｎ型の微結晶を含有する非晶質シリコンカーボン合金の堆積条件を見いだした。その結果、白色発光素子が実現できたわけである。

【００２４】またこの発光素子は白色発光するだけでなく、発光効率の低下が極めて少ない。これは、一般に多孔質シリコンは水素でターミネートされているが、水素は熱等に対して不安定であるため多孔質シリコンから外れ易いのに対し、窒素は熱等に対して安定しているため多孔質シリコンから外れ難いので、多孔質シリコンをターミネートしている水素を窒素に置換することにより、多孔質シリコンのダングリングボンドによる特性劣化を防止することができるからである。

【００２５】また、ｎ型単結晶シリコン基板を用いて発光素子を作製する条件について、ｎ型単結晶シリコン基板から高速熱窒化多孔質シリコン層に電子が良好に注入できる高速熱窒化多孔質シリコン層の作製条件は、陽極化成の際に光を照射しなければならないことを除けば、ｐ型単結晶シリコン基板を用いた場合と同じ条件であること、ｐ型の微結晶を含有する非晶質シリコンカーボン合金膜から高速熱窒化多孔質シリコン層に正孔が良好に注入できるｐ型の微結晶を含有する非晶質シリコンカーボン合金の堆積条件は、原料ガスとしてPH_3 の代わりにB_2H_6 を用いることを除けば、ｎ型の微結晶を含有する非晶質シリコンカーボン合金の堆積条件と同じであることを見いだした。

【００２６】さらに、ｐ型多結晶シリコンを用いて発光素子を作製する条件について、ｐ型多結晶シリコンから高速熱窒化多孔質シリコン層に正孔が良好に注入できる高速熱窒化多孔質シリコン層の作製条件は、陽極化成の際に光を照射しなければならないことを除けば、ｐ型単結晶シリコン基板を用いた場合と同じ条件であること、およびｎ型多結晶シリコンを用いて発光素子を作製する条件について、ｎ型単結晶シリコン基板を用いた場合と同じ条件であることを見いだした。

【００２７】尚、発明者等が調べたところでは、単結晶シリコンの抵抗率が４０Ωｃｍを越えると基板の抵抗が高くなって基板から高速熱窒化多孔質シリコン層に電荷が良好に注入されなくなり、良好な発光素子を作製できないことが分かった。なお、多結晶シリコンは薄膜で用いるため、多結晶シリコンの抵抗率が10^6 Ωｍまで、多結晶シリコンから高速熱窒化多孔質シリコンに電荷が注入される接合が得られることが分かった。

【００２８】また、陽極化成法により多孔質シリコン層を作製するに際し、エチルアルコールと弗酸の比率がエチルアルコール：弗酸＝０．１：１未満になると陽極化成の際に生じる泡のため多孔質シリコンが均一にできず、また電流密度が５０ｍＡ／cm^2 を越えると除々にシリコンの電界研磨が起こり始めてくるため、良好な発光素子を作製できないことが分かった。

【００２９】さらに、電子サイクロトロン共鳴プラズマＣＶＤ法により微結晶を含有する非晶質シリコンカーボン合金膜を作製するに際し、ガス圧が０．００１Ｔｏｒｒ未満ではエッチング効果により下地の高速熱窒化多孔質シリコン層にダメージを与え、０．００８Ｔｏｒｒを越えるとプラズマが安定せず微結晶を含有する非晶質シリコンカーボン合金が作製不可能となるため、良好な発光素子を作製できないことが分かった。

【００３０】また、基板温度が１５０℃未満では微結晶を含有する非晶質シリコンカーボン合金が作製不可能となり、３５０℃を越えると高速熱窒化多孔質シリコン層の表面状態が変化し発光しなくなるため、良好な発光素子を作製できないことが分かった。

【００３１】さらに、多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層を作製するに際し、熱窒化時間が１０秒未満では多孔質シリコンをターミネートしている水素の大部分を窒素に置換することができず、１２０秒を越えると多孔質シリコンの構造が変化するため、良好な発光を示さず、結果として発光素子を作製できないことが分かった。

【００３２】

【実施例】本発明の第一実施例について、図１、図５、図７を参照して説明する。図１は、本発明の第一実施例であるｐ型単結晶シリコンを用いた発光素子の概略構造図である。図５は、陽極化成法により多孔質シリコンを作製する方法を説明するための図である。図７は、図１に示す発光素子のインジウムティンオキサイド（ＩＴＯ）側に３０Ｖの正電圧を印加した場合における発光スペクトルを表した図である。

【００３３】図１に示す発光素子１は、ｐ型単結晶シリコン基板１２の裏面にＡｌ１１を蒸着し、ｐ型単結晶シリコン基板１２の表面に高速熱窒化多孔質シリコン層１３を形成し、高速熱窒化多孔質シリコン層１３の上にｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４を形成し、さらにｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４の上に透明電極としてＩＴＯ１５を形成したものである。

【００３４】図１に示す発光素子１の製造方法について説明する。先ず、ｐ型単結晶シリコン基板１２（（１００）面、抵抗率０．２～１０Ωｃｍ）の裏面にＡｌ１１を蒸着してオーミックコンタクトをとり、第一中間生成物を作製する。

【００３５】次に、図５に示すように、ｐ型単結晶シリコン基板１２の表面に多孔質化したい部分を除いて第一中間生成物をワックスで覆い、陰極側に白金電極Ｐｔを接続し、また陽極側にＡｌ１１を接続して、白金電極Ｐｔ及び第一中間生成物をエチルアルコール：弗酸（４８％の水溶液）＝１：１の溶液（C_2H_5OH：HF：H_2O）の中に浸す。定電流電源を用いて電流密度を１０

Savant Technologies LLC - 1004.781

～３０ｍＡ／ｃｍ^2 に固定し約３～５分間陽極化成を行うことによって多孔質シリコン層を作製し、第二中間生成物を作製する。

【００３６】第二中間生成物の表面に付着したワックスを有機溶剤で解かし、Ａｌをエッチングし純水で洗浄した後、ｐ型単結晶シリコン基板１２上に作製した多孔質シリコン層を窒素、アンモニア又は窒素及びアンモニア雰囲気中において、赤外線高速加熱炉を用いて８００℃～１２００℃で３０秒～６０秒間熱窒化することにより高速熱窒化多孔質シリコン層１３を作製し、第三中間生成物を作製する。その後再び、ｐ型単結晶シリコン基板１２の裏面にＡｌ１１１を蒸着しオーミックコンタクトをとる。

【００３７】第三中間生成物を電子サイクロトロン共鳴プラズマＣＶＤ装置に入れ、ｎ型の微結晶を含有する非晶質シリコンカーボン合金を高速熱窒化多孔質シリコン層１３の上に１５０オングストローム堆積してｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４を作製し、第四中間生成物を作製する。堆積条件はガス圧０．００５～０．００８Ｔｏｒｒ、投入電力３００Ｗ、SiH_4 ：CH_4 ：PH_3 ：H_2 ＝１：１～３：０．００５～０．０３：１００～２００、基板温度３００℃である。

【００３８】電子ビーム蒸着装置を用い、第四中間生成物のｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４の上に透明電極としてＩＴＯ１５を６００オングストローム堆積し、発光素子１を作製する。

【００３９】ＩＴＯ１５側に３０Ｖの負電圧を印加したときの発光スペクトルは、図７に示すように、発光波長が約４００～７００ｎｍでピーク波長は６００ｎｍであった。

【００４０】本発明の第一実施例によれば、ｐ型単結晶シリコン基板１２上に形成された高速熱窒化多孔質シリコン層１３とｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４からなるｐｎ接合を用いたので、ｐ型単結晶シリコン基板１２から正孔を、またｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４から電子を高速熱窒化多孔質シリコン層１３に良好に注入することができる。また、第一実施例の発光素子は、図７に示すように白色発光となる。

【００４１】また、発光層である多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層１３としたので、多孔質シリコンをターミネートしている水素を窒素に置換することにより熱等の原因によって発光効率が低下するのを防止することができる。

【００４２】さらに、多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層１３としたので、多孔質シリコンの構造を変化させることなく多孔質シリコンをターミネートしている水素を窒素に置換することができる。

【００４３】次に、本発明の第二実施例について、図２、図６、図８を参照して説明する。図２は、本発明の第二実施例であるｎ型単結晶シリコンを用いた発光素子の概略構造図である。図６は、陽極化成法により多孔質シリコンを作製する方法を説明するための図である。図８は、図２に示す発光素子のＩＴＯ側に３０Ｖの正電圧を印加した場合における発光スペクトルを示す図である。

【００４４】図２に示す発光素子２は、ｎ型単結晶シリコン基板２２の裏面にＡｌ２１を蒸着し、ｎ型単結晶シリコン基板２２の表面に高速熱窒化多孔質シリコン層２３を形成し、高速熱窒化多孔質シリコン層２３の上にｐ型の微結晶を含有する非晶質シリコンカーボン合金膜２４を形成し、さらにｐ型の微結晶を含有する非晶質シリコンカーボン合金膜２４の上に透明電極としてＩＴＯ２５を形成したものである。発光素子２の製造方法は、陽極化成を行う際、図６に示すように、ｎ型単結晶シリコン基板２２の多孔質シリコンを作製する面にタングステンランプ光を照射すること、及び、電子サイクロトロン共鳴プラズマＣＶＤ装置を用いてｐ型の微結晶を含有する非晶質シリコンカーボン合金を高速熱窒化多孔質シリコン層２３上に堆積する条件がSiH_4 ：CH_4 ：B_2H_6 ：H_2 ＝１：１～３：０．００５～０．０３：１００～２００であることを除けば、第一実施例と同様であるので、その詳細な説明を省略する。

【００４５】ＩＴＯ２５側に３０Ｖの正電圧を印加したときの発光スペクトルは、図８に示すように、発光波長が約４００～７００ｎｍでピーク波長は６００ｎｍであった。

【００４６】本発明の第二実施例によれば、ｎ型単結晶シリコン基板２２上に形成された高速熱窒化多孔質シリコン層２３とｐ型の微結晶を含有する非晶質シリコンカーボン合金膜２４からなるｐｎ接合を用いたので、ｎ型単結晶シリコン基板２２から電子を、またｐ型の微結晶を含有する非晶質シリコンカーボン合金膜２４から正孔を高速熱窒化多孔質シリコン層２３に良好に注入することができる。その他の効果は、第一実施例と同様である。

【００４７】次に、本発明の第三実施例について、図３を参照して説明する。図３は、本発明の第三実施例であるｐ型単結晶シリコンを用いた発光素子の概略構造図である。

【００４８】図３に示す発光素子３は、ｐ型単結晶シリコン基板３２の裏面にＡｌ３１を蒸着し、ｐ型単結晶シリコン基板３２の表面に高速熱窒化多孔質シリコン層３３を形成し、高速熱窒化多孔質シリコン層３３の上にｎ型の非晶質シリコンカーボン合金（ａ－ＳｉＣ）膜３４を形成し、さらにｎ型の非晶質シリコンカーボン合金膜３４の上に透明電極としてＩＴＯ３５を形成したものである。発光素子３の製造方法は、電子サイクロトロン共

Savant Technologies LLC - 1004.782

鳴プラズマＣＶＤ装置を用いずに通常のプラズマＣＶＤ装置を用いて、ｎ型の非晶質シリコンカーボン合金膜を高速熱窒化多孔質シリコン層３３上に作製できる点を除いては、第一実施例と同様であるので、その詳細な説明を省略する。

【００４９】本発明の第三実施例によれば、通常のプラズマＣＶＤ装置を用いてｎ型の非晶質シリコンカーボン合金膜３４を高速熱窒化多孔質シリコン層３３上に作製することができるので、第一実施例に比べて発光素子の作製装置を簡略化することができる。しかし、非晶質シリコンカーボン合金は、バンドギャップ２．０ｅＶの所で導電率10^{-5} Ｓ／ｃｍであり、微結晶を含有する非晶質シリコンカーボン合金と比べてバンドギャップ、導電率共に低い値を示すため、第一実施例に示す発光素子に比べて若干発光輝度が低下する。その他の効果は、第一実施例と同様である。

【００５０】尚、第三実施例では、ｐ型単結晶シリコン基板３２の表面に高速熱窒化多孔質シリコン層３３を形成し、高速熱窒化多孔質シリコン層３３の上にｎ型の非晶質シリコンカーボン合金膜３４を形成したが、本発明はこれに限定されず、ｎ型単結晶シリコン基板の表面に高速熱窒化多孔質シリコン層を形成し、高速熱窒化多孔質シリコン層の上にｐ型の非晶質シリコンカーボン合金膜を形成するものであってもよい。

【００５１】また、非晶質シリコンカーボン合金膜に代えて微結晶を含有するシリコン（μｃ　Ｓｉ）膜を用いてもよい。しかし、微結晶を含有するシリコンも、微結晶を含有する非晶質シリコンカーボン合金ほどバンドギャップが広い所で導電率を高くすることができなため、非晶質シリコンカーボンを用いた場合と同様に第一実施例に示す発光素子に比べて若干発光輝度が低下する。

【００５２】次に、本発明の第四実施例について、図４を参照して説明する。図４は、本発明の第四実施例であるｐ型単結晶シリコンを用いた発光素子の構造図である。

【００５３】図４に示す発光素子４は、ｐ型単結晶シリコン基板４２の裏面にＡｌ４１を蒸着し、ｐ型単結晶シリコン基板４２の表面に高速熱窒化多孔質シリコン層４３を形成し、高速熱窒化多孔質シリコン層４３の上にＩＴＯ４４を直接形成したものである。発光素子４の製造方法は、電子サイクロトロン共鳴プラズマＣＶＤ装置を用いてｎ型の微結晶を含有する非晶質シリコンカーボン合金を多孔質シリコン層の上に作製する工程がない点を除いては、第一実施例と同様であるので、その詳細な説明を省略する。

【００５４】本発明の第四実施例によれば、高速熱窒化多孔質シリコン層４３の上にＩＴＯ４４を直接形成しているので、第一実施例に比べて、発光素子の構造を簡単にできる。しかし、第一実施例に示す発光素子に比べて若干発光輝度が低下する。その他の効果は、第一実施例と同様である。

【００５５】尚、第四実施例ではｐ型単結晶シリコン基板４２の表面に高速熱窒化多孔質シリコン層４３を形成し、高速熱窒化多孔質シリコン層４３の上にＩＴＯ４４を直接形成したが、本発明はこれに限定されず、ｎ型単結晶シリコン基板の表面に高速熱窒化多孔質シリコン層を形成し、高速熱窒化多孔質シリコン層の上にＩＴＯを直接形成するものであってもよい。

【００５６】また、ＩＴＯ４４に代えてＡｕを用いてもよい。しかし、ＩＴＯを用いた場合と同様に第一実施例に示す発光素子に比べて若干発光輝度が低下する。

【００５７】本発明は、上記の各実施例に限定されるものではなく、その要旨の範囲内において種々の変形が可能である。上記の各実施例では、ｐ型又はｎ型単結晶シリコン基板上に形成された多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層を作製したが、たとえば、ステンレス基板、石英基板等の上に低圧ＣＶＤ法等により形成されたｐ型又はｎ型多結晶シリコン層上に形成された多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層を作製してもよい。多結晶シリコンを用いて発光素子を作製した場合、純粋なシリコンウェハから切り出した単結晶シリコン基板を用いて発光素子を作製する場合に比べて大面積のものを安価に作製することができる。

【００５８】また、多孔質シリコン層を高速熱窒化して高速熱窒化多孔質シリコン層を作製したが、多孔質シリコン層を通常の熱窒化炉に入れて、数秒で取り出すことにより熱窒化多孔質シリコン層を作製するものでも代用できる。

【００５９】

【発明の効果】以上説明したように請求項１記載の発明によれば、ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを発光層として用いたので、その発光層が青色より広いエネルギーバンドギャップ（約２．５ｅＶ以上）を持ち、かつ電子と正孔が発光再結合し、その発光再結合過程のエネルギー差が青から赤まで幅広く有しており、このため白色発光素子が実現できる。

【００６０】また、発光層に多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことにより、ダングリングボンドによる多孔質シリコンの特性劣化を防止することができ、発光効率の低下を防止することができる発光素子を提供することができる。

【００６１】請求項２記載の発明によれば、ｐ型又はｎ型の単結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記単結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたので、発光層である熱窒化多孔質シリコンに正孔や電子を注入し、再結合させることができる。このため、請求項１記載の発明の効果に加えて効率よく発光させることが

Savant Technologies LLC - 1004.783

できる発光素子を提供することができる。

【００６２】請求項３記載の発明によれば、請求項２記載の発明において、半導体として微結晶を含有する非晶質シリコンカーボン合金を用いたので、発光層である熱窒化多孔質シリコンに正孔や電子を良好に注入し、再結合させることができる。このため、請求項１記載の発明の効果に加えて効率よく発光させることができる発光素子を提供することができる。

【００６３】請求項４記載の発明によれば、請求項２記載の発明において、半導体として非晶質シリコンカーボン合金を用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項１記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

【００６４】請求項５記載の発明によれば、請求項２記載の発明において、半導体として微結晶を含有するシリコンを用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項１記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

【００６５】請求項６記載の発明によれば、多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンを用いたことにより、請求項１記載の発明の効果に加えて純粋なシリコンウェハから切り出した単結晶シリコン基板上に作製した熱窒化多孔質シリコンを用いて作製した発光素子に比べて大面積のものを安価に作製できる発光素子を提供することができる。

【００６６】請求項７記載の発明によれば、多結晶シリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコンと前記多結晶シリコンと異なる伝導型を持つ半導体からなるｐｎ接合を用いたので、発光層である熱窒化多孔質シリコンに正孔や電子を注入し、再結合させることができる。このため、請求項６記載の発明の効果に加えて効率よく発光させることができる発光素子を提供することができる。

【００６７】請求項８記載の発明によれば、請求項６記載の発明において、半導体として微結晶を含有する非晶質シリコンカーボン合金を用いたので、発光層である熱窒化多孔質シリコンに正孔や電子を良好に注入し、再結合させることができる。このため、請求項６記載の発明の効果に加えて効率よく発光させることができる発光素子を提供することができる。

【００６８】請求項９記載の発明によれば、請求項６記載の発明において、半導体として非晶質シリコンカーボン合金を用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項６記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

【００６９】請求項１０記載の発明によれば、請求項６記載の発明において、半導体として微結晶を含有するシリコンを用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項５記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

【００７０】請求項１１記載の発明によれば、ｐ型又はｎ型の単結晶又は多結晶のシリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコン上にＩＴＯを直接形成したので、構造の簡単な発光素子を提供することができる。

【００７１】請求項１２記載の発明によれば、ｐ型又はｎ型の単結晶又は多結晶のシリコン上に形成された多孔質シリコンを熱窒化した熱窒化多孔質シリコン上にＡｕを直接形成したので、構造の簡単な発光素子を提供することができる。

【００７２】請求項１３記載の発明によれば、熱窒化多孔質シリコンは、高速熱窒化した高速熱窒化多孔質シリコンであるので、多孔質シリコンの構造を変化させることなく多孔質シリコンをターミネートしている水素を窒素に置換することができ、したがって特性劣化を防止することができる発光素子を提供することができる。

【図面の簡単な説明】

【図１】本発明の第一実施例であるｐ型単結晶シリコンを用いた発光素子の概略構造図である。

【図２】本発明の第二実施例であるｎ型単結晶シリコンを用いた発光素子の概略構造図である。

【図３】本発明の第二実施例であるｐ型単結晶シリコンを用いた発光素子の概略構造図である。

【図４】本発明の第四実施例であるｐ型単結晶シリコンを用いた発光素子の概略構造図である。

【図５】陽極化成法により多孔質シリコンを作製する方法を説明するための図である。

【図６】陽極化成法により多孔質シリコンを作製する方法を説明するための図である。

【図７】図１に示す発光素子のＩＴＯ側に３０Ｖの正電圧を印加した場合における発光スペクトルを表した図である。

【図８】図２に示す発光素子のＩＴＯ側に３０Ｖの正電圧を印加した場合における発光スペクトルを表した図である。

【符合の説明】

１，２，３，４　　発光素子

１１，２１，３１，４１　　Ａｌ

１２，３２，４２　　ｐ型単結晶シリコン基板

１３，２３，３３，４３　　高速熱窒化多孔質シリコン層

１４　　ｎ型の微結晶を含有するシリコンカーボン合金膜

１５，２５，３５，４４　　ＩＴＯ

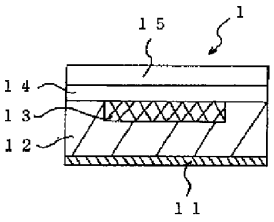
２２　　ｎ型単結晶シリコン基板

２４　　ｐ型の微結晶を含有するシリコンカーボン合金

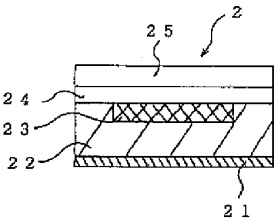
Savant Technologies LLC - 1004.784

膜　　３４　　ｎ型の非晶質シリコンカーボン合金膜

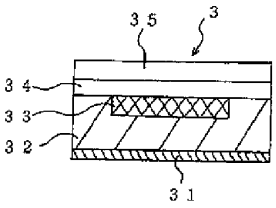
【図１】



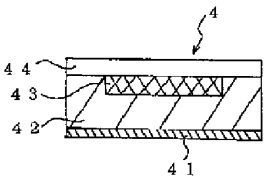
【図２】



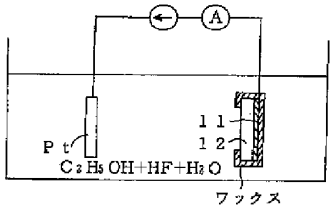
【図３】



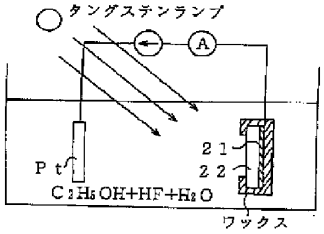
【図４】



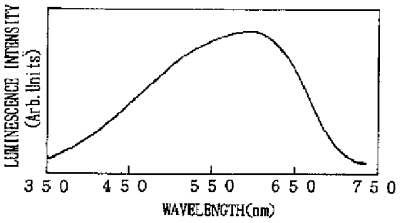
【図５】



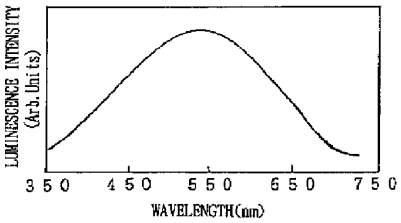
【図６】



【図７】



【図８】



【手続補正書】
【提出日】平成５年６月１８日
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】請求項５
【補正方法】変更
【補正内容】
【請求項５】　前記半導体が微結晶を含有する非晶質シリコンからなることを特徴とする請求項２記載の発光素子。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】請求項１０
【補正方法】変更
【補正内容】
【請求項１０】　前記半導体が微結晶を含有する非晶質シリコンからなることを特徴とする請求項７記載の発光素子。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】００１０
【補正方法】変更
【補正内容】
【００１０】請求項５記載の発明の発光素子は、請求項２記載の発明において、前記半導体が微結晶を含有する非晶質シリコンからなることを特徴とするものである。
【手続補正４】
【補正対象書類名】明細書
【補正対象項目名】００１５
【補正方法】変更
【補正内容】

Savant Technologies LLC - 1004.785

【００１５】請求項１０記載の発明の発光素子は、請求項７記載の発明において、前記半導体が微結晶を含有する非晶質シリコンからなることを特徴とするものである。

【手続補正５】
【補正対象書類名】明細書
【補正対象項目名】００２０
【補正方法】変更
【補正内容】
【００２０】本発明者等は、ｐ型又はｎ型の単結晶シリコン基板（面方位（１１１）及び（１００）、抵抗率０．０５～５０Ωｃｍ）の上に、陽極化成法（エチルアルコール：弗酸（４８％の水溶液）＝０：１～１０：１の水溶液中で、陽極側に単結晶シリコンを接続し、また陰極側に白金等の電極を接続して電流密度：１ｍＡ／ｃｍ^2 ～２００ｍＡ／ｃｍ^2 の電流を流し、単結晶シリコンを加工する方法）で３０秒～１０分間処理することにより、多孔質シリコン（ｐｏｒｏｕｓ　Ｓｉ）層を作製し、その後前記多孔質シリコン層を高速熱窒化（窒素、アンモニア又は窒素及びアンモニア雰囲気中において、８００℃～１２００℃で１０秒～１２０秒間熱窒化を行う）することにより作製した高速熱窒化多孔質シリコン層が紫外光励起により強い白色ホトルミネッセンスを示すことを見いだした。また、高速熱窒化多孔質シリコン上に、高速熱窒化多孔質シリコンを作製した単結晶シリコン基板と異なる伝導型の広いバンドギャップ（２．０～２．４ｅＶ）と高い導電率（10^{-2}～10^{1} Ｓ／ｃｍ）とを有する微結晶を含有する非晶質シリコンカーボン合金（μｃ－ＳｉＣ）を堆積すると良好なｐｎ接合が得られることを見いだした。また、単結晶シリコン基板のかわりにｐ型又はｎ型の多結晶シリコン基板を用い高速熱窒化多孔質シリコンを作製した場合にも、同様の方法で良好なｐｎ接合が得られることを見いだした。

【手続補正６】
【補正対象書類名】明細書
【補正対象項目名】００３７
【補正方法】変更
【補正内容】
【００３７】第三中間生成物を電子サイクロトロン共鳴プラズマＣＶＤ装置に入れ、ｎ型の微結晶を含有する非晶質シリコンカーボン合金を高速熱窒化多孔質シリコン層１３の上に１００～６００オングストローム堆積してｎ型の微結晶を含有する非晶質シリコンカーボン合金膜１４を作製し、第四中間生成物を作製する。堆積条件はガス圧０．００５～０．００８Ｔｏｒｒ、投入電力３００Ｗ、SiH_4 ：CH_4 ：PH_3 ：H_2 ＝１：１～３：０．００５～０．０３：１００～２００、基板温度３００℃である。

【手続補正７】
【補正対象書類名】明細書
【補正対象項目名】００５１
【補正方法】変更
【補正内容】
【００５１】また、非晶質シリコンカーボン合金膜に代えて微結晶を含有する非晶質シリコン（μｃ－Ｓｉ）膜を用いてもよい。しかし、微結晶を含有する非晶質シリコンも、微結晶を含有する非晶質シリコンカーボン合金ほどバンドギャップが広い所で導電率を高くすることができないため、非晶質シリコンカーボンを用いた場合と同様に第一実施例に示す発光素子に比べて若干発光輝度が低下する。

【手続補正８】
【補正対象書類名】明細書
【補正対象項目名】００６４
【補正方法】変更
【補正内容】
【００６４】請求項５記載の発明によれば、請求項２記載の発明において、半導体として微結晶を含有する非晶質シリコンを用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項１記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

【手続補正９】
【補正対象書類名】明細書
【補正対象項目名】００６９
【補正方法】変更
【補正内容】
【００６９】請求項１０記載の発明によれば、請求項６記載の発明において、半導体として微結晶を含有する非晶質シリコンを用いたので、通常のプラズマＣＶＤ装置を用いて発光素子を作製することができる。このため、請求項５記載の発明の効果に加えて作製が容易で安価な発光素子を提供することができる。

Savant Technologies LLC - 1004.786

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-099345
(43)Date of publication of application : 11.04.1995

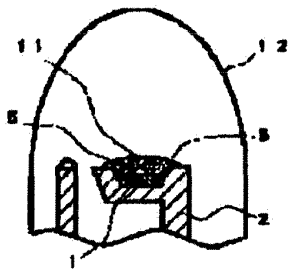
(51)Int.Cl. H01L 33/00
H01L 23/29
H01L 23/31

(21)Application number : 05-241449
(22)Date of filing : 28.09.1993

(71)Applicant : NICHIA CHEM IND LTD
(72)Inventor : MATOBA KOSUKE
KISHI AKITO
NAKAMURA SHUJI

(54) LIGHT EMITTING DIODE

(57)Abstract:
PURPOSE: To provide a LED capable of avoiding color mixture even if the LEDs in different wavelength are closely arranged when a fluorescent pigment is used while the focussing of converted and emitted light is enhanced for increasing the brightness of the LED when a wavelength conversion material is contained in a resin of LED for wavelength conversion of light emitting chip.
CONSTITUTION: A sealing resin of LED comprises the first resin 11 filling up the inside of a cup 3 and the second resin 12 encircling the first resin 11 while the first resin 11 contains the fluorescent material converting the light emitting wavelength of a light emitting chip to the other wavelength or a wavelength converting material 5 such as a filter material, etc., partly absorbing the light emitting wavelength thereby increasing the brightness, focussing efficiency due to the wavelength conversion light reflected on the cup 3.



LEGAL STATUS

[Date of request for examination] 24.04.1996

[Date of sending the examiner's decision of rejection]

Savant Technologies LLC - 1004.787

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	application converted
[Date of final disposal for application]	14.04.1997
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

Savant Technologies LLC - 1004.788

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The first resin with which it is the light emitting diode which comes to close the whole light emitting device by which the luminescence chip was laid in the pars basilaris ossis occipitalis of the cup which reflects luminescence of a luminescence chip in a luminescence observation side side by resin, and said resin is filled up with said interior of a cup, Light emitting diode which consists of the second resin which surrounds the first resin, and is characterized by the fluorescent material which changes the luminescence wavelength of a luminescence chip into other wavelength, or the filter matter which absorbs a part of luminescence wavelength of a luminescence chip containing to said first resin.
[Claim 2] It is the light emitting diode according to claim 1 characterized by for the matter contained in the resin of said first resin being a fluorescent material, and filling up with said first resin so that it may become lower than the horizontal plane of the edge of said cup.

[Translation done.]

Savant Technologies LLC - 1004.789

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to LED which changes or absorbs a part of luminescence of a luminescence chip on wavelength which is applied to light emitting diode (it is called Following LED.), especially is different in the luminescence wavelength of a luminescence chip.
[0002]
[Description of the Prior Art] Drawing 2 is the type section Fig. showing one structure of the conventional LED, and the cup prepared in order for the luminescence chip with which 1 consists of a compound semiconductor, and 2 to reflect luminescence of a luminescence chip in a leadframe and to reflect 3 in a luminescence observation side side, and 4 are resin which closes the whole light emitting device. Usually, although highly transparent resin is chosen in order for resin 4 to emit luminescence of a luminescence chip efficiently into air The fluorescent material which changes luminescence of a luminescence chip into other wavelength into the resin 4 in order to be the purpose which changes the luminescent color of the luminescence chip into others or to amend a color, or filter matter 5 (it is hereafter called the wavelength conversion ingredient 5.) which absorbs a part of luminescence wavelength of luminescence wavelength It may be mixed. In this case, usually it is mixed so that the wavelength conversion ingredient 5 may be distributed to resin 4 at homogeneity.
[0003]
[Problem(s) to be Solved by the Invention] However, when homogeneity is made to distribute the wavelength conversion ingredient 5 in resin 4 for the above-mentioned purpose, as shown in this drawing, the light by which wavelength conversion was carried out, or the light into which unnecessary wavelength was cut are scattered about in all directions in resin 4, and have the problem that condensing worsens. The arrow head of drawing 2 is drawing having shown typically signs that the light by which wavelength conversion of the light of a luminescence chip was carried out in the wavelength conversion ingredient 5 was scattered about. That is, when the light by which wavelength conversion was carried out is scattered about, the quantity of light by the side of a luminescence observation side decreases, and brightness becomes low.
[0004] Moreover, when the wavelength conversion ingredient 5 is limited to a fluorescent material, it approaches and LED of the different luminescent color is installed as a new trouble, there is a problem of excessive luminescence of the fluorescent material by other LED luminescence. For example, green LED containing the fluorescent material from which green luminescence is obtained with a blue luminescence chip, If green LED is switched off and blue LED is turned on when it approaches horizontally on the same flat surface and blue LED which consists only of a mere blue luminescence chip is put in order, by the light which leaks and comes out of blue LED, i.e., the scattered-about light The fluorescent material of green LED is excited, it will be in the condition that green LED which put out the light lit up, and the color mixture of both LED will occur.
[0005] Therefore, the place made into the purpose of this invention sets it as another purpose to offer LED to which color mixture does not happen even if it approaches and installs LED from which wavelength differs, when a fluorescent pigment is used [and] for the purpose of improving condensing of luminescence changed first and raising the brightness of LED, in case the resin of LED is made to contain a wavelength conversion ingredient and wavelength conversion of a luminescence chip is performed.
[0006]

Savant Technologies LLC - 1004.790

[Means for Solving the Problem] The first resin with which LED of this invention is LED which comes to close the whole light emitting device by which the luminescence chip was laid in the pars basilaris ossis occipitalis of the cup which reflects luminescence of a luminescence chip in a luminescence observation side side by resin, and said resin is filled up with said interior of a cup, It consists of the second resin which surrounds the first resin, and is characterized by the fluorescent material which changes the luminescence wavelength of a luminescence chip into said first resin at other wavelength, or the filter matter which absorbs a part of luminescence wavelength of a luminescence chip containing.

[0007]

[Function] LED of this invention absorbs a part of conversion or unnecessary wavelength for luminescence of a luminescence chip on desired wavelength in the first resin. Thus, although the light by which wavelength conversion was carried out is scattered about in all directions, it is reflected by the cup and most scattered light is condensed at a luminescence observation side side.

Savant Technologies LLC - 1004.791

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Industrial Application] This invention relates to LED which changes or absorbs a part of luminescence of a luminescence chip on wavelength which is applied to light emitting diode (it is called Following LED.), especially is different in the luminescence wavelength of a luminescence chip.

[Translation done.]

Savant Technologies LLC - 1004.792

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] Drawing 2 is the type section Fig. showing one structure of the conventional LED, and the cup prepared in order for the luminescence chip with which 1 consists of a compound semiconductor, and 2 to reflect luminescence of a luminescence chip in a leadframe and to reflect 3 in a luminescence observation side side, and 4 are resin which closes the whole light emitting device. Usually, although highly transparent resin is chosen in order for resin 4 to emit luminescence of a luminescence chip efficiently into air The fluorescent material which changes luminescence of a luminescence chip into other wavelength into the resin 4 in order to be the purpose which changes the luminescent color of the luminescence chip into others or to amend a color, or filter matter 5 (it is hereafter called the wavelength conversion ingredient 5.) which absorbs a part of luminescence wavelength of luminescence wavelength It may be mixed. In this case, usually it is mixed so that the wavelength conversion ingredient 5 may be distributed to resin 4 at homogeneity.

[Translation done.]

Savant Technologies LLC - 1004.793

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] Since conversion light reflects inside a cup since LED of this invention has filled up the interior of a cup with the first resin containing a wavelength conversion ingredient as explained above, and it is condensed, brightness improves more than twice. Moreover, when making the cup depth deep and making it the first resin not overflow a cup, and the first resin is made to contain a fluorescent pigment, wavelength conversion is performed and a flat-surface display is realized [the color mixture between LED does not occur, for example,] by LED, an image with very sufficient resolution can be obtained.

[Translation done.]

Savant Technologies LLC - 1004.794

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, when homogeneity is made to distribute the wavelength conversion ingredient 5 in resin 4 for the above-mentioned purpose, as shown in this drawing, the light by which wavelength conversion was carried out, or the light into which unnecessary wavelength was cut are scattered about in all directions in resin 4, and have the problem that condensing worsens. The arrow head of drawing 2 is drawing having shown typically signs that the light by which wavelength conversion of the light of a luminescence chip was carried out in the wavelength conversion ingredient 5 was scattered about. That is, when the light by which wavelength conversion was carried out is scattered about, the quantity of light by the side of a luminescence observation side decreases, and brightness becomes low.
[0004] Moreover, when the wavelength conversion ingredient 5 is limited to a fluorescent material, it approaches and LED of the different luminescent color is installed as a new trouble, there is a problem of excessive luminescence of the fluorescent material by other LED luminescence. For example, green LED containing the fluorescent material from which green luminescence is obtained with a blue luminescence chip, If green LED is switched off and blue LED is turned on when it approaches horizontally on the same flat surface and blue LED which consists only of a mere blue luminescence chip is put in order, by the light which leaks and comes out of blue LED, i.e., the scattered-about light The fluorescent material of green LED is excited, it will be in the condition that green LED which put out the light lit up, and the color mixture of both LED will occur.
[0005] Therefore, the place made into the purpose of this invention sets it as another purpose to offer LED to which color mixture does not happen even if it approaches and installs LED from which wavelength differs, when a fluorescent pigment is used [and] for the purpose of improving condensing of luminescence changed first and raising the brightness of LED, in case the resin of LED is made to contain a wavelength conversion ingredient and wavelength conversion of a luminescence chip is performed.

[Translation done.]

Savant Technologies LLC - 1004.795

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] The first resin with which LED of this invention is LED which comes to close the whole light emitting device by which the luminescence chip was laid in the pars basilaris ossis occipitalis of the cup which reflects luminescence of a luminescence chip in a luminescence observation side side by resin, and said resin is filled up with said interior of a cup, It consists of the second resin which surrounds the first resin, and is characterized by the fluorescent material which changes the luminescence wavelength of a luminescence chip into said first resin at other wavelength, or the filter matter which absorbs a part of luminescence wavelength of a luminescence chip containing.

[Translation done.]

Savant Technologies LLC - 1004.796

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

OPERATION

[Function] LED of this invention absorbs a part of conversion or unnecessary wavelength for luminescence of a luminescence chip on desired wavelength in the first resin. Thus, although the light by which wavelength conversion was carried out is scattered about in all directions, it is reflected by the cup and most scattered light is condensed at a luminescence observation side side. that is, since the cup of this application reflects the light by which wavelength conversion was carried out with the wavelength conversion ingredient and can be condensed within the first resin, the condensing effectiveness of conversion light is markedly alike, and improves.
[0008] Furthermore, if it is filled up with the first resin containing a fluorescent material so that it may become lower than the horizontal plane of the edge of a cup when a wavelength conversion ingredient is used as a fluorescent material, when the light which carries out incidence from the outside is interrupted on the edge of a cup and does not reach even a fluorescent material, the color mixture between LED can be prevented. If it says simply, when making it the first resin which makes the cup depth deep and contains a fluorescent material not overflow a cup, the source of excitation of a fluorescent material can be restricted only to the luminescence wavelength of a luminescence chip.

[Translation done.]

Savant Technologies LLC - 1004.797

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EXAMPLE

[Example] Drawing 1 is the type section Fig. showing the structure of LED of one example of this application, and is taken as the structure which closed the whole light emitting device which laid the luminescence chip 1 which consists of a compound semiconductor like drawing 2 on the leadframe 2 which has a cup 3 by resin. However, a different place from drawing 2 consists of the first resin 11 with which closure resin is filled up with the cup 3 interior, and the second resin 12 which surrounds the first resin, and conversion or the wavelength conversion ingredient 5 which is absorbed in part and to change contains the luminescence wavelength of a luminescence chip to the first resin 11 at other wavelength.
[0010] The same ingredient is sufficient as the ingredient of the first resin 11 and the second resin, for example, it constitutes both from an epoxy resin, and should just make only the first resin contain a fluorescent material 5 in LED of this invention. Furthermore, a good thing cannot be overemphasized even when the ingredient of the second resin 12 is the same as the resin 4 of drawing 2 . Moreover, as long as the wavelength conversion ingredient 5 is an ingredient which can change the luminescence wavelength of luminescence chips, such as fluorescent dye, a fluorescent pigment, and a fluorescent substance, into other wavelength if it is a fluorescent material, it may use what kind of thing, and if it is the filter matter, the unnecessary wavelength of luminescence of a luminescence chip will be absorbed, the ingredient which improves color purity is chosen, and inorganic [which usually has the same color as the luminescent color of a luminescence chip], and an organic filter pigment are used.
[0011] Although the interior of a cup in which the luminescence chip 1 was beforehand laid in order to usually drive out the air of a cup 3 is pre dipped by resin in an LED production process in order to obtain LED of such structure for example In case it pre dips, the first resin 11 is made to contain the wavelength conversion ingredient 5, and after the first resin 11 containing the wavelength conversion ingredient 5 hardens, it can obtain by closing by the second resin 12.

Savant Technologies LLC - 1004.798

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The type section Fig. showing the structure of 1LED of this invention.
[Drawing 2] The type section Fig. showing the structure of the conventional LED.
[Drawing 3] The type section Fig. expanding and showing the part of the cup 3 of LED concerning other examples of this invention.
[Drawing 4] The type section Fig. expanding and showing the part of the cup 3 of LED concerning other examples of this invention.
[Description of Notations]
1 ... Luminescence chip 2 ... Leadframe
3 ... Cup 5 ... Wavelength conversion ingredient
11 ... The first resin 12 ... The second resin

[Translation done.]

Savant Technologies LLC - 1004.799

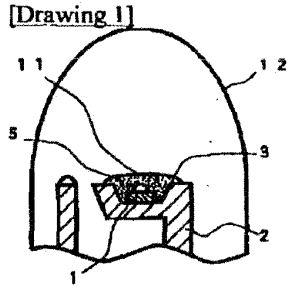
* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

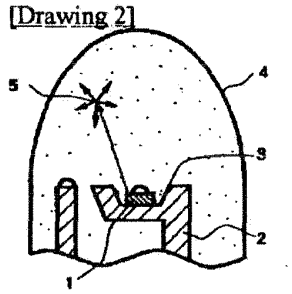
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

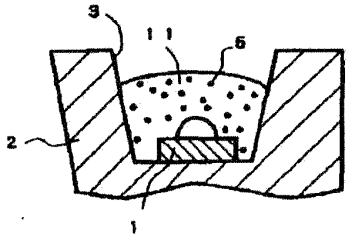
[Drawing 1]



[Drawing 2]

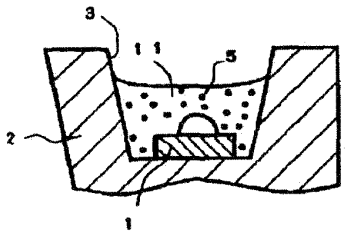


[Drawing 3]



[Drawing 4]

Savant Technologies LLC - 1004.800



[Translation done.]

Savant Technologies LLC - 1004.801

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平7－99345

(43)公開日　平成７年(1995)４月11日

(51)Int.Cl.[6]	識別記号	庁内整理番号	Ｆ Ｉ		技術表示箇所
Ｈ０１Ｌ　33/00	Ｎ				
	Ａ				
	Ｈ				
		8617－4Ｍ	Ｈ０１Ｌ　23/ 30	Ｂ	
		8617－4Ｍ		Ｃ	

審査請求　未請求　請求項の数２　ＯＬ　（全　４　頁）　最終頁に続く

(21)出願番号　特願平5－241449

(22)出願日　平成５年(1993)９月28日

(71)出願人　000226057
日亜化学工業株式会社
徳島県阿南市上中町岡491番地100

(72)発明者　的場　功祐
徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

(72)発明者　岸　明人
徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

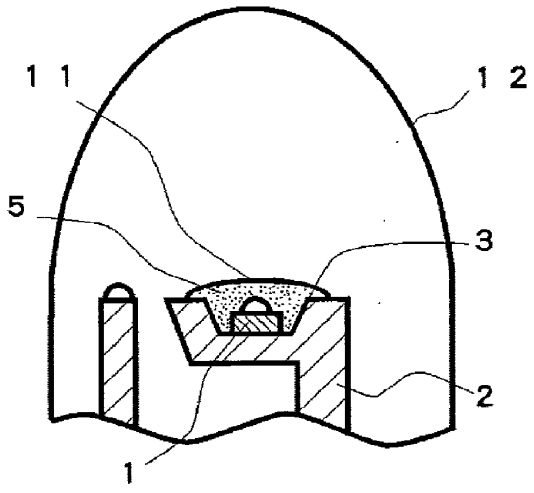
(72)発明者　中村　修二
徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

(54)【発明の名称】　発光ダイオード

(57)【要約】

【目的】　ＬＥＤの樹脂に波長変換材料を含有させて発光チップの波長変換を行う際、まず変換された発光の集光をよくしてＬＥＤの輝度を高めることを目的とし、また蛍光顔料を使用した際、波長の異なるＬＥＤを近接して設置しても混色の起こらないＬＥＤを提供する。

【構成】　ＬＥＤの封止樹脂が、カップ３内部を充填する第一の樹脂１１と、その第一の樹脂を包囲する第二の樹脂１２とからなり、第一の樹脂１１には発光チップの発光波長を他の波長に変換する蛍光物質、または発光波長を一部吸収するフィルター物質等の波長変換材料５が含有されていることにより、波長変換光がカップ３に反射されるため輝度、集光効率が向上する。



Savant Technologies LLC - 1004.802

1

【特許請求の範囲】

【請求項１】　発光チップの発光を発光観測面側に反射するカップの底部に発光チップが載置された発光素子全体を、樹脂で封止してなる発光ダイオードであって、前記樹脂は前記カップ内部を充填する第一の樹脂と、その第一の樹脂を包囲する第二の樹脂とからなり、前記第一の樹脂には発光チップの発光波長を他の波長に変換する蛍光物質、または発光チップの発光波長を一部吸収するフィルター物質が含有されていることを特徴とする発光ダイオード。

【請求項２】　前記第一の樹脂の樹脂に含まれる物質が蛍光物質であって、前記第一の樹脂は前記カップの縁部の水平面よりも低くなるように充填されていることを特徴とする請求項１に記載の発光ダイオード。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は発光ダイオード（以下ＬＥＤという。）に係り、特に発光チップの発光波長を異なる波長に変換する、または発光チップの発光を一部吸収するＬＥＤに関する。

【０００２】

【従来の技術】図２は従来のＬＥＤの一構造を示す模式断面図であり、１は化合物半導体よりなる発光チップ、２はリードフレーム、３は発光チップの発光を発光観測面側に反射させる目的で設けられたカップ、４は発光素子全体を封止する樹脂である。通常、樹脂４は発光チップの発光を空気中に効率よく放出する目的で透明度の高い樹脂が選択されるが、他にその発光チップの発光色を変換する目的で、あるいは色を補正する目的で、その樹脂４の中に発光チップの発光を他の波長に変換する蛍光物質、または発光波長の発光波長を一部吸収するフィルター物質５（以下、波長変換材料５という。）が混入される場合がある。この場合、波長変換材料５は樹脂４に均一に分散するように混入されるのが通常である。

【０００３】

【発明が解決しようとする課題】しかしながら、上記の目的で波長変換材料５を樹脂４中に均一に分散させると、この図に示すように、波長変換された光、または不要な波長がカットされた光は樹脂４中で四方八方に散乱してしまい、集光が悪くなるという問題がある。図２の矢印は発光チップの光が波長変換材料５にあたり、波長変換された光が散乱する様子を模式的に示した図である。つまり、波長変換された光が散乱されることにより、発光観測面側の光量が減少して輝度が低くなるのである。

【０００４】また、波長変換材料５を蛍光物質に限定した場合、新たな問題点として、異なる発光色のＬＥＤを接近して設置した際に、他のＬＥＤ発光による蛍光物質のよけいな発光の問題がある。例えば、青色発光チップで緑色発光が得られる蛍光物質を含む緑色ＬＥＤと、単

2

なる青色発光チップのみからなる青色ＬＥＤとを同一平面上に水平に近接して並べた場合、緑色ＬＥＤを消灯して、青色ＬＥＤを点灯すると、青色ＬＥＤから洩れ出る光、つまり散乱する光により、緑色ＬＥＤの蛍光物質が励起され、消灯した緑色ＬＥＤがあたかも点灯したような状態となり、両ＬＥＤの混色が発生する。

【０００５】従って本発明の目的とするところは、ＬＥＤの樹脂に波長変換材料を含有させて発光チップの波長変換を行う際、まず変換された発光の集光をよくしてＬＥＤの輝度を高めることを目的とし、また蛍光顔料を使用した際、波長の異なるＬＥＤを近接して設置しても混色の起こらないＬＥＤを提供することをもう一つの目的とする。

【０００６】

【課題を解決するための手段】本発明のＬＥＤは、発光チップの発光を発光観測面側に反射するカップの底部に発光チップが載置された発光素子全体を、樹脂で封止してなるＬＥＤであって、前記樹脂は前記カップ内部を充填する第一の樹脂と、その第一の樹脂を包囲する第二の樹脂とからなり、前記第一の樹脂には発光チップの発光波長を他の波長に変換する蛍光物質、または発光チップの発光波長を一部吸収するフィルター物質が含有されていることを特徴とする。

【０００７】

【作用】本発明のＬＥＤは、発光チップの発光を第一の樹脂内において所望の波長に変換、または不要な波長を一部吸収する。このようにして波長変換された光は四方八方に散乱するが、散乱した光のほとんどはカップにより反射され、発光観測面側に集光される。つまり本願のカップは第一の樹脂内で波長変換材料により波長変換された光を反射して集光できるので、変換光の集光効率が格段に向上する。

【０００８】さらに、波長変換材料を蛍光物質とした場合、蛍光物質を含む第一の樹脂をカップの縁部の水平面よりも低くなるように充填すると、外部から入射する光がカップの縁で遮られ、蛍光物質にまで到達しないことにより、ＬＥＤ間の混色を防止することができる。簡単にいうと、カップ深さを深くして蛍光物質を含む第一の樹脂がカップからはみ出さないようにすることにより、蛍光物質の励起源を発光チップの発光波長のみに制限できる。

【０００９】

【実施例】図１は本願の一実施例のＬＥＤの構造を示す模式断面図であり、図２と同様に、カップ３を有するリードフレーム２上に化合物半導体よりなる発光チップ１を載置した発光素子全体を、樹脂で封止した構造としている。しかし、図２と異なるところは、封止樹脂がカップ３内部を充填する第一の樹脂１１と、その第一の樹脂を包囲する第二の樹脂１２とからなり、第一の樹脂１１には発光チップの発光波長を他の波長に変換、または一

Savant Technologies LLC - 1004.803

3

部吸収する変換する波長変換材料５が含有されている。

【００１０】本発明のＬＥＤにおいて、第一の樹脂１１と第二の樹脂の材料は同一材料でもよく、例えば両方ともエポキシ樹脂で構成し、第一の樹脂にのみ蛍光物質５を含有させればよい。さらに、第二の樹脂１２の材料は図２の樹脂４と同一でもよいことはいうまでもない。また、波長変換材料５は蛍光物質であれば蛍光染料、蛍光顔料、蛍光体等、発光チップの発光波長を他の波長に変換できる材料であればどのようなものを使用してもよく、またフィルター物質であれば発光チップの発光の不要な波長を吸収し、色純度をよくする材料が選択され、通常発光チップの発光色と同一色を有する無機、有機のフィルター顔料が使用される。

【００１１】このような構造のＬＥＤを得るには、例えばＬＥＤ製造工程において、通常カップ３の空気を追い出す目的で、予め発光チップ１を載置したカップ内部を樹脂でプレディップするのであるが、プレディップする際に第一の樹脂１１に波長変換材料５を含有させておき、波長変換材料５を含む第一の樹脂１１が硬化した後、第二の樹脂１２で封止することにより得ることができる。また予め波長変換材料５を含む第一の樹脂１１をカップ３内部に注入してもよい。このようにして、波長変換材料５を含む第一の樹脂１１をカップの３の内部に充填し、第一の樹脂１１で波長変換された光のほとんどがカップ３の反射鏡内に戻り、発光観測面に反射することによりＬＥＤの集光が格段に向上する。

【００１２】また第一の樹脂１１と第二の樹脂１２とを異なる材料とし、第一の樹脂１１、第二の樹脂１２の屈折率を順に小さくして空気の屈折率１に近くなるように設定することにより波長変換された光の外部量子効率が向上する。なおこの場合、第一の樹脂１１の材料には、発光チップ１の屈折率よりも小さい材料を選定することは言うまでもない。

4

【００１３】図３、および図４は本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図であり、図３は第一の樹脂１１の表面が凸状になって硬化してカップ３に充填された状態、図４は逆に凹状となって硬化して充填された状態を示している。いずれの状態においても、波長変換材料５を蛍光物質とした場合、その蛍光物質を含む第一の樹脂１１がカップ３の縁部の水平面よりも低くなるように充填されており、カップ３からはみ出していないので、カップ３の縁部により蛍光物質を励起する外部光を遮断でき、ＬＥＤの混色を防止することができる。

【００１４】

【発明の効果】以上説明したように、本発明のＬＥＤはカップ内部に波長変換材料を含有する第一の樹脂を充填しているため、変換光がカップ内部で反射して集光されるため、輝度は倍以上に向上する。また、蛍光顔料を第一の樹脂に含有させて波長変換を行う場合、カップ深さを深くして、第一の樹脂がカップからはみ出さないようにすることにより、ＬＥＤ間の混色が発生せず、例えばＬＥＤで平面ディスプレイを実現した際には、非常に解像度のよい画像を得ることができる。

【図面の簡単な説明】

【図１】　本発明の一ＬＥＤの構造を示す模式断面図。

【図２】　従来のＬＥＤの構造を示す模式断面図。

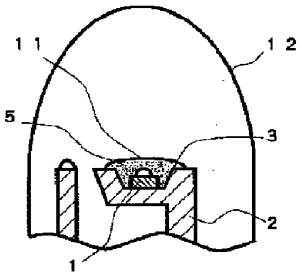
【図３】　本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図。

【図４】　本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図。

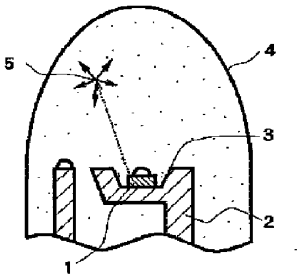
【符号の説明】

１・・・発光チップ	２・・・リードフレーム
３・・・カップ	５・・・波長変換材料
１１・・・第一の樹脂	１２・・・第二の樹脂

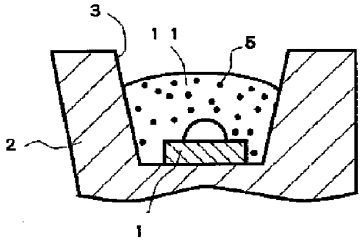
【図１】



【図２】

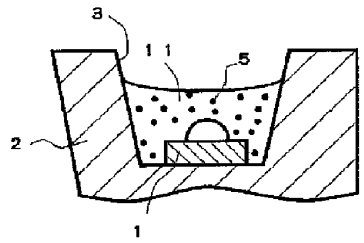


【図３】



Savant Technologies LLC - 1004.804

【図４】



フロントページの続き

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　23/29				
23/31				

Savant Technologies LLC - 1004.805

(Translation)

Japanese Patent Application Publication No. 176794/1995

Published: July 14, 1995

Japanese Patent Application No. 318276/1993

Filed: December 17, 1993

Inventors: Yoshinori Shimizu

Applicant: Nichia Corporation

Title: PLANAR LIGHT SOURCE

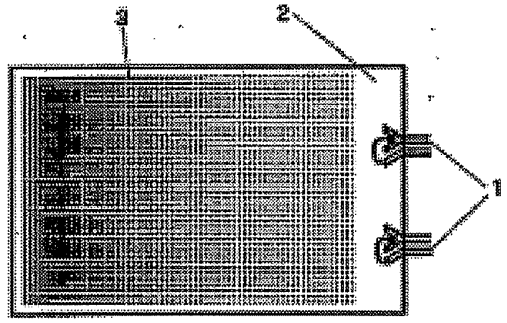
[Abstract]

[Object]

To realize a planar light source which can emit white light by use of a blue light emitting diode and to provide a planar light source which makes it possible to observe uniform white light emission.

[Constitution]

Light emitting diodes are optically connected to an end face of a transparent light guide plate. Further, either one of the main surfaces of the light guide plate has a fluorescent light scattering layer coated with a mixture of a fluorescent substance excited upon light emission from the blue light emitting diode to emit fluorescent light and a white powder for scattering the fluorescent light. The light emission from the blue light emitting diode is converted, in terms of wavelength, with the fluorescent light scattering layer.



Savant Technologies LLC - 1004.806

[Claims]

1. A planar light source characterized in that:

a blue light emitting diode is optically connected to at least one place in an end face of a transparent light guide plate; further

either one of the main surfaces of the light guide plate has a fluorescent light scattering layer coated with a mixture of a fluorescent substance excited upon light emission from the blue light emitting diode to emit fluorescent light and a white powder for scattering the fluorescent light;

the light emission from the blue light emitting diode is converted, in terms of wavelength, with the fluorescent light scattering layer, and is observed from the side of the main surface of the light guide plate opposite to the fluorescent light scattering layer.

2. A planar light source according to claim 1 wherein the blue light emitting diode has a main emission wavelength of shorter than 500 nm and an emission output of at least 500 μW.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a planar light source for use, for example, as a backlight of displays, or in an illumination type operation switch, more specifically, relates to a planar light source which can be suitably used as a backlight for liquid crystal displays.

[0002]

[Prior Art]

Generally, EL and cold cathode ray tubes, for example, are used as planar light sources for backlighting of liquid crystal displays for use in laptop type personal computers, word processors and the like. EL is a planar light source *per se*, and cold cathode ray tubes serve as planar light sources with the help of a diffuser. Currently, most of the light emission colors from such backlighting are white.

[0003]

On the other hand, light emitting diodes (hereinafter abbreviated as "LEDs") are utilized in part as light sources for backlighting use. However, when LEDs are used to obtain white light emission, there are conventionally some drawbacks. Namely, blue LEDs have a poor emission output of several tens of microwatts. Thus, when

Savant Technologies LLC - 1004.807

other red and green LEDs are used to realize white light emission, the properties of these LEDs are difficult to match, so that the color of the light obtained greatly varies. Further, even when three primary color LEDs were gathered and positioned at geometrically the same position in the same plane, those LEDs could not provide uniform white light emission as viewed from a close position when used as backlights. Accordingly, planar white light sources for liquid crystal backlights are used separately depending on the size required. More specifically, cold cathode ray tubes are used as large-sized planar light sources, and ELs are used as middle to small-sized planar light sources. Backlight for white light emission using LEDs is hardly known.

[0004]

As light sources for white light emission or monochrome light source, some attempts have been made to enclose the periphery of a blue LED chip with a resin containing a fluorescent substance for color conversion. However, since the periphery of the chip is exposed to light beams having a radiant intensity higher than that of sunlight, the deterioratoin of the fluorescent substance becomes problematic, and is notable, especially, for organic fluorescent pigments. Further, ionic organic dyes can cause electrophoretic migration due to direct electric field, leading to changes in color tone. Additionally, conventional blue LEDs merely had insufficient output for color conversion with a fluorescent substance, and were not practicable even if color-changed.

[0005]

[Problem to be solved by the Invention]

The present invention has been made to solve these drawbacks, and an object thereof is to realize a planar light source which can use LEDs to emit white light, and can also be mainly utilized as a backlight, and also to provide a planar light source which makes it possible to observe uniform white light emission. A further object of the present invention is to provide a planar light source which can emit light of any color other than white, and to utilize the properties of highly reliable LEDs, and to use such a planar light source in various operation switch applications and the like.

[0006]

[Means for Solving the Problem]

The planar light source of the present invention is characterized in that

a blue light emitting diode is optically connected to at least one place in an end face of a transparent light guide plate; further

Savant Technologies LLC - 1004.808

either one of the main surfaces of the light guide plate has a fluorescent light scattering layer (hereinafter, the main surface on the fluorescent light scattering layer side referred to as the "second main surface") coated with a mixture of a fluorescent substance excited, upon light emission from the blue light emitting diode, to emit fluorescent light, and a white powder for scattering the fluorescent light;

part of the light emission from the blue light emitting diode is converted, in terms of wavelength, with the fluorescent light scattering layer, and is observed from the side of the main surface (hereinafter, the main surface on the light emission observation side referred to as the "first main surface") of the light guide plate opposite to the fluorescent light scattering layer.

[0007]

FIG. 1 is a plane view when a light guide plate 2 of a planar light source according to the present invention is viewed from the side of a fluorescent light scattering layer 3. The light guide plate 2 is made, for example, of a transparent material such as an acrylic resin or glass. A blue LED 1 is embedded in an end face of the light guide plate 2 so that the light guide plate 2 and the blue LED 1 are optically connected to each other. In the meantime, the state where "the blue LED 1 and an end face of the light guide plate 2 are optically connected to each other" briefly refers to the introduction, from the end face of the light guide plate 2, of the light emitted from the blue LED. For example, this can be realized not only by embedding the blue LED 1 as shown in this figure, but also by adhering the blue LED to the end face or by guiding the light emission from the blue LED to the end face of the light guide plate 2 by means of an optical fiber or the like.

[0008]

Next, an ink obtained by blending a fluorescent substance and a white pigment is applied to a fluorescent light scattering layer 3 to enable observation of the desired color. The light emitted from the blue LED 1 is converted, in terms of wavelength, with the fluorescent substance, and, at the same time, the fluorescent light is scattered with the white pigment within the light guide plate 2. Especially, in FIG. 1, the fluorescent light scattering layer 3 is formed into a dotted sheet, and has such a pattern that, as closer to the LED 1, the area of the fluorescent light scattering layer 3, per unit area, on the second main surface side becomes smaller. Further, the area of the end part of the second main surface most distant from the LED 1 is slightly smaller than the maximum area. Here, the symbol "■" in FIG. 1 represents the pattern of the

Savant Technologies LLC - 1004.809

fluorescent light scattering layer 3. Although two blue LEDs are arranged on one end face in FIG. 1, LEDs may, of course, be connected to all the four end faces of the light guide plate when formed into a rectangle. The number of LEDs is not limited. In addition, the coating form or state of the fluorescent light scattering layer can be suitably varied to uniformize, over the plane, the light emission observed from the first main surface side.

[0009]

[Action]

FIG. 2 is a cross-sectional diagram when the planar light source according to the present invention is mounted, for example, as a backlight for use in liquid crystal panels. In this arrangement, a reflection plate is provided on the side of the second main surface of the planar light source shown in FIG. 1, which has been formed by laminating a scattering reflection layer 6 comprising, for example, barium titanate, titanium oxide, aluminium oxide or the like and a base 7 comprising, for example, Al. Further, a light diffuser 5 having an uneven surface is provided on the side of the first main surface. This arrangement does not especially differ from that of a backlight using a cold cathode ray tube as a light source.

[0010]

First, part of the light emitted from the blue LED 1 is radiated to the outside, not to the light guide plate, near the chip, as indicated by an arrow in FIG. 2. Most of the light, repeating full reflection through the light guide plate 2, reaches the end face of the light guide plate. The light, which has reached the end face, is reflected on reflection films 4 formed on all the end faces, and repeats full reflection. At this time, part of the light is scattered by the fluorescent light scattering layer 3 provided on the second main surface side of the light guide plate 2, and another part of the light is absorbed by the fluorescent substance, simultaneously, converted in terms of wavelength, and then emitted. As the color of the emitted light observed from the first main surface of the light guide plate 2, the color of the light obtained by compositing these light can be observed. For example, as for the planar light source provided with a fluorescent light scattering layer 3 comprising an orange fluorescent pigment and a white pigment, the light emitted from the blue LED turns to be blue due to the above-described action, and then can be observed. Further, the color tone can be optically adjusted by changing the blending ratio between the fluorescent substance type and the white pigment. Especially, one blue LED has an emission wavelength of

Savant Technologies LLC - 1004.810

shorter than 500 nm at its main emission peak, and is required to have an emission output of at least 200 μW, more preferably 300 μW, in the present invention. The reason for this is as follows. All the colors become difficult to be realized when the emission wavelength is 500 nm or more. Further, when the emission output is less than 200 μW, the light source tends to be difficult to provide uniform planar light emission with sufficient brightness even when having more blue LEDs optically connected to the end face of the light guide plate.

[0011]

[Examples]

[Example 1]

A fluorescent light scattering layer 3 was formed, by screen printing method, on one surface of an acrylic plate having a thickness of about 2 mm in the dot pattern shown in FIG. 1. The fluorescent light scattering layer 3 was formed by printing method, on the acrylic plate, a product obtained by blending a fluorescent pigment comprising a mixture of a red fluorescent pigment, FA-001, available from SINLOIH Co., Ltd. and a green fluorescent pigment, FA-005, available therefrom in equal amounts, and barium titanate as a white powder in a weight ratio of 1 : 5, and dispersing the mixture in an acrylic binder.

[0012]

Next, the acrylic plate formed with the thus formed fluorescent light scattering layer was cut in accordance with a desired pattern. After all the end faces (cut surfaces) of the acrylic plate were polished, a reflection layer 4 comprising A1 was formed on the polished surfaces, thereby obtaining a light guide plate 2 formed with the fluorescent light scattering layer 3.

[0013]

The end face of the light guide plate 2 was perforated at two places, and one blue LED comprising a gallium nitride-based compound semiconductor and having an emission wavelength of 480 nm and an emission output of 1200 μW was embedded in the respective holes, thereby obtaining a planar light source according to the present invention. When the blue LEDs in this planar light source were lightened at the same time, substantially-uniform, rather-yellowish white planar light emission was obtained from the light emission observation plane side of the light guide plate 2. Further, a preliminarily matted light diffuser 5 and a reflection plate obtained by applying a barium titanate layer 6 to an Al base 7 were provided on the sides of the light emission

Savant Technologies LLC - 1004.811

observation plane and the fluorescent light scattering layer 3, respectively. When this light source was used for backlighting use, completely uniform planar white light emission was obtained from the side of the light diffuser 5. The brightness was 55 cd/m^2.

[0014]

[Example 2]

A planar light source according to the present invention was obtained in a similar manner as in Example 1, except that a fluorescent light scattering layer 3 was formed by using a mixture of a fluorescent dye obtained by blending a yellow fluorescent dye, LumogenF Yellow-083, available from BASF and an orange fluorescent dye, Orange-240, available therefrom in substantially equal amounts, and then dissolving the mixture in butyl carbitol acetate, and barium titanate as a while substance in a weight ratio of 1 (dye) : 200. Then, substantially uniform planar light emission was observed. Further, when this light source was similarly used for backlighting use, completely uniform planar light emission was observed.

[0015]

[Effect of the Invention]

Since the planar light source of the present invention employs blue LEDs, and, additionally, and has a fluorescent light scattering layer which contains a fluorescent substance and a white powder and can convert the wavelength of the light emitted from the blue LEDs, as explained above, it has been possible to realize a planar light source comprising highly reliable LEDs. Further, since the white powder contained in the fluorescent light scattering layer has the function to reflect and diffuse the light converted in terms of wavelength with the fluorescent substance, the amount of the fluorescent substance used may be small. More advantageously, the LED chips and the fluorescent substance are not in direct contact, resulting in less deterioration of the fluorescent substance and no change in color tone of the planar light source over a long term. Further, concerning the color tone, any color tone, including white, can be provided by changing the types of the fluorescent substance and white powder, amounts thereof to be blended, and the like.

[0016]

As the exciters for the fluorescent light scattering layer, on the other hand, blue LEDs having a light emission of 200 μW or more are most preferably used. Accordingly, the fluorescent substance can efficiently convert the wavelength of the

Savant Technologies LLC - 1004.812

light emission, thereby making it possible to attain a bright planar light source with a large area. In this manner, the planar light source of the present invention can be used not only as a light source for backlighting, but also in an illumination type operation switches using a fluorescent substance.

[Brief Description of the Drawings]

FIG. 1 is a plane view when a light guide plate 2 of a planar light source according to one embodiment of the present invention is viewed from the side of a fluorescent light scattering layer 3.

FIG. 2 is a cross-sectional diagram when a planar light source according to one embodiment of the present invention is equipped as a backlight.

[Explanation of Reference Numerals]

1. Blue-color LED
2. Light guide plate
3. Fluorescent scattering layer
4. Reflection layer
5. Light diffuser
6. Scattering reflection layer
7. Al base

Fig. 1

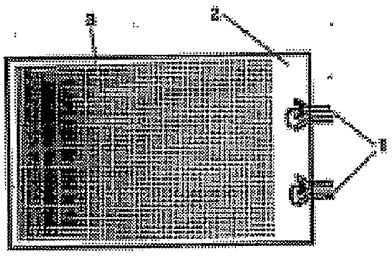
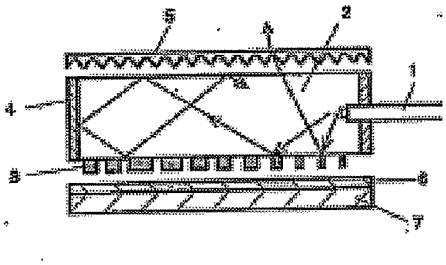


Fig. 2



Savant Technologies LLC - 1004.813

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（A）　(11)特許出願公開番号

特開平7－176794

(43)公開日　平成７年(1995)７月14日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　33/00		Ｎ		
Ｇ０９Ｆ　9/00	３３６	Ｈ　7610－5Ｇ		

審査請求　未請求　請求項の数２　ＯＬ　（全４頁）

(21)出願番号　特願平5－318276

(22)出願日　平成５年(1993)12月17日

(71)出願人　000226057
日亜化学工業株式会社
徳島県阿南市上中町岡491番地100

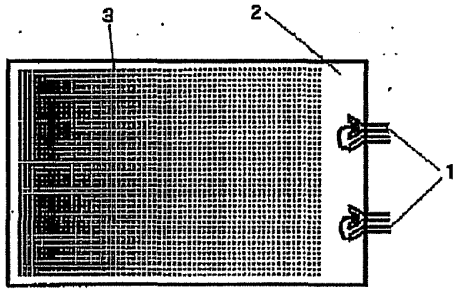
(72)発明者　清水　義則
徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

(54)【発明の名称】　面状光源

(57)【要約】

【目的】　青色発光ダイオードを用いた白色可能な面状光源を実現し、均一な白色発光を観測できる面状光源を提供する。

【構成】　透明な導光板の端面に発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換される。



Savant Technologies LLC - 1004.814

1

【特許請求の範囲】

【請求項1】　透明な導光板の端面の少なくとも一箇所に青色発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の主面側から観測されることを特徴とする面状光源。

【請求項2】　前記青色発光ダイオードは、その主発光波長が５００ｎｍよりも短く、発光出力が５００μＷ以上であることを特徴とする請求項１に記載の面状光源。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明はディスプレイのバックライト、照光式操作スイッチ等に使用される面状の光源に係り、特に液晶ディスプレイのバックライトとして好適に用いることができる面状光源に関する。

【０００２】

【従来の技術】一般にノート型パソコン、ワープロ等に使用される液晶ディスプレイのバックライト用の面状光源には、例えばＥＬ、冷陰極管が使用されている。ＥＬはそれ自体が面状光源であり、冷陰極管は拡散板を用いて面状光源とされ、現在それらのバックライトの発光色はほとんどが白色とされている。

【０００３】一方発光ダイオード（以下ＬＥＤと記す。）もバックライト用光源として一部利用されている。しかしＬＥＤを用いて白色発光を得る場合、従来では青色ＬＥＤの発光出力が数十μＷほどしかないため、他の赤色ＬＥＤ、緑色ＬＥＤを用いて白色発光を実現させるには、それら各色発光ＬＥＤの特性を合致させにくく色変化が大きいという欠点がある。また、三原色のＬＥＤを集合させて、同一平面上に幾何学的に同じ位置に配置しても、バックライトとしてはそれらのＬＥＤを接近した位置で視認するため、均一な白色光源にすることは不可能であった。従って現在白色の液晶バックライトの面状光源には、大型では冷陰極管、小型～中型にはＥＬと使い分けられているのが現状で、ＬＥＤを用いた白色発光のバックライトはほとんど知られていない。

【０００４】また白色発光、あるいはモノクロの光源として、一部では青色ＬＥＤチップの周囲を蛍光物質を含む樹脂で包囲して色変換する試みもあるが、チップ周辺は太陽光よりも強い放射強度の光線にさらされるため、蛍光物質の劣化が問題となり、特に有機蛍光顔料で顕著である。更にイオン性の有機染料はチップ近傍では直流電界により電気泳動を起こし、色調が変化する可能性がある。また従来の青色ＬＥＤは蛍光物質で色変換するには十分な出力を有しておらず、たとえ色変換したとしても実用できるものではなかった。

2

【０００５】

【発明が解決しようとする課題】本発明はこのような欠点を解決するために成されたもので、その目的とするところは、ＬＥＤを用い、主としてバックライトとして利用できる白色発光可能な面状光源を実現すると共に、均一な白色発光を観測できる面状光源を提供することにあり、さらには白色以外の任意色の発光が可能な面状光源を提供し、信頼性に優れたＬＥＤの特性を利用し、各種操作スイッチ等に利用することにある。

【０００６】

【課題を解決するための手段】本発明の面状光源は、透明な導光板の端面の少なくとも一箇所に青色ＬＥＤが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層（以下、蛍光散乱層側の主面を第二の主面という。）を有し、前記青色発光ダイオードの発光の一部が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の主面（以下発光観測側の主面を第一の主面という。）側から観測されることを特徴とする。

【０００７】図１は本発明の面状光源の導光板２を蛍光散乱層３側から見た平面図である。導光板２は例えばアクリル、硝子等の透明な材料よりなり、その導光板２の端面に青色ＬＥＤ１が埋設されることにより、導光板２と青色ＬＥＤ１とが光学的に接続されている。なお本発明において、青色ＬＥＤ１と導光板２の端面とが光学的に接続されているとは、簡単に言えば、導光板２の端面から青色ＬＥＤの光を導入することをいい、例えばこの図に示すように青色ＬＥＤ１を埋設することはもちろんのこと、青色ＬＥＤを接着したり、また、光ファイバー等を用いて導光板２の端面に青色ＬＥＤの発光を導くことによって実現可能である。

【０００８】次に、蛍光散乱層３は、所望の色が観測できるように、蛍光物質と白色顔料とを調合したインクが塗布されてなり、青色ＬＥＤ１の発光を蛍光物質で波長変換すると同時に、白色顔料でその蛍光を導光板２内に散乱させている。特に図１では前記蛍光散乱層３をドット状とし、第一の主面側の表面輝度が一定となるように、ＬＥＤ１に接近するにつれて、第二の主面側の単位面積あたりの蛍光散乱層３の面積を減じるようなパターンとし、さらにはＬＥＤ１と最も離れた第二の主面の端部の面積はやや最大面積に比して若干小さくしている。ここで、図１中の■は蛍光散乱層３のパターンを表している。図１では青色ＬＥＤを一つの端面に２個配した構造としているが、導光板が四角形であれば四方の端面全てにＬＥＤを接続してもよいことはいうまでもなく、ＬＥＤの個数も限定するものではない。さらに、ＬＥＤの配置状況により、第一の主面側から観測する発光を面状均一とするように蛍光散乱層の塗布形状、塗布状態を適

Savant Technologies LLC - 1004.815

宜変更することができる。

【0009】

【作用】図2は本発明の面状光源を例えば液晶パネルのバックライトとして実装した場合の模式断面図である。これは図1に示す面状光源の第二の主面側に、例えばチタン酸バリウム、酸化チタン、酸化アルミニウム等よりなる散乱反射層6と、例えばAlよりなるベース7とが積層された反射板を設置し、第一の主面側に表面が凹凸とされている光拡散板5を設置しており、これらの構成は光源を冷陰極管とするバックライトと特に変わるものではない。

【0010】まず図2の矢印で示すように、青色LED1から出た光は、チップ近傍で一部導光板以外の外部に放射されるが、大部分の光は導光板2の中を全反射を繰り返しながら、導光板の端面に達する。端面に達した光は端面全てに形成された反射膜4に反射されて、全反射を繰り返す。この時、導光板2の第二の主面側に設けられた蛍光散乱層3により一部の光は散乱され、また一部の光は蛍光物質により吸収され同時に波長変換されて放射され、導光板2の第一の主面側から観測する発光色はこれらの光を合成した光が観測できる。例えば橙色の蛍光顔料と白色顔料からなる蛍光散乱層3を設けた面状光源では、先に述べた作用により、青色LEDからの発光色が白色となって観測できる。また色調は蛍光物質の種類と白色顔料の混合比により任意に調整できる。特に本発明では一つの青色LEDの発光波長はその主発光ピークが500nmよりも短く、その発光出力は200μW以上、更に好ましくは300μW以上の出力が必要である。なぜなら発光波長が500nm以上であると全ての色が実現しにくくなり、またその発光出力が200μWよりも少ないと、たとえ導光板の端面に光学的に接続する青色LEDの数を増やしても、充分な明るさの均一な面状発光の光源が得られにくい傾向にあるからである。

【0011】

【実施例】

[実施例1] 厚さ約2mmのアクリル板の片面に、図1に示すドット状のパターンで、蛍光散乱層3をスクリーン印刷により形成した。蛍光散乱層3は、赤色蛍光顔料であるシンロイヒ化学製FA－001と緑色蛍光顔料である同社製FA－005とを等量に混合した蛍光顔料と、白色粉末としてチタン酸バリウムとを重量比で1：5の割合で混合し、それをアクリル系バインダー中に分散したものを印刷して形成した。

【0012】次に上記のようにして蛍光散乱層が形成されたアクリル板を、所望のパターンに従って切断し、アクリル板の端面（切断面）を全て研磨した後、研磨面にAlよりなる反射層4を形成することにより、蛍光散乱層3が形成された導光板2を得た。

【0013】前記導光板2の端面に二箇所、穴を設け、その穴に発光波長480nm。発光出力1200μWを

有する窒化ガリウム系化合物半導体よりなる青色LEDをそれぞれ1個づつ埋め込むことにより、本発明の面状光源を得た。この面状光源の青色LEDを同時に点灯させたところ、導光板2の発光観測面側からはやや黄色みを帯びた白色のほぼ均一な面状発光が得られた。さらに、発光観測面側に予めマット加工が施された光拡散板5と、蛍光散乱層3側にAlベース7上にチタン酸バリウム層6が塗布された反射板を設置して、バックライト用光源としたところ、光拡散板5側から完全に面状均一な白色発光が得られた。輝度は55cd／m²であった。

【0014】[実施例2] 蛍光散乱層3を、黄色蛍光染料としてBASF社のLumogenF Yellow－083と橙色蛍光染料として同社製Orenge－240とをほぼ等量混合し、それらをブチルカルビトールアセテートに溶解した蛍光染料と、白色物質としてチタン酸バリウムとを重量比で1（染料）：200の割合で混合したものを用いて形成する他は、実施例1と同様にして本発明の面状光源を得たところ、ほぼ均一な面状発光が観測された。さらに同様にしてバックライト用光源としたところ、完全に均一な面状発光が観測された。

【0015】

【発明の効果】以上説明したように、本発明の面状光源は、青色LEDを用い、しかも導光板の片方の面に青色LEDにより波長変換できる蛍光物質と白色粉末とを含有した蛍光散乱層を有していることにより、信頼性に優れたLEDによる面状光源を実現することが可能となった。しかも蛍光散乱層の白色粉末は、蛍光物質により波長変換された光を反射、拡散させる作用があるため、使用する蛍光物質の使用量が少なくて済む。更に好都合なことには、LEDチップと蛍光物質とが直接接することがないので、蛍光物質の劣化が少なく、長期間に渡って面状光源の色調変化を起こすことがない。さらに、色調に関しては、蛍光物質、白色粉末の種類、混合量等を変更することにより、白色を含め任意の色調を提供することができる。

【0016】一方蛍光散乱層を励起する側として、最も好ましくは使用する青色LEDの発光出力が200μW以上のものとすることにより、蛍光物質により効率的に波長変換して大きな面積の明るい面状光源を実現することができる。このように、本願の面状光源は、バックライト用光源とだけでなく、蛍光物質を利用した照光式操作スイッチ等に利用することもできる。

【図面の簡単な説明】

【図1】　本発明の一実施例の面状光源の導光板2を蛍光散乱層3側から見た平面図。

【図2】　本発明の一実施例の面状光源をバックライトとして実装した場合の模式断面図。

【符号の説明】

1・・・・・青色LED

Savant Technologies LLC - 1004.816

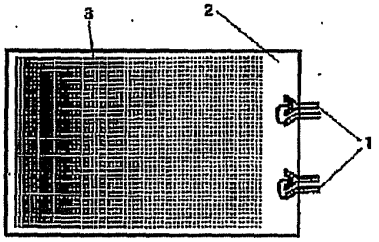
5

2・・・・・導光板
3・・・・・蛍光散乱層
4・・・・・反射層

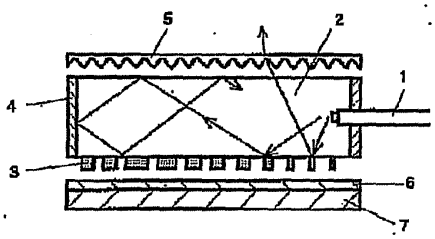
6

5・・・・・光拡散板
6・・・・・散乱反射層
7・・・・・Alベース

【図1】



【図2】



Savant Technologies LLC - 1004.817

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-235207
(43)Date of publication of application : 05.09.1995

(51)Int.Cl. F21V 8/00
G02B 6/00
G02F 1/1335

(21)Application number : 06-022347
(22)Date of filing : 21.02.1994

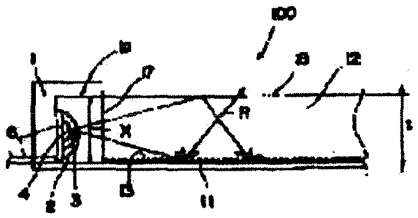
(71)Applicant : COPAL CO LTD
(72)Inventor : SEKINE MITSUHARU

(54) BACK LIGHT

(57)Abstract:

PURPOSE: To thin a back light and prevent light leakage by making the opening width of a reflecting cover almost the same with the thickness of a light diffusing plate end face, in a structure wherein light is made incident from the side face of the diffusing plate having a reflecting face on its bottom and radiated out of the face opposite to the reflecting face.

CONSTITUTION: LED light R emitted out of a LED element 4 goes straight or is reflected on a reflecting sheet 11 or a reflecting end face 1a to be incident upon a diffusing plate 12. The light R is repeatedly reflected between the inner face of a radiating face 18 and a diffusing face 13, which is the bottom of the diffusing plate and the light reaches the radiating face 18 at critical angle or more is radiated to the outside. In this case, a gradation pattern is formed in the diffusing face 13 due to a large number of projected parts formed more densely as the distance from the element 4 is larger and the light is diffused and reflected efficiently and at the same time the brightness of the light R is made uniform. With this structure, since the width X of the opening part of a reflecting cover 1 in the light emitting part and the thickness (t) of the diffusing plate 12 are set almost equal to each other, the gap between them is eliminated to thin the structure and the light R is prevented from leaking outside.



LEGAL STATUS

Savant Technologies LLC - 1004.818

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Savant Technologies LLC - 1004.819

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] It is the back light which a base is made to carry out ON light of the light of the light source from the side-face edge of the optical diffusion plate member which comes to have a reflector, and acts as Idemitsu from the reflector of said optical diffusion plate member, and the field of the opposite side. The back light characterized by making the board thickness of said optical diffusion plate member carry out abbreviation coincidence of the distance between the reflectors arranged in the vertical side of the space section formed between reflective covering holding said light source, and said side-face edge.
[Claim 2] Said reflective covering is a back light according to claim 1 characterized by making at least one side fit into the crevice which was equipped with the wrap flange section and formed in the side-face edge of said optical diffusion plate member among the vertical sides of the luminescence reflective section which makes the light from said light source reflect in said optical diffusion plate member side while being formed in said board thickness and abbreviation same thickness, and said space section.

[Translation done.]

PAGE 69/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.820

JAPANESE [JP,07-235207,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS OPERATION EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

Savant Technologies LLC - 1004.821

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the back light of the liquid crystal display section which has for example, the LED light source.
[0002]
[Description of the Prior Art] Many back lights conventionally used for irradiating the liquid crystal display section are proposed. For example, as shown in drawing 10 , back light 100' is equipped with the LED component 4, reflective covering 1', and the diffusion plate 12. The LED component 4 is fixed to a part of reflective covering 1' which reflects the LED light R while it fixes the LED component 4 on a substrate 5. Reflective covering 1' is fixed on a substrate 5. Moreover, the LED component 4 is electrically connected to the leadframe 6 through lead wire 3. As for the LED light source 4, the LED array of COB, an LED lamp, an LED chip lamp, etc. are used. Outgoing radiation of the LED light R emitted from the light source is carried out outside, reflecting between the reflective sheet 11 of the diffusion plate 12, and the diffusing surfaces 13. Thus, the diffusion plate 12 functions as the surface light source. Moreover, the total thickness of the conventional back light is the back light of a larger configuration than board thickness t' of a diffusion plate.
[0003]
[Problem(s) to be Solved by the Invention] however, the back light whose min is also threshold value and about [whose] a 1.5mm piece it is the total thickness of about 0.8mm with many present demands when an LED chip, a COB array, etc. are used for the total thickness as a back light in the conventional example constituted as mentioned above -- ** -- if carried out, there was a fault of not being suitable.
[0004] Moreover, the aperture width of light-emitting part reflective covering was constituted widely, and the conventional back light was that to which a clearance cannot but exist between the reflective end face of light-emitting part reflective covering, and the end face (outgoing radiation side 18) of the diffusion plate 12. For this reason, the leakage of light could not be prevented but there was a problem that futility arose in the amount of LED luminescence. Therefore, it is offering the back light with an optical high transmission efficiency which prevents the leakage of the light which the back light of this invention was made in view of the above-mentioned situation, the place made into the purpose made total thickness thinner, could be miniaturized, and emitted light.
[0005]
[Means for Solving the Problem] In order to solve an above-mentioned technical problem and to attain the purpose, the back light of this invention It is the back light which a base is made to carry out ON light of the light of the light source from the side-face edge of the optical diffusion plate member which comes to have a reflector, and acts as Idemitsu from the reflector of said optical diffusion plate member, and the field of the opposite side. It is characterized by making the board thickness of said optical diffusion plate member carry out abbreviation coincidence of the distance between the reflectors arranged in the vertical side of the space section formed between reflective covering holding said light source, and said side-face edge.
[0006] Moreover, preferably, said reflective covering is characterized by making at least one side fit into the crevice which was equipped with the wrap flange section and formed in the side-face edge of said optical diffusion plate member among the vertical sides of the luminescence reflective section which makes the light from said light source reflect in said optical diffusion plate member side, and said space section while it is formed in said board thickness and

Savant Technologies LLC - 1004.822

abbreviation same thickness.
[0007]
[Function] As mentioned above, since the back light concerning this invention is constituted, by making equivalent aperture width of reflective covering, and thickness of the end face of a diffusion plate, total thickness is made thinner, it can miniaturize and the back light with an optical high transmission efficiency which prevents the leakage of the light which emitted light can be offered.
[0008]
[Example] With reference to an attached drawing, it explains about the example of this invention at a detail below. Drawing 1 is the external view of the back light of this example. Moreover, drawing 2 is a top view in the condition that drawing 1 assembled. Drawing 3 is the perspective view showing the configuration of a diffusion plate and a reflective sheet. Drawing 4 is the front view of the light-emitting part reflective covering 1 of drawing 1 . Drawing 5 is the top view of drawing 4 . Drawing 6 is the side elevation of the light-emitting part reflective covering 1. Hereafter, with reference to drawing 6 , the configuration of the back light of this example is explained from drawing 1 . A back light 100 carries out fitting of the light-emitting part reflective covering 1 and the diffusion plate 12, as shown in drawing 1 , and the appearance is constituted. In case it assembles, both are fixed by carrying out fitting of the height 15 for immobilization installed in the both-sides surface part 9 of the light-emitting part reflective covering 1, and the crevice 16 established in the diffusion plate 12. Moreover, the flange section 14 projected from the lateral portion 9 on both sides is formed in the upper part of the reflective covering 1, and the diffusion plate 12 is contacted so that the reflective covering 1 may not fall out caudad by this flange section 14. Moreover, a back light 100 is equipped with the reflective sheet 11 (refer to drawing 3), the light-emitting part reflective covering 1 which fixes the LED component 4, the leadframe 6 which mounts the LED component 4 and which is both electrically connected through lead wire 3, and the diffusion plate 12 which reflects LED light and is diffused (refer to drawing 4). Moreover, a back light 100 is a back light equipped with two LED components 4. The light-emitting part reflective covering 1 is constituted by luminescence side 1b which fixes reflective section end-face 1a, a lateral portion 9, and the LED component 4 and the leadframe tee 8, and the lens 2 which passes the light which emitted light from the LED component 4. A lens 2 is a concave lens to the LED component 4. The light-emitting part reflective covering 1 is manufactured by PBT in which the glass material was mixed. Moreover, the reflective covering 1 is constituted so that LED light can be reflected by reflective end-face 1a and luminescence side 1b. Moreover, the leadframe 6 intervenes between the light-emitting part reflective covering 1 and the reflective sheet 11, and the leadframe which fixes the LED component 4, and the leadframe which connects a light emitting device 4 electrically through lead wire 3 are soldered and (refer to drawing 7 and drawing 8) connected to the external substrate 5, respectively. Preferably, the leadframe 6 consists of flexible materials, and it is prepared so that it may mention later and may be bent. It is attached in the top face of the reflective sheet 11, and the diffusion plate 12 is formed in the part which counters opening of the light-emitting part reflective covering 1. As shown in drawing 3 , the diffusion plate 12 equips with the outgoing radiation side 17 the side-face edge 14 as for which LED light carries out ON light, and the top-face section, and the reflective sheet 11 is attached in the bottom surface part. Moreover, the diffusion plate 12 has a certain amount of thickness t, and it diffuses LED light effectively by forming a light guide line by Hazama of the outgoing radiation side 18 and the reflective sheet 11, and it is constituted so that it may act as reflective Idemitsu. It is formed so that it may become dense, as much heights keep away from the side near the LED component 4, and the so-called gradation pattern by heights is formed, and the diffusing surface 13 of the bottom surface part of the diffusion plate 12 is made as [perform / diffusion and reflection of LED light / efficiently]. Moreover, the reflective sheet 11 is an ingredient which has flexibility, and is formed in the diffusion plate 12 and this area. And as shown in drawing 1 , after the reflective covering 1 is fixed to the diffusion plate 12, adhesion immobilization of the reflective sheet 11 is carried out with Adhesives C at the rear face of the diffusion plate 12. In addition, one field S of the reflective sheet 11 forms the reflector which has a high reflection factor.
[0009] Moreover, as shown in drawing 9 mentioned later, the width of face X of opening (part of Hazama of reflective section end-face 1a and the reflective sheet 11) of the light-emitting part reflective covering 1 and thickness t of the diffusion plate 12 are set up so that it may become equivalent. In drawing 5 , between two LED components 4, while the installation section 10 installed from the reflective covering 1 is formed and reinforcing the reflective covering 1, after the LED light from two LED components 4 passes a lens 2, it is prepared so that it may reflect in the side-face edge 17 direction of a light guide plate 12 and may act as Idemitsu efficiently. The above is the whole back light

Savant Technologies LLC - 1004.823

configuration of this example.
[0010] Next, with reference to drawing 6 , the erector of the back light of this example degree is explained from drawing 4 . The leadframe 6 shown in drawing 4 in drawing 6 from drawing 4 is equipped with the leadframe tee 8 which branches to four from the leadframe body (un-illustrating). The mounting section in which the LED component 4 is mounted with lead wire 3, and the extension further extended from the edge are prepared in the edge of the leadframe tee 8. Light-emitting part reflective covering is fabricated by the PCB resin by which the glass mentioned above was mixed so that this leadframe tee 8 may be included (insertion forming cycle).
[0011] Next, as the extension 6 of the leadframe tee 8 is shown in drawing 6 , it bends in the direction of View Y, and it bends so that it may be parallel to reflective end-face 1a and may project at the tooth back (part where the diffusion plate 12 is opposite) of the reflective covering 1 (terminal area folding process). In this condition, in four leadframe tees 8, bonding of the LED chip 4 is carried out to the edge of two tees, respectively, and bonding of the lead wire 3 is carried out to other two edges (bonding process).
[0012] Then, in order to protect the LED chip 4 and lead wire 3, a potting is carried out, and it is made to harden (potting process). Finally, after cutting off the unnecessary part of the leadframe tee 8, an examination of products is conducted and it becomes completion of the reflective covering 1 of this example (a leadframe clipping process and inspection process).
[0013] The back light of this example is manufactured through the above processes. Moreover, after the reflective covering 1 and the diffusion plate 12 are fixed, as are shown in drawing 7 , and it is shown in drawing 8 whether it is soldered on the mounting substrate 5, after inserting the leadframe 6 back projected at the terminal area folding process in the hole which was able to be made in the substrate, it is soldered, and is connected electrically.
[0014] Next, the optical actuation by the back light of this example is explained. Drawing 9 is the typical side elevation of the back light of this example. In drawing 9 , after going straight on as it is, and carrying out incidence to the diffusion plate 12 or reflecting by the reflective sheet 11 or reflective end-face 1a, respectively, incidence of the LED light R which emitted light from the LED component 4 is carried out to the diffusion plate 12. The field which the LED light R of the reflective sheet 11 reflects is a reflector which has a high reflection factor, as mentioned above. Here, the LED light R by which incidence was carried out to the diffusion plate 12 repeats reflection by Hazama with the inside of the outgoing radiation side 18 of the diffusion plate 12, the diffusion plate 13, or the reflective sheet 11, and the inside of the diffusion plate 12 is led to it in the LED component 4 and the direction of the opposite side. Outgoing radiation of the light which arrived at the outgoing radiation side 18 by the middle above the critical angle is carried out from the outgoing radiation side 18 outside. In the process, scattered reflection of the light which reached the scattered reflection section which consists of heights prepared in the diffusing surface 13 is carried out there to the outgoing radiation side 18 side. Therefore, without only the part near the LED component becoming bright since it is made so dense that it keeps away to the LED component 4 and the opposite side, these heights are formed so that LED light may become homogeneity at the outgoing radiation side 18 side.
[0015] (Effectiveness of an example) By processing the width of face X of opening of the reflective covering 1 on a par with the board thickness t of the diffusion plate 12, and assembling the reflective sheet 11 as a base as mentioned above, the clearance produced between the diffusion plate 12 and the light-emitting part reflective covering 1 is lost, and the leak by the exterior of the LED light R can be prevented.
[0016] Moreover, since leakage can be prevented, the variation in the brightness of the light by which outgoing radiation is carried out from the outgoing radiation side 18 can be prevented. Moreover, since the lower frame section of reflective covering is removed, it fixes to the reflective sheet 11 directly and width of face of opening and board thickness of a diffusion plate are made the same, the miniaturization of a back light is realizable.
[0017] Moreover, since it is manufactured by resin insert molding, the variation in the process tolerance at the time of mass-producing can be suppressed to min. In addition, this invention can apply the above-mentioned example to what corrected or deformed in the range which does not deviate from the meaning. For example, although the configuration of the back light of the liquid crystal display used for small devices, such as a handy terminal and a pager, was explained as an application of this example, there is nothing that is restricted to it, of course. Moreover, it cannot be overemphasized that the GURAJIESHON pattern which the surface roughening of the diffusing surface is not really limited to the gradation pattern of the projection by shaping, and prints the dot pattern of white ink, and the surface roughening by hairline processing may be used.
[0018]

Savant Technologies LLC - 1004.824

[Effect of the Invention] Like explanation, by making equivalent aperture width of light-emitting part reflective covering, and thickness of the end face of a diffusion plate, total thickness is made thinner, and it can miniaturize and, according to the back light of this invention, is above effective in the ability to offer the back light with an optical high transmission efficiency which prevents the leakage of the light which emitted light.

[Translation done.]

Savant Technologies LLC - 1004.825

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Industrial Application] This invention relates to the back light of the liquid crystal display section which has for example, the LED light source.

[Translation done.]

PAGE 75/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.826

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] Many back lights conventionally used for irradiating the liquid crystal display section are proposed. For example, as shown in drawing 10 , back light 100' is equipped with the LED component 4, reflective covering 1', and the diffusion plate 12. The LED component 4 is fixed to a part of reflective covering 1' which reflects the LED light R while it fixes the LED component 4 on a substrate 5. Reflective covering 1' is fixed on a substrate 5. Moreover, the LED component 4 is electrically connected to the leadframe 6 through lead wire 3. As for the LED light source 4, the LED array of COB, an LED lamp, an LED chip lamp, etc. are used. Outgoing radiation of the LED light R emitted from the light source is carried out outside, reflecting between the reflective sheet 11 of the diffusion plate 12, and the diffusing surfaces 13. Thus, the diffusion plate 12 functions as the surface light source.

PAGE 76/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.827

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

(Effectiveness of an example) By processing the width of face X of opening of the reflective covering 1 on a par with the board thickness t of the diffusion plate 12, and assembling the reflective sheet 11 as a base as mentioned above, the clearance produced between the diffusion plate 12 and the light-emitting part reflective covering 1 is lost, and the leak by the exterior of the LED light R can be prevented.
[0016] Moreover, since leakage can be prevented, the variation in the brightness of the light by which outgoing radiation is carried out from the outgoing radiation side 18 can be prevented. Moreover, since the lower frame section of reflective covering is removed, it fixes to the reflective sheet 11 directly and width of face of opening and board thickness of a diffusion plate are made the same, the miniaturization of a back light is realizable.
[0017] Moreover, since it is manufactured by resin insert molding, the variation in the process tolerance at the time of mass-producing can be suppressed to min. In addition, this invention can apply the above-mentioned example to what corrected or deformed in the range which does not deviate from the meaning. For example, although the configuration of the back light of the liquid crystal display used for small devices, such as a handy terminal and a pager, was explained as an application of this example, there is nothing that is restricted to it, of course.

PAGE 77/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.828

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] however, the back light whose min is also threshold value and about [whose] a 1.5mm piece it is the total thickness of about 0.8mm with many present demands when an LED chip, a COB array, etc. are used for the total thickness as a back light in the conventional example constituted as mentioned above -- ** -- if carried out, there was a fault of not being suitable.
[0004] Moreover, the aperture width of light-emitting part reflective covering was constituted widely, and the conventional back light was that to which a clearance cannot but exist between the reflective end face of light-emitting part reflective covering, and the end face (outgoing radiation side 18) of the diffusion plate 12. For this reason, the leakage of light could not be prevented but there was a problem that futility arose in the amount of LED luminescence. Therefore, it is offering the back light with an optical high transmission efficiency which prevents the leakage of the light which the back light of this invention was made in view of the above-mentioned situation, the place made into the purpose made total thickness thinner, could be miniaturized, and emitted light.

[Translation done.]

PAGE 78/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.829

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] In order to solve an above-mentioned technical problem and to attain the purpose, the back light of this invention It is the back light which a base is made to carry out ON light of the light of the light source from the side-face edge of the optical diffusion plate member which comes to have a reflector, and acts as Idemitsu from the reflector of said optical diffusion plate member, and the field of the opposite side. It is characterized by making the board thickness of said optical diffusion plate member carry out abbreviation coincidence of the distance between the reflectors arranged in the vertical side of the space section formed between reflective covering holding said light source, and said side-face edge.
[0006] Moreover, preferably, said reflective covering is characterized by making at least one side fit into the crevice which was equipped with the wrap flange section and formed in the side-face edge of said optical diffusion plate member among the vertical sides of the luminescence reflective section which makes the light from said light source reflect in said optical diffusion plate member side, and said space section while it is formed in said board thickness and abbreviation same thickness.

[Translation done.]

Savant Technologies LLC - 1004.830

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

OPERATION

[Function] As mentioned above, since the back light concerning this invention is constituted, by making equivalent aperture width of reflective covering, and thickness of the end face of a diffusion plate, total thickness is made thinner, it can miniaturize and the back light with an optical high transmission efficiency which prevents the leakage of the light which emitted light can be offered.

[Translation done.]

Savant Technologies LLC - 1004.831

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EXAMPLE

[Example] With reference to an attached drawing, it explains about the example of this invention at a detail below. Drawing 1 is the external view of the back light of this example. Moreover, drawing 2 is a top view in the condition that drawing 1 assembled. Drawing 3 is the perspective view showing the configuration of a diffusion plate and a reflective sheet. Drawing 4 is the front view of the light-emitting part reflective covering 1 of drawing 1 . Drawing 5 is the top view of drawing 4 . Drawing 6 is the side elevation of the light-emitting part reflective covering 1. Hereafter, with reference to drawing 6 , the configuration of the back light of this example is explained from drawing 1 . A back light 100 carries out fitting of the light-emitting part reflective covering 1 and the diffusion plate 12, as shown in drawing 1 , and the appearance is constituted. In case it assembles, both are fixed by carrying out fitting of the height 15 for immobilization installed in the both-sides surface part 9 of the light-emitting part reflective covering 1, and the crevice 16 established in the diffusion plate 12. Moreover, the flange section 14 projected from the lateral portion 9 on both sides is formed in the upper part of the reflective covering 1, and the diffusion plate 12 is contacted so that the reflective covering 1 may not fall out caudad by this flange section 14. Moreover, a back light 100 is equipped with the reflective sheet 11 (refer to drawing 3), the light-emitting part reflective covering 1 which fixes the LED component 4, the leadframe 6 which mounts the LED component 4 and which is both electrically connected through lead wire 3, and the diffusion plate 12 which reflects LED light and is diffused (refer to drawing 4). Moreover, a back light 100 is a back light equipped with two LED components 4. The light-emitting part reflective covering 1 is constituted by luminescence side 1b which fixes reflective section end-face 1a, a lateral portion 9, and the LED component 4 and the leadframe tee 8, and the lens 2 which passes the light which emitted light from the LED component 4. A lens 2 is a concave lens to the LED component 4.

PAGE 81/88 * RCVD AT 8/23/2006 6:39:30 PM [Eastern Daylight Time] * SVR:USPTO-EFXRF-5/19 * DNIS:2738300 * CSID:9194199354 * DURATION (mm-ss):35-50

Savant Technologies LLC - 1004.832

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective view showing the outline of the back light of this example.
[Drawing 2] It is the top view of the back light of this example.
[Drawing 3] It is the perspective view showing the configuration of a diffusion plate and a reflective sheet.
[Drawing 4] It is the front view of light-emitting part reflective covering.
[Drawing 5] It is the top view of drawing 4 .
[Drawing 6] It is the side elevation of drawing 5 .
[Drawing 7] It is drawing showing an example of the mounting gestalt when mounting the back light of this example in a substrate.
[Drawing 8] It is drawing showing an example of the mounting gestalt when mounting the back light of this example in a substrate.
[Drawing 9] It is the side elevation showing the outline of the back light of **********, and the principle of operation of light.
[Drawing 10] It is the side elevation showing the outline of the conventional back light, and the principle of operation of light.
[Description of Notations]
1 Light-emitting Part Reflective Covering
1a Reflective end face
1b Reflective side face
2 Lens
3 Lead Wire
4 LED Component
5 Mounting Substrate
6 Leadframe
8 Leadframe Tee
9 Reflective Covering Lateral Portion
10 Reflective Covering Installation Section
11 Reflective Sheet
12 Diffusion Plate
13 Diffusing Surface
t Diffusion plate thickness
R Light from the light source

[Translation done.]

Savant Technologies LLC - 1004.833

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号

特開平7－235207

(43)公開日　平成７年(1995)９月５日

(51)Int.Cl.[6]		識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｆ２１Ｖ	8/00		Ｄ		
Ｇ０２Ｂ	6/00	３３１			
Ｇ０２Ｆ	1/1335	５３０			

審査請求　未請求　請求項の数２　ＯＬ　（全　５　頁）

(21)出願番号　特願平6－22347

(22)出願日　平成６年(1994)２月21日

(71)出願人　000001225
株式会社コパル
東京都板橋区志村２丁目16番20号

(72)発明者　関根　光治
東京都板橋区志村２丁目16番20号　株式会社コパル内

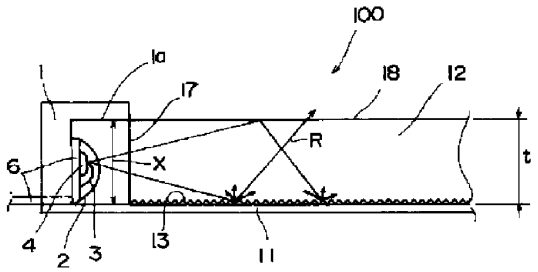
(74)代理人　弁理士　大塚　康徳　（外１名）

(54)【発明の名称】　バックライト

(57)【要約】

【目的】総厚をより薄くして小型化でき、発光された光の漏れを防止する光伝達効率の高いバックライトを提供する。

【構成】底面に反射面１１を有してなる光拡散板部材１２の側面縁部１７から光源を入光させて光拡散板部材１２の反射面と反対側の出射面１８から出光するバックライト１００であって、光源４を保持する反射カバーとと側面縁部１７との間に形成される空間部の上下面に配設される反射面１ａと反射面１１との間の距離を光拡散板部材１２の板厚ｔに略一致させることを特徴とするバックライト。



Savant Technologies LLC - 1004.834

1

【特許請求の範囲】

【請求項１】　底面に反射面を有してなる光拡散板部材の側面縁部から光源の光を入光させ前記光拡散板部材の反射面と反対側の面から出光させるバックライトであって、

前記光源を保持する反射カバーと前記側面縁部との間に形成される空間部の上下面に配設される反射面間の距離を前記光拡散板部材の板厚に略一致させることを特徴とするバックライト。

【請求項２】　前記反射カバーは、前記板厚と略同厚に形成されると共に前記光源からの光を前記光拡散板部材側へと反射せしめる発光反射部と、

前記空間部の上下面のうち少なくとも一方を覆うつば部とを備え、

前記光拡散板部材の側面縁部に形成された凹部に嵌合せしめることを特徴とする請求項１に記載のバックライト。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、例えば、ＬＥＤ光源を有する液晶表示部のバックライトに関するものである。

【０００２】

【従来の技術】従来より、液晶表示部を照射するのに用いられるバックライトは数多く提案されている。例えば、図１０に示すように、バックライト１００’は、ＬＥＤ素子４と、反射カバー１’と、拡散板１２とを備えるものである。ＬＥＤ素子４は、基板５上にＬＥＤ素子４を固定すると共に、ＬＥＤ光Ｒを反射する反射カバー１’の一部に固定される。反射カバー１’は、基板５上に固定される。また、ＬＥＤ素子４は、リード線３を介してリードフレーム６に電気的に接続されている。ＬＥＤ光源４は、ＣＯＢのＬＥＤアレー、ＬＥＤランプ、ＬＥＤチップランプ等が使用される。光源から放たれたＬＥＤ光Ｒは、拡散板１２の反射シート１１と拡散面１３との間を反射しながら外部に出射される。このようにして、拡散板１２は、面光源として機能するのである。また、従来のバックライトの総厚は、拡散板の板厚ｔ’よりも大きい構成のバックライトである。

【０００３】

【発明が解決しようとする課題】しかしながら、上記のように構成される従来例においては、バックライトとしての総厚は、ＬＥＤチップやＣＯＢアレー等を使用すると最小でも1.5㎜幅程度が限界値であり、現在要求の多い総厚0.8㎜程度のバックライトをとしては適さないという欠点があった。

【０００４】また、従来のバックライトは、発光部反射カバーの開口幅が広く構成されており、発光部反射カバーの反射端面と拡散板１２の端面（出射面１８）との間に隙間が存在せざるをえないものであった。このため、光の漏れを防止することができずＬＥＤ発光量に無駄が

2

生じるという問題があった。従って、本発明のバックライトは、上記の事情に鑑みてなされたものであり、その目的とするところは、総厚をより薄くして小型化でき、発光された光の漏れを防止する光伝達効率の高いバックライトを提供することである。

【０００５】

【課題を解決するための手段】上述の課題を解決し、目的を達成するために、本発明のバックライトは、底面に反射面を有してなる光拡散板部材の側面縁部から光源の光を入光させ前記光拡散板部材の反射面と反対側の面から出光させるバックライトであって、前記光源を保持する反射カバーと前記側面縁部との間に形成される空間部の上下面に配設される反射面間の距離を前記光拡散板部材の板厚に略一致させることを特徴としている。

【０００６】また、好ましくは、前記反射カバーは、前記板厚と略同厚に形成されると共に前記光源からの光を前記光拡散板部材側へと反射せしめる発光反射部と、前記空間部の上下面のうち少なくとも一方を覆うつば部とを備え、前記光拡散板部材の側面縁部に形成された凹部に嵌合せしめることを特徴としている。

【０００７】

【作用】以上のように、この発明に係わるバックライトは構成されているので、反射カバーの開口幅と拡散板の端面の厚さとを同等にすることにより、総厚をより薄くして小型化でき、発光された光の漏れを防止する光伝達効率の高いバックライトを提供できる。

【０００８】

【実施例】以下に本発明の実施例につき、添付の図面を参照して詳細に説明する。　図１は、本実施例のバックライトの外観図である。また、図２は、図１の組み立てた状態の平面図。図３は、拡散板と反射シートとの構成を示す斜視図。図４は、図１の発光部反射カバー１の正面図。図５は、図４の平面図。図６は、発光部反射カバー１の側面図である。以下、図１から図６を参照して、本実施例のバックライトの構成を説明する。バックライト１００は、図１に示すように、発光部反射カバー１と拡散板１２を嵌合させてその外形が構成される。組み立てる際には、発光部反射カバー１の両側面部９に延設された固定用突起部１５と、拡散板１２に設けられた凹部１６とを嵌合させることによって両者を固定する。また、反射カバー１の上部には、両側に側面部９から突出したつば部１４が形成され、このつば部１４によって、反射カバー１が下方に抜け落ちることのないように、拡散板１２に当接する。また、バックライト１００は、反射シート１１（図３参照）と、ＬＥＤ素子４を固定する発光部反射カバー１と、ＬＥＤ素子４を実装する共に、リード線３を介して、電気的に接続するリードフレーム６と、ＬＥＤ光を反射し、拡散する拡散板１２とを備える（図４参照）。また、バックライト１００は、ＬＥＤ素子４を２つ備えたバックライトである。発光部反射カ

Savant Technologies LLC - 1004.835

バー１は、反射部端面１ａと、側面部９と、ＬＥＤ素子４及びリードフレーム分岐部８を固定する発光面１ｂと、ＬＥＤ素子４から発光された光を通過させるレンズ２とにより構成されている。レンズ２は、ＬＥＤ素子４に対して凹状なレンズである。発光部反射カバー１は、ガラス素材が混入されたＰＢＴで製造されている。また、反射カバー１は、ＬＥＤ光を反射端面１ａと発光面１ｂで反射できるように構成されている。また、発光部反射カバー１と反射シート１１との間には、リードフレーム６が介在しており、ＬＥＤ素子４を固定するリードフレームと、リード線３を介して発光素子４を電気的に接続するリードフレームが夫々外部の基板５に対してハンダ付けされて（図７、図８参照）、接続されている。リードフレーム６は、好ましくは、フレキシブルな素材で構成されており、後述するように折曲げられるように設けられている。反射シート１１の上面に取付けられていて、発光部反射カバー１の開口部に対向する部位には拡散板１２が設けられている。図３に示すように、拡散板１２は、ＬＥＤ光が入光する側面縁部１４と、上面部に出射面１７を備え、底面部に反射シート１１が取り付けられている。また、拡散板１２は、ある程度の厚さｔを有し、出射面１８と反射シート１１との間で導光路を形成することでＬＥＤ光を有効に拡散させ、反射出光させるように構成されている。拡散板１２の底面部の拡散面１３は、多数の凸部がＬＥＤ素子４に近い側から遠ざかるに従って密になるように形成されており、凸部による所謂グラディエーションパターンが形成され、ＬＥＤ光の拡散及び反射を効率的に行なうようになされている。また、反射シート１１は、可撓性を有する材料であり、拡散板１２と同面積に形成されている。そして、反射シート１１は、図１に示すように、反射カバー１が拡散板１２に固定された後に、拡散板１２の裏面に接着剤Ｃで接着固定される。尚、反射シート１１の一方の面Ｓが、高反射率を有する反射面を形成している。

【０００９】また、後述する図９に示すように、発光部反射カバー１の開口部（反射部端面１ａと反射シート１１との間の部分）の幅Ｘと拡散板１２の厚さｔとは同等になるように設定されている。図５において、２つのＬＥＤ素子４との間には、反射カバー１から延設された延設部１０が設けられ、反射カバー１を補強すると共に、２つのＬＥＤ素子４からのＬＥＤ光がレンズ２を通過した後に導光板１２の側面端部１７方向に反射して効率よく出光するように設けられている。以上が本実施例のバックライトの全体構成である。

【００１０】次に、図４から図６を参照して、本実施例のバックライトの組立工程について説明する。図４から図６において、図４に示すリードフレーム６は、リードフレーム本体（不図示）から４本に分岐するリードフレーム分岐部８を備えている。リードフレーム分岐部８の端部には、ＬＥＤ素子４がリード線３と共に実装される

実装部と、端部から更に延長された延長部とが設けられている。このリードフレーム分岐部８を含めるように、前述したガラスが混入されたＰＣＢ樹脂で発光部反射カバーを成形する（インサート成形工程）。

【００１１】次に、リードフレーム分岐部８の延長部６を、図６に示す如く、矢視Ｙの方向に折曲げ、反射端面１ａに平行で反射カバー１の背面（拡散板１２とは反対の部位）に突出するように折曲げる（端子部折曲げ工程）。この状態で、４本のリードフレーム分岐部８のなかで、２本の分岐部の端部にＬＥＤチップ４を夫々ボンディングし、他の２本の端部にリード線３をボンディングする（ボンディング工程）。

【００１２】その後、ＬＥＤチップ４とリード線３とを保護するためにポッテングして、硬化させる（ポッティング工程）。最後に、リードフレーム分岐部８の不要な部分を切り落とした後、製品検査を行なって本実施例の反射カバー１の完成となる（リードフレーム切り落とし工程及び検査工程）。

【００１３】以上のような工程を経て、本実施例のバックライトは製造される。また、反射カバー１と拡散板１２とが固定された後、端子部折曲げ工程で後方に突出したリードフレーム６は、図７に示すように、実装基板５上にハンダ付けされるか、図８に示すように基板に開けられた穴に挿入してからハンダ付けされ、電気的に接続される。

【００１４】次に、本実施例のバックライトによる光学的な動作について説明する。図９は、本実施例のバックライトの模式的側面図である。図９において、ＬＥＤ素子４から発光されたＬＥＤ光Ｒは、そのまま直進して拡散板１２に入射するか、反射シート１１又は反射端面１ａで夫々反射した後、拡散板１２に入射される。反射シート１１のＬＥＤ光Ｒが反射する面は、前述したように、高反射率を有する反射面である。ここで、拡散板１２に入射されたＬＥＤ光Ｒは、拡散板１２の出射面１８の内面と拡散板１３又は反射シート１１との間で反射を繰り返して拡散板１２内をＬＥＤ素子４と反対側の方向へと導かれる。その途中で、出射面１８に臨界角以上で到達した光は、出射面１８から外部へと出射される。その過程において、拡散面１３に設けられた凸部からなる乱反射部に到達した光は、そこで出射面１８側へと乱反射される。従って、この凸部は、ＬＥＤ素子４と反対側に遠ざかるほど密にされているので、ＬＥＤ素子の近くの部分だけ明るくなることなく、出射面１８側までＬＥＤ光が均一になるように形成されている。

【００１５】（実施例の効果）以上のように、反射カバー１の開口部の幅Ｘを、拡散板１２の板厚ｔと同等に加工し、反射シート１１を基部として組み立てることによって、拡散板１２と発光部反射カバー１との間に生じる隙間を無くし、ＬＥＤ光Ｒの外部へのもれを防止できるのである。

Savant Technologies LLC - 1004.836

5

【００１６】また、漏れを防止できることから、出射面１８から出射される光の輝度のバラツキを防止できるのである。また、反射カバーの下部フレーム部を取り去り、反射シート１１に直接固定して、開口部の幅と拡散板の板厚とを同じにすることから、バックライトの小型化が実現できるのである。

【００１７】また、樹脂インサート成形によって製造されるので、量産する際の加工精度のバラツキを最小に抑えることができる。尚、本発明は、その趣旨を逸脱しない範囲で上記実施例を修正又は変形したものに適用可能である。例えば、本実施例の用途として、ハンディターミナルやページャ等の小型機器に用いられる液晶ディスプレイのバックライトの構成を説明したが、もちろんそれに限られるものはない。また、拡散面の粗面化は、一体成形による突起のグラディエーションパターンに限定されるものでなく、白インキのドットパターンを印刷するグラジェーションパターンや、ヘアライン加工による粗面化でも良いことは言うまでもない。

【００１８】

【発明の効果】以上説明のように、本発明のバックライトによれば、発光部反射カバーの開口幅と拡散板の端面の厚さとを同等にすることにより、総厚をより薄くして小型化でき、発光された光の漏れを防止する光伝達効率の高いバックライトを提供できる効果がある。

【図面の簡単な説明】

【図１】本実施例のバックライトの概略を示す斜視図である。

【図２】本実施例のバックライトの平面図である。

【図３】拡散板と反射シートとの構成を示す斜視図である。

6

【図４】発光部反射カバーの正面図である。

【図５】図４の平面図である。

【図６】図５の側面図である。

【図７】本実施例のバックライトを基板に実装するときの実装形態の一例を示す図である。

【図８】本実施例のバックライトを基板に実装するときの実装形態の一例を示す図である。

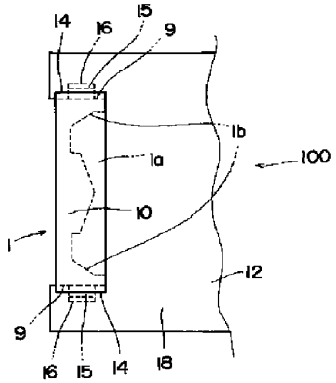
【図９】本実施例ののバックライトの概略と光の動作原理を示す側面図である。

【図１０】従来のバックライトの概略と光の動作原理を示す側面図である。

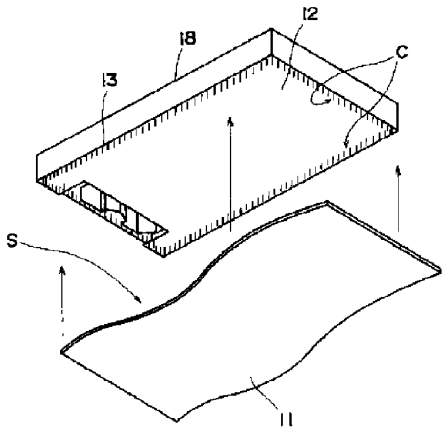
【符号の説明】

１　発光部反射カバー
１ａ　反射端面
１ｂ　反射側面
２　レンズ
３　リード線
４　ＬＥＤ素子
５　実装基板
６　リードフレーム
８　リードフレーム分岐部
９　反射カバー側面部
１０　反射カバー延設部
１１　反射シート
１２　拡散板
１３　拡散面
ｔ　拡散板厚さ
Ｒ　光源からの光

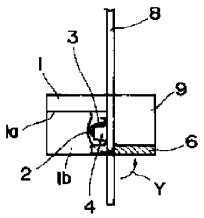
【図２】



【図３】

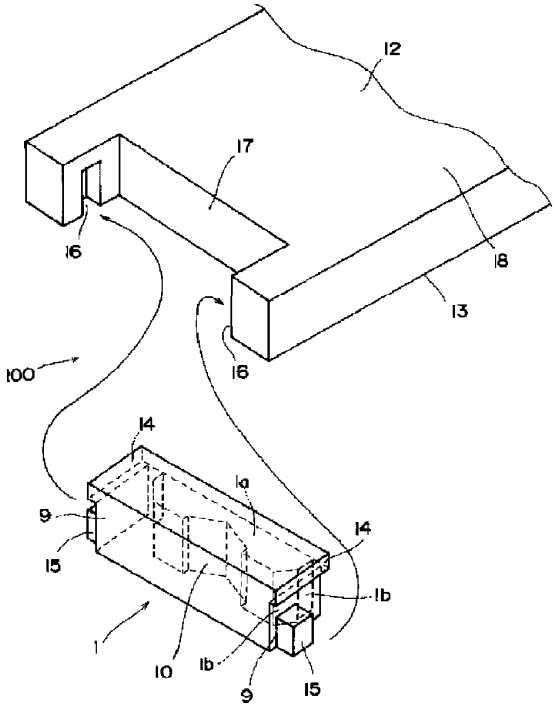


【図６】

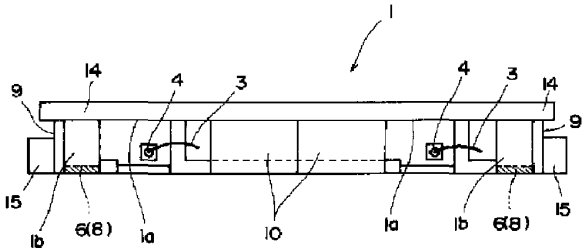


Savant Technologies LLC - 1004.837

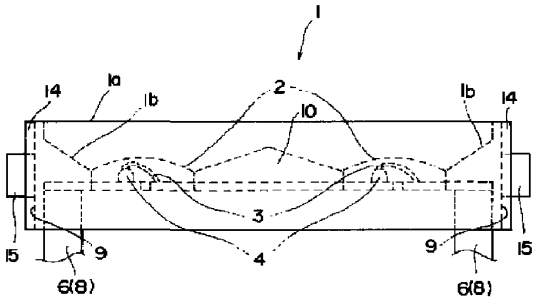
【図１】



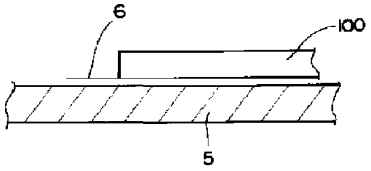
【図４】



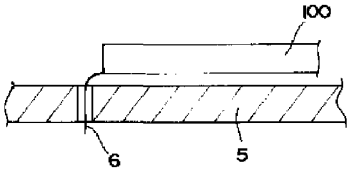
【図５】



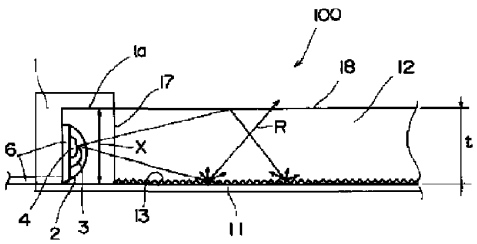
【図７】



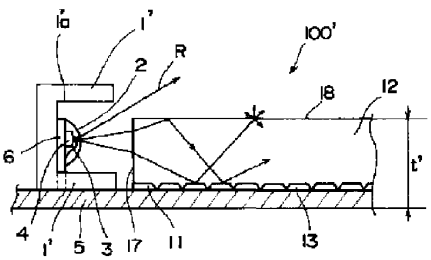
【図８】



【図９】



【図１０】



Savant Technologies LLC - 1004.838

Menda II machine translation

H08-250281 Machine Translation

[Claim 1]A light emitting device comprising:
A solid state component which emits light of wavelength shorter than 400 nm.
A photogen which emits light of long wave length rather than the wavelength.

[Claim 2]A light emitting device comprising:
A ZnO ultraviolet luminous layer.
A ZnS barrier layer provided on this ultraviolet luminous layer.
A transparent electrode formed on this barrier layer.
A photogen provided on this transparent electrode.

[Claim 3]The display device according to claim 1 or 2 arranging the aforementioned light emitting device to matrix form, and displaying a character and/or video information.

[Detailed Description of the Invention]
[0001]
[Industrial Application]About a light emitting device, especially this invention belongs to electroluminescence (EL) and photoluminescence (PL) technology, and is used for display devices and light sources, such as an EL display, a plasma display, and CRT.
[0002]
[Description of the Prior Art]Conventionally, the EL element is having structure which sandwiched the photogen (fluorescent substance) 51 by the two electrodes 52 and 53 as shown in drawing 5. A direct current or a volts alternating current is applied among these electrodes 52 and 53, by generating electric field in the photogen 51, an electron is accelerated and collision excitation of the luminescence center added in the photogen 1 is carried out (for example, "electroluminescent display" Inoguchi [Toshio] work, Sangyo Tosho Publishing). Therefore, the photogen in which the photogen 51 has resulted in practical use at present by the luminescence intensity (luminosity) having to fulfill not only the optical characteristics, such as a luminous wavelength (color), but electrical properties, such as electronic acceleration (generation of a hot electron), is only ZnS:Mn.
[0003]
[Problem to be solved by the invention]Only the photogen which is optical and satisfied with conventional technology of both electrical properties is applicable to a light emitting device. This invention was made in consideration of such a situation, and an object of this invention is to provide the display device using the light emitting device and this which can carry out [element]-izing even if it is a photogen which filis only the optical characteristic.
[0004]
[Means for solving problem]Application-concerned the 1st invention is a light emitting device possessing the solid state component which emits the light of wavelength shorter than 400 nm, and the photogen which emits the light of long wave length rather than the wavelength.

Savant Technologies LLC - 1004.839

[0005]Application-concerned the 2nd invention is a light emitting device possessing a ZnO ultraviolet luminous layer, the ZnS barrier layer provided on this ultraviolet luminous layer, the transparent electrode formed on this barrier layer, and the photogen provided on this transparent electrode. Application-concerned the 3rd invention is a display device arranging the aforementioned light emitting device to matrix form, and displaying a character and/or video information.

[0006]

[Function]The light emitted from the solid light emitting device excites a photogen, and makes it emit light in this invention. Therefore, even if it uses various kinds of things for a photogen, it cannot be based on the electrical property, but it can be made to emit light, since a photogen is excited by ultraviolet radiation.

[0007]Each photogen corresponding to each element is excited by driving separately the ultraviolet light emitting device allotted to matrix form, for example like drawing 6. Therefore, a character and/or video information can be displayed by making the light emitting device consisting of an ultraviolet light emitting device and a photogen emit light selectively.

[0008]

[Working example]Hereafter, the working example of this invention is described with reference to Drawings.

(Working example 1) Drawing 1 is referred to. The mark 1 in a figure is an ultraviolet light emitting device (solid state component) which is put between the transparent electrode 2 and the electrode 3, and emits the light of wavelength shorter than 400 nm. The photogen (fluorescent substance) 4 is arranged above the aforementioned transparent electrode 2.

[0009]In the light emitting device of such composition, between the transparent electrode 2 and the electrode 3, electric field are impressed and ultraviolet radiation is emitted through the transparent electrode 2. The emitted ultraviolet radiation is absorbed with the photogen 4 arranged in the radial direction (excitation), and the photogen 4 emits the visible light whose wavelength is longer than ultraviolet radiation. And a luminous wavelength, i.e., the luminescent color, is changeable by changing the kind of photogen 4. For example, since the emission spectrum of closed shell transition metal complex ion will be produced in broadcloth form in a visible wavelength region if what formed the $CdMoO_4$ thin film with the substrate temperature of 490 ** on the quartz glass substrate is used as the photogen 4, the white light which has a peak near 480 nm can be acquired. In $CdWO_4$, it becomes the white light which has a peak near 440 nm.

[0010](Working example 2) Drawing 2 is referred to. The band gap by which the mark 21 in a figure was constituted from the ZnO ultraviolet luminous layer 21a and the ZnS barrier layer 21b is a not less than 3-eV ultraviolet light emitting device. The transparent electrode 22 and the photogen 23 are formed on the aforementioned ultraviolet light emitting device 21, and the electrode 24 is formed in the rear face of the ultraviolet light emitting device 21.

[0011]In the light emitting device of such composition, interband transition luminescence (luminous wavelength of about 380 nm) of ZnO arises in the interface of the aforementioned ultraviolet luminous layer 21a and the barrier layer 21b. This light excites the luminescence center (Mn) of the photogen 23 (for example, ZnS:Mn) formed on the transparent electrode 22. As a result, the photogen 23 emits light (it is ****** in the case of Mn). If ZnO:Zn is used for the photogen 23, light will be emitted green.

[0012](Working example 3) Drawing 3 is referred to. The mark 31 in a figure is the ultraviolet light

Savant Technologies LLC - 1004.840

emitting device which comprised the ZnO ultraviolet luminous layer 31a and the ZnS barrier layer 31b. The photogen 32 and the transparent electrode 33 are formed on the aforementioned ultraviolet light emitting device 31, and the electrode 34 is formed in the rear face of the ultraviolet light emitting device 31.

[0013]In the light emitting device of such composition, although SnO_2 or ITO (indium tin oxide) is common as construction material of the transparent electrode 33, absorption of as opposed to ultraviolet radiation at such construction material is large. Therefore, the photogen 32 can be efficiently excited by forming the transparent electrode 33 in the top layer.

[0014](Working example 4) Drawing 4 is referred to. The mark 41 in a figure is the ultraviolet light emitting device which comprised the ZnO ultraviolet luminous layer 41a and the ZnS barrier layer 41b. The luminescence electrode 42 is formed on the aforementioned ultraviolet light emitting device 41, and the electrode 43 is formed in the rear face of the ultraviolet light emitting device 41.

[0015]In the light emitting device of such composition, what added the rare earth ions (Eu, Tm, etc.) which become transparent conductive material, such as SnO_2 or ITO, with a luminescence center is used as construction material of the luminescence electrode 42. And electric field are impressed between the luminescence electrode 42 and the electrode 43, ultraviolet radiation is generated, and a luminescence center is excited by the ultraviolet radiation.

[0016]Since an electrode and a photogen are constituted from same substance according to the above-mentioned working example 4, a manufacturing cost can be reduced. Since a luminous layer turns into the top layer and extraction efficiency improves, a bright luminescence element is producible.

[0017](Working example 5) Drawing 6 (A) and (B) is referred to. However, drawing 6 (A) is the explanatory view which developed some display devices concerning this working example 5, and the explanatory view which unified drawing 6 (B).

[0018]The mark 61 in a figure is the ultraviolet light emitting device produced by matrix form, and those elements 61 are wired so that it can drive independently separately. The electrode 62 is formed in the rear face of this ultraviolet light emitting device 61. On the aforementioned ultraviolet light emitting device 61, two or more transparent electrodes 64 are arranged between the diaphragms 63. On the aforementioned diaphragm 63, the transparent base 66 by which two or more photogens 65a, 65b, and 65c were produced by matrix form on the undersurface corresponding to the aforementioned ultraviolet light emitting device is formed. Here, the aforementioned photogens 64a, 64b, and 64c are arranged so that the aforementioned transparent electrode 64 may be faced.

[0019]In this display device, if the ultraviolet light emitting device 61 is made to drive selectively, a character and an image will be displayed. Although explained to details above, the following invention is included in this application.

[0020]1. Light emitting device characterized by what is made for a photogen (fluorescent substance) to emit light (photoluminescence) with the light of the wavelength shorter than 400 nm made to emit light using a (i) solid light emitting device.

[0021](ii) The light emitting device possessing the solid state component which emits the light of wavelength shorter than 400 nm, and the photogen which emits the light of long wave length rather than the wavelength.

(iii) The light emitting device possessing a ZnO ultraviolet luminous layer (S), ZnS barrier layer (I) provided on this ultraviolet luminous layer, and the transparent electrode (M) formed on this barrier

Savant Technologies LLC - 1004.841

layer and the photogen provided on this transparent electrode.
[0022](iV) The light emitting device which has M(luminescence electrode) I(ZnS barrier layer) S (ZnO ultraviolet luminous layer) structure.
(Elements of the Invention) The working examples 1-4 correspond (however, it explains only using the code number of the working example 1). It comprises the photogen 4 arranged on the position with which the ultraviolet radiation emitted from the solid state component (1, 2, 3) which emits the ultraviolet radiation of wavelength shorter than 400 nm, and its element is irradiated. About the electrode 2, it does not necessarily need to be transparent, the ultraviolet radiation emitted in this case is taken out to a substrate and a parallel direction, and the photogen 4 is also located in parallel.
[0023](OPERATION) The light emitted from the solid light emitting device excites the photogen 4, and makes it emit light.
(EFFECT OF THE INVENTION) Even if it uses various kinds of things for the photogen 4, it cannot be based on the electrical property, but it can be made to emit light, since the photogen 4 is excited by ultraviolet radiation.
[0024]2. -- (i) -- a light emitting device, wherein the band gap is produced for the solid state component which emits the light of wavelength shorter than 400 nm with a not less than 3-eV semiconductor in (i) of the 1st clause of the above, and (ii).
[0025](ii) The light emitting device which comprises material in which the semiconductor which has a not less than 3-eV band gap uses a zinc oxide or zinc sulfide as the main ingredients in (i) of the 1st clause of the above.
(iii) The light emitting device of (iii) of the 1st clause of the above.
[0026](iV) The light emitting device of (iV) of the 1st clause of the above.
(Elements of the Invention) The working examples 1-4 correspond. A band gap uses for the ultraviolet light emitting device 1 (or 21, 31, 41) sulfide semiconductor materials, such as oxide semiconductors, such as ZnO which exists not less than 3 eV, or ZnS.
[0027](OPERATION) Since there are not less than 3 eV of band gaps, interband transition luminescence from the semiconductor material serves as wavelength of 400 nm or less, and excites the photogen 4 (or 23, 33) with the light.
[0028](EFFECT OF THE INVENTION) Interband transition luminescence of high luminous efficiency can be used for ultraviolet radiation radiation because a band gap uses a not less than 3-eV semiconductor. Therefore, the photogen 4 (or 23, 33) can be excited by ultraviolet radiation, and a bright luminescence element can be produced.
[0029]3. -- (i) -- the light emitting device which comprises material in which a photogen uses a zinc oxide or zinc sulfide as the main ingredients in (i) of the 1st clause of the above, and (ii).
(ii) The light emitting device of (iii) of the 1st clause of the above.
[0030](Elements of the Invention) The working examples 2 and 3 correspond. The material which added transition metal complex ion and rare earth ions as a luminescence center to ZnO or ZnS is used for a photogen (23 or 32).
(OPERATION) The luminescence center added in ZnO or ZnS is excited by ultraviolet radiation, and emits light.
[0031](EFFECT OF THE INVENTION) Since ZnO and ZnS which are semiconductors can be used also as a material of the ultraviolet light emitting device 21 (or 31) and can be used also as a material of the

photogen 23 (or 32), unification of the photogen 23 (or 32) and the ultraviolet light emitting device 21 (or 31) is possible for them, and they can perform small-size(thin shape)-izing and low cost-ization.
[0032]4. -- (i) -- the light emitting device whose photogen is a closed shell transition metal complex ion compound in (i) of the 1st clause of the above, and (ii).
(ii) The light emitting device of (iii) of the 1st clause of the above.
[0033](Elements of the Invention) The working examples 1-3 correspond. As the photogen 4 (or 23, 32), the compound containing closed shell transition metal complex ion (MoO_4^{2-}, WO_4^{2-}, etc.), such as $CdMoO_4$ and $CdWO_4$, is used.
[0034](OPERATION) Closed shell transition metal complex ion is excited, and is made to emit light by ultraviolet radiation.
(EFFECT OF THE INVENTION) Since the emission spectrum of closed shell transition metal complex ion is produced in broadcloth form in a visible wavelength region, a white light element is producible by using this photogen.
[0035]5. Thin-film-fabrication method where substrate is heated closed shell transition metal complex ion compound of (i) of the 4th clause of the above, wherein it is produced.
(Elements of the Invention) Vacuum deposition is carried out, where it heated the photogen using a closed shell transition metal complex ion compound on the transparent electrode of an ultraviolet light emitting device and a substrate is heated on a transparent base (for example, glass substrate). For example, in a $CdMoO_4$ thin film, a good thin film is producible with the substrate temperature near 490 ** (forming temperature).
[0036](****) By heating a substrate at the time of membrane formation, the reaction ($Cd+MoO_3+1/2\ O_2->CdMoO_4$) in the membrane formation surface is promoted.
(EFFECT OF THE INVENTION) By heating a substrate and promoting the above-mentioned reaction on the surface of membrane formation, the photogen thin film which the closed shell transition metal fully ionized can be obtained, and the bright luminescence element using it can be produced.
[0037]6. -- (i) -- a light emitting device, wherein a photogen functions also as an electrode in (i) of the 1st clause of the above, and (ii).
(ii) The light emitting device which comprises material in which the photogen used the multiple oxide or stannic acid ghost of indium and tin as the main ingredients in (i) of the 6th clause of the above.
[0038](iii) The light emitting device of (iV) of the 1st clause of the above.
(Elements of the Invention) The working example 4 corresponds. Instead of the electrode for making the ultraviolet light emitting device 41 drive, the material which added the luminescence center of a transition metal ion, rare earth ions, closed shell transition metal complex ion, etc. is used for transparent conductive material. As transparent conductive material, there are SnO_2 (tin oxide), ITO (oxide of indium and tin), etc.
[0039](OPERATION) In the material shown above, since it has conductivity and the luminescence center is included as an electrode, it functions also as a photogen.
(EFFECT OF THE INVENTION) A manufacturing cost can be reduced with constituting an electrode and a photogen from same substance. Since a luminous layer turns into the top layer and extraction efficiency improves, a bright luminescence element is producible.
[0040]7. Display device arranging aforementioned light emitting device to matrix form, and displaying character and/or video information (display).

Savant Technologies LLC - 1004.843

(Elements of the Invention) The working example 5 corresponds. The ultraviolet light emitting device 61 which can be driven independently is put in order by matrix form, and if it corresponds to each element, the photogens 65a, 65b, and 65c are equipped. This photogen may be congener (same color luminescence), or may be different species (unique luminescence).

[0041](OPERATION) By driving separately the ultraviolet light emitting device 61 allotted to matrix form, the photogens 65a, 65b, and 65c corresponding to each element are excited.

(EFFECT OF THE INVENTION) A character and/or video information can be displayed by making the light emitting device consisting of the ultraviolet light emitting device 61 and the photogens 65a, 65b, and 65c emit light selectively.

[0042]

[Effect of the Invention]As explained in full detail above, according to this invention, even if it is a photogen which fills only the optical characteristic, the display device using the light emitting device and this which can carry out [element]-izing can be provided.

Savant Technologies LLC - 1004.844

Menda II - 2nd translation of selected portions

H08-250281 -Menda – Olympus Optical Co.

Page 1: composition- Light emitting element which contains solid element (1) which emits less than 400nm and light emitter (4) which emits longer light wave

[0005] This light emitting element has ZnO UV-ray emitting layer, ZnS barrier layer which is located on t ZnO layer, transparent electrode which is located on ZnS layer, and light emitter which is located on the transparent electrode.

[0008] see Fig.1 , (1) UV-ray emitting element is wedged between (2) transparent electrode and (3)electrode.
(1) is a UV ray emitting element (solid element) which emit less than 400nm. (4) light emitter (Phosphor) is located above (2) transparent electrode

[0010] see Fig 2, (21) is UV ray light emitting element which has more than 3eV band gap and composed with (21a) ZnO UV ray emitting layer and (21b) ZnS barrier Layer.
(22) transparent electrode and (23) light emitter are composed on (21) UV Ray emitting element.

[0011] At the interface of (21a) and (21b), return- light emitting (about 380nm) between band.
This light excites the center of light emitting (Mn) in (23) light emitter(example ZnS:Mn) which is located on (22) transparent electrode. As a result, (23) emits light (yellowy color in Mn). If you use Zno:Zn in (23), it will emit green light.

[0012] see Fig.3, (31) is UV ray light emitting element which is composed of ZNO UV ray emitting layer (31a) and ZnS Barrier layer (31b). (32) light emitter and (33) transparent electrode are located on (31) Backside of (31) is (34) electrode.

[0013] Material of (33) transparent electrode is mostly used SnO2 or ITO and these materials absorb UV Ray light. Placing (33) on the top of the layer excite (32) light emitter effectively.

[0014] see fig. 4 , (41) is UV ray light emitting element which is composed of ZNO UV ray emitting layer (41a) and ZnS Barrier layer (41b). (42) light emitter is located on (31)
Backside of (41) is (43) electrode.

[0015] Materials of (41) are mostly used SnO2 or ITM....

[0021] (i) light emitting element which flash light emitter (phosphor) by light less than 400nm by using solid light emitting element (Photoluminescence)

[0022] (ii) Light emitting element which has solid element which emits less than 400nm and light emitter which emits longer than 400nm

Savant Technologies LLC - 1004.845

(iii) light emitting element which has (S) ZnO UV Ray emitting layer, ZNS barrier layer (I) which is located on (S), (M) transparent electrode which is located on (I).

[0022] (iv) Light emitting element which is composed on M(light emitting electrode), I (ZnS barrier layer), and S (ZnO UV ray emitting layer)

[0024] under (i) solid element is a semiconductor which band gap is more than 3eV.

[0025] under (i), the semiconductor which band bap is more than 3eV is made of Zinc Oxide or Zinc Sulfide.

[0026] UV ray emitting element (1) or (21, 31, 41) is used oxide semiconductor such as ZnO or sulfide semiconductor such as ZnS which band gap has more than 3eV.

[0031] ZnO or ZnS is used as UV ray emitting element (21) (or (31)) and used as light emitter (23) (or (32)). Accordingly, (23) or (32) and (21) or (31) could be combined and the combination will reduce the cost.

Savant Technologies LLC - 1004.846

Espacenet

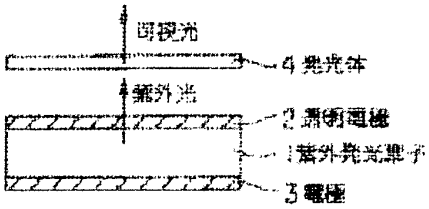
Bibliographic data: JP8250281 (A) — 1996-09-27

LUMINESCENT ELEMENT AND DISPLAYING APPARATUS

Inventor(s):	MENDA KAZUNORI ±	
Applicant(s):	OLYMPUS OPTICAL CO ±	
Classification:	**- international:**	***G09F13/20; G09F13/22; H05B33/12; H05B33/14;*** (IPC1-7): G09F13/20; G09F13/22; H05B33/14
	- European:	
Application number:	JP19950048498 19950308	
Priority number (s):	JP19950048498 19950308	

Abstract of JP8250281 (A)

PURPOSE: To integrate a light emitting body and an ultraviolet-ray emitting element and miniaturize a dislay apparatus by providing a solid element to emit light rays with wavelength shorter than a specified nm and a light emitting body to emit light rays with wavelength longer than the specified nm. CONSTITUTION: An ultraviolet-ray emitting element 1 to emit light rays with a wavelength shorter than, for example, 400nm is installed while being sandwiched between a transparent electrode 2 and an electrode 3. A light emitting body 4 is put above the transparent electrode 2. When an electric field is applied between the transparent electrode 2 and the electrode ultraviolet-rays are emitted through the transparent electrode 2. The emitted ultraviolet-rays are absorbed by the light emitting body 4 set in the radiation direction and the light emitting body 4 emits visible light rays with longer wavelength than ultraviolet-rays. The wave length of emitted light for example the colors of the emitted light rays can be changed by changing the type of the light emitting body 4. For example, in the case a CdMoO4 thin film formed on a quartz glass substrate at the substrate temperature 490 deg.C is used as a light emitting body, incandescent light rays are



obtained and the light emission spectrum of the light rays attributed to the closed shell complex ion of the transition metal has a peak around 480nm.

Last updated: 14.03.2012 Worldwide Database 5.7.38; 92p

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平8－250281

(43)公開日　平成８年(1996)９月27日

(51)Int.Cl.⁶		識別記号	庁内整理番号	ＦＩ			技術表示箇所
Ｈ０５Ｂ	33/14			Ｈ０５Ｂ	33/14		
Ｇ０９Ｆ	13/20			Ｇ０９Ｆ	13/20	Ｄ	
	13/22				13/22	Ａ	

審査請求　未請求　請求項の数３　ＯＬ　（全 5 頁）

(21)出願番号　特願平7－48498

(22)出願日　平成７年(1995)３月８日

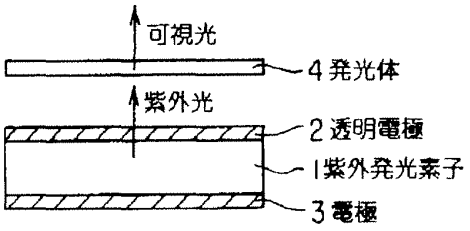
(71)出願人　000000376
オリンパス光学工業株式会社
東京都渋谷区幡ヶ谷２丁目43番２号

(72)発明者　免田　和典
東京都渋谷区幡ヶ谷２丁目43番２号　オリンパス光学工業株式会社内

(74)代理人　弁理士　鈴江　武彦

(54)【発明の名称】　発光素子及び表示装置

(57)【要約】
【目的】本発明は、光学的特性のみを満たす発光体であつても素子化できることを主要な目的とする。
【構成】４００ｎｍよりも短い波長の光を放射する固体素子(1)と、その波長よりも長い波長の光を放射する発光体(4)とを具備することを特徴とする発光素子。



Savant Technologies LLC - 1004.849

【特許請求の範囲】
【請求項１】　４００ｎｍよりも短い波長の光を放射する固体素子と、その波長よりも長い波長の光を放射する発光体とを具備することを特徴とする発光素子。
【請求項２】　ＺｎＯ紫外発光層と、この紫外発光層上に設けられたＺｎＳ障壁層と、この障壁層上に形成された透明電極と、この透明電極上に設けられた発光体とを具備することを特徴とする発光素子。
【請求項３】　前記発光素子をマトリクス状に配置して文字及び／又は映像情報を表示することを特徴とする請求項１又は請求項２記載の表示装置。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は発光素子に関し、特にエレクトロルミネッセンス（ＥＬ），ホトルミネッセンス（ＰＬ）技術に属し、ＥＬディスプレイ，プラズマディスプレイ，ＣＲＴなどの表示装置や光源に利用されるものである。
【０００２】
【従来の技術】従来、ＥＬ素子は、図５に示すように発光体（蛍光体）51を２つの電極52，53で挟んだ構造をしている。これらの電極52，53間に直流または交流電圧を加えて、発光体51内に電界を発生させることによって電子を加速し、発光体１中に添加されている発光中心を衝突励起する（例えば、「エレクトロルミネセントディスプレイ」猪口敏夫著，産業図書）。従って、発光体51は、発光強度（輝度）は発光波長（色）などの光学的特性だけでなく、電子加速（ホットエレクトロンの生成）等の電気的特性をも満たしていなければならず、現在のところ、実用に至っている発光体はＺｎＳ：Ｍｎだけである。
【０００３】
【発明が解決しようとする課題】従来技術では、光学的及び電気的特性の両方を満足する発光体しか発光素子に応用することができない。本発明はこうした事情を考慮してなされたもので、光学的特性のみを満たす発光体であっても素子化できる発光素子及びこれを用いた表示装置を提供することを目的とする。
【０００４】
【課題を解決するための手段】本願第１の発明は、４００ｎｍよりも短い波長の光を放射する固体素子と、その波長よりも長い波長の光を放射する発光体とを具備することを特徴とする発光素子である。
【０００５】本願第２の発明は、ＺｎＯ紫外発光層と、この紫外発光層上に設けられたＺｎＳ障壁層と、この障壁層上に形成された透明電極と、この透明電極上に設けられた発光体とを具備することを特徴とする発光素子である。本願第３の発明は、前記発光素子をマトリクス状に配置して文字及び／又は映像情報を表示することを特徴とする表示装置である。
【０００６】
【作用】この発明においては、固体発光素子から放射された光が発光体を励起し、発光させる。従って、発光体を紫外光で励起するので、発光体に様々な種類のものを用いても、その電気的特性によらず、発光させることができる。
【０００７】また、例えば図６のようにマトリックス状に配した紫外発光素子を個々に駆動することで、各々の素子に対応した各発光体を励起する。従って、紫外発光素子と発光体とからなる発光素子を選択的に発光させることで、文字及び／又は映像情報を表示させることができる。
【０００８】
【実施例】以下、本発明の実施例について図面を参照して説明する。
（実施例１）図１を参照する。図中の符号１は、透明電極２と電極３により挟まれ、４００nmよりも短い波長の光を放射する紫外発光素子（固体素子）である。前記透明電極２の上方には、発光体（蛍光体）４が配置されている。
【０００９】こうした構成の発光素子において、透明電極２と電極３間に電界を印加して、紫外光を透明電極２を通して放射する。放射された紫外光は、放射方向に配置されている発光体４で吸収（励起）され、発光体４は紫外光より波長の長い可視光を発する。そして、発光体４の種類を変えることで、発光波長、即ち、発光色を変えることができる。例えば、発光体４として、石英ガラス基板上に基板温度４９０℃で$CdMoO_4$薄膜を成膜したものを用いると、閉殻遷移金属錯イオンの発光スペクトルは可視波長域にブロードな形状で生じるので、４８０nm付近にピークを有する白色光を得ることができる。また、$CdWO_4$では、４４０nm付近にピークを有する白色光となる。
【００１０】（実施例２）図２を参照する。図中の符号21は、ＺｎＯ紫外発光層21ａとＺｎＳ障壁層21ｂから構成されたバンドギャップが３ｅＶ以上の紫外発光素子である。前記紫外発光素子21上には透明電極22，発光体23が形成され、紫外発光素子21の裏面には電極24が形成されている。
【００１１】こうした構成の発光素子において、前記紫外発光層21ａと障壁層21ｂの界面でＺｎＯのバンド間遷移発光（発光波長約３８０nm）が生じる。この光が透明電極22上に形成された発光体23（例えば、ＺｎＳ：Ｍｎ）の発光中心（Ｍｎ）を励起する。その結果、発光体23は発光（Ｍｎの場合は黄澄色）する。また、発光体23にＺｎＯ：Ｚｎを用いると緑色に発光する。
【００１２】（実施例３）図３を参照する。図中の符号31は、ＺｎＯ紫外発光層31ａとＺｎＳ障壁層31ｂから構成された紫外発光素子である。前記紫外発光素子31上には発光体32，透明電極33が形成され、紫外発光素子31の

Savant Technologies LLC - 1004.850

裏面には電極34が形成されている。

【００１３】こうした構成の発光素子において、透明電極33の材質としては、SnO_2 又はＩＴＯ（インジウム－錫酸化物）が一般的であるが、これらの材質では紫外光に対する吸収が大きい。よって、透明電極33を最上層に形成することで、効率良く発光体32を励起できる。

【００１４】（実施例４）図４を参照する。図中の符号41は、ＺｎＯ紫外発光層41ａとＺｎＳ障壁層41ｂから構成された紫外発光素子である。前記紫外発光素子41上には発光電極42が形成され、紫外発光素子41の裏面には電極43が形成されている。

【００１５】こうした構成の発光素子において、発光電極42の材質としては、SnO_2 又はＩＴＯ等の透明導電性物質に発光中心となる希土類イオン（Ｅｕ，Ｔｍ等）を添加したものを用いる。そして、発光電極42と電極43の間に電界を印加して紫外光を発生させ、その紫外光によって発光中心を励起する。

【００１６】上記実施例４によれば、電極と発光体とを同一物質で構成するので、製造コストを低減できる。また、発光層が最上層となり、取り出し効率が向上するので、高輝度発光素子を作製することができる。

【００１７】（実施例５）図６（Ａ），（Ｂ）を参照する。但し、図６（Ａ）はこの実施例５に係る表示装置の一部を展開した説明図、図６（Ｂ）は一体化した説明図である。

【００１８】図中の符号61はマトリクス状に作製された紫外発光素子で、それらの素子61は個々に独立して駆動できるように配線されている。この紫外発光素子61の裏面には、電極62が形成されている。前記紫外発光素子61上には、仕切り板63間に複数の透明電極64が配置されている。前記仕切り板63上には、下面に複数の発光体65ａ，65ｂ，65ｃが前記紫外発光素子に対応してマトリックス状に作製された透明基板66が設けられている。ここで、前記発光体64ａ，64ｂ，64ｃは、前記透明電極64と向い合うように配置されている。

【００１９】この表示装置において、紫外発光素子61を選択的に駆動させると、文字や映像が表示される。以上詳細に説明したが、本出願には以下の発明が含まれる。

【００２０】１．(i) 固体発光素子を用いて発光させた４００㎚よりも短い波長の光で、発光体（蛍光体）を発光させる（ホトルミネッセンス）ことを特徴とする発光素子。

【００２１】(ii)４００㎚よりも短い波長の光を放射する固体素子と、その波長よりも長い波長の光を放射する発光体とを具備することを特徴とする発光素子。

(iii) ＺｎＯ紫外発光層（Ｓ）と、この紫外発光層上に設けられたＺｎＳ障壁層（Ｉ）と、この障壁層上に形成された透明電極（Ｍ）と、この透明電極上に設けられた発光体とを具備することを特徴とする発光素子。

【００２２】(iv)Ｍ（発光電極）Ｉ（ＺｎＳ障壁層）Ｓ（ＺｎＯ紫外発光層）構造を有する発光素子。

（構成）　実施例１～４が該当する（但し、実施例１の符番のみを用いて説明する）。４００㎚よりも短い波長の紫外光を放射する固体素子（１，２，３）とその素子から放射された紫外光が照射される位置に配した発光体４とで構成される。電極２については必ずしも透明である必要はなく、この場合は放射された紫外光は基板と平行方向に取り出し、発光体４も平行方向に位置する。

【００２３】（作用）　固体発光素子から放射された光が、発光体４を励起し、発光させる。

（効果）　発光体４を紫外光で励起するので、発光体４に様々な種類のものを用いても、その電気的特性によらず、発光させることができる。

【００２４】２．(i) 上記第１項の(i)，(ii)において、４００㎚よりも短い波長の光を放射する固体素子がバンドギャップが３ｅＶ以上の半導体で作製されていることを特徴とする発光素子。

【００２５】(ii)上記第１項の(i) において、３ｅＶ以上のバンドギャップを有する半導体が、酸化亜鉛または硫化亜鉛を主成分とする材料で構成されている発光素子。

(iii) 上記第１項の(iii) の発光素子。

【００２６】(iv)　上記第１項の(iv)の発光素子。

（構成）　実施例１～４が該当する。紫外発光素子１（又は21，31，41）に、バンドギャップが３ｅＶ以上あるＺｎＯなどの酸化物半導体またはＺｎＳなどの硫化物半導体材料を用いる。

【００２７】（作用）　バンドギャップが３ｅＶ以上あるので、その半導体材料からのバンド間遷移発光は４００㎚以下の波長となり、その光で発光体４（又は23，33）を励起する。

【００２８】（効果）　バンドギャップが３ｅＶ以上の半導体を用いることで、紫外光放射に高発光効率のバンド間遷移発光を用いることができる。従って、発光体４（又は23，33）を紫外光で励起でき、高輝度発光素子を作製することができる。

【００２９】３．(i) 上記第１項の(i)，(ii)において、発光体が酸化亜鉛または硫化亜鉛を主成分とする材料で構成されている発光素子。

(ii)上記第１項の(iii) の発光素子。

【００３０】（構成）　実施例２，３が該当する。発光体（23又は32）にＺｎＯまたはＺｎＳに遷移金属錯イオンや希土類イオンを発光中心として添加した材料を用いる。

（作用）　ＺｎＯやＺｎＳ中に添加された発光中心が紫外光によって励起され発光する。

【００３１】（効果）　半導体であるＺｎＯやＺｎＳは、紫外発光素子21（又は31）の材料としても使用でき、かつ発光体23（又は32）の材料としても使用できるので、発光体23（又は32）と紫外発光素子21（又は31）

Savant Technologies LLC - 1004.851

の一体化が可能であり、小型（薄型）化及び低コスト化ができる。

【００３２】４．(i) 上記第１項の(i)，(ii)において、発光体が閉殻遷移金属錯イオン化合物である発光素子。

(ii)上記第１項の(iii) の発光素子。

【００３３】（構成）　実施例１～３が該当する。発光体４（又は23，32）として、$CdMoO_4$，$CdWO_4$等の閉殻遷移金属錯イオン（MoO_4^{2-}，WO_4^{2-}など）を含んだ化合物を用いる。

【００３４】（作用）　閉殻遷移金属錯イオンを紫外光で励起し、発光させる。

（効果）　閉殻遷移金属錯イオンの発光スペクトルは、可視波長域にブロードな形状で生じるので、この発光体を用いることで白色発光素子を作製することができる。

【００３５】５．上記第４項の(i) の閉殻遷移金属錯イオン化合物が、基板を加熱した状態で作製されたことを特徴とする薄膜製造方法。

（構成）　閉殻遷移金属錯イオン化合物を用いた発光体を、紫外発光素子の透明電極上に透明基板（例えばガラス基板）上に、基板を加熱した状態で真空蒸着する。例えば、$CdMoO_4$ 薄膜では、４９０℃付近の基板温度（成膜温度）で良好な薄膜を作製できる。

【００３６】（作用）　成膜時に基板を加熱することで、成膜表面における反応（$Cd+MoO_3+1/2\ O_2 \rightarrow CdMoO_4$）が促進される。

（効果）　基板を加熱して成膜表面での上記反応を促進することにより、閉殻遷移金属が十分にイオン化した発光体薄膜を得ることができ、それを利用した高輝度発光素子が作製できる。

【００３７】６．(i) 上記第１項の(i)，(ii)において、発光体が電極としても機能することを特徴とする発光素子。

(ii)上記第６項の(i) において、発光体がインジウムと錫の複合酸化物または錫酸化物を主成分とした材料で構成されている発光素子。

【００３８】(iii) 上記第１項の(iv)の発光素子。

（構成）　実施例４が該当する。紫外発光素子41を駆動させるための電極の代わりに、透明導電性物質に遷移金属イオン，希土類イオン，閉殻遷移金属錯イオンなどの発光中心を添加した材料を用いる。透明導電性物質としては、SnO_2（酸化錫）やＩＴＯ（インジウムと錫の酸化物）等がある。

【００３９】（作用）　上記に示した材料では、導電性を有するため電極として、かつ発光中心を含んでいるため発光体としても機能する。

（効果）　電極と発光体とを同一物質で構成することで、製造コストが低減できる。又、発光層が最上層となり、取り出し効率が向上するので、高輝度発光素子を作製することができる。

【００４０】７．前記発光素子をマトリクス状に配置して文字及び／又は映像情報を表示することを特徴とする表示装置（ディスプレイ）。

（構成）　実施例５が該当する。独立して駆動することができる紫外発光素子61がマトリックス状に並べられており、各々の素子に対応しては発光体65ａ，65ｂ，65ｃが備わっている。この発光体は同種（同色発光）であっても、異種（異色発光）であっても良い。

【００４１】（作用）　マトリックス状に配した紫外発光素子61を個々に駆動することで、各々の素子に対応した発光体65ａ，65ｂ，65ｃを励起する。

（効果）紫外発光素子61と発光体65ａ，65ｂ，65ｃとからなる発光素子を選択的に発光させることで、文字及び／又は映像情報を表示させることができる。

【００４２】

【発明の効果】以上詳述したようにこの発明によれば、光学的特性のみを満たす発光体であっても素子化できる発光素子及びこれを用いた表示装置を提供できる。

【図面の簡単な説明】

【図１】本発明の実施例１に係る発光素子の説明図。

【図２】本発明の実施例２に係る発光素子の説明図。

【図３】本発明の実施例３に係る発光素子の説明図。

【図４】本発明の実施例４に係る発光素子の説明図。

【図５】従来の発光素子の説明図。

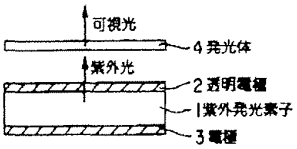
【図６】本発明の実施例５に係る表示装置の説明図で、図６（Ａ）はこの表示装置の一部を展開した説明図、図６（Ｂ）は一体化した説明図。

【符号の説明】

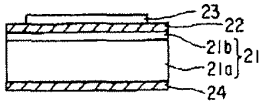
１，21，31，41，61…紫外線発光素子、　２，22，33，64…透明電極

３，24，34，43，62…電極、　４，22，32，65ａ～65ｃ…発光体、63…仕切り板。

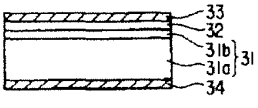
【図１】



【図２】

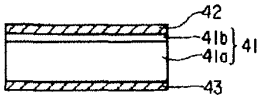


【図３】

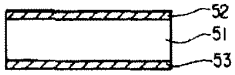


Savant Technologies LLC - 1004.852

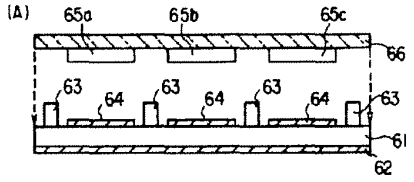
【図4】

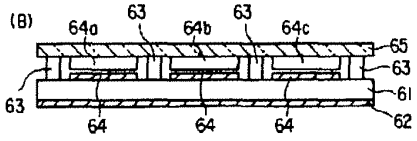


【図5】



【図6】





Savant Technologies LLC - 1004.853

(19) Japan Patent Office (JP)

(12) Published Unexamined Patent Application (A)

(11) Publication No. S60-170194

(43) Date of Publication of Application: September 3, 1985

(51) Int. Cl.[4]	ID Code	JPO File No.
H 05 B 33/14		7254-3K
C 09 K 11/08		7215-4H

Request for Examination: Not yet made
Number of inventions: 1
Total pages: 4

(54) Title of the Invention: EL Element

(21) Application No.: S59-24744

(22) Application Filing Date: February 13, 1984

(72) Inventor: Yuji Shiina, Sony Corporation, 6-7-35 Kita-Shinagawa, Shinagawa-ku, Tokyo

(71) Applicant: Sony Corporation, 6-7-35 Kita-Shinagawa, Shinagawa-ku, Tokyo

(74) Agent: Tei Ito, Patent Attorney (and 1 other)

Specification

Title of the Invention: EL Element

We claim:

An EL element containing a mixture of a fluorescent material and Rhodamine S in a light-emitting layer as a light-emitting material, wherein the fluorescent material gives out blue green light.

Detailed Explanation of the Invention

Industrial Field of Application

The present invention relates to an EL element that gives out white light.

Prior Art and Problems that the Invention is to Solve

An EL device having a white-light emitting EL element has conventionally been used as a surface light source and the like in many applications. However, there is no fluorescent material that can give out white light singly. Therefore, a mixture of various types of fluorescent materials or a mixture of a fluorescent material and a fluorescent dye has been used as a white light emitting material for an EL element. By way of example, the mixture of fluorescent materials include a combination of ZnS:Cu,Cl (wherein Cu and Cl are activators) that emits blue green light and ZnS:Cu,Mn that emits orange light. The mixture of a fluorescent material and a fluorescent dye is exemplified by a combination of ZnS:Cu,Br that emits green light and Rhodamine B that emits red light. In the case of a light-emitting material formed by mixing different types of fluorescent material, however, the problem is that light tones change and luminance declines with time because the use life of each fluorescent material is different. On the other hand, in the case of a combination of a fluorescent material and a fluorescent dye, the problem is that only yellowing white light can be produced rather than high-purity white light and luminance is low.

Purpose of the Invention

In view of the abovementioned problems, the purpose of the present invention is to provide en EL element characterized in that color purity is excellent and that highly-luminous white light can be produced stably.

Summary of the Invention

The present invention relates to an EL element, wherein a mixture of a blue green color-emitting fluorescent material and Rhodamine S is contained in a light-emitting layer as a light-emitting material.

The abovementioned constitution enables to produce highly-luminous white light having excellent color purity.

Embodiments

The light-emitting material contained in the light-emitting layer of an EL element according to the present invention may be exemplified by a mixture of a fluorescent material that emits blue green color such as ZnS:Cu,Cl and a fluorescent dye such as Rhodamine S (molecular formula: $C_{20}H_{23}N_2O_3Cl$).

The Rhodamine S is a basic dye and is excited by light of about 5000 angstroms in wavelength to emit orange fluorescent light with high intensity. As a fluorescent material that emits blue green light, ZnS:Cu,I may also be used in place of ZnS:Cu,Cl.

Savant Technologies LLC - 1004.854

Next, a description of an EL device that uses an EL element having the abovementioned light-emitting layer and a production method thereof are given below.

Fig. 1 is a sectional view of a flexible type EL device (1). The EL device (1) may be formed by vertically sandwiching a substantially squared thin plate-like EL element (2) by two sheets of transparent moisture-proof films (3) air-tightly and is flexible as a whole. The EL element (2) is constituted of a transparent polyester film (4), a transparent electrode (5) made of ITO and formed by vacuum deposition on the abovementioned polyester film (4), a light-emitting layer (6) and a back electrode (7) formed of an aluminum foil. The light-emitting layer (6) is formed by dispersing a mixture of ZnS:Cu,Cl (50 to 95 % by weight) and Rodamine S (0.01 to 0.1 % by weight) according to the present invention in a binding agent (5 to 50 % by weight) having a high dielectric ratio. The contents of Cu and Cl in ZnS:Cu,Cl are 0.045 % by weight and 0.020 % by weight, respectively. The binding agent having a high dielectric constant may include trifluoroethylene-polyvinylidene fluoride and cyanoethyl cellulose. The light-emitting layer (6) is formed by coating the transparent electrode (5) with slurry light-emitting layer (6) materials to a thickness of 50μm by screen printing and then drying at 150°C for 30 minutes. The light-emitting layer (6) may contain a proper amount of dimethyl acetamide as a viscosity adjusting solvent. An aluminum foil is placed on the back electrode (7) by subjecting 100μm of the aluminum foil to thermo-compression bonding on the light-emitting layer (6) by a heated roll. The EL element having the abovementioned configuration is vertically sandwiched by two sheets of moisture-proof films (3) air-tightly by thermo-compression bonding to produce the device (1) according to the present invention. Since this sealing of the EL element (2) is performed in dry Ar or N_2 gas, the dry Ar or N_2 gas fills a gap (8) within the EL device (8).

The moisture-proof film (3) may include a fluorohalo-carbon film (e.g., Acra *[Only phonetically equivalent; spelling could not be confirmed – Tr. Note]* (product name) manufacture by Allied Chemical Corporation) and a polychlorotrifluoroethylene film. Each of the electrodes (5) and (7) is provided with a lead terminal (not shown here), and a lead (not shown here) is led through the two sheets of moisture-proof films (3) to the outside to be connected with an outside power source.

An AC voltage is applied to the electrodes (5) and (7) of the EL device (1) via the lead in order to emit light from the light-emitting layer (6). Light emitted through the transparent electrode (5) and polyester film (4) of the EL device (1) is used as a surface light source.

Fig. 2 shows the results of measuring the relationship between the wavelength of light produced by the present EL device (1) and relative energy. In Fig. 2, light having a peak in the vicinity of 4700 angstroms is blue green light emitted from ZnS:Cu,Cl, and light having a peak in the vicinity of 5700 angstroms is orange light emitted from Rhodamine S. This chart shows that Rhodamine S is effectively excited by the blue green light of ZnS:Cu,Cl, which has comparatively high relative energy in the vicinity of 5000 angstroms, to emit light having high relative energy.

Fig. 3 is an x,y chromaticity chart showing the chromaticity of light. The chromaticity of light produced by the present EL device (1) is 0.2918 in x (x = 0.2918) and 0.3212 in y (y = 0.3212) and is highly-pure white light as shown by a mark X in Fig. 3.

Fig. 4 shows the results of measuring the luminance of light by changing the voltage of an AC power source having a frequency of 1 kHz for the EL device (1) having the EL element (2) according to the present invention and a conventional EL device in which a mixture of two fluorescent materials, that is, ZnS:Cu,Cl and ZnS:Cu,Mn is used as a light-emitting material. Curves A and B show the luminance of light in the present EL device and one in the conventional EL device, respectively. As shown in Fig. 4, the EL device (1) according to the present invention can produce light of high luminance even at a low voltage as compared with the conventional EL device.

The EL device used in the EL device (1) according to the present invention may be one other than the flexible type as described in the abovementioned embodiment. Moreover, the both-face light emission type may also be used, wherein both electrodes are transparent.

Effect of the Invention

The present invention enables to give out white light having good color purity. Moreover, stable white light can be generated regardless of time elapsed because the present invention does not use a light-emitting material made of a mixture of different types of fluorescent materials having different use life unlike conventional cases. Furthermore, since Rhodamine S is excited to blue green color and emits orange fluorescent light with strong intensity, high-luminance white light can be produced even at a low voltage.

Savant Technologies LLC - 1004.855

Brief Description of Drawings

Fig. 1 is a sectional view of a flexible type EL device using an EL element according to the present invention. Fig. 2 is a characteristic chart showing the relationship between the wavelength of light and relative energy. Fig. 3 is an x, y chromaticity chart. Fig. 4 is a characteristic chart comparing between luminance by an EL device according to the present invention and luminance by a conventional EL device.

Reference numerals are as follows: (1) EL device; (2) EL element; (5) transparent electrode; (6) light-emitting layer; and (7) back electrode.

Agent: Tei Ito *[An illegible impression appears here – Tr. Note]*

Agent: Hidemori Matsukuma *[An illegible impression appears here – Tr. Note]*

Fig. 1

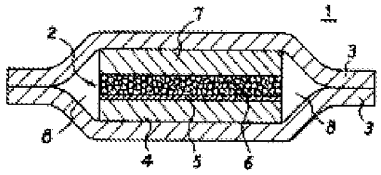


Fig. 2

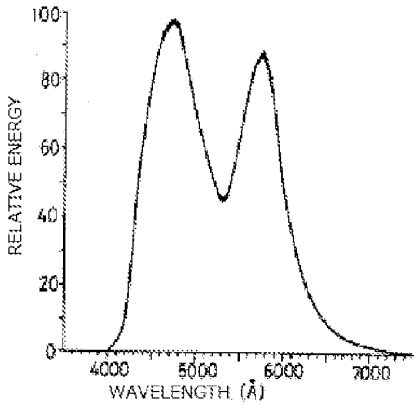


Fig. 3

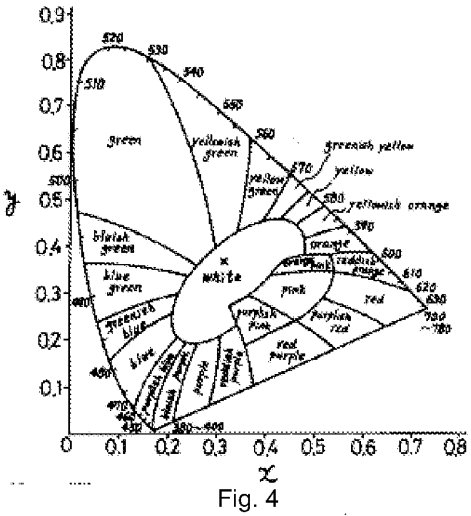
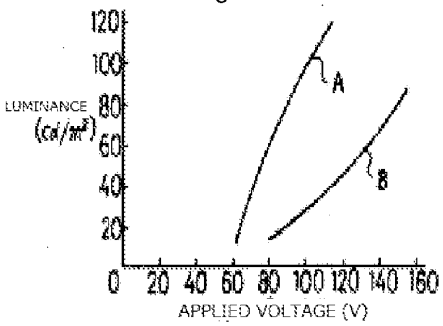


Fig. 4



Amendment

Date: May 17, 1984

To: Mr. Kazuo Wakasugi, The Commissioner of JPO
(Mr. , Presiding judge of JPO)

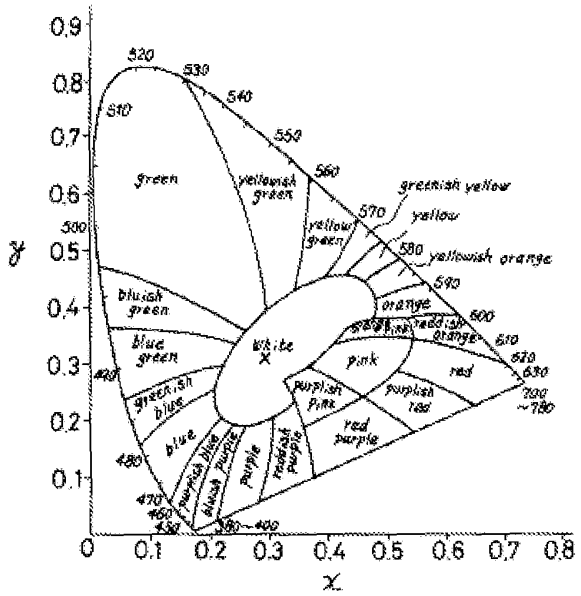
1.Case Identification
Patent Application No. S59-24744
2. Title of the Invention: EL Element
3. Party Filing the Amendment
Relationship to the Case: Patent Applicant
Address: 6-7-35 Kita-Shinagawa, Shinagawa-ku, Tokyo
Name: (218) Sony Corporation
Representative Director: Norio Oga
4. Agent: Shinjuku Bldg., 1-8-1 Shinjuku, Shinjuku-ku, Tokyo
(3388) Tei Ito, Patent Attorney

5. Date of Amendment Directive:
6. Number of Inventions to be increased by the Amendment:
7. Parts Amended: Drawings
8. Content of the Amendment
(1) Fig. 3 in the drawings is amended as shown in the attachment.

JPO
May 18, '84
(illegible)

Savant Technologies LLC - 1004.856

Fig. 3



Savant Technologies LLC - 1004.857

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re United States Patent of:		**Docket No.:**	**4241-198-REEXAM**
Patentees:	**BARETZ, Bruce H. and TISCHLER, Michael A.**	**Conf. No.:**	**4549**
Control No.:	**90/010,940**	**Art Unit:**	**3992**
Patent Under Reexamination:	**6,600,175**	**Examiner:**	**Erik Kielin**
Title:	**SOLID WHITE LIGHT EMITTER AND DISPLAY USING SAME**	**Customer No.:**	**23448**

SUBMISSION OF RESPONSE TO NOVEMBER 7, 2011 OFFICE ACTION; DECLARATIONS OF BRANDES, BARETZ, TISCHLER, ELLIOT AND STRINGFELLOW; SIXTH SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT; DAVID ROMAN ARTICLE REFERENCE AND ENGLISH TRANSLATION OF JAPANESE PATENT APPLICATION PUBLICATION NO. 60-170194 REFERENCE

***EX PARTE* REEXAMINATION CONTROL NO. 90/010,940**

CERTIFICATE OF SERVICE

I hereby certify that on this 7th day of January, 2012, a true and correct copy of each of the RESPONSE TO NOVEMBER 7, 2011 OFFICE ACTION; DECLARATIONS OF BRANDES, BARETZ, TISCHLER, ELLIOT AND STRINGFELLOW; INFORMATION DISCLOSURE STATEMENT; DAVID ROMAN ARTICLE REFERENCE AND ENGLISH TRANSLATION OF JAPANESE PATENT APPLICATION PUBLICATION NO. 60-170194 REFERENCE in *EX PARTE* REEXAMINATION CONTROL NO. 90/010,940 is being served via First Class U.S. Mail on:

Harness, Dickey & Pierce, P.L.C.
P.O. Box 828
Bloomfield Hills, Michigan 48303
Attn: Michael E. Hilton, Esquire

/steven j. hultquist/
Steven J. Hultquist
Reg. No. 28021
Attorney for Patent Owner

HULTQUIST IP
P.O. Box 14329
Research Triangle Park, NC 27709
Phone: (919) 419-9350
Fax: (919) 419-9354
Attorney File No.: 4241-198-REEXAM

Electronic Acknowledgement Receipt	
EFS ID:	11783922
Application Number:	90010940
International Application Number:	
Confirmation Number:	4549
Title of Invention:	SOLID STATE WHITE LIGHT EMITTER AND DISPLAY USING SAME
First Named Inventor/Applicant Name:	6600175
Customer Number:	23448
Filer:	Steven John Hultquist
Filer Authorized By:	
Attorney Docket Number:	1300-000044/US/RXA
Receipt Date:	07-JAN-2012
Filing Date:	06-MAY-2010
Time Stamp:	16:31:40
Application Type:	Reexam (Patent Owner)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Reexam Response to Final Rejection	198REEXAMResponse_110711FinalOA.pdf	436232 5a1add00995c78e6d3c2aff9d8da0cadf4ba5835	no	74

Warnings:

Information:

Savant Technologies LLC - 1004.859

2	Rule 130, 131 or 132 Affidavits	198Reexam131DeclarationII_Elliott.pdf	743384 b072c0ff1b5c694b5885870ba9b1eeaff1ec5a4e	no	23
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
3	Rule 130, 131 or 132 Affidavits	198REEXAM131DeclarationIII_Tischler.pdf	116019 aea8f792daee51f186d814dff8b4e66634a6f01c	no	4
Warnings:					
Information:					
4	Rule 130, 131 or 132 Affidavits	198REEXAM132Declaration_Stringfellow.pdf	527846 0c399a2e680542d99dba577100049448f3d2b251	no	10
Warnings:					
Information:					
5	Rule 130, 131 or 132 Affidavits	198REEXAM132DeclarationIIBrandes.pdf	2396663 ddefd5c105551c2a7d6a636047d55ea4563e3ebb	no	20
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
6	Information Disclosure Statement (IDS) Form (SB08)	198REEXAM_SixthSuppIDS.pdf	611916 222fb402a27e309ec42aaa80de23e6887b03e2d8	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
7	Non Patent Literature	Roman_1995.pdf	211554 ff8de46003ba7446818649dcc6eb7a173bfc0285	no	2
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
8	Rule 130, 131 or 132 Affidavits	198Reexam131DeclarationIII_Baretz.pdf	3676721 51de201299f7d254176601bbfa7b1e206cd61d3e	no	28
Warnings:					
Information:					

9	Miscellaneous Incoming Letter	198REEXAMSixthSupplDSSubmission.pdf	30267 34f806b109942618645b805c78ed4af0a1c8af85	no	2
Warnings:					
Information:					
10	Foreign Reference	JP60170194AENGTRANS.pdf	192824 badeae096b6dbb6c22fe31a31af5016e3384d025	no	4
Warnings:					
Information:					
11	Reexam Certificate of Service	198REEXAMCertificateService.pdf	30449 7c1fb242cd7d38bbc7b98a1b834f63287a554c2c	no	1
Warnings:					
Information:					
		Total Files Size (in bytes):	8973875		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　昭60－170194

⑤1Int.Cl.⁴	識別記号	庁内整理番号	⑬公開　昭和60年(1985)9月3日
H 05 B 33/14		7254－3K	
C 09 K 11/08		7215－4H	

審査請求　未請求　発明の数 1　（全4頁）

⑤4発明の名称　EL素子

⑳特　願　昭59－24744

㉒出　願　昭59(1984)2月13日

㉗発明者　椎名　祐二　東京都品川区北品川6丁目7番35号　ソニー株式会社内

㉑出願人　ソニー株式会社　東京都品川区北品川6丁目7番35号

㉔代理人　弁理士 伊藤　貞　外1名

明　細　書

発明の名称　EL素子

特許請求の範囲

青緑色に発光する螢光体とローダミンSとの混合物が発光材料として発光層中に含有されて成るEL素子。

発明の詳細な説明

産業上の利用分野

本発明は、白色に発光するEL素子に関する。

背景技術とその問題点

白色に発光するEL素子を有するEL装置は、面光源等として従来から多用されているが、単独で白色に発光する螢光体はない。このため、EL素子用の白色発光材料としては、各種の螢光体の混合物又は螢光体と螢光染料の混合物が使用されている。例えば螢光体同士の混合物としては、青緑色に発光するZnS:Cu,Cℓ（CuとCℓは付活剤）と橙色に発光するZnS:Cu,Mnの組み合わせがある。また、螢光体と螢光染料の混合物としては、緑色に発光するZnS:Cu,Brと赤色に発光するローダミンBとの組み合わせなどがある。しかし、異種の螢光体同士の混合による発光材料の場合、各螢光体に寿命差があるため、時間の経過と共に光の色調が変化し、また輝度も低いという問題点がある。一方、螢光体と螢光染料を組み合わせた場合には、純度の良い白色ではなく黄色がかつた白色の光しか得ることができず、また輝度も低いという問題点がある。

発明の目的

本発明は、上述の点に鑑みて、色純度が良く、高輝度の白色光を安定して得ることができるEL素子を提供することを目的とする。

発明の概要

本発明は、青緑色に発光する螢光体とローダミンSとの混合物が発光材料として発光層中に含有されて成るEL素子である。

上記構成により、色純度が良く、高輝度の白色光を得ることができる。

実施例

本EL素子の発光層中に含有される発光材料とし

Savant Technologies LLC - 1004.862

ては、例えばZnS:Cu,Cℓのような青緑色に発光する螢光体と螢光染料であるローダミンS（分子式$C_{20}H_{23}N_2O_5Cℓ$）との混合物を使用する。

このローダミンSは、塩基性染料であり、波長が5000Å近傍の光によつて励起され、橙色に強く螢光する。また、青緑色に発光する螢光体としては、ZnS:Cu,Cℓの代わりに例えばZnS:Cu,Iを使用することもできる。

次に、上記発光層を有するEL素子を使用したEL装置及びその製法を示す。

第1図は、フレキシブル型EL装置(1)の断面図である。このEL装置(1)は、例えば略正方形の薄板状EL素子(2)を上下2枚の透明な防湿フイルム(3)で密封することにより構成し、全体が可撓性を有している。EL素子(2)は、透明なポリエステルフイルム(4)、この上に真空蒸着により形成されたITOよりなる透明電極(5)、発光層(6)、Aℓ箔の背面電極(7)より成る。発光層(6)の材料は、本発明に基づくZnS:Cu,Cℓ（50～95重量%）とローダミンS（0.01～0.1重量%）との混合物を高誘電率の結合剤（5～50重量%）中に分散させることにより構成する。ZnS:Cu,Cℓ中のCu及びCℓの含有量は、それぞれ0.045重量%及び0.020重量%である。高誘電率結合剤としては、トリフロルエチレン-ポリフツ化ビニリデン、シアノエチルセルロース等を使用することができる。この発光層(6)は、透明電極(5)の上にスラリー状の発光層(6)材料をスクリーン印刷により50μmの厚さに塗布した後、150℃で30分間乾燥させることにより形成する。なお、発光層(6)中には、粘度調整用の溶剤としてジメチルアセトアミドを適量含有させてもよい。背面電極(7)となるAℓ箔は、発光層(6)の上に100μmのAℓ箔を180℃の熱ロールで熱圧着することにより設ける。このように構成したEL素子(2)に上下2枚の防湿フイルム(3)を熱圧着することにより、EL素子(2)を密封し、本EL装置(1)を得る。このEL素子(2)の密封は、乾燥したAr又はN_2ガス中で行なわれるので、EL装置(1)内の隙間(8)には、乾燥したAr又はN_2ガスが封入されている。防湿フイルム(3)としては、フロロハロカーボンフイルム（例えば米国アライドケミカル社製のアクラー（商品名））、ポリクロルトリフロロエチレンフイルム等を使用する。電極(5)，(7)には、リード端子（図示せず）を設けてあり、外部電源との接続のためにリード（図示せず）が2枚の防湿フイルム(3)の間から外部に導出されている。

このEL装置(1)の電極(5)，(7)にリードを介して交流電圧を印加し、発光層(6)を発光させる。このEL装置(1)の透明電極(5)、ポリエステルフイルム(4)を通つて取り出された光が、面光源として使用される。

第2図に、本EL装置(1)によつて得られた光の波長と相対エネルギーとの関係を測定した結果を示す。第2図で4700Å近傍にピークを有する光はZnS:Cu,Cℓからの青緑光であり、5700Å近傍にピークを有する光はローダミンSからの橙光である。この図から、ローダミンSは、5000Å近傍の比較的高い相対エネルギーを有しているZnS:Cu,Cℓの青緑色によつて有効に励起されるため、高い相対エネルギーを有する光を発光することがわかる。

第3図は、光の色度点を示すx,y色度図である。本EL装置(1)により得られた光の色度点は、x=0.2918，y=0.3212であり、第3図のX印で示すように非常に純度の良い白色であることがわかる。

第4図に、本発明に係るEL素子(2)を有するEL装置(1)及び発光材料としてZnS:Cu,Cℓ とZnS:Cu,Mnの螢光体同士の混合物を使用した従来式のEL素子を有するEL装置について、周波数1kHzの交流電源の電圧を変えて光の輝度を測定した結果を示す。曲線Aが本EL装置、曲線Bが従来のEL装置による輝度を示す。第4図から明らかなように、本発明に係るEL装置(1)は、従来のEL装置と比べて、低電圧でも高輝度の光を得ることができる。

なお、本EL素子が使用されるEL装置は、上記実施例のフレキシブル型以外のものでもよく、また両方の電極が透明な両面発光型のものでもよい。

発明の効果

本発明によれば、色純度の良い白色光を得ることができる。また、従来のように寿命差のある異種の螢光体同士が混合されてなる発光材料を使用し

Savant Technologies LLC - 1004.863

ていないので、時間の経過に拘わらず安定した白色光が得られる。更に、ローダミンSは青緑光に励起されて橙色に強く螢光するので、低電圧でも高輝度の白色光を得ることができる。

図面の簡単な説明

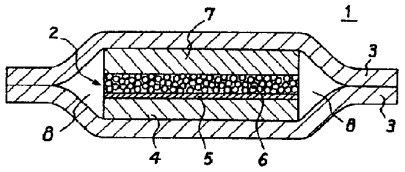
第1図は本発明に係るEL素子を使用したフレキシブル型EL装置の断面図、第2図は本EL装置による光の波長と相対エネルギーとの関係を示す特性図、第3図はx,y色度図、第4図は本EL装置と従来のEL装置による輝度を比較した特性図である。

(1)はEL装置、(2)はEL素子、(5)は透明電極、(6)は発光層、(7)は背面電極である。

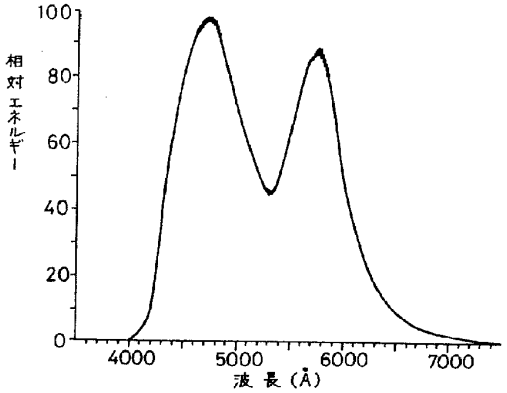
代理人　伊藤　貞

同　松隈秀盛

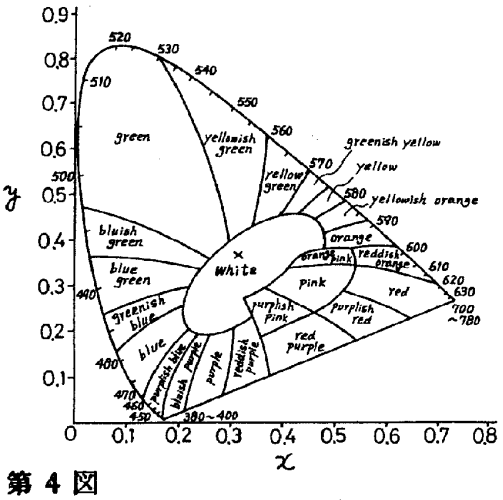
第1図



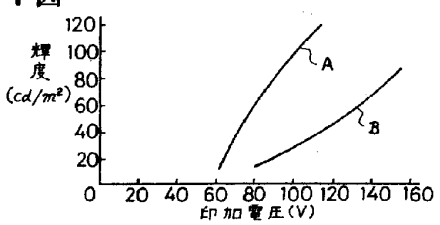
第2図



第3図



第4図



手続補正書

昭和59年5月17日

特許庁長官　若杉和夫　殿
(特許庁審判長　殿)

1. 事件の表示

昭和59年特許願第　24744　号

2. 発明の名称　EL素子

3. 補正をする者

事件との関係　特許出願人

住所　東京都品川区北品川6丁目7番35号

名称　(218)　ソニー株式会社

代表取締役　大賀典雄

4. 代理人　東京都新宿区西新宿1丁目8番1号(新宿ビル)

TEL 東京(03)343-5821(代表)

(3388) 弁理士　伊藤　貞

5. 補正命令の日付　昭和　年　月　日

6. 補正により増加する発明の数

7. 補正の対象　図面

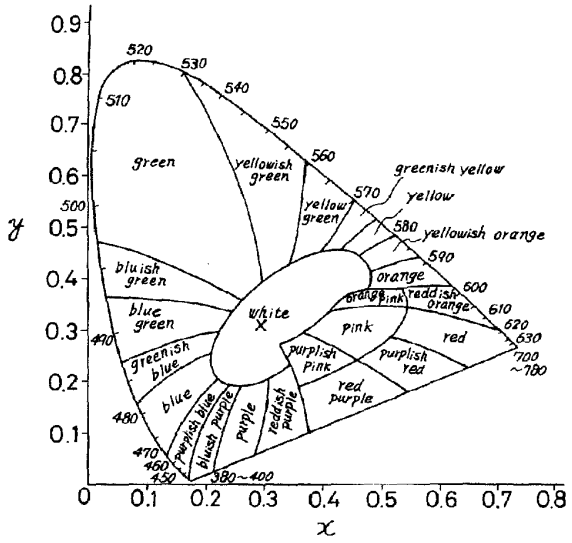
8. 補正の内容

(1) 第3図を別紙の通り補正する。

特許庁 59.5.18 日向野

Savant Technologies LLC - 1004.864

第 3 図



Savant Technologies LLC - 1004.865

(19) Japan Patent Office (JP)

(11) Patent Application Publication No.

S62-189770

(12) Patent Application Publication (A)

(43) Publication Date: Aug. 19, 1987

(51) Int. Cl.[4]	Classification symbol	Internal reference No.
H 01 L 33/00		A-6819-5F
H 01 S 3/18		7377-5F

Examination request: Requested

Number of Inventions: 1 (Total 5 pages)

---

(54) Invention Title:

Junction-Type Light Emitting Semiconductor Device

(21) Application No.: S61-31573

(22) Application Date: Feb. 15, 1986

(72) Inventor: Fumio Inaba 1-13-1 Yagi-sann Minami, Sendai-shi

(72) Inventor: Hiroaki Ito 390-82 Aza-Aoba, Aramaki, Sendai-shi

(72) Inventor: Akira Mizuyoshi c/o Itami Works, Dainichi Nihon Densen Co., LTD 4-3 Ikejiri, Itami-shi

(71) Applicant: Fumio Inaba 1-13-1 Yagi-sann Minami, Sendai-shi

(71) Applicant: Hiroaki Ito 390-82 Aza-Aoba, Aramaki, Sendai-shi

(71) Applicant: Mitsubishi Densen Co., LTD. 3-Banchi, Nishinoshima, Higashimukoujima, Amagasaki-shi

(74) Agent: Patent Attorney: Hajime Takashima

Specification

1. Invention Title:

Savant Technologies LLC - 1004.866

Junction-Type Light Emitting Semiconductor Device

2. What is Claimed is:

A junction-type light emitting semiconductor device which is equipped with a flat plate section, a pillar protrusion which is provide on one surface of said flat plate section, and electrodes which are provided on any location of the flat plate section and the pillar protrusion; and which has a pn junction extending at least within the pillar protrusion along a direction perpendicular to the flat plate section; wherein a phosphor layer is provided on a top surface of the pillar protrusion and covers at least a portion of an emission section including the pn junction which is exposed on said top surface.

3. Detailed Explanation of the Invention

{Field of Industrial Application}

The present invention relates to a junction-type light emitting semiconductor device which can be employed in a light emitting diode and semiconductor laser. In particular, the present pertains to a junction-type light emitting semiconductor device which is equipped with a flat plate section, a pillar protrusion which is provide on one surface of said flat plate section, and electrodes which are provided on any location of the flat plate section and the pillar protrusion; and which has a pn junction extending at least within the pillar protrusion along a direction perpendicular to the flat plate section; wherein the wavelength of an emission from an emission section including the pn junction is converted.

{Conventional Technologies}

A light emitting device which provides an emission in a direction perpendicular to its substrate (flat plate section) can be easily coupled to an optical fiber. Moreover, when such devices are arranged in a one or two dimensional array, various applications can be

Savant Technologies LLC - 1004.867

expected in OA (Office Automation) information apparatuses and the like. Therefore, researches are being conducted for its development in laboratories for semiconductor lasers and light emitting diodes. In recent years, various types were put to practical use.

{Issues to be Resolved by the Invention}

A basic structural example of a junction type light emitting semiconductor device whose pn junction within a pillar protrusion formed along a direction perpendicular to its substrate provides an emission in a direction perpendicular to the substrate consists of a flat plate section (B), a pillar protrusion (P) which is provided on one surface of the flat plate section, a p-side electrode (E1) which is provided on a side periphery of pillar protrusion (P) and on an upper surface of flat plate section (B), and an n-side electrode (E2) which is provided on a bottom surface of flat plate section (B), as illustrated in Figure 4. Through pillar protrusion (P), there exists a pn junction PN1 which extends in a direction perpendicular to flat plate section (B), and through flat plate section (B), there exists a pn junction PN2 which extends in a direction parallel to said flat plate section (B). The structure is designed so that a current is injected between electrodes (E1) and (E2) so that an emission in a perpendicular direction can be obtained. Such a light emitting device principally excels in emission collection efficiency when it is compared to conventional devices with a structure for emitting in a direction parallel or perpendicular to the flat plate section. Such a light emitting device can be coupled with an optical fiber with good efficiency.

Meanwhile, most of such light emitting devices are made of gallium arsenide (GaAs) because of their purpose to emit light. The first reason for employing GaAs is that source materials are inexpensive and can be stably supplied and the second reasons is that reactive ion etching and reaction ion beam etching can be readily performed.

However, GaAs has a narrow band gap and its emission wavelengths are 0.91 ~ 0.98 microns, which are long, and thereby provides infrared radiations. Therefore, its emission is not visible to human. Thus, there is no problem when light emitting devices made of GaAs are employed as light emitting diodes or semiconductor lasers. When such light emitting devices are arranged in a one- or two-dimensional array structure and employed in a display apparatus, however, it is necessary to convert their emissions to

Savant Technologies LLC - 1004.868

visible ones. In the current state of progress, such light emitting devices equipped with a concrete means are not yet provided.

Thus, the purpose of the present invention is to provide a junction-type light emitting semiconductor device in which the wavelength of an emission from an emission section is converted so that one or a plurality of such devices in an array form can be employed to a display apparatus.

{Means to Resolve the Issues}

The above purpose is accomplished by a junction-type light emitting semiconductor device which is equipped with a flat plate section, a pillar protrusion which is provide on one surface of said flat plate section, and electrodes which are provided on any location of the flat plate section and the pillar protrusion; and which has a pn junction extending at least within the pillar protrusion along a direction perpendicular to the flat plate section; wherein a phosphor layer is provided on a top surface of the pillar protrusion and covers at least a portion of an emission section including the pn junction which is exposed on said top surface.

Further, the principal purpose of a junction type light emitting semiconductor device such as the one described above is to obtain an emission from the pn junction (pn junction PN1) which extends in a direction perpendicular to a flat plate section. It is preferred to implement various techniques so that there is no pn junction (pn junction PN2) which extends in a direction parallel to the flat plate section, or so that even if it exists, it does not provide an emission. As an example of such technique, when a pn-junction is formed in a pillar protrusion and a flat plate section, a mask can cover the top surface of the flat plate section during impurity diffusion. Then, a junction type light emitting semiconductor device which does not essentially have a pn junction PN2 which extends within the flat plate section in a direction parallel to the flat plate section can be obtained. In the present invention, a junction type light emitting semiconductor device with such a structure is preferably employed.

Moreover, a phosphor layer is for converting the wavelength of an emission form an emission section within a pillar protrusion, in other words wavelengths of 0.91 ~ 0.98 microns in the case of GaAs which is often employed as a material for such a pillar

Savant Technologies LLC - 1004.869

protrusion. It is necessary to employ a phosphor which can be excited by a radiated emission (infrared radiation in the case of GaAs) and emits light. As for a phosphor to convert an emission to visible light, $Y_{0.74}Yb_{0.25}Er_{0.01}OCl$ (emission wavelength of 0.66microns) can be employed as an example for a red emission among visible ones, $Y_{0.84}Yb_{0.15}Er_{0.01}F_3$ (emission wavelength of 0.55microns) can be employed for a green emission, and $Y_{0.65}Yb_{0.35}TM_{0.001}F_3$ (emission wavelength of 0.47microns) can be employed for a blue emission. A proper phosphor can be selected for a different application.

{Operation}

A junction type light emitting semiconductor device of the present invention employs a phosphor layer which is provided on a top surface of a pillar protrusion to convert the wavelength of an emission from a GaAs active layer.

{Embodiments}

Below, examples of a junction type light emitting semiconductor device of the present invention are explained while referencing figures.

Figures 1 and 2 depict an example of a junction type light emitting semiconductor device of the present invention. The junction type light emitting semiconductor device in this example utilizes GaAs as its material. The emission from GaAs is converted into a visible one so that the devices can be employed in a display apparatus and the like. Any of the above examples can be utilized as a phosphor. As is obvious in the figures, the light emitting device was equipped with a flat plate section (B) having a double layer structure consisting of a substrate (B1) and a top section layer (B2), a pillar protrusion (P) which was provided on one surface of flat plate section (B), a p-side electrode (E1) which was provide on a side periphery of pillar protrusion (P) and a top surface of flat plate section (B), an n-side electrode (E2) which was provided on a bottom surface of flat plate section (B), an SiO_2 layer (5) which was formed on the entire top surface of pillar protrusion (P), and a phosphor layer (7) which was provided on SiO_2 layer (5), and an insulator layer (10) which was provided between the top surface of flat plate section (B) and electrode (E1). Within pillar protrusion (P), a cylindrical pn junction PN1 was

Savant Technologies LLC - 1004.870

formed and extended in a direction perpendicular to flat plate section (B). Within flat plate section (B), however, a pn junction PN2 extending in a direction parallel to said flat plate section (B) was not formed. Therefore, when an electric current was injected between electrodes (E1) and (E2), pn junction essentially provided an emission solely in a direction perpendicular to flat plate section (B). Moreover, providing insulator layer (10) prohibits a current from flowing from electrode (E1) on the top surface of flat plate section (B) to electrode (E2) through flat plate section (B) along its vertical direction. Thus, the injection efficiency of current flowing from electrode (E1) on the side periphery of pillar protrusion (P) through pn junction PN1 to electrode (E2) can be enhanced.

In the light emitting device structure, phosphor layer (7) to convert the wavelength of an emission from the emission section within pillar protrusion (P) to another wavelength covers the light emission section exposed on the top surface of pillar protrusion (P) and is provided on SiO2 layer (5) formed on the entire top surface of pillar protrusion (P). Thus, the infrared emission can be converted into visible light. Therefore, when the light emitting devices are arranged in a one- or two-dimensional array structure, a precise display apparatus such as those in OA information apparatuses and the like and these devices are very important in terms of practical applications.

Next, an example of production method of a light emitting device with a structure depicted in Figure 1 is briefly explain for a case in which GaAs is employed as a substrate, in which AlGaAs is epitaxially grown on the substrate and in which the wavelength of an emission form AlGaAs is converted to visible light.

First, on an n-type GaAs substrate (B1), an n-type AlxGa1-xAs epitaxial layer for a pillar protrusion (P) was grown. The epitaxial layer was etched using a reactive ion etching method and a pillar protrusion (P) was formed. The remaining section of the epitaxial layer after forming said pillar protrusion (P) became a top section layer (B2) as illustrated in the figure. Top section layer (B2) is not absolutely necessary. A pillar protrusion (P) can be formed by etching through part of substrate (B1). Next, a mask covered the top surface of pillar protrusion (P) and the surface of top section layer (B2) while exposing the side periphery of pillar protrusion (P). Then, a p-type impurity

Savant Technologies LLC - 1004.871

(preferably zinc) was diffused to form a cylindrical pn junction PN1 within pillar protrusion (P).

After the diffusion process, a p-side electrode (E1) was formed on the side periphery and the top surface of pillar protrusion (P) and on the top surface of top section layer (B2), and an n-side electrode (E2) was formed on the bottom surface of substrate (B1). Then, unnecessary portions of the electrode materials and mask layer were removed using a lift-off method, thereby producing a junction-type light emitting semiconductor device which can be utilized as a light emitting diode which has only pn junction PN1 extending within pillar protrusion (P) in a direction perpendicular to substrate (B1), but not a pn junction PN2 in flat plate section (B).

After producing the light emitting device, a desired phosphor among the aforementioned ones which convert an emission to visible light can be applied on the top surface of pillar protrusion (P). Then, a junction-type light emitting semiconductor device having a phosphor layer (7) which can convert an emission wavelength to another as illustrated in Figure 1 can be produced.

In the aforementioned example of light emitting device, an epitaxial layer made of the same material as the substrate was grown on the substrate. However, a substrate alone can be employed for light emitting devices. It is, however, preferred that an epitaxial layer be provided in order to obtained an even more powerful emission. Moreover, a phosphor layer (7) does not need to be formed on the entire top surface of a pillar protrusion (P). When a phosphor layer covers at least a portion of the emission section exposed on the top surface, the wavelength of an emission can be converted. Prom the view point of conversion efficiency, however, it is preferred that a phosphor layer be provided to cover the entirety of the emission section. Further, it is not necessary to provided a phosphor layer (7) on an SiO_2 layer (5) which is formed on the top surface of a pillar protrusion (P). It may be formed directly on the top surface of a pillar protrusion (P).

Figure 3 illustrates a light emitting device in which the above items are taken into consideration. In the light emitting device of this example, a phosphor layer (7) was not formed on an SiO_2 layer (5) and is not provided on the entire top surface of a pillar protrusion (P). I only covers the emission section which was exposed on the top surface.

Savant Technologies LLC - 1004.872

A flat plate section (B) was made of solely a substrate. Pillar protrusion (P) was formed from the substrate. The other conditions were the same as in the case of the light emitting device depicted in Figure 1. The emission from the emission section can be converted to visible light.

In the present invention, positions and size of electrodes (E1) and (E2) are not limited to those illustrated in the examples. The electrode can be formed at any location with any size. Moreover, there are no particular limitations for a formation method of a pn junction. For example, an impurity diffusion method, a vapor phase epitaxial growth method of a p- (or n-)type semiconductor layer and an n- (or p-)type semiconductor layer, or other methods can be employed.

In the present invention, the length of a pn junction PN1 which contributes to the vertical emission can be made longer by making a pillar protrusion (P) taller. Therefore, it is preferred that the height of a pillar protrusion (P) be at least 2 microns and more preferred that it be at least 10 microns. A pillar protrusion (P) can be formed on a surface of a semiconductor wafer employing, as an example, a reactive ion etching method. Thereby, a light emitting device of the present invention having a pillar protrusion (P) with a height of a few tens to a few hundreds of microns can be fabricated with ease.

In the present invention, a pillar protrusion (P) being in a "direction perpendicular" to a flat plate section (B) does not need to be restrictively interpreted as being a 90 degrees angle to flat plate section (B). An angle a little larger or smaller than 90 degrees with respect to a substrate can be included. For example, a pillar protrusion (P) itself, or solely a concentrically cylindrical pn junction PN1 formed therein can be made in a form of a truncated cone with a larger diameter on the bottom, so that the output emission can be focused for an easier coupling to an optical fiber. Alternatively, a reverse truncated cone which is opposite of the above can be employed for a diversion as necessary for an application.

Examples of emission materials which can be employed in a junction type light emitting semiconductor device of the present invention include III-V compound semiconductors such as GaAs, GaP, AlGaAs, InP and InGaAsP, II-VI compound semiconductors such as ZnSe, ZnS, ZnO, CdSe and CdTe, IV-VI compound semiconductors such as PbTe, PbSnTe and PbSnSe, and further IV-IV compound

Savant Technologies LLC - 1004.873

semiconductors such as SiC. Advantages of each material can be taken into consideration for application.

{Advantages of the Invention}

As is obvious from the above, in a junction type light emitting semiconductor device of the present invention, a phosphor layer covers at least part of the emission section including a pn junction exposed on the top surface of a pillar protrusion extending in a direction perpendicular to a flat plate section and having a pn junction. Thus, the wavelength of an emission from the emission section can be converted to another. For example, when a phosphor layer made of a phosphor to convert an emission to visible light, the emission can be visible to human. Therefore, an array structure of such devices can produce precise display apparatus and the like. Such a device is very useful in practical applications.

4. Brief Explanation of Figures

Figure 1 is an angled view of an example of a junction type light emitting semiconductor device according to the present invention. Figure 2 depicts a cross section of the light emitting device in Figure 1. Figure 3 is a cross section of another example of a junction type light emitting semiconductor device according to the present invention.

(B)	Flat plate section	(5)	SiO_2 layer
(B1)	Substrate	(7)	Phosphor layer
(B2)	Top section layer	(10)	Insulator layer
(P)	Pillar protrusion	(E1) and (E2)	Electrode
(PN1) and (PN2)	pn Junction		

Savant Technologies LLC - 1004.874

Patent Applicant: Fumio Inaba

Patent Applicant: Hiroaki Itto

Patent Applicant: Dainichi Nihon Densen Co., LTD

Agent: Patent Attorney: Hajime Takashima

Figure 1

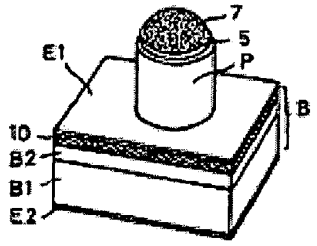


Figure 4

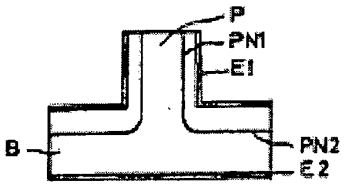


Figure 3

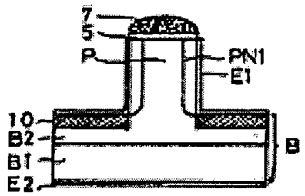
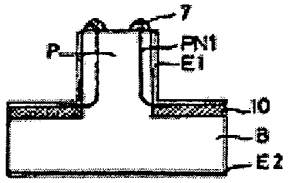


Figure 3



Amendment

April 26, 1986

To: Patent Office Commissioner

1. Case Identificaiton

   Patent Application No. S61-031573

2. Invention Title

   Junction Type Light Emitting Semiconductor Device

BEST AVAILABLE COPY

3. Those who make the Amendment

Relationship to the Case: Patent Applicants

Names: Fumio Inaba

Hiroaki Ito

Dainichi Nihon Densen Co., LTD

4. Agent

Address: No. 406 New Life Hiranomachi

4-53-3 Hiranomachi, Higashi-ku, Osaka

Tel: 06-227-1156

Takashima International Law Office

Name: Patent Attorney: (8079) Hajime Takashima

5. Amendment Date:

April 22, 1986 (submission date)

6. What is to be Amended.

"Document to verify representative right" and "Brief Explanation of Figures in Specification."

7. Contents of Amendment

(1) A power of attorney is submitted as attached.

(2) Insert "Figure 4 is a cross section of an ordinary junction type light emitting semiconductor device" in the last sentence of "Brief Explanation of Figures."

8. List of Attachments

(1) Power of Attorney 1 copy

Savant Technologies LLC - 1004.876

(12) Patent Application Publication (A)

(19) Patent Office of Japan (11) Patent Application Publication No.

H08-7614

(43) Publication Date: Jan. 12, 1996

(51)	Int. Cl.6 Classification Symbol		Internal Reference No.	FI	Technical indication sections
F 21 S	1/00	E			
G 02 F	1/133	535			
H 01 L	33/00	L			
		N			

Examination Request: Not made

Number of claims: 2 OL (Total 4 pages

(21) Application No.: H06-134763

(22) Application Date: June 17, 1994

(71) Applicant: Nichia Corporation
491-100 Oka, Kaminakamachi, Ananshi
Tokushima

(72) Inventor: Yoshinori Shimizu
c/o Nichia Chemical Industries Co., LTD.
491-100 Oka, Kaminakamachi, Anansh
Tokushima

(54) [Invention Title] Planar Light Source

(57) [Summary]

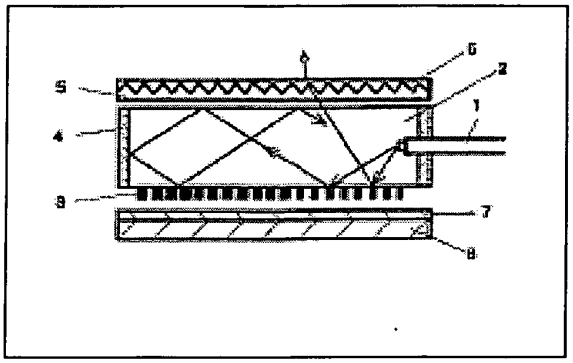
[Purpose]

To realize and provide a planar light source which can provide white light by employing blue light emitting diodes and on which a uniform white emission can be observed.

[Constitution]

Savant Technologies LLC - 1004.877

Blue light emitting diodes 1 are optically connected to an edge surface(s) of a transparent optical waveguide 2; there is a scattering layer 3 to scatter fluorescence in which white powder is applied on one primary surface of said optical waveguide 2; a transparent film 6 is provided on a primary surface side of optical waveguide opposing said scattering layer 3; and a phosphor which emits fluorescence when it is excited by an emission from said blue light emitting diodes 1 is provided to film 6.



BEST AVAILABLE COPY

[What is Claimed is:]

[Claim 1]

A planar light source, wherein blue light emitting diodes 1 are optically connected to at least one section of an edge surface(s) of a transparent optical waveguide 2; there is a scattering layer 3 in which white powder is applied on one primary surface of said optical waveguide 2; a transparent film 6 is provided on a primary surface side of optical waveguide opposing said scattering layer 3; and a phosphor which emits fluorescence when it is excited by an emission from said blue light emitting diodes 1 is provided on a surface of or in film 6.

[Claim 2]

The planar light source according to Claim 1, wherein fine bumps are provided on a surface of said film which comes in contact with the optical waveguide.

[Detailed Explanation of the Invention]

[0001]

[Field of Industrial Application]

The present invention pertains to a planar light source which is employed for a backlight of a display, an illuminated switch and the like. In particular, it pertains to a planar light source which can be excellently employed for a backlight of a liquid crystal display.

[0002]

[Conventional Technologies]

EL or cold cathode tube, as an example, is employed as a planar light source for a backlight of a liquid crystal display which is in general utilized in a notebook personal computer and word processor. EL itself is a planar light source. A cold cathode tube utilizes a diffuser plate to form a planar light source. At present, an emission color of most of these backlights is white.

Savant Technologies LLC - 1004.879

[0003]

On the other hand, light emitting diodes (in general, abbreviated as LED's) are also employed in some light sources for a backlight. When LED's are employed to obtain white emission, however, the emission power of conventional blue LED's is as little as approximately a few tens of micro W. Therefore, it is difficult to match the properties of LED's emitting each color when blue LED's are combined with red and green LED's to realize white emission, and there is a disadvantage in that color variations are large. Moreover, even when LED's for the three primary colors are combined and positioned geometrically at the same positions on the same plane, it is impossible to obtain a uniform white light source for a backlight because LED's are seen from a close distance and each can be recognized. Therefore, under the present circumstances, different sources are utilized for a different application: cold cathode tubes are employed for a white backlight of a large liquid crystal display and EL is employed for a white backlight of a small to medium liquid crystal display. Hardly any white backlight using LED's is known.

[0004]

Moreover, attempts are made in some white or monochromatic light sources to convert color by surrounding a blue LED chip with a resin containing a phosphor. The areas around the chip are exposed to radiation with a larger intensity than that of the solar ray, however, and degradation of phosphor is an issue. In particular, degradation is severe in an organic fluorescent dye. Further, the electrophoresis takes places in an ionic organic dye under an electric field and its color tone may change. Moreover, conventional blue LED's do not have enough power for color conversion through a phosphor and even if color conversion is conducted, practical results are not obtained.

[0005]

[Issues to be Resolved by the Invention]

The present invention was conceived in order to resolve these disadvantages. Its purpose is to realize a planar light source to produce uniform white emission which can

be utilized primarily as a backlight and at the same time, to provide a planar light source on which uniform white emission can be observed. Further, its purpose is to employ the reliable properties of LED's and apply them to various switches and the like.

[0006]

[Means to Solve the Issues]

Claim 1

[0007]

Figure 1 is a top view in which optical waveguide 2 of a planar light source according to the present invention is observed from the side of the second primary surface. Optical waveguide 2 is made of a transparent material such as an acrylic material or glass. Blue LED's 1 are embedded in the edge surface of optical waveguide 2, thereby optically connecting optical waveguide 2 and blue LED's 1. Further, in the present invention, optically connected an edge surface of optical waveguide 2 and blue LED's 1 means introducing light from blue LED's 1 through the edge surface of optical waveguide 2 in simple words, which can be accomplished, for example, by not to mention embedding blue LED's as illustrated in the figure, but also attaching blue LED's with an adhesive, or guiding emission from the blue LED's to the edge surface of optical waveguide 2 using optical fibers and the like.

[0008]

Next, scattering layer 3 uses a white dye to scatter light within optical waveguide 3. Particularly in Figure 1, aforementioned scattering layer 3 is made of stripes and has a pattern in which the surface area occupied with scattering layer 3 per unit surface area of the second primary surface is smaller in a portion to LED's 1 so that the surface brightness across the first primary surface is constant. Further, the occupied surface area over the edge section pf the second primary surface farthest from LED's 1 is slightly smaller than its maximum. Here in the figure, solid squares represent the pattern of scattering layer 3. The structure in Figure 1 has 6 blue LED's which are arranged on one

edge surface. It goes without saying that LED's can be connected on all four edge surfaces if the optical waveguide is rectangular or square. There is no limit on the number of LED's. Further, depending on how LED's are arranged, in what shape and how scattering layer 3 should be applied in order to make the emission observed on the first primary surface planar and uniform can be appropriately altered.

[0009]

[Operation]

Figure is a schematic cross-sectional diagram of a planar light source of the present invention when it is employed for a backlight of a liquid crystal panel as an example. On the second primary surface of the planar light source depicted in Figure 1, a reflecting plate in which a scattering reflection layer 7 made of a material such as barium tananate, titanium oxide and aluminum oxide, and a base 8 made of, for example, Al are stacked is provided. On the first primary surface, a transparent film 6 with a fine bumpy pattern on its surface is provided. On the bumpy surface of film 6, a phosphor which emits fluorescence when it is excited with the emission from blue LED's 1 is applied.

[0010]

As an arrow depicts in Figure 2, some light from blue LED's 1 is emitted outside of optical waveguide 2 in the vicinity of the chips. Most of the light, however, repeats total reflections within optical waveguide 2 and reaches edges of optical waveguide 2. The light reaching the edges is reflected by a reflecting layer 4 which is formed on all edge surfaces and repeats total reflections. At this time, scattering layer 3 which is provided on the second primary surface of optical waveguide 2 scatters the light. Fluorescent layer 5 absorbs part of the scattered light, at the same time, converts its wavelength and radiates fluorescence. Light with an emission color from combining both emissions is observed from the first primary surface of optical waveguide 2. For example, in a case of a planar light source with a fluorescent layer 5 made of a fluorescent dye for orange light, the aforementioned effects enables a white emission to be observed from blue LED's 1.

Savant Technologies LLC - 1004.882

[0011]

Particularly in the present invention, the primary emission peak from blue LED's needs to be shorter than 500nm and each blue LED needs to have an emission power of 200 microW or larger, more preferably 300 microW or larger, because it is difficult to realize all colors when the emission wavelength is 500nm or longer and there is a tendency in that it is more difficult to obtain a uniform planar light source with sufficient brightness even if more blue LED's are optically connected to edge surfaces of an optical waveguide when each LED has an emission power of less than 200 microW.

[0012]

The present inventor propsed a planar light source which can provide a uniform white emission by forming a scattering fluorescent layer on a primary surface of an optical waveguide opposing a surface through which an emission is observed in Patent Application No. H05-318267. In this method, however, the scattering fluorescent layer which is formed on an optical waveguide must be removed and a scattering fluorescent layer for a desired color tone must be printed in order to change its color tone. In the present invention, however, a fluorescent layer 5 and a scattering layer 3 are independent from each other and in particular, a fluorescent layer 5 which determines the color tone is formed on a film which can be attached and removed. Therefore, merely changing a film on which a fluorescent layer 5 is formed can alter the color tone. Moreover, multiple colors can be separately emitted at once.

[0013]

Furthermore, bumps are formed on the surface which comes in contact with the first primary side of a film 6, and therefore, the bumps are very useful in scattering the emitted light. Moreover, the bumps prevent a film 6 from plastering on an optical waveguide 6, thereby preventing interference bands from appearing.

[0014]

[Embodiments]

Savant Technologies LLC - 1004.883

[Example 1]

On a surface of an acrylic plate with a thickness of approximately 2mm, a scattering layer 3 was formed with the stripe pattern illustrated in Figure 1, using a screen printing method. A white material made of barium titanate was dispersed in an acrylic binder and scattering layer 3 was printed and formed with the mixture.

[0015]

The acrylic plate on which scattering layer 3 was formed in the manner above was cut to a desired shape and all edge surfaces of the acrylic plate were polished. Then, a reflecting layer 4 made of Al was formed on the polished surfaces. Thus, an optical waveguide 2 on which scattering layer 3 was formed was obtained.

[0016]

Next, on a film 6 on one surface of which bumps were formed, a fluorescent layer 5 was formed. An equal amount of a fluorescent dye for red, FA-001 manufactured by Shinloihi Chemical Co. LTD., and a fluorescent dye for green, FA-005 manufactured by the same company, were mixed and the fluorescent dyes were dispersed in an acrylic binder, which was painted to form fluorescent layer 5.

[0017]

Six holes were made on an edge surface of aforementioned optical waveguide 2. In each hole, a blue LED made of gallium nitride-related compound semiconductors with an emission power of 1,200 microW was embedded. Subsequently, film 6 on which fluorescent layer 5 was formed as above was provided on the emission observation side, and a reflecting plate in which a barium titanate layer 7 was applied on an Al base 8 was provided on the side with scattering layer 3 to prepare a light source for backlight. Then, completely planar and uniform white emission was obtained from the first primary surface. The luminance was 55cd/m^2.

[0018]

[Example 2]

Savant Technologies LLC - 1004.884

A nearly equal amount of a fluorescent dye for yellow, LumogenF Yellow-083 by BASF, and a fluorescent dye for orange, Orenge-240 by the same company, were mixed. A fluorescent dye in which the mixture and an acrylic resin were dissolved in butylcarbitol acetate was applied on a film 6 on which fine bumps were provided. The rest was performed in the same manner as in Example 1 and a planar light source of the present invention was prepared. Then, nearly uniform planar emission was observed. Further, in the same manner, the light source was employed as a light source for backlight. Then, completely uniform planar emission was observed.

[0019]

[Advantages of the Invention]

As explained above, a planar light source of the present invention employs blue LED's and moreover, there is a scattering layer 3 in which white powder is applied on a primary surface side of an optical waveguide. Further, on the other primary surface side, a transparent film 6 on which a phosphor which can convert the wavelength of emission from the blue LED's is applied is provided. Thus, a planar light source using LED's with excellent reliability can be realized. Furthermore, the white powder in scattering layer 3 has effects to reflect and scatter the emission from the blue LED's and hence, a small amount of the phosphor will suffice. Further, fine bumps are formed on film 6. Thus, the effect to scatter light is enhanced and the film is prevented from plastering on optical waveguide 2 and interference bands are prevented from appearing. To make the matters even better, the LED chips and phosphor do not come into contact with each other. Therefore, the phosphor does not degrade as much and the color tone of a planar light source does not change over a long time period. Moreover, a proper selection of a phosphor in fluorescent layer 5 can provide for any color tone including white. Moreover, the phosphor is provided with the film and therefore, merely replacing the film can alter the color tone of the planar light source.

[0020]

On the other hand, as for the excitation of a fluorescent layer 5, specifying that the blue LED's employed most preferably have an emission power of 200 microW or more

Savant Technologies LLC - 1004.885

facilitate effective4 wavelength conversion by the phosphor and realization of bright planar light source over a large area. Thus, a planar light source of the present invention can not applied to an illuminated switch and the like, in addition to a light source for backlight.

[Brief Explanation of Figures]

[Figure 1]

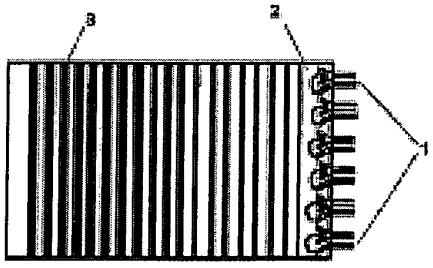
A top view when an optical waveguide 2 of an example of a planar light source of the present invention is observed from the side with a scattering layer 3.

[Figure 2]

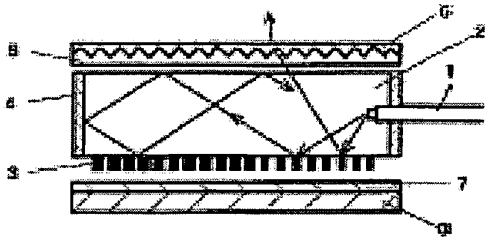
A schematic cross-sectional diagram when an example of a planar light source of the present invention is assembled as a backlight.

Savant Technologies LLC - 1004.886

[Figure 1]



[Figure 2]



BEST AVAILABLE COPY

(19) Japan Patent Office (JP)

(11)Patent Application Publication No.
H02-91980

(12) Patent Application Publication (A)

(43) Publication Date: March 30, 1990

(51) Int. CL.4	Classification symbol	Internal reference No.
H 01 J33/00		A-7733-5F

Examination request: Requested
Number of claims: 2 (Total 3 pages)

---

(54) Invention Title:

(21) Application No.: S63-244806
(22) Application Date: Sep. 29, 1998

(72) Inventor: Masayuki Nakamoto c/o Yokosuka Factory, Toshiba 1
-201-1 Funakoshicho Yokosukashi Kanagawaken

(72) Inventor Masaaki Yada c/o Yokosuka Factory, Toshiba
1-201-1 Funakoshicho Yokosukashi Kanagawaken

(71) Applicant Toshiba Raiteku Corporation 1-4-28 Sanda Minamiku Tokyoto

(74) Agent Lawyer Takehiko Suzue and three other people

Specification

1. Invention Title

Solid State Light Emitting Device

2. What is Claimed is:

(Claim 1) A solid state light emitting device, wherein said solid state light emitting device is equipped with a base comprising a p-type boron nitride crystal layer containing a small quantity of Be and an n-type boron nitride crystal layer containing a small quantity of Si formed on the above p-type layer, granular phosphor layers consisting of grains with a 0.3 - 13μm grain diameter covering at least a junction between the p-type boron nitride and the n-type boron nitride crystal layers which appears on the sides of the base, and electrodes formed on an upper and lower surface of the above base, respectively.

Savant Technologies LLC - 1004.888

(Claim 2) A solid state light emitting device, wherein said solid state light emitting device is equipped with a base comprising a p-type boron nitride crystal layer containing a small quantity of Be and an n-type boron nitride crystal layer containing a small quantity of Si formed on the above p-type layer, thin film phosphor layers with a film thickness of 0.6 – 2.6μm covering at least a junction between the p-type boron nitride and the n-type boron nitride crystal layers which appears on the sides of the base, and electrodes formed on an upper and lower surface of the above base, respectively.

3. Detailed Explanation of the Invention

[Purpose of the Invention]

(Field of Industrial Application)

This invention pertains to improved solid state light emitting devices having a PN junction.

(Conventional Technologies)

In recent years, not only discharge tubes, but solid state light emitting devices are also widely used as electronics technology advances.

Conventionally, as a typical solid state light emitting devices, red light emitting devices with a structure as illustrated in Figure 2 is known in which an n-type GaP epitaxial layer 2 containing a small quantity of Te is formed on an n-type GaP crystal substrate 1, in which a p-type GaP epitaxial layer 3 containing a small quantity of Zn and O is formed thereupon, and in which furthermore, electrodes 4 and 5 are formed on p-type GaP epitaxial layer 3 and the back surface of aforementioned substrate 1, respectively. Moreover, although they are not illustrated in the figure, red light emitting devices employing a pn junction with GaAsP-GaAIAs on an n-type GaAs substrate, orange and yellow light emitting devices employing a pn junction with $GaAs_{1-x}P_x$ on the same substrate as above, green light emitting devices employing a pn junction with GaP on GaP as above, and blue light emitting devices employing a pn-junction with SiC on a SiC substrate are known.

These solid state light emitting devices have advantages in that they are small, and compatible with electronic circuits. On the other hand, however, the emission wavelength of solid state light emitting devices is restricted to that which is specific to each material system. Moreover, even if other emission colors are selected, it was difficult to obtain a desired emission color because solid state light emitting devices have very few varieties themselves.

Savant Technologies LLC - 1004.889

(Issues to be Resolved by the Invention)

The invention is conceived upon giving considerations to the above circumstances. The purpose of the present invention is to provide a solid light emitting device having various emission colors while being equipped with the same PN junction.

[Constitution of the Invention]

(Means to Resolve the Issues)

In the first present invention, a solid state light emitting device is equipped with a base comprising a p-type boron nitride crystal layer containing a small quantity of Be and an n-type boron nitride crystal layer containing a small quantity of Si formed on the above p-type layer, granular phosphor layers consisting of grains with a 0.3 - 13μm grain diameter covering at least a junction between the p-type boron nitride and the n-type boron nitride crystal layers which appears on the sides of the base, and electrodes formed on an upper and lower surface of the above base, respectively.

In the second present invention, a solid state light emitting device is equipped with a base comprising a p-type boron nitride crystal layer containing a small quantity of Be and an n-type boron nitride crystal layer containing a small quantity of Si formed on the above p-type layer, thin film phosphor layers with a film thickness of 0.6 – 2.6μm covering at least a junction between the p-type boron nitride and the n-type boron nitride crystal layers which appears on the sides of the base, and electrodes formed on an upper and lower surface of the above base, respectively.

When the diameter of grains making up the granular phosphor layer goes outside the range of 0.3 - 13μm in the first invention of the present application, it is impossible to obtain an enough emission intensity. In the second invention, moreover, it is also impossible to obtain a sufficient emission intensity when the film thickness of the phosphor layer goes outside the range of 0.6 - 2.6μm.

Before the above phosphor layer was formed, the present inventors flew a current of 0.5.mA in the forward bias direction and obtained an emission spectrum having a peak wavelength in an ultraviolet region of approximately 200 - 400μm as illustrated in Figure 3. Therefore, the present inventors conducted experiments to form various phosphor layers having different grain demisters and film thickness above a pn junction and achieved the above inventions.

Below, the present invention will be explained in further details referring to Figure 1.

In the figure, numeral 11 denotes a p-type boron nitride crystal layer (p-type layer) containing a small quantity of Be. An n-type boron nitride crystal layer (n-type layer) 12 containing a small quantity of Si is formed on p-type layer 11. Here, above p-type layer 11 and n-type layer 12 are collectively called the base. On the sides of the base, granular phosphor layers 13 consisting of grains with a 0.3 - 13μm grain diameter are formed. Further, phosphor layers 13 do

Savant Technologies LLC - 1004.890

not have to be formed to surround the entire sides of the base. It will suffice as long as the layers cover the junction between p-type layer 11 and n-type layer 12. Electrodes 14 and 15 are formed on the upper-and-lower surfaces of the above base, Respectively.

(Operations)

According to the present invention, solid state light emitting devices which provide various emission colors while being equipped with the same pn junction can be formed through forming various phosphor layers having different grain demisters and a different film thickness on the pn junction.

(Example 1)

Self-activating phosphor M_gWO_4 was stirred and mixed in a solution consisting of 6% by weight of nitrocellulose, 2.5% by weight of ethanol , 86.5% by weight of butyl acetate and 5.0% by weight of diethyl phthalate. Next, the grains of M_gWO_4 were applied on the sides of a base containing a pn junction as described above, heated to 400°C and then, cooled down to room temperature to form phosphor layers. Thus, solid state light emitting devices were obtained.

When an electrical of 20V was applied between electrodes and a current of 2mA was flown in the forward bias direction in the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength at 480nm was obtained, and a blue emission was observed. Further, phosphor layers with $MgWO_4$ particles having different grain diameters were formed on a pn junction in the same way as above, respectively. Afterward, an emission spectrum was measured and the relative emission intensity at the peak wavelength at 400nm was obtained. The relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 4 was obtained. According to the same figure, the emission efficiency of the phosphors was very poor when the phosphor grain diameter was than 0.6μm or less. With this diameter, the efficiency decreased to 20% or less of that with the phosphor grain diameter of approximately 4.0μm which is capable of producing the highest emission intensity, the phosphor rarely contributed for the emission. On the other hand, the relative emission intensity also decreased to 20% or less when the phosphor grain diameter was 11μm or more, and the phosphor's contribution to the emission was slight. Based on the above, it is preferable that the diameter of $MgWO_4$ grains making up the phosphor layers be 0.6-11μm.

(Example 2)

Self-activating phosphor $CaWO_4$ as sample powder was dispersed in an organic solution, and stirred and mixed in the same way as the Example 1. Next, the particles of $CaWO_4$ were

Savant Technologies LLC - 1004.891

applied on the sides of a base containing a pn junction as described above, heated to 470 °C and then, cooled down to room temperature to form phosphor layers. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 30V was applied between electrodes and a current of 3mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength at approximately 415nm was obtained, and a blue emission was observed.

Further, phosphor layers with $CaWo_4$ particles having different grain diameters were formed on a pn junction in the same way as above, respectively. Afterward, an emission spectrum was measured and the relative emission intensity at the peak wavelength of 480nm was obtained. The relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 5 was obtained. According to the same figure, the highest emission intensity was obtained when the phosphor grain diameter was approximately 6μm. However, the emission intensity decreased to 20% or less when the phosphor grain diameter was 2μm or less, or 13μm or more as is the case with $MgWO_4$. Therefore, it is preferable that the diameter of grains in phosphor layers be 2- 13μm when utilizing $CaWO_4$ phosphor.

(Example 3)

Through employing a phosphor Zn_2SiO_4: Mn, particles of this material were applied on the sides of a base containing a pn junction, and phosphor layers makde of this material were formed in the same way as in Example 1. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 25V was applied between electrodes and a current of 2.5mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength of 525 nm was obtained, and a green emission was observed.

Further, the particle diameter of the phosphor was varied and the relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 6 was obtained. According to the same figure, the highest emission intensity was obtained when the phosphor grain diameter was around 5μm. However, the emission intensity decreased to 20% or less, and the phosphor did not contribute for the emission when the phosphor grain diameter was 1.3μm or less, or 13μm or more. Therefore, it is preferable that the diameter of grains in phosphor layers be 1.3-13μm when utilizing Zn_2SiO_4: Mn phosphor.

(Example 4)

Savant Technologies LLC - 1004.892

Through employing a phosphor Y_2O_3: Eu, particles of this material were applied on the sides of a base containing a pn junction, and phosphor layers made of this material were formed in the same way as the Example 1. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 30V was applied between electrodes and a current of 3.0mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength of 611 nm was obtained, and a green emission was observed.

Further, the relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 7 was obtained while changing the phosphor grain diameter. According to the same figure, the highest emission intensity was obtained when the phosphor grain diameter was around 4.2μm. However, the emission intensity decreased to 20% or less, and the phosphor did not contribute for the emission when the phosphor grain diameter was 0.7μm or less, or 11μm or more. Therefore, it is preferable that the diameter of grains in phosphor layers be 0.7-11μm when utilizing Y_2O_3: Eu phosphor.

(Example 5)

Self-activating phosphor $MgWO_4$ was put into a vacuum bell jar, and the vacuum was pumped to around 1 $x10^{-6}$ -6x 10^{-6} mmHg. Ar gas was introduced into the above vacuum bell jar, and $MgWO_4$ powder was sputtered in a 2 10 ~ 2 10mmHg Ar atmosphere. Phosphor layers with a desired thickness were formed on a part of pn junction set up on the opposite side of $MgWO_4$ powder inside the same vacuum bell jar through a sputtering method. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 20V was applied between electrodes and a current of 2mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength of 480 nm was obtained, and a blue emission was observed. Further, $MgWO_4$ thin film phosphor layers with different film thicknesses were formed on a pn junction in the same way as above, respectively. Afterward, an emission spectrum was measured and the relative emission intensity at the peak wavelength of 480nm was obtained. The relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 8 was obtained. According to the same figure, the emission efficiency of the phosphors was very poor when the phosphor grain diameter was 0.6μm or less. The efficiency decreased to 20% or less of that with the phosphor grain diameter of around 1 μm which was capable of producing the highest emission intensity, and the phosphor rarely contributed for the emission. On the other hand, the relative emission intensity also decreased to 20% or less when the phosphor grain diameter was 2.6 μm or more, and the phosphor's

Savant Technologies LLC - 1004.893

contribution to the emission was slight. Based on the above, it is preferable that the diameter of $MgWO_4$ grains in phosphor layers be 0.6-2.6μm.

(Example 6)

Self-activating phosphor $CaWO_4$ as sample powder was applied on the sides of a base containing a pn junction as described above through the vacuum sputtering method in the same way as the Example 5, and phosphor layers were formed. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 30V was applied between electrodes and a current of 3mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength of around 415nm was obtained, and a blue emission was observed.

Further, $CaWO_4$ particle phosphor layers with different film thicknesses were formed on a pn junction in the same way as above, respectively. Afterward, an emission spectrum was measured and the relative emission intensity at the peak wavelength was obtained. The relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 9 was obtained. According to the same figure, the highest emission intensity was obtained when the phosphor grain film thickness was around 1.6μm. However, the emission intensity decreased to 20% or less when the film thickness was 0.6 μm or less, or 2.6 μm or more as in the case with $MgWO_4$. Therefore, it is preferable that the diameter of grains in phosphor layers be 0.6-2.6μm when utilizing $CaWO_4$ phosphor.

(Example 7)

Through employing a phosphor Zn_2SiO_4:Mn, particles of this material were applied on the sides of a base containing a pn junction, and phosphor layers made of this material were formed in the same way as the Example 5. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 25V was applied between electrodes and a current of 2.5mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength at 525 nm was obtained, and a green emission was observed.

Further, the relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 10 was obtained while changing the film thickness of the phosphor layers. According to the same figure, the highest emission intensity was obtained when the phosphor film thickness was around 1.4μm. However, the emission intensity decreased to 20% or less when the film thickness was 0.4 μm or less, or 3.0 μm or more, and the phosphor's

Savant Technologies LLC - 1004.894

contribution to the emission was slight. Therefore, it is preferable that the diameter of grains in phosphor layers be 0.4-3.0μm when utilizing Zn_2SiO_4 :Mn phosphor.

(Example 8)

Through employing a phosphor Y_2O_3:Eu, particles of this material were applied on the sides of a base containing a pn junction, and phosphor layers made of this material were formed in the same way as the Example 5. Thus, solid state light emitting devices were obtained.

When an electrical voltage of 30V was applied between electrodes and a current of 3.0mA was flown in the forward bias direction of the solid state light emitting devices which were obtained through the above procedure, an emission spectrum with a peak wavelength at 611 nm was obtained, and a green emission was observed.

Further, the relationship between the relative emission intensity and phosphor grain diameter as illustrated in Figure 11 was obtained while changing the film thickness of the phosphor layers. According to the same figure, the highest emission intensity was obtained when the phosphor film thickness was around 1μm. However, the emission intensity decreased to 20% or less when the film thickness was 0.3 μm or less, or 3.0 μm or more, and the phosphor's contribution to the emission was slight. Therefore, it is preferable that the diameter of grains in phosphor layers be 0.3-3.0μm when utilizing Y_2O_3:Eu phosphor.

[Advantages of the Invention]

According to the present invention described above in detail, solid state light emitting devices having various emission colors, while being equipped with the same pn junction, can be provided.

4. Brief Explanation of the Figures

Figure 1 is a cross section of an example of a solid state light emitting device of the present invention. Figure 2 is a cross section of a conventional solid state light emitting device. Figure 3 shows an emission spectrum of emission from a pn junction surface of a solid state light emitting device related to the present invention. Figures 4-7 show the relationship between the relative emission intensity and phosphor grain diameter measured through applying particle phosphor layers with different grain diameters, respectively. Figures 8-11 show the relationship between the relative emission intensity and phosphor film thickness measured through applying thin film phosphor layers with different film thicknesses, respectively.

11: P-type boron nitride crystal layer 12: NP -type boron nitride crystal layer
13: Phosphor layers 14 and15: Electrode

Savant Technologies LLC - 1004.895

Patent Applicant Agent:	Lawyer Takehiko Suzue

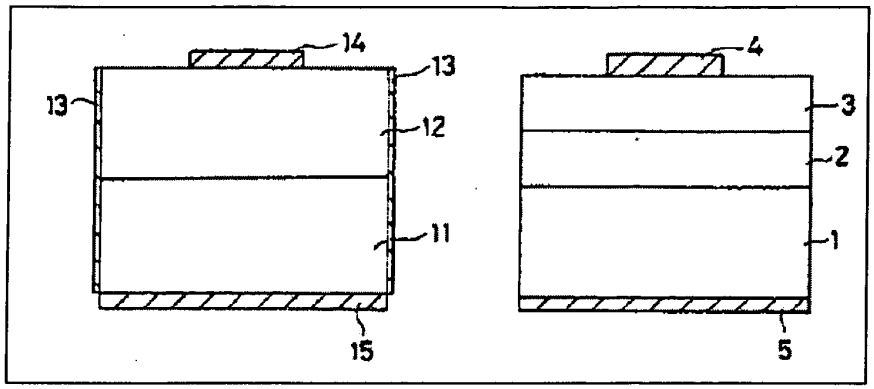
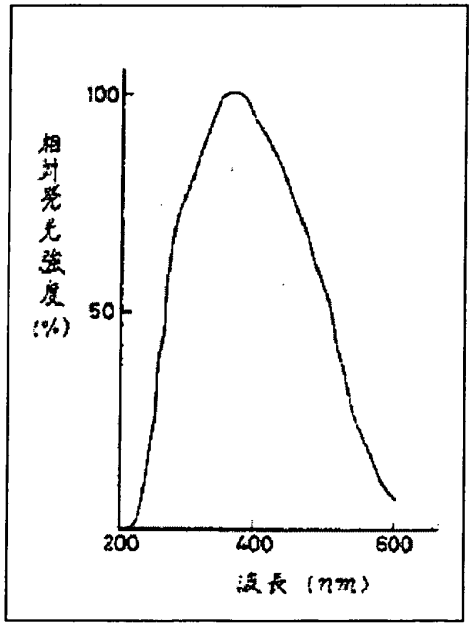


Figure 1 Figure 2

Relative emission intensity (%)



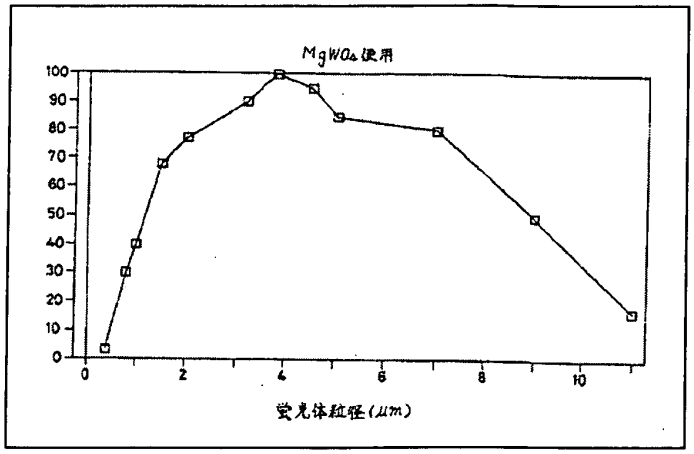
Wavelength (microns)

Figure 3

Savant Technologies LLC - 1004.897

MgWO4 is employed

Relative emission intensity (%)

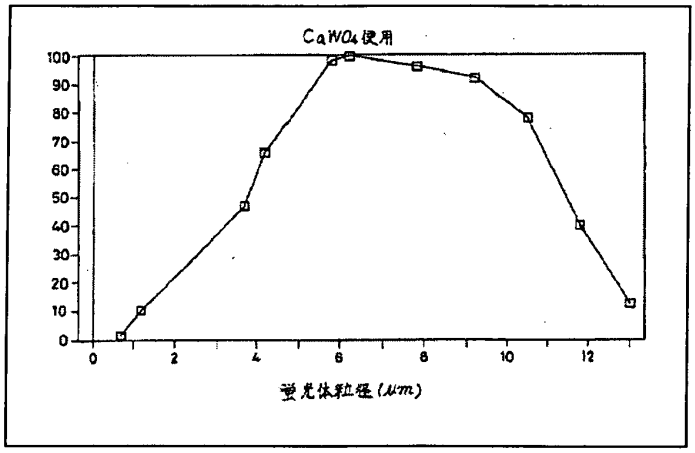


Phosphor particle diameter (microns)

Figure 4

CaWO4 is employed

Relative emission intensity (%)



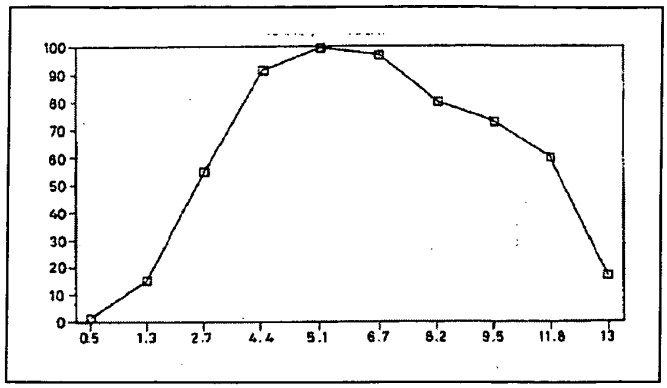
Phosphor particle diameter (microns)

Figure 5

Savant Technologies LLC - 1004.898

Zn2SiO4: Mn is employed

Relative emission intensity (%)

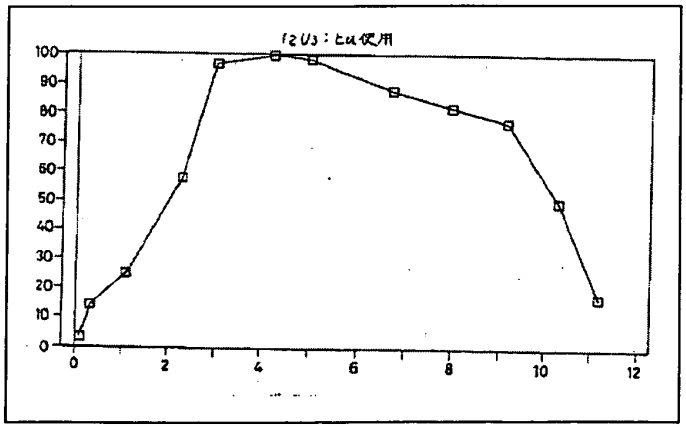


Phosphor particle diameter (microns)

Figure 6

Y2O3:Eu is employed

Relative emission intensity (%)



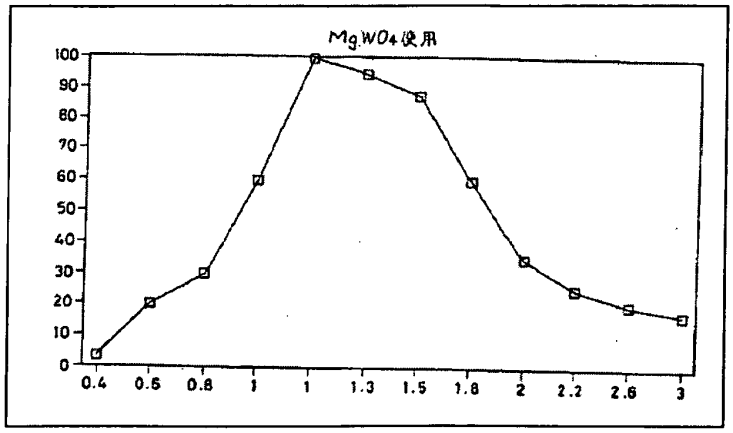
Phosphor particle diameter (microns)

Figure 7

Savant Technologies LLC - 1004.899

MgWO4 is employed

Relative emission intensity (%)

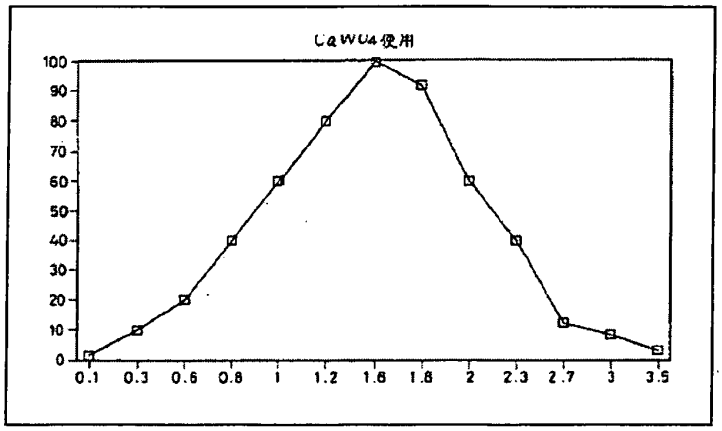


Phosphor layer thickness (microns)

Figure 8

CaWO4 is employed

Relative emission intensity (%)

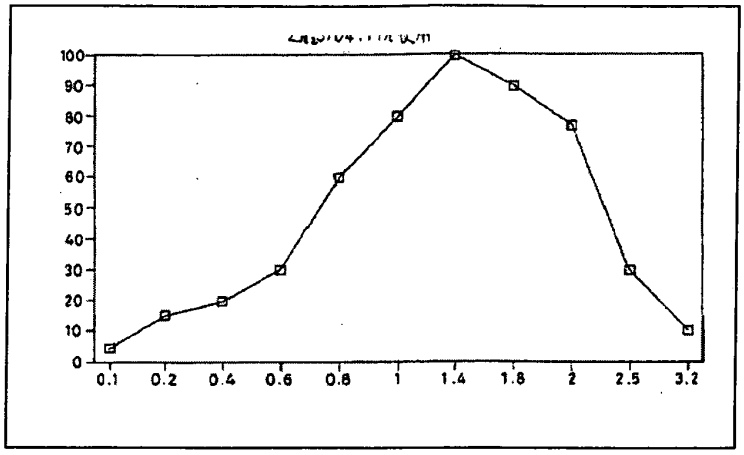


Phosphor layer thickness (microns)

Figure 9

Zn2SiO4: Mn is employed

Relative emission intensity (%)

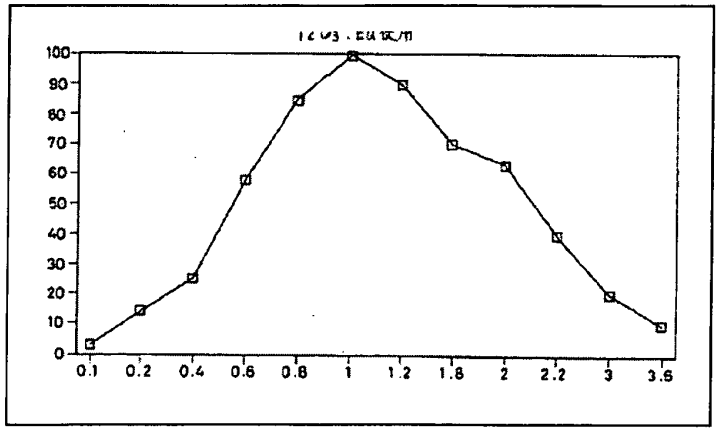


Phosphor layer thickness (microns)

Figure 10

Y2O3:Eu is employed

Relative emission intensity (%)



Phosphor layer thickness (microns)

Figure 11

BK

(19) Japanese Patent Office (JP)

(11) Patent No.

(12) **Examined Patent Publication (B2)**

P3724490

(45) Publication Date: Dec. 17, 2005

(24) Registration Date: Sept. 30, 2005

(51) Int. Cl.[7]	FI	
H01L 33/00	H01L 33/00	N
	H01L 33/00	C

Number of Claims: 1 (Total of 5 pages)

(21)	Patent Application No.:	P2004-11214
(22)	Application Date:	January 19, 2004
(62)	Indication of Division:	Division of P2003-67318
	Original Application Date:	November 25, 1991
(65)	Application Publication No.:	P2004-158873A
(43)	Application Publication Date:	June 3, 2004
	Examination Request Date:	February 16, 2004
	Preliminary Examination	
(73)	Patent Right Holder:	000226057 Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
(74)	Agent:	100074354 Patent Attorney: Yasuhiro Toyosu
(74)	Agent:	100104949 Patent Attorney: Koji Toyosu
(72)	Inventor:	Yoshiaki Tadatsu c/o Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
(72)	Inventor:	Shuji Nakamura c/o Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
	Examiner	Kaduyo Kadota

Continued to the last page

Savant Technologies LLC - 1004.902

(54) [Invention Title] Light Emitting Diode

(57) [What is Claimed is:]

[Claim 1] A light emitting diode in which a light emitting device placed on a concave metal piece is surrounded with a resin, wherein

said light emitting device is a gallium nitride related compound semiconductor device in which n-type and p-type layers are stacked; electrodes of said light emitting device and the metal piece are electrically connected with each other by wire-boding them with gold wires; a fluorescent dye or pigment which is excited with light from the light emitting device and which emits visible light with a longer wavelength that that of the excitation light, thereby correcting the color of the light emitting diode and improving its luminosity factor, is added to said resin; and said resin is formed with a convex shapes in its cross section.

[Detailed Explanation of Invention]

[Technological Field]

[0001]

The present invention relates to a light emitting diode (hereafter referred to as an LED) in which a light emitting device is surrounded with a resin mold. In particular, the present invention relates to a light emitting diode which can emit a variety of light emissions using one type of light emitting device, which is bright and which can vary the emission wavelength.

[Technological Background]

[0002]

In general, an LED has a structure as illustrated in Figure 1. The numeral designator 1 represents a light emitting device which is cut to a piece of 1mm square or smaller and which is made of materials such as GaAlAs and GaP, the numeral designator 2 represents a metal stem, the numeral designator 3 represents a metal post and the numeral designator 4 represents a resin mold which surrounds the light emitting device. The back surface electrode of the light emitting device 1 is attached on the metal stem 2 using a material such as silver paste, thereby electrically connecting it thereto. A gold wire coming from the metal post 3, which is the other electrode, is bonded to the surface of the front surface electrode of the light emitting device 1. Further, the light emitting device 1 is molded using the transparent resin mold 4.

[0003]

Ordinarily, a resin with a large index of refraction and a high transparency is selected for the resin mold 4, so that the emission light from the light emitting device is efficiently emitted to the air. In other cases, an

Savant Technologies LLC - 1004.903

inorganic or organic pigment is mixed as a coloring agent in the resin mold 4 in order to convert or correct the emission color of the light emitting device. For instance, when a red pigment is added to a resin mold around a green light emitting device having GaP semiconductor materials, its emission color turns into white.

[Disclosure of Invention]

[Issues to be Resolved by Invention]

[0004]

Conventionally, however, most of technologies to convert the wavelength by adding a coloring agent to a resin mold are not put into practical use and only handful technologies to employ a coloring agent for color correction are utilized. This is because adding an enough amount of a coloring agent, which is a non-light-emission material, to realize the wavelength conversion greatly reduces the brightness of an LED.

[0005]

In addition, currently realized LED's are infrared, red, yellow and green light emitting ones. Blue and ultraviolet LED's are not yet realized. Research is being conducting with semiconductors such as ZnSe which is a II-VI group material, SiC which is a IV-IV group material, and GaN which is a III-V group material. Recently, among these materials, gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$) are attracting attentions because it was found that they exhibit relatively superior light emission at normal temperatures. Moreover, LED's employing gallium nitride related compound semiconductors in which a pn junction was realized for the first time were reported (Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991). According to this publication, LED's employing gallium nitride related compound semiconductors have a main emission peak at around 430nm and also have another emission peak in the ultraviolet range of around 370nm. These wavelengths are the shortest among those for the above semiconductor materials. Such LED's, however, have a disadvantage in that their luminosity factor is poor because the emission color is close to violet, as their emission wavelength indicates.

[0006]

The present invention was conceived with considerations being given to such circumstances. Its purpose is to improve the luminosity factor and brightness of LED's having a light emission device which is made of gallium nitride related compound semiconductors whose emission peaks are in the vicinities of 430nm and 370nm.

[Means to Resolve Issues]

[0007]

Savant Technologies LLC - 1004.904

In the light emitting diode of the present invention, a light emitting device placed on a concave metal piece is surrounded with a resin. In the aforementioned light emitting device, said light emitting device is a gallium nitride related compound semiconductor device in which n-type and p-type layers are stacked; and electrodes of said light emitting device and the metal piece are electrically connected with each other by wire-boding them with gold wires. A fluorescent dye or pigment which is excited with light from the light emitting device and which emits visible light with a longer wavelength that that of the excitation light, thereby correcting the color of the light emitting diode and improving its luminosity factor, is added to said resin; and said resin is formed with a convex shapes in its cross section.

[Advantages of Invention]

[0008]

A fluorescent dye or pigment is generally excited with a short-wavelength light and emits light with a longer wavelength than that of the excitation light. Contrarily, there are fluorescent pigments which are excited with a long-wavelength light and which emit light with a shorter wavelength than that of the excitation light. Such materials, however, have a very poor energy efficiency and provides a very week emission light. As discussed above, gallium nitride related compound semiconductors have emission peaks in the shortest wavelength range among semiconductor materials which are employed for LED's. Moreover, they have an emission peak in the ultraviolet range. Therefore, when they are employed as materials for a light emitting device and when a fluorescent dye or pigment is added to a resin mold surrounding the light emitting device, the fluorescent material can be most optimally excited. Therefore, different types of a fluorescent dye or pigment can not only correct color of blue LED's but also convert light into a variety of wavelengths. Further, light with a shorter wavelength is converted to one with a longer wavelength with a good energy efficiency and hence, the amount of a fluorescent dye or pigment can be small and the invention is very excellent from the view point of reducing the degradation of luminosity factor.

[Best Embodiment to Implement Invention]

[0009]

Figure 2 illustrate an example to depict the structure of an LED according to the present invention. The numeral designator 11 represents a blue light emitting device in which n-type and p-type GaAlN layers are stacked on a sapphire substrate, the numeral designators 2 and 3 represent a metal stem and a metal post, respectively, in the same manner as in Figure 1, and the numeral designator 4 represents a resin mold surrounding the light emitting device. There is the sapphire insulating substrate on the back surface of the light emitting device 11 and an electrode can not be made on the back surface. Therefore, in order to electrically connect an n-electrode on the GaAlN layer to the metal stem 2, a method is employed in which the GaAlN

Savant Technologies LLC - 1004.905

layers are etched to expose the surface of the n-type layer, upon which an ohmic electrode is attached. The ohmic electrode and the metal stem 2 are electrically connected using a gold wire. Moreover, the other electrode is wire-bonded to the surface of the p-type layer using a gold wire coming from the metal post 3 in the same manner as in Figure 1. Further, a fluorescent dye 5 which is excited with light with a wavelength near 420 to 440nm and which emits light with an emission peak near 480nm is added to the resin mold 4.

[Brief Explanation of Figures]

[0010]

[Figure 1] A schematic cross section to illustrate the structure of a conventional LED.

[Figure 2] A schematic cross section to illustrate the structure of an example of an LED according to the present invention.

[Explanation of Numeral Designators]

[0011]

11 Light emitting device

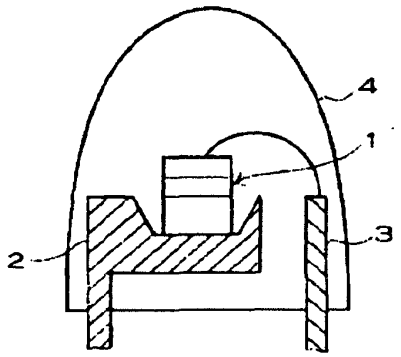
2 Metal stem

3 Metal post

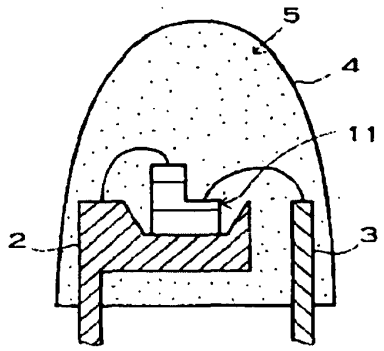
4 Resin mold

5 Fluorescent dye

[Figure 1]



[Figure 2]



Continued from the first page

(56) References: Examined Utility Model Patent Publication S54-041660 (JP, Y1)
Utility Modal Patent Application Publication S50-079379 (JP, U)
Patent Application Publication H03-152897 (JP, A)
Patent Application Publication S64-017484 (JP, A)
Patent Application Publication H03-203388 (JP, A)
Patent Application Publication S57-186376 (JP, A)
Patent Application Publication H05-152609 (JP, A)

(58) Searched Fields (Int. Cl.[7], Name of Data Base)
H01L 33/00

Savant Technologies LLC - 1004.907

OIPE JC48
JAN 11 2005
PATENT & TRADEMARK OFFICE

Utility Model Application Publication H3-24692

(19) Japan Patent Office (JP) (11) Utility Model Application Publication Number

(12) Utility Model Application Publication (U)

H3-24692

(51) Int. Cl.[5]	Classification Symbol	Office Internal Number	(43) Published On: Heisei 3 (1991) March 14
B 09 F 13/20	G	2109-5C	
13/04	J	2109-5C	
H 01 L 33/00	L	7733-5L	

Examination Request: Not Requested Number of Claims: 2 (Total pages)

(54) Title of Invention: Display Apparatus

(21) Utility Model Application No.: H1-84443
(22) Filing Date: Heisei 1 (1989) July 18

(72) Inventor: Kentaro Fujii
c/o Nissha Printing Co., Ltd.
3 Mibu Hanai-cho, Chukyo-ku, Kyoto-shi, Kyoto Prefecture

(71) Applicant: Nissha Printing Co., Ltd.
3 Mibu Hanai-cho, Chukyo-ku, Kyoto-shi, Kyoto Prefecture

Specification

1. Title of invention

Display Apparatus

2. What is claimed is:

Claim 1: A display apparatus wherein a luminescence layer is provided on a display panel, and an LED which emits ultraviolet light is arranged in the rear of the display panel.

Claim 2: The display apparatus according to Claim1, wherein the luminescence layer is formed through a transcription method.

3. Detailed explanation of the invention

[Field of industrial application]

The present invention pertains to a display apparatus having a section whose shape is not limited and which emits lights of various colors.

[Prior art technologies]

Conventionally, there have been such display apparatuses using an LED as follows.

1. A display apparatus in which a hole is provided on a display panel and an LED is engaged therein. Light emitted by the LED is directly visible.

2. A display apparatus in which an LED is arranged in the rear of a transparent

Savant Technologies LLC - 1004.909

portion of a display panel and a light blocking layers are formed on in the portions other than the light emitting section of the display panel. The light emitted by the LED is visible through the transparent portion.

[Issues to be solved by the invention]

However, conventional display apparatuses had such disadvantages as follows. Namely, in the display apparatus of 1, as many holes as the number of LEDs should be provided on the display panel. Moreover, because an LED serves as a light emitting section, the shape of the light emitting section was limited to the shape of the LED, such as rectangle or circle. Furthermore, an emitted color is just as that of an LED itself, and thus only a limited number of colors can be displayed.

Besides, because the display apparatus of 2 emits light through the transparent section of the display panel, an LED with a high light emission intensity must be employed. At the time, light leaks unless the light is sufficiently blocked by the light blocking layer, and the shape of the light emitting section may be unclear. The light blocking layer is typically formed through a printing method, however, the thickness of the light blocking layer formed through a printing method is thin. Therefore, it is difficult to obtain satisfactory light blocking properties. In addition,

Savant Technologies LLC - 1004.910

the capability of the display apparatus of 2 is also limited to displaying the number of colors limited to the colors of LEDs themselves.

The purpose of the present invention is to provide a display apparatus which solves issues such as mentioned above, the shape of whose light emitting section is not limited, and which is capable of emitting lights of various colors.

[Means to solve the issues]

In order to accomplish the above stated purpose, in the present invention a display apparatus is constituted in such a fashion that a luminescence layer is provided on a display panel and an LED which emits ultraviolet light is arranged in the rear of the display panel.

The present invention is explained further in detail in reference to a figure.

Figure 1 is a cross-sectional view which illustrates an example of the display apparatus of the present invention. Numerical references 1, 2, 3 and 4 indicate a display panel, a luminescence layer, a light blocking payer and an LED respectively.

On display panel 1, luminescence layer 2 is formed. The shape of display panel 1 is not limited to a simple plate shape but it can be of an arbitrary shape such as

Savant Technologies LLC - 1004.911

a plastic mold. Luminescence layer 2 can be formed on either side of display panel 1. In the case in which luminescence layer 2 is formed on the front surface side of display panel 1, display panel 1 must be formed with a material which transmits ultraviolet light emitted by LED 4. Moreover, in the case in which luminescence layer 2 is formed on the back surface of display panel 1, display panel 1 must be formed of a material which transmits the light emitted by luminescence layer 2. For instance, when luminescence layer 2 is formed on the back surface side, one can employ acrylic resin, AS resin, vinyl chloride and so forth as a material of display panel 1.

Luminescence layer 2 becomes a light emitting section which emits fluorescence or phosphorescence when it is irradiated with ultraviolet light. Luminescence layer 2 can be formed in an arbitrary shape on the front or back surface side of display panel 1 through a printing method and so forth. Further, if one desires to form light blocking layer 3 or a pattern layer on display panel 1 in addition to luminescence layer 2, such a layer may be formed through a transcription method at the

1380

Savant Technologies LLC - 1004.912

same time when luminescence layer 2 is formed.

On the back surface of display panel 1 where luminescence layer 2 is formed in such a manner, LED 4 is arranged. Unlike an ordinary LED, LED 4 which is employed here emits ultraviolet light. As LED 4 which emits ultraviolet light, the one which emits light having a wavelength region of 400nm or less is used. For example, the ones utilizing GaN or ZnS which are group III-IV compounds in the periodic table as a semiconductor material may be employed.

[Effects]

LED 4 is arranged in the rear of display panel 1 where luminescence layer 2 is formed thereupon. Ultraviolet light is irradiated on luminescence layer 2 and thereby light is emitted by luminescence layer 2. Luminescence layer 2 can be formed in an arbitrary shape. Furthermore, one can adopt luminescence layer 2 which emits lights of various colors.

[Advantages of the invention]

The display apparatus of the present invention makes a luminescence layer emits light with an

Savant Technologies LLC - 1004.913

LED which emits ultraviolet light. Therefore, through forming the luminescence layer which is a light emitting section with an arbitrary pattern, a light emitting section of an arbitrary shape can be formed.

Furthermore, the luminescence layer determines the color of light emission. Hence, unlike in the case in which an LED alone emits light, the light emitting section can be of an arbitrary color.

4. Brief Explanation of Figures

Figure 1 is a cross-sectional view which shows an example of the display apparatus of the present invention.

1: Display plate, 2: Luminescence layer, 3: Light blocking layer and 4: LED.

Applicant of the Utility Model Registration: Nissha Printing Co., Ltd.

Savant Technologies LLC - 1004.914

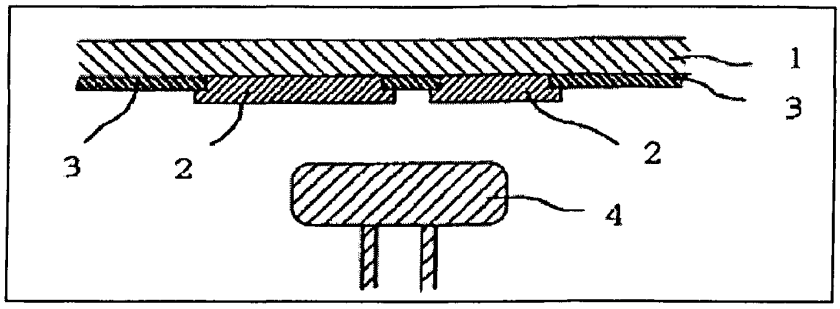


Figure 1

1: Display plate

2: Luminescence layer

3: Light blocking layer

4: LED

Savant Technologies LLC - 1004.915

(19) Japan Patent Office (JP)

(11) Patent Application Publication No.

H01-179471

(12) Patent Application Publication (A)

(43) Publication Date: July 17, 1989

(51) Int. Cl.[4] Classification symbol Internal reference No.

H 01 L 33/00 A-7733-5F

Examination request: Requested

Number of claims: 2 (Total 3 pages)

---

(54) Invention Title:

P-N Junction Light Emitting Device Made of Cubic Boron Nitride

(21) Application No.: S63-1605

(22) Application Date: Jan. 7, 1988

(72) Inventor: Osamu Mishima 4-914-203 Namiki, Tsukubashi Ibaraki-kenn

(72) Inventor: Akira Era 1-13-12 Senmgenn, Tsukubashi Ibaraki-kenn

(72) Inventor: Junzou Tanaka 2-803-203 Azuma, Tsukubashi Ibaraki-kenn

(72) Inventor: Osamu Mishima 3-14-10 Nihomiya, Tsukubashi Ibaraki-kenn

(71) Applicant: Chief of Inorganic Materail Labs the Science and Technology Agency 1-1 Namiki, Tsukubashi, Ibaraki-kenn

Savant Technologies LLC - 1004.916

Specification

1. Invention Title:

P-N Junction Light Emitting Device Made of Cubic Boron Nitride

2. What is Claimed is:

1) A light emitting device made of a device having a p-n junction employing cubic boron nitride as a mother crystal.

2) A light emitting device in which a phosphor is provided at a p-n junction section or on its n-side surface of a device having a p-n junction employing cubic boron nitride as a mother crystal.

3. Detailed Explanation of the Invention

Field of Industrial Application

The present invention relates to a light emitting device. In further detail, it relates to a light emitting device which employs cubic boron nitride as a mother crystal and which can emit light in a wide range of infrared to UV.

Conventional Technologies

Conventionally, gallium arsenide and gallium phosphide are known and put into practice as materials for making up p-n junction light emitting devices. The emission ranges of these light emitting devices, however, span from infrared to ultraviolet regions. Silicon carbide and zinc selenide have been developed as materials for devices to provide blue emissions. It is difficult, however, to obtain silicon carbide with excellent quality and to prepare p-type crystals with zinc selenide, making it difficult to obtain a p-n junction. Therefore, their devices are not put into practical use. Moreover, gallium

Savant Technologies LLC - 1004.917

nitride and zinc sulfide which have a band gap corresponding to the ultraviolet region can not be prepared in p-type and their p-n junction light emitting devices in UV region do not exist.

Purpose of the Invention

The present invention intends to provide light emitting devices which can provide an emission in the infrared to UV regions, which was difficult or impossible to achieve when conventional p-n junction light emitting devices are employed.

Constitution of the Invention

As a result of dedicated research to achieve the above purpose, the present inventors were able to confirm that emissions in the infrared to the UV regions were obtained when a current was flown through a p-n junction section of p-n junction devices employing cubic boron nitride as a mother crystal and that these devices are excellent light emitting devices. Moreover, the present inventors found that a phosphor placed on the p-n junction section or on the surface of its n-side can alter the emission to any color. Based on these pieces of knowledge, the present inventors have completed the present invention.

The essence of the present invention lies in

1) A light emitting device made of a device having a p-n junction employing cubic boron nitride as a mother crystal; and

2) A light emitting device in which a phosphor is provided at a p-n junction section or on its n-side surface of a device having a p-n junction employing cubic boron nitride as a mother crystal.

The device having a p-n junction employing cubic boron nitride as a mother crystal can be produced according to the following method.

A high and low temperature zones are prepared in a vessel sealed under a high pressure and high temperature made of a material such as molybdenum. Cubic BN source pieces and a p- or n-type dopant are dissolved in their solvent such as lithium calcium nitride (LiCaBN2) solvent and the melt is introduced into the high temperature

Savant Technologies LLC - 1004.918

zone. A cubic boron nitride crystal substrate with a type opposite to the above dopant type is placed in the low temperature zone. Utilizing a difference in the solubility between different temperatures, cubic boron nitride with a conductivity which is different from that of the crystal substrate which is placed in the low temperature zone precipitates and grows. Thus, a p-n junction device is obtained. The growth can be conducted under a vessel pressure of 4 ~ 7GPa and temperatures of 1,300 ~ 2,400°C. A preferred pressure is 5.5GPa and temperature is about 1,700°C.

An example of an n- and p-type dopant are silicon and beryllium, respectively. A very small junction area produces a weak emission. Therefore, a preferred junction area is 0.3 mm^2. There is no restriction on the size and shape of a mother crystal. The crystal may be a chunk or a thin film in the shape. When a current flows through this p-n junction, recombination of electrons and holes in the vicinity of the p-n junction produces an emission. A zero current does not produce any emission, while a larger current produces a stronger emission. For a device with a p-n junction of about 1mm in area, a current of 1mA or larger is preferably flown. In order to flow a current across a p-n junction, an electrode shall be attached on a p- and n-type side and then, a current can flow between the electrodes. A current ordinarily flows from the p-type to n-type side. An emission occurs, however, even in a reverse direction.

The emission can occur, not only in wavelengths longer than red, but across a range including the red to ultraviolet region.

A phosphor placed on the p-n junction section or on a surface of the n-side can alter the emission color.

Example 1

Preparation of p-Type Cubic Boron Nitride Crystal Substrate

325 ~ 400 Mesh cubic boron nitride particles and LiCaBN solvent powder were placed within a growth vessel made of molybdenum (an inner diameter of 4mm, an inner height of 3mm and a thickness of 1mm). At this time, the solvent contained 1% by weight of metallic beryllium powder. The aforementioned growth vessel made of molybdenum is designed to maintain a temperature difference between a high and low temperature zone. The high temperature zone was pressurized to 5.5GPa and heated to

Savant Technologies LLC - 1004.919

1,700°C, which were maintained for 20 hours. Thus, a p-type cubic boron nitride crystal substrate was obtained in the low temperature zone.

P-N Junction

The above p-type cubic boron nitride crystal substrate was placed as a seed crystal in the low temperature zone of the growth vessel. The same cubic boron nitride particles as above and LiCaBN2 solvent powder containing 5% by weight of silicon particles were placed in the vessel. Under the same conditions as above, a growth was conducted and thereby, an n-type single crystal was grown on the p-type crystal. This p-n junction crystal was a single crystal with an overall size of approximately 1mm. Its center section was dark blue and of p-type and the surrounding section was made of an n-type crystal with a transparent orange color.

As illustrated in Figure 1, electrodes 4 made of silver paste were made on a p- and n- type section across the p-n junction. When a forward bias of 70 volts was applied with a positive on the p-type side and a negative on the n-side, a current of 2 mA flew from the p- to n-type side. The voltage between the p- and n-type sections across the p-n junction with voltage drops between the cubic boron nitride semiconductor and silver paste electrodes were excluded was approximately 5 volts across a distance of approximately 0.2mm. When the p-n junction device was observed under a real image microscope during the current of 2mA flew, a bluish white emission was observed on the n-type side along and vicinity of the p-n junction section.

Example 2

When a reverse bias of 70 volts was applied in Example 1, the voltage between the p- and n-type sections across the p-n junction was -40 volts and a current of 0.5 mA flew from the n- to p-type side. The n-type section was bright with orange emission.

Example 3

As the current was varied in Example 1, the emission intensity was measured using a photometer, which found that the emission intensity increased as the current increased. A few mA of current produces an emission which naked eyes can observe.

Savant Technologies LLC - 1004.920

Example 4

Under the conditions in Examples 1 and 2, the emission spectrum was observed using a spectrometric photometer. The results are as illustrated in Figure 2. The figure shows raw data without calibrations for the measurement systems' sensitivity. As illustrated in the results, it was confirmed that the emission takes place even in a range of ultraviolet at 2,000 Angstroms to blue. Moreover, as the current increased, the emission range expanded toward shorter wavelengths.

Furthermore, emissions were not detected when a current flew through devices made of solely a p- or n-type material.

Example 5

On the p-n junction section or the surface of the n-side of the devices in Example 1, a phosphor, silver doped zinc sulfide, cupper doped zinc sulfide or europium doped yttrium oxysulfide, was applied. A forward current was flown through the p-n junction. Then, blue, green or red emission was observed, respectively.

Advantages of the Invention

The present invention can facilitate a p-n junction light emitting device which can produce an emission in a range of blue to ultraviolet, which a p-n junction light emitting device employing conventional materials can not accomplish. Further, cubic boron nitride is employed as a mother crystal and therefore, the device is superior to conventional one in the thermal conductivity, hardness and chemical stability. Thus, the present invention also has an advantage in that the device can be utilized under harsh environments such as a high temperature.

4. Brief Explanation of the Invention

Figure 1 depicts an example of a light emitting device of the present invention. Figure 2 illustrates a spectrum obtained in Example 4.

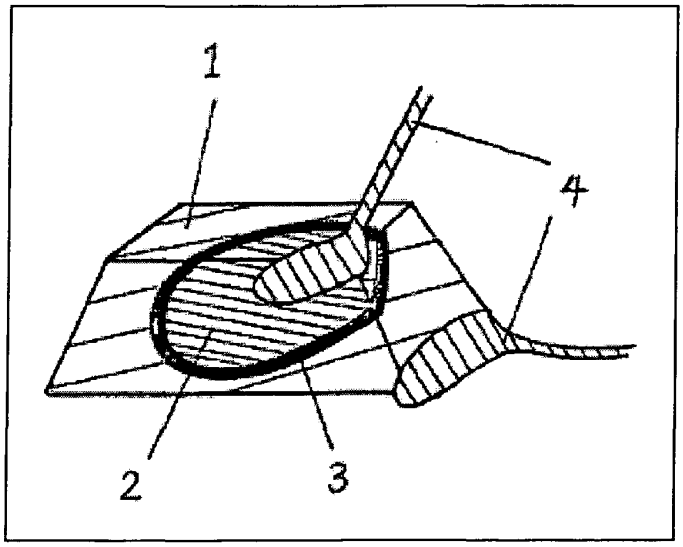
Savant Technologies LLC - 1004.921

1:	n-Type	2:	p-Type
3:	p-n Junction surface	4:	Electrode

Patent Applicant: Chief of Inorganic Materail Labs
the Science and Technology Agency

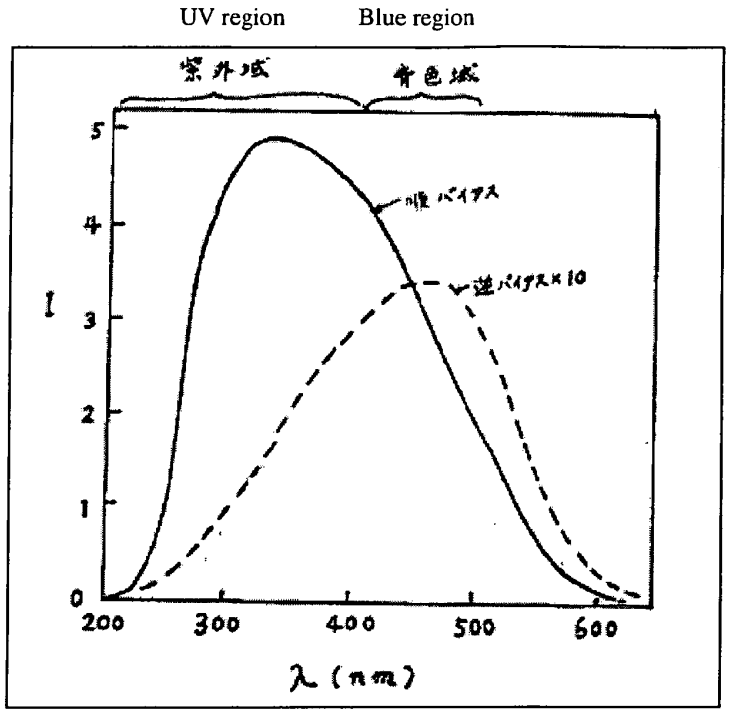
Nobuo Sedaka

Figure 1



BEST AVAILABLE COPY

Figure 2



Forward bias

Reverse bias x 10

(19) Japan Patent Office (JP)
(12) Laid Open Patent Application (A)

(11) Patent Application Publication Number
H7-282609
(43) Laid Open: Heisei 7 (1995) October 27

(51) Int,Cl.[5]	Classification	Office Internal Number	FI	Technology Indication
F21S 5/00		Z		
H01S 3/18				

Examination Request: Requested Number of Claims: 10 OL (Total 8 pages)

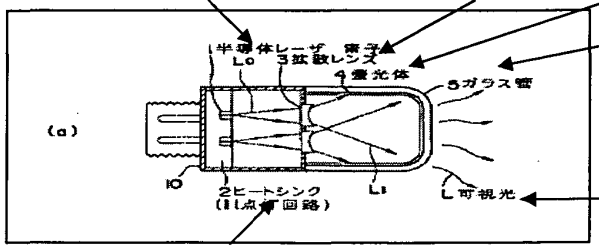
(21) Patent Application Number: H6-68595
(22)Filing Date: Heisei 6 (1994) April 6
(71) Applicant: 594059558
Shogo Tsuzuki
3026-7 Nogawa, Miyamae-ku, Kawasaki-shi, Kanagawa
(72) Inventor: Tadashi Abe
3-4-5 Aza-Komine, Fukuokakuramoto, Shiroishi-shi, Miyagi
(74) Agent: Patent Attorney, Tomo Kumon

(54) [Title of Invention] Light source equipment for illumination in which a laser diode device is employed.

(57) [Abstract]
[Purpose] To achieve such properties as small energy consumption, excellent endurance, exceeding safety on a light source equipment for illumination, and to enable the equipment to provide the most suitable light such as white light with sufficient output.

[Constitution] The equipment comprises of laser diode device 1 which emits laser light with specific wavelength between infrared rays and ultraviolet rays, a lens 3 which diffuses the laser light emitted from the laser diode device, and a phosphor 4 which converts the laser light diffused by the diffusion lens into a visible light. In addition, this equipment comprises of laser diode devices 1R, 1G, and 1B which emit laser light of three primary colors of red, green, blue, lens 3 which diffuses the laser light emitted by each laser diode device, and lenses 8 and 9 which superimpose the laser lights diffused from these diffusion lenses.

(a)



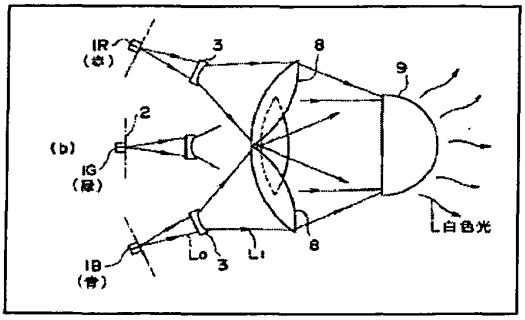
BEST AVAILABLE COPY

Savant Technologies LLC - 1004.924

(b) (red)

(green)

(blue)



White light

BEST AVAILABLE COPY

[What is claimed is]

[Claim 1] A light source equipment for illumination comprising of a laser diode device which generates laser light with specific wavelength between infrared rays and ultraviolet rays, a lens which diffuses the laser light emitted from the laser diode device, and a phosphor which converts the diffused laser light through the diffusion lens into a visible light.

[Claim 2] The light source equipment for illumination according to Claim 1, wherein the laser diode device is a phased array type in which stripes are divided into multiple stripes with narrow width.

[Claim 3] The light source equipment for illumination according to Claim 1 or 2, wherein a reflection member is installed on a cleaved facet at one side of active layer of laser diode device.

[Claim 4] The light source equipment for illumination according to Claim 1, 2 or 3, wherein mercury atoms or a rare-earth substance is doped to the active layer of laser diode device.

[Claim 5] The light source equipment for illumination according to Claim 1, 2 or 3, wherein second harmonic medium is placed at the output side of laser diode device.

[Claim 6] A light source equipment for illumination comprising; a group of laser diode devices which generate laser light of three primary colors of red, green, blue; a lens which diffuses the laser light from these laser diode devices; and a lend which superimposes the diffused laser lights from the diffusion lens with each other.

[Claim 7] The light source equipment for illumination according to Claim 6, wherein the laser diode device is a phased array type in which stripes are divided into multiple stripes with narrow width.

[Claim 8] The light source equipment for illumination according to Claim 6 or 7, wherein a reflection member is installed on a cleaved facet at one side of active layer of laser diode device.

[Claim 9] The light source equipment for illumination according to Claim 6, 7 or 8, wherein mercury atoms or a rare-earth substance is doped to the active layer of laser diode device.

[Claim 10] The light source equipment for illumination according to Claim 6, 7 or 8, wherein second harmonic medium is placed at the output side of laser diode device.

[Detailed Explanation of Invention]

[0001]

[Field of Industrial Application] The present invention pertains to a light source equipment in which a laser diode is employed which is suitable as a light source to be implemented in such shaky locations as in vehicles or in tunnel, or in locations where it is difficult to exchange light

Savant Technologies LLC - 1004.926

bulbs, in addition to general illumination equipments including interior light, street light, and flashlights.

[0002]
[Prior Art Technologies] The light sources employed in general illumination equipments include incandescent bulbs wherein a current flows through the filaments in vacuum glass ball filled with argon gas and so on , and visible light is obtained from the heat radiated by the candent filament, and fluorescent lights wherein a glass tube with low pressure of 1Pa (6-10 x 10^{-3} Torr) is filled with mercury vapor with pressure of 100Pa (2-3 Torr), and ultraviolet rays acquired through the collision of thermal electron from electrode filament against mercury atom (wavelength of 253.7nm) are converted into visible light by being emitted to phosphor applied on the internal surface of fluorescent tubes.

[0003] Moreover, light-emitting diode (hereafter described as LED) which is employed in OA equipments and display equipments as a display device is another example. In LED, a current flows through a p-n junction of semiconductors to generate light. As a result of an appropriate selection of the types and compositions of crystallization, LED is commercialized and practically employed in variety of fields including the one where infrared rays are utilized for remote controlling, sensor, and optical communications and the one where visible light is utilized for displaying.

[0004] Regarding visible light LED, there are ones with such light emitting layers as GaA1As (660nm; red), GaAsP (N dope) (590nm: yellow), GaP (555nm: green), SiC (470nm: blue), GaN (450nm: blue). The LEDs with low cost and high luminance have been provided in such colors as red and blue which lagged in development.

[0005]
[Issues that the Invention Intends to Solve] However, incandescent bulbs suffer some problems including the followings. (1) The efficiency of light emitting is unfavorable because almost all of electric current is lost as heat and part of it is radiated as light. (2) The amount of electric consumption is large. (3) Fragile to shake and inferior in endurance (Average life cycle of general illumination bulb is approximately 1000 hours).

[0006] Compared to incandescent bulbs, fluorescent tubes have a superior efficiency of light emitting generating almost no heat. Having said that, there are some problems including (1) Large amount of electric consumption, (2) Inferior endurance (Average life cycle is approximately 10000 hours), (3) Difficulty in achieving small products.
[0007] Furthermore, regarding visible light LED, it has been practically applied in several colors and has such advantages as low cost and small amount of electric consumption. However it has weak output and is difficult to be applied for illumination.

[0008] In addition, as a light source equipment for illumination in which a laser diode is employed, carrying type illumination equipments such as flashlights and searchlights have been proposed. (For example, Laid open utility model application H4-16801). These carrying type illumination equipments employ visible light laser diode as a light source and radiate beam by diffusing the visible light emitted from laser diode through diverging lens. However, because

laser diode generates coherent single color, white light for illumination such as those of white bulbs and fluorescent tubes may not be obtained, and it is a problem that only single color lights such as red and green can be obtained. Moreover the outputs of red and green laser diode are not sufficient at current point, and they can not be applied for illumination without modification.

[0009] The present invention was achieved considering the situations mentioned above. The purpose of the invention is to provide a light source equipment for illumination in which a laser diode is employed with such properties as small amount of electric consumption, excellent endurance, exceeding safety which can generate sufficient amount of preferable light such as white light.

[0010]
[Means to Resolve the Issues] A laser diode device has been applied in such fields as communication, medical care, manufacturing equipments, measurement in civil engineering. The present invention made it possible to apply this device in illumination. In further detail, the invention comprises of a laser diode device which generates laser light with specific wavelength between infrared rays and ultraviolet rays, a lens which diffuses the laser light generated by this laser diode device, and phosphor which converts the diffused laser light from diffusion lens into visible light.

[0011] Moreover, the invention comprises of a group of laser diode devices which generates laser light of three primary colors, red, green, blue, a lens which diffuses the laser light from each laser diode device, and a lens which merges the diffused laser light emitted from diffusion lens.

[0012] Both of AC power and DC power may serve as a power source. When AC power is utilized, a commutation equipment is installed in lighting circuit, and laser diode device and lighting circuit and so on are integrated in single chip.

[0013] The laser diode device is a double hetero junction laser diode. It can have single stripe structure, however, in order to achieve higher output, phased array type in which stripes are divided into smaller stripes is utilized. In addition, such measures as installation of reflection member on the cleave facet at one side of active layer of laser diode device, thickening light guide layer, and employing quantum well structure can be taken.

[0014] Moreover it is also possible to dope mercury atom and rare-earth substance to the active layer of laser diode device so that each color in visible light to ultraviolet regions can be obtained. Furthermore, Second harmonic medium can be installed at the output side of laser diode device to obtain short-wavelength laser light.

[0015]
[Function] In the structure mentioned above, in case of phosphor-type, laser beam with small diameter generated from laser diode device is diffused by lens and emitted onto phosphors, and the light with wavelength between ultraviolet region and infrared region is converted into visible light by the phosphors.

[0016] In case of three-color superimpose type, red, green, and blue laser beams generated by each laser diode device are simultaneously diffused and merged to obtain white light.

Savant Technologies LLC - 1004.929

[0017] Even in case of laser diode with single stripe structure and relatively small output, a sufficient luminance for illumination is obtainable by installing several of them. If phased array type is applied, it is possible to acquire brighter light with small number of laser diodes.

[0018]
[Embodiment] Hereafter, explanations are made based on examples which describe the present invention. Figure 1 (a) describes an examples of phosphor type light source equipment for illumination in which a laser diode is employed pertaining to the present invention. Figure 1 (B) shows an example of three primary color margining type.

[0019] < phosphor type> In figure 1 (a), multiple laser diode devices 1 are buried or installed in heat sink (heat absorption body) 2. Diffusion lens 3 is installed in front of each laser diode device 1. Phosphors 4 is set on internal surface of vacuum glass tube 5 which is filled with argon gas and so on. Laser beam L_0 generated from laser diode device 1 is diffused by diffusion lens 3, and diffused light L_1 excites fluorescent substance of phosphor 4 to obtain visible light L.

[0020] The structure of laser diode device 1, as described in the following sections, comprises of active layer (light emitting layer) 100, cladding layer 101,102, substrate 103 (Please refer to Figure 5). The crystal structure with the most suitable wavelength for the conversion into visible light conducted by phosphor 4 is selected from the ones whose oscillation wavelength are between infrared range and ultraviolet range.

[0021] Among the crystal structures of laser diode device 1, the one described in Table 1 has been practically employed. However, it is favorable to utilize $A1_xGa_{1-x}As$ in 0.7μm, 0.8 μm region, $In_{1-x}Ga_xAs_vP_{1-v}$ in 1 μm region, and $(A1_xGa_{1-x})In_{0.5}P_{0.5}$ in 0.6 μm region which can continuously oscillate at room temperature in a stable manner with relatively large output.

[0022] Laser diode device 1 in blue to ultraviolet ray regions with short wavelength currently has such problems as a short life cycle of continuous oscillation at room temperature. Therefore it is possible to utilize laser diode device 1 with following structure.

[0023] As described in Figure 2 (a), in this device, mercury Hg is doped by for example, filling the active layer 100 of laser diode device 1 in 0.8 μm region which has relatively large output with mercury vapor when it is generated. Light within active layer 100 is converted into ultraviolet rays by mercury atom Hg generating the laser light with wavelength in ultraviolet region. Moreover, it is possible to generate visible lights of each color and laser light with wavelength in different regions by doping rare-earth substances instead of mercury atom.

[0024] As a method to grow crystal, some new methods, including liquid phase epitaxy in which the crystal to grow is extracted from supersaturated solution or melt, gas phase epitaxy in which raw material is provided in the forms of vapor or gas and accumulated through degradation or synthesis reactions on heated substrate, molecular beam epitaxy, and hot wall epitaxy have been employed. As a method to dope mercury and so on to active layer, it is possible to adapt optical epitaxy in which the vapor generated by shading laser light to gas material is accumulated on substrate.

[0025] In addition, as described in Figure 2 (b), it is possible to obtain the light in blue to ultraviolet regions utilizing laser diode device 1 in 0.8 μm region with relatively large output and SHG (Second Harmonic Generation) device 200 which contains waveguide.

By applying for example, lithium tantalate crystal with polarization reversal layer as SHG device 200, laser light with 870nm of wavelength and 140mW of output can be converted into the blue light with approximately 435nm of wavelength and 10mW of output.

*[0026] The material described in Table 2 is one of the examples for fluorescent substance of phosphor 4. The most suitable fluorescent substance is selected based on oscillation wavelength of the laser diode device 1 to be utilized.

[0027]
*[Table 1]
Double hetero junction laser diode crystal and oscillation wavelength

Group	Active layer	Cladding layer	Substrate	Oscillation wavelength
II-VI	ZnSeS	ZnSeTe	GaP	0.35-0.4 (Ultraviolet-violet)
	ZnSeS	ZnSeTe	GaAs	0.4-0.45(Violet-blue)
	ZnCdSe	ZnSSe	GaAs	0.49-0.53(Blue-blue green)
	ZnSeTe	ZnSeTe	InP	0.5-0.6(Green)
III-V	AlGaInP	AlGaInP	GaAs	0.55-0.4(Yellow-red)
	InGaAsP	AlGaAs	GaAs	0.64-0.9(Red-infrared)
	AlGaAs	AlGaAs	GaAs	0.7-0.9(Infrared)
	InGaAsP	InP	InP	0.9-1.8(Infrared)
	GaInAsSb	GaInAsSb	GaSb	1.8-4.3(Infrared)
IV-VI	PbEuSeTe	PbEuSeTe	PbTe	2.5-6.5(Infrared)
	PbSnSeTe	PbSeTe	PbSnTe	5.5-(Infrared)

[0028] ** [Table 2]
Fluorescent substance and light color

Fluorescent substance	Light color
Calcium tantalate	Blue
Magnesium tantalate	Blue white
Silicate zinc	Green
Halphosphate calsium	White (Daylight color)
Silicate zinc beryllium	Yellow white
Silicate calcium	Yellow red
Cadmium borate	Red

[0029] As described in Figure 3, AC or battery DC power 6 and lighting circuit 7 are connected to laser diode device 1 described above. Current-limit resistance R_1 and luminance adjustment resistance R_2 are imposed in lighting circuit 7 when necessary. When AC power is applied as power 6, rectification diode D is set for a half-wave rectification, or full-wave rectifier D' conducts a full-wave rectification after voltage is lowered to a required level by transformer T. In addition, plurality of laser diode device 1 are installed, and they should be connected with each other in parallel or in the combination of parallel and series connections because lighting failure of one device can fail the lighting of all devices when they are connected in series.

Savant Technologies LLC - 1004.932

[0030] Regarding diffusion lens 3, when it has single stripe structure as described in the following sections, the shape of the lens is horizontally long oval with beam size of 1x3 μm (AlGaAs: wavelength 0.78 μm) at Near Field Pattern (NFP). The beam expands with divergence angle of approximately 15° (horizontally) and 45° (longitudinal) to generate Far Field Pattern (FFP) of longitudinally long oval shape (Please refer to Figure 5).

The beam diameter is short, and the lens can enlarge a laser beam light with such a short diameter.

[0031] Therefore, diverging lenses are favorable for diffusion lens 3. The lens is made of quarts glass which has high refractive index and small loss of light. The lens is installed with a designated space from laser diode device. Moreover it is possible to improve refraction index by adding lantern which has small loss of light into quartz glass. Furthermore, in production process of the lens, cerium and so on are utilized as an abrasive in grinding the lenses.

[0032] Electric bulbs and fluorescent tubes are the examples of the form of light source equipment for illumination itself. Figure 4 (a) describes the electric bulb type. Heat sink 2 is installed on socket 10, and plurality of laser diode device 1 is installed on heat sink 2. In this case, the size of laser diode device 1 is approximately 4 mm at each side in general, and approximately 12 of the device can be installed in electric bulbs with ordinal size.

[0033] Moreover, lighting circuit 11 which comprises AC-DC converter can be installed in heat sink 2. In this case, optical device and electronic device are integrated in single chip. In addition, plurality of laser diode device 1 can be integrated in single chip. In this case, diffusion lens 3 can be single lens, and plate shape microlens obtained by two-dimensional array (matrixing) of minim lens which corresponds to laser diode device also can serve as diffusion lens 3.

[0034] Furthermore, the laser beam generated by laser diode device 1 with single stripe structure has oval shape and directional property as mentioned above. Therefore, as explained in Figure 4 (b), the directional property is changed by each device 1 in order to make the beam almost omnidirectional. Moreover, phased array, which is explained in the following sections, is also installed with the change of array direction in the same way.

[0035] Figure (C)-(g) describe the examples of fluorescent tube types. (c) and (d) explain double terminal types, and (e) and (f) show single terminal types. Moreover, as described in (g), it is possible to install long heat sink 2 at the one side of glass tube 5, and to place plurality of laser diode device 1 and diffusion lens 3 in the sink with certain space between them.

[0036] <three colors superimpose type> In Figure 1 (b), laser diode device 1R, 1G, 1B are the devices of three primary colors, red, green, blue, respectively. They are buried or installed in heat sink (heat absorption body) 2. Diffusion lens 3 is placed in front of each laser diode device 1, and is overlapped with merger-diffusion lens 9 through collimating lens 8. Laser bema light L_0 which is generated from each laser diode device 1 is diffused by diffusion lens 3 and merged by collimating lens 8 and superimposed to merger-diffusion lens 9 to generate white light. White light L can be radiated in this way.

[0037] Laser diode device 1 is placed, for instance, on single circumference with even space between them. Diffusion lens 3 and collimating lens 8 are installed with their optical axes tilted. In addition, materials for lens 3,8,9 are same as that of phosphor type. Both diverging and converging lenses can function as merger-diffusion lens 9.

[0038] Crystal structure described in aforementioned Table 1 can be employed as that of laser diode device 1R, 1G, 1B. In this case, as the laser diode device 1 of blue with short wavelength, similarly to the case of phosphor type, it is possible to apply the laser diode device 1 with the structure explained as follows.

[0039] In other words, rare-earth substance is doped to the active layer 100 of laser diode device 1 in 0.8 μm region which has relatively large output by filling the layer with vaporized gas of rare-earth substance when it is generated. (Please refer to Figure 2 (a))Through selecting appropriate rare-earth substances, the laser light with wavelength within visible region of each color can be generated.

[0040] Moreover, similarly to the case of phosphor type, it is practical to obtain blue light utilizing laser diode device 1 in 0.8 μm region which has relatively large output and SHG (Second Harmonic Generation) device 200 (Please refer to Figure 2 (b)).

[0041] In addition, the form of equipments and the system of lighting circuits are same as those of phosphor type.

[0042] The structure and principle of laser diode device 1 are explained hereafter. As described in Figure 5, laser diode device generally employs double hetero junction in which active layer (light emitting layer) 100 is sandwiched by cladding layer 101, 102. These structures are formed on metal contact 107 and substrate 104, and contact layer 105, insulation layer 106, and metal contact 107 are formed on cladding layer 101.

[0043] Active layer 100 is the semiconductor with small band gap (Energy gap between valance band and conductor of semiconductors). Cladding layer 101 and 102 are n-type and p-type with lager band gap. When forward voltage is imposed on those layers, electrons and electron holes influx into active layer 100 from n-type region and p-type region respectively.

[0044] These carriers (electrons and electron holes) are confined in active layer 100 due to the energy barrier attributed to band gap in hetero (of different substances) junction. This confinement promotes an efficient reconbination of electrons and electron holes generating spontaneously radiated light. At this stage, like the case of LED, non-coherent light is radiated in all directions.

[0045] Such light which is spontaneously radiated promotes the next recombination of electrons and electron holes triggering induced emission. Edge facet 100a of active layer 100 is the cleaved facet (specific part in crystal grating which is fragile) of crystal, and functions as a reflecting mirror of optical resonator. Therefore induced emission and optical amplification are accelerated while light reciprocates in the optical resonator. In addition, in case of double hetero junction, because the refractive index of active layer 100 is larger than that of cladding layer 101 and 102, active layer 100 functions as a light guide. Therefore light is confined in active layer 100 reducing the loss of light.

[0046] In this case, when imposed current becomes large to certain extent,

laser oscillation can be triggered at certain point, and output of light emitting skyrockets. As a result, the laser light with directionality and narrow spectrum range is shade from both edge facet 100. Compared to LED, the lifecycle of A1GaAs-A1GaAs-GaAs laser is slightly shorter (for instance, 1.3 million hours at 40°C of air temperature, 270 thousand hours at 40°C). However, large light output is obtainable (More than 10mW, 100mW at maximum, to approximately 100mW in practical level).

[0047] By installing plurality of fundamental double hetero junction laser diode device, required output can be obtained. In order to achieve higher output and efficiency, the structure explained below is adapted.

[0048] (1) Phased array type laser diode device is utilized.

[0049] As described in Figure 5, double hetero junction laser diode device in general employs the single stripe structure wherein the region to which electric current is imposed is limited by insulation layer 106 in order to achieve clean oscillation mode and lower threshold current. Widening stripe width can enlarge output. However when the figure exceeds 10 μm, multimode oscillation in filament shape is triggered, making the oscillation uncontrollable, and enlarging oscillation threshold current. Therefore when this single stripe structure is employed, stripe width is enlarged with the limit of 20 μm or more favorably 10 μm.

[0050] Moreover, in order to increase output, as described in Figure 6, phased array type laser diode device (phase-coherent type laser) wherein wide stripes are divided into multiple stripes with narrow width is applied. In this structure, oscillation mode at adjoining each stripe is combined with each other and each phase synchronizes and oscillates as a group to generate a large output. The phase array type has several structures including parallel waveguide type, type to change imposed current, type to change stripe width, diffractive-binding type, offset stripe type, and the output of 10-30W at continuous oscillation is achievable. In practical term, it is favorable to limit the output at 10W considering hear resistance and lifecycle.

[0051] (2) Reflection mirror and reflection film are installed on edge facet of active layer.

[0052] In general, the laser light emitted from cleave facet (reflection facet) at the one side of active layer 100 is utilized for main purpose as a main beam, and the laser light emitted from the other side is utilized for control purpose in order to stable laser output as a monitor beam. As described in Figure 7, reflection mirror 110 is installed at one cleaved facet of active layer 100. The reflection mirror 110 is obtained by the deposition of silver or mercury 110 b on the external surface of quartz glass 110 a.

[0053] When cleaving facet is left as it is, the reflection rate remains around 25%. However, the installation of reflection mirror can drastically improve the figure to, for instance, 90% achieving the substantial reduction of oscillation threshold current and improving light emitting efficiency.

[0054] (3) Thickening optical guide layer.

[0055] As described in Figure 8 (a), thickening optical guide layer 120 can achieve larger output.

[0056] (4) Quantum well structure.
As described in Figure 8 (b), quantum well 130 wherein the thickness of active layer 100 is modified from ordinal figure of 1000-2000 angstrom to 100 angstrom or lower is created. Because the energy situation of electrons can be efficiently converged into specific wave range, high-performance laser with extremely low oscillation threshold current can be obtained. In addition, oscillation wavelength can be changed simply by changing the width of quantum well.

[0057] In addition to the methods mentioned above, surface-emitting laser wherein two-dimensional array can be employed is another option to increase the output of laser diodes and can be adapted when necessary.

[0058] In addition, the applications of the illumination equipment pertaining to the present invention include flashlight, room light, street light, guiding light, courtesy light of automobiles and trains, interior light of vessels, air plane, army vehicles, light in tunnels, light in underground passages, light in harbor tunnel, light in water, stands, decollated chandeliers, and the list goes on.

[0059]
[Advantages of Invention] Because the present invention comprises of the structures described above, it realizes following advantages.

[0060] (1) Energy consumption is small, and the contribution to energy conservation can be made. For instance, the energy consumption of single substance with single stripe structure is 2V of voltage and 20mmA of electric current.

[0061] (2) Life cycle is approximately five times longer than that of mercury lamp, the existing product with longest life cycle. For example, the figure for single substance with single stripe structure is 50-100 thousand hours. The invention is suitable for the application in the locations with difficulty to change bulbs.

[0062] (3) Laser diode device is small, solid, free from disconnection, and excellent in endurance. Therefore it is suitable for the use in shaky locations.

[0063] (4) Because of low voltage, risk of fine is extremely low, and therefore it is safer compared to traditional products.

[0064] (5) Because of the conversion from alternate current to direct current, it is free from flickering and does not exhaust eyes.

[Simple Explanation of Figures]

[Figure 1] Simple cross-section figure which explains light source equipment for illumination pertaining to the present invention. (a) shows phosphor type, and (b) shows three color superimpose type.
[Figure 2] (a) is the simple cross-section figure which describes laser diode device to which mercury and so on are doped. (b) is the simple cross-section figure which shows the example wherein SHG device is installed in laser diode device.

[Figure 3] Circuit pattern which shows the example of power and lighting circuit.

[Figure 4] Simple cross-section figure which describes various forms of the light source equipment for illumination of the present invention.

[Figure 5] Perspective view of the structure of laser diode device with general single stripe structure.

[Figure 6] Perspective view which shows one structure of phased array type laser diode device.

[Figure 7] Cross-section figure which describes the reflection member of active layer of laser diode device.

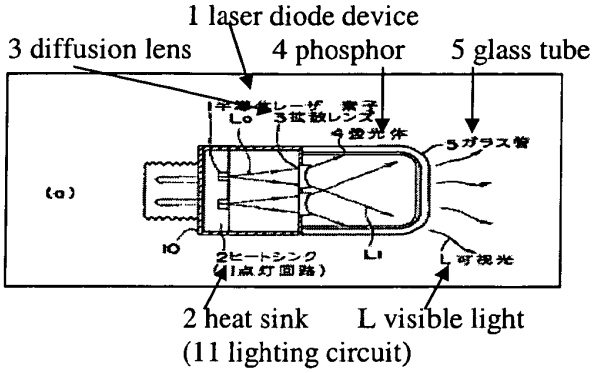
Savant Technologies LLC - 1004.938

[Figure 8] (a) is the simple elevation view which shows one example of laser diode device in which optical guide layer is created. (b) is the simple elevation view of one example of laser diode device with quantum well structure.

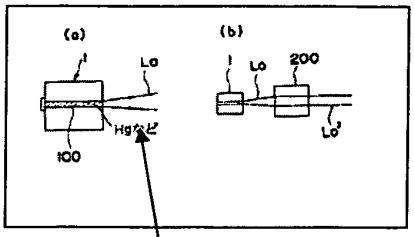
[Explanation of Codes]
*1 laser diode device, 2 heat sink, 3 diffusion lens, 4 phosphor, 5 glass tube, 6 power, 7 lighting circuit, 8 collimating lens, 9 merger-diffusion lens.

*

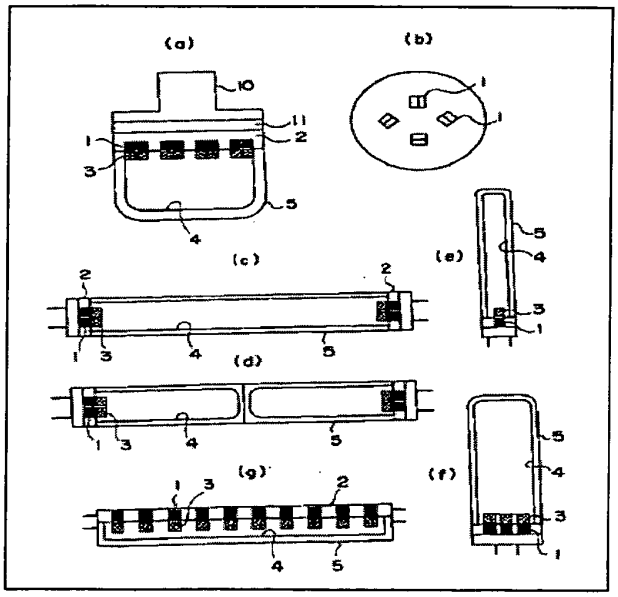
[Figure 1]



[Figure 2]



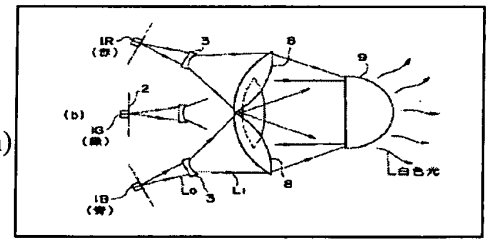
[Figure 4]



(red)

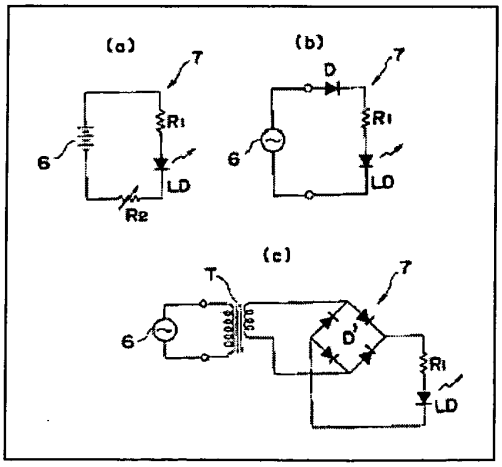
(green)

(blue)



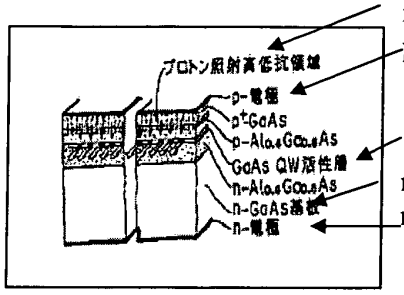
L white light

[Figure 3]

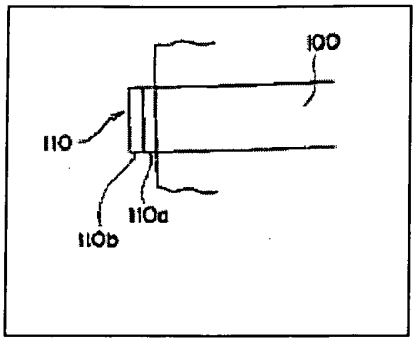


BEST AVAILABLE COPY

[Figure 6]



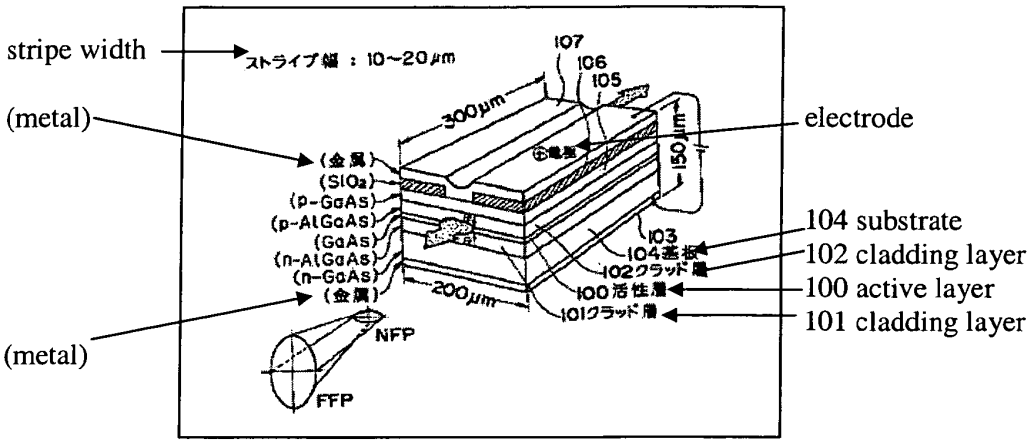
[Figure 7]



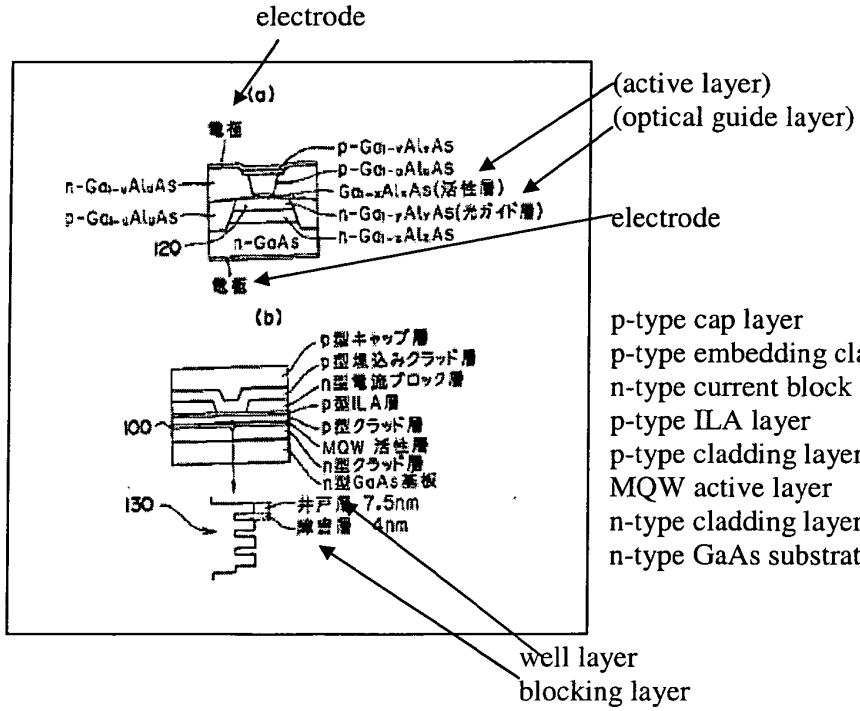
BEST AVAILABLE COPY

(8)

[Figure 5]



[Figure 8]



BEST AVAILABLE COPY

Electronic Acknowledgement Receipt

EFS ID:	15973654
Application Number:	13273212
International Application Number:	
Confirmation Number:	8795
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Customer Number:	101130
Filer:	Peter C. Mei/Tony Nguyen
Filer Authorized By:	Peter C. Mei
Attorney Docket Number:	ITMX-00318US1
Receipt Date:	06-JUN-2013
Filing Date:	13-OCT-2011
Time Stamp:	18:48:04
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	MIURA-NOBORU-ET-AL-Several-Blue-Emitting-Thin-Film-Electroluminescent-Devices-Jpn-J-Appl-.pdf	306075 082ae0aebb22377936b9a0c6da5e7aa07075fab4	no	3

Warnings:

Information:

Savant Technologies LLC - 1004.942

2	Non Patent Literature	MORKOC-H-ET-AL--Large-band-gap-SiC-111-V-nitride-and-II-VI-ZnSe-based-semiconductor-devic.pdf	3426524 67b658c3316bd37898e4b66d54eb241b038ba0a2	no	37
Warnings:					
Information:					
3	Non Patent Literature	MUENCH-WV-ET-AL-Silicon-carbide-light-emitting-diodes-with-epitaxial-junctions-Solid-Stat.pdf	294467 f80ffe19fceb57a137acc46f753571e4f0745111	no	4
Warnings:					
Information:					
4	Non Patent Literature	MUKAI-T-ET-AL-Recent-progress-of-nitride-based-light-emitting-devices-Phys-Stat-Sol-Septe.pdf	464046 87399e7df74dc22ad5edc5e9aa3b6f73fa7a8f82	no	6
Warnings:					
Information:					
5	Non Patent Literature	NAKAMURA-S-ET-AL-High-power-InGaN-single-quantum-well-structure-blue-and-violet-light-emi.pdf	365476 b925d84782c428a85351c0da976537638301fb2ce	no	4
Warnings:					
Information:					
6	Non Patent Literature	NAKAMURA-S-ET-AL-The-Blue-Laser-Diode-GaN-Based-Light-Emitters-and-Lasers-March-21-1997-P.pdf	165150 2a7d61b2c78401218c4b7bdbcc8a0bddefc9ece0	no	3
Warnings:					
Information:					
7	Non Patent Literature	NAKAMURA-S-ET-AL-The-Blue-Laser-Diode-The-Complete-Story-2nd-Revised-and-Enlarged-Edition.pdf	1138344 ee696e79694fc7129c0c7ee60612310dde1a0fc5	no	6
Warnings:					
Information:					
8	Non Patent Literature	November-30-2010-Office-Action-in-US-Patent-Application-No-12131118issued-by-Examin.pdf	1707712 9d861358b0d8debd78283adc3b6326a172b0032a	no	32
Warnings:					
Information:					
9	Non Patent Literature	October-20-2008-Office-Action-in-US-Patent-Application-No-10623198-issued-by-Abu-l-Kalam-.pdf	584630 3fc8719fc9f09c9fbee3a20b5e105dd637af4b0d	no	13
Warnings:					
Information:					
10	Non Patent Literature	PANKOVE-JI-ET-AL-Scanning-electron-microscopy-studies-of-GaN-Journal-of-Applied-Physics-A.pdf	305204 e341e17695e7df97028d49680126fdf805e1d024	no	2
Warnings:					
Information:					

11	Non Patent Literature	PAVAN-P-ET-AL-Explanation-of-Current-Crowding-Phenomena-Induced-by-Impact-Ionization-in-A.pdf	346806 438160c1e030161cf9fc8ffe9b249c2885e273aa	no	4
Warnings:					
Information:					
12	Non Patent Literature	PEl-Q-ET-AL-Polymer-Light-Emitting-Electrochemical-Cells-Science-August-25-1995-Pages-108.pdf	430602 64afb3ff571baaafcff948a1e78e30203a6b2107	no	3
Warnings:					
Information:					
13	Non Patent Literature	90010940_Advisory_Action_09_28_12.pdf	128872 5e405426b01321a68b1d53b7fbfd9d1481b9b408	no	4
Warnings:					
Information:					
14	Non Patent Literature	90010940_FOA_05_24_12.pdf	13256417 0d62efff1a734aae0f80931a6e3642b46cde1d82	no	256
Warnings:					
Information:					
15	Non Patent Literature	90010940_FOA_11_07_11.pdf	8452676 963b7fee1d7c9e58f748432da065dc121da1e5f1	no	82
Warnings:					
Information:					
16	Non Patent Literature	90010940_NFOA_01_26_12.pdf	3359476 179d51d5de75fd57809d23844af908d4a03b3cce	no	70
Warnings:					
Information:					
17	Non Patent Literature	90010940_NFOA_03_03_11.pdf	2095677 68dcacf5f7d1528070e577684984adbc73435d1c	no	45
Warnings:					
Information:					
18	Non Patent Literature	90010940_NFOA_09_20_10.pdf	2003750 adb384cb2049f17995c54ae7de9535f32ef4db36	no	43
Warnings:					
Information:					
19	Non Patent Literature	ROMAN-D-LEDs-Turn-A-Brighter-Blue.pdf	245012 6d7b2b76b7771a6f2ca088e510c02b7e1042a106	no	1
Warnings:					
Information:					

20	Non Patent Literature	Saleh-and-Teich-Fundamentals-of-Photonics-New-York-John-Wiley-Sons-1991-pp-592-594.pdf	380774 bea939fd627353262375 9bfe75ff1a027dce ecf7	no	8
Warnings:					
Information:					
21	Non Patent Literature	SATO-YUICHI-ET-AL-Full-color-fluorescent-display-devices-using-a-near-UV-light-emitting.pdf	291633 fca00dc8cf74e88d9e9b0ba067c888805e01 fa8c	no	2
Warnings:					
Information:					
22	Non Patent Literature	September-17-2009-Notice-of-Allowance-Notice-of-Allowability-Examiners-AmendmeniComment-a.pdf	494281 1f2f872a60ce0d43d4f8a34e37148cb8a492 10ba	no	7
Warnings:					
Information:					
23	Non Patent Literature	September-29-2009-Office-Action-in-US-Patent-Application-No-11264124-issued-by-Abu-l-Kala.pdf	389890 fe42bfae8ef4904058a9ab489b07727b8c69 ade9	no	8
Warnings:					
Information:					
24	Non Patent Literature	TANAKA-SHOSAKU-ET-AL-Bright-white-light-electroluminescence-based-on-nonradiative-energy.pdf	5197316 74780a138832b494ea144534185a05e50e3 95166	no	3
Warnings:					
Information:					
25	Non Patent Literature	TANAKA-SHOSAKU-ET-AL-White-Light-Emitting-Thin-Film-Electroluminescent-Devices-with-SrSCe.pdf	299075 8c9495534a5066d960defa4d109427dc8da 99fa8	no	3
Warnings:					
Information:					
26	Non Patent Literature	The-Penguin-Dictionary-of-Electronics-3rd-edition-pp-315437-438-509-510-copyright-1979-19.pdf	371676 153fb23b9df689ab5770d574623e89f19a2 97211	no	7
Warnings:					
Information:					
27	Non Patent Literature	URA-M--Recent-trends-of-development-of-silicon-monocarbide-blue-light-emission-diodes-Kin.pdf	645334 d9a28064eedb2a072b482f2de5da7963fdd 868d6	no	10
Warnings:					
Information:					
28	Non Patent Literature	WERNER-K--Higher-Visibility-for-LEOs-IEEE-Spectrum-July-1994-Pages-30-392.pdf	888503 0df5fd7ff072bbe306b476592d1136d9f9c7 b832	no	8
Warnings:					
Information:					

29	Non Patent Literature	WOJCIECHOWSKI-J-ET-AL--INFRARED-TO-BLUE-UP-CONVERTING-PHOSPHOR-Electron-Technology-1978-P.pdf	1022966 609869a513925e8cd32a68cdcc80bfd905e4e251	no	17
Warnings:					
Information:					
30	Non Patent Literature	YAMAGUCHI-Y-ET-AL-HIGH-BRIGHTNESS-SiC-BLUE-LEOS-AND-THEIR-APPLICATION-TO-FULL-COLOR-LED-L.pdf	710940 29910a19a5d7343fb8385923ecf461f6025a9ddf	no	12
Warnings:					
Information:					
31	Non Patent Literature	YANG-Y-ET-AL-Voltage-controlled-two-color-light-emitting-electrochemical-cells-Appl-Phys-.pdf	331194 6b7f3a9fec973ba28d7efa3963ed166426e117bd	no	3
Warnings:					
Information:					
32	Non Patent Literature	YOSHIMI-MASASHI-ET-AL-Amorphous-carbon-basis-blue-light-electroluminescent-device-Optoele.pdf	913802 74108ba0360f67070d05c49287859c17f4f26901	no	13
Warnings:					
Information:					
33	Non Patent Literature	ZANONI-E-ET-AL-Impact-ionization-recombination-and-visible-light-emission-in-ALGaAsGaAs-h.pdf	322215 a9604b4d98f3978c5e9596daf82092ecc7021321	no	3
Warnings:					
Information:					
34	Non Patent Literature	ZANONI-E-ET-AL-Measurements-of-Avalanche-Effects-and-Light-Emission-in-Advanced-Si-and-Si.pdf	297094 6cd8f4d3db5d3d34f11a016f1ae3f4cbd8031c7e	no	4
Warnings:					
Information:					
35	Non Patent Literature	ZDANOWSKI-MAREK-Pulse-operating-up-converting-phosphor-LED-Electron-Technol--1978-Pages-4.pdf	873951 407210b8cce68987d09507c309bbf4c95ee379c3	no	13
Warnings:					
Information:					
36	Non Patent Literature	ZHIMING-CHEN-ET-AL-Amorphous-thin-film-white-LED-and-its-light-emitting-mechanism-Confere.pdf	439005 c7fcead7c7585c7857cba85a56544d76e3c01cc3	no	5
Warnings:					
Information:					
37	Foreign Reference	EP0647694.pdf	1873951 0f64ec5c49eec0ac02c1bef4d7930d8dc827b3f5	no	45
Warnings:					
Information:					

38	Foreign Reference	GB2017409.pdf	245621 92975abc2eddbdfa7e2c96248fd0609a56ec1a90	no	4
Warnings:					
Information:					
39	Foreign Reference	JP01260707.pdf	581345 3935ca2b6ecf6892849762063 75a2dc279462a65	no	13
Warnings:					
Information:					
40	Foreign Reference	JP2900928.pdf	359238 ed982a40546512019f62ccb6f5cbdf86afa39d8b	no	5
Warnings:					
Information:					
41	Foreign Reference	JP4010665.pdf	424294 ff092a849d61edca299854aec777c1de76032282	no	11
Warnings:					
Information:					
42	Foreign Reference	JP4010666.pdf	424081 8a53af811739af1c2a9f5458a793d773d3f50e34	no	11
Warnings:					
Information:					
43	Foreign Reference	JP04289691.pdf	311762 5bd300b7b42824620b47966ced976136ed2a2aeb	no	5
Warnings:					
Information:					
44	Foreign Reference	JP4321280.pdf	234224 bcea377011afc4df3ad91be539ce45ba5ae52ee0	no	5
Warnings:					
Information:					
45	Foreign Reference	JP05152609.pdf	209514 af21adcecf68482d0b337f3253a380b7584a927c	no	6
Warnings:					
Information:					
46	Foreign Reference	JP6207170.pdf	1582344 0fbb4d69aba7806da0ce22bd7005b95ad37a00f9	no	49
Warnings:					
Information:					

47	Foreign Reference	JP6267301.pdf	917725 78b68dbb35198010ae3dd77ec127ccf6a3c0055b	no	15
Warnings:					
Information:					
48	Foreign Reference	JP6283755.pdf	778913 27c889830fb67d678da97ae07d333465cd1b02e3	no	10
Warnings:					
Information:					
49	Foreign Reference	JP07099345.pdf	1166803 60eed8205862984c0cd08d45394113776ef592de	no	19
Warnings:					
Information:					
50	Foreign Reference	JP7176794.pdf	640837 27423354ccf3bad7a0b28c7121ea2cbfcfa070fd	no	12
Warnings:					
Information:					
51	Foreign Reference	JP7235207.pdf	1651635 e90b28644bbd0b32a55349ac76798d6f86c5d3c7	no	21
Warnings:					
Information:					
52	Foreign Reference	JP8250281.pdf	731127 334ced75ba098cfe7ff810fe6b4679d5a64b16f2	no	15
Warnings:					
Information:					
53	Foreign Reference	JP60170194.pdf	516944 bbc41c79ed2b8f3a6842f7ef83ecc7b7e5d9b7a5	no	12
Warnings:					
Information:					
54	Foreign Reference	JP862189770.pdf	456672 83b31c87ece10fa4beb1214d92a722a96837745e	no	11
Warnings:					
Information:					
55	Foreign Reference	JPH087614.pdf	372475 5ccc8cd038a01dae2883dcd1094b962023a61b86	no	11
Warnings:					
Information:					

56	Foreign Reference	JPH0291980.pdf	519609 4f07a4735faa4c1ca2fe36ed0f97e8bfcb119d68	no	14
Warnings:					
Information:					
57	Foreign Reference	JPP3724490.pdf	213447 0075356b40d2d5c15184edaa76e56623a3630797	no	6
Warnings:					
Information:					
58	Foreign Reference	JPH324692.pdf	177021 a7c34c6bb0134331aeca5b588cd3ec1f7c848825	no	8
Warnings:					
Information:					
59	Foreign Reference	JPH01179471.pdf	250507 1db6bb928d48e16304b5d7ad53b335833b7f87a1	no	8
Warnings:					
Information:					
60	Foreign Reference	JPH7282609.pdf	752559 489e8a4c4c7904d7a7b7ac1b00ae3ab76144befc	no	18
Warnings:					
Information:					
		Total Files Size (in bytes):	68339213		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

BL

(19) Japanese Patent Office (JP)

(11) Patent No.

(12) **Examined Patent Publication (B2)** P3724498

(45) Publication Date: Dec. 17, 2005

(24) Registration Date: Sept. 30, 2005

(51) Int. Cl.[7]	FI	
H01L 33/00	H01L 33/00	C
	H01L 33/00	N

Number of Claims: 1 (Total of 5 pages)

(21)	Patent Application No.:	P2004-280288
(22)	Application Date:	September 27, 2004
(62)	Indication of Division:	Division of P2003-67318
	Original Application Date:	November 25, 1991
(65)	Application Publication No.:	P2004-363635A
(43)	Application Publication Date:	December 24, 2004
	Examination Request Date:	October 26, 2004
(73)	Patent Right Holder:	000226057 Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
(74)	Agent:	100074354 Patent Attorney: Yasuhiro Toyosu
(74)	Agent:	100104949 Patent Attorney: Koji Toyosu
(72)	Inventor:	Yoshiaki Tadatsu c/o Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
(72)	Inventor:	Shuji Nakamura c/o Nichia Corporation 491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima
	Examiner	Kaduyo Kadota

Continued to the last page

(54) [Invention Title] Light Emitting Diode

(57) [What is Claimed is:]

Savant Technologies LLC - 1004.950

[Claim 1] A light emitting diode in which a light emitting device is surrounded with a resin, wherein

said light emitting device emits visible light having an emission peak in a blue range, and is a gallium nitride related compound semiconductor device in which n-type and p-type layers are stacked;

a fluorescent dye or pigment is added to the resin surrounding said light emitting device;

said fluorescent dye or pigment is excited with light with wavelengths near 420nm to 440nm and emit light,

said fluorescent dye or pigment is excited with the visible light from the light emitting device, and emits visible light with a longer wavelength that that of the excitation light, thereby improving its luminosity factor of the light emitting diode.

[Detailed Explanation of Invention]

[Technological Field]

[0001]

The present invention relates to a light emitting diode (hereafter referred to as an LED) in which a light emitting device is surrounded with a resin mold. In particular, the present invention relates to a light emitting diode which can emit a variety of light emissions using one type of light emitting device, further which is bright, and which can vary the emission wavelength.

[Technological Background]

[0002]

In general, an LED has a structure as illustrated in Figure 1. The numeral designator 1 represents a light emitting device which is cut to a piece of 1mm square or smaller and which is made of materials such as GaAlAs and GaP, the numeral designator 2 represents a metal stem, the numeral designator 3 represents a metal post and the numeral designator 4 represents a resin mold which surrounds the light emitting device. The back surface electrode of the light emitting device 1 is attached on the metal stem 2 using a material such as silver paste, thereby electrically connecting it thereto. A gold wire coming from the metal post 3, which is the other electrode, is bonded to the surface of the front surface electrode of the light emitting device 1. Further, the light emitting device 1 is molded using the transparent resin mold 4.

[0003]

Ordinarily, a resin with a large index of refraction and a high transparency is selected for the resin mold 4, so that the emission light from the light emitting device is efficiently emitted to the air. In other cases, an inorganic or organic pigment is mixed as a coloring agent in the resin mold 4 in order to convert or correct the emission color of the light emitting device. For instance, when a red pigment is added to a resin mold around a green light emitting device having GaP semiconductor materials, its emission color turns into white.

Savant Technologies LLC - 1004.951

[Disclosure of Invention]

[Issues to be Resolved by Invention]

[0004]

Conventionally, however, most of technologies to convert the wavelength by adding a coloring agent to a resin mold are not put into practical use and only handful technologies to employ a coloring agent for color correction are utilized. This is because adding an enough amount of a coloring agent, which is a non-light-emission material, to realize the wavelength conversion greatly reduces the brightness of an LED.

[0005]

In addition, currently realized LED's are infrared, red, yellow and green light emitting ones. Blue and ultraviolet LED's are not yet realized. Research is being conducting with semiconductors such as ZnSe which is a II-VI group material, SiC which is a IV-IV group material, and GaN which is a III-V group material. Recently, among these materials, gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$) are attracting attentions because it was found that they exhibit relatively superior light emission at normal temperatures. Moreover, LED's employing gallium nitride related compound semiconductors in which a pn junction was realized for the first time were reported (Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991). According to this publication, LED's employing gallium nitride related compound semiconductors have a main emission peak at around 430nm and also have another emission peak in the ultraviolet range of around 370nm. These wavelengths are the shortest among those for the above semiconductor materials. Such LED's, however, have a disadvantage in that their luminosity factor is poor because the emission color is close to violet, as their emission wavelength indicates.

[0006]

The present invention was conceived with considerations being given to such circumstances. Its purpose is to improve the luminosity factor and brightness of LED's having a light emission device which is made of gallium nitride related compound semiconductors whose emission peaks are in the vicinities of 430nm and 370nm.

[Means to Resolve Issues]

[0007]

The present invention provides a light emitting diode in which a light emitting device is surrounded with a resin, wherein said light emitting device emits visible light having an emission peak in a blue range, and is a gallium nitride related compound semiconductor device in which n-type and p-type layers are stacked; a fluorescent dye or pigment is added to the resin surrounding said light emitting device; said fluorescent dye or pigment is excited with light with wavelengths near 420nm to 440nm and emit light, said fluorescent dye or pigment is excited with the visible light from the light emitting device, and emits visible light with a longer

wavelength that that of the excitation light, thereby improving its luminosity factor of the light emitting diode. Moreover, the present invention provides a resin for a wavelength variable light emitting diode, whereas the resin contains a fluorescent dye or pigment for converting light from a light emitting device in which n-type and p-type gallium nitride related compound semiconductor layers are stacked; wherein said resin a wavelength variable light emitting diode is placed in a concave section on which said light emitting device is mounted; the fluorescent dye or pigment in said resin for a wavelength variable light emitting diode is excited with blue visible light from the light emitting device and emits visible light with wavelengths longer than that of the excitation light, thereby improving the luminosity factor of the light emitting diode.

[Advantages of Invention]

[0008]

A fluorescent dye or pigment is generally excited with a short-wavelength light and emits light with a longer wavelength than that of the excitation light. Contrarily, there are fluorescent pigments which are excited with a long-wavelength light and which emit light with a shorter wavelength than that of the excitation light. Such materials, however, have a very poor energy efficiency and provides a very week emission light. As discussed above, gallium nitride related compound semiconductors have emission peaks in the shortest wavelength range among semiconductor materials which are employed for LED's. Moreover, they have an emission peak in the ultraviolet range. Therefore, when they are employed as materials for a light emitting device and when a fluorescent dye or pigment is added to a resin mold surrounding the light emitting device, the fluorescent material can be most optimally excited. Therefore, different types of a fluorescent dye or pigment can not only correct color of blue LED's but also convert light into a variety of wavelengths. Further, light with a shorter wavelength is converted to one with a longer wavelength with a good energy efficiency and hence, the amount of a fluorescent dye or pigment can be small and the invention is very excellent from the view point of reducing the degradation of luminosity factor.

[Best Embodiment to Implement Invention]

[0009]

Figure 2 illustrate an example to depict the structure of an LED according to the present invention. The numeral designator 11 represents a blue light emitting device in which n-type and p-type GaAlN layers are stacked on a sapphire substrate, the numeral designators 2 and 3 represent a metal stem and a metal post, respectively, in the same manner as in Figure 1, and the numeral designator 4 represents a resin mold surrounding the light emitting device. There is the sapphire insulating substrate on the back surface of the light emitting device 11 and an electrode can not be made on the back surface. Therefore, in order to electrically connect an n-electrode on the GaAlN layer to the metal stem 2, a method is employed in which the GaAlN layers are etched to expose the surface of the n-type layer, upon which an ohmic electrode is attached. The ohmic electrode and the metal stem 2 are electrically connected using a gold wire. Moreover, the other

Savant Technologies LLC - 1004.953

electrode is wire-bonded to the surface of the p-type layer using a gold wire coming from the metal post 3 in the same manner as in Figure 1. Further, a fluorescent dye 5 which is excited with light with a wavelength near 420 to 440nm and which emits light with an emission peak near 480nm is added to the resin mold 4.

[Brief Explanation of Figures]

[0010]

[Figure 1] A schematic cross section to illustrate the structure of a conventional LED.

[Figure 2] A schematic cross section to illustrate the structure of an example of an LED according to the present invention.

[Explanation of Numeral Designators]

[0011]

11 Light emitting device

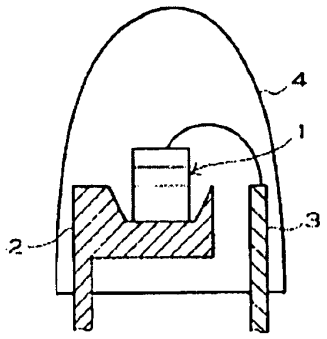
2 Metal stem

3 Metal post

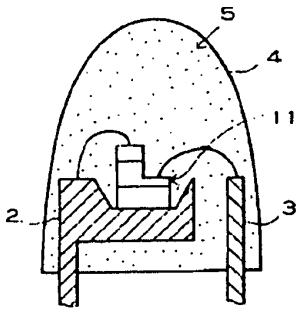
4 Resin mold

5 Fluorescent dye

[Figure 1]



[Figure 2]



Savant Technologies LLC - 1004.954

Continued from the first page

(56) References:

Patent Application Publication H03-152897 (JP, A)

Patent Application Publication H03-203388 (JP, A)

Patent Application Publication S64-017484 (JP, A)

Patent Application Publication S57-186376 (JP, A)

Patent Application Publication S54-082988 (JP, A)

Patent Application Publication S52-070783 (JP, A)

Patent Application Publication S63-000180 (JP, A)

Utility Model Patent Application Publication H03-067462 (JP, U)

Utility Model Patent Application Publication H03-081652 (JP, U)

Utility Model Patent Application Publication S50-079379 (JP, U)

Examined Utility Model Patent Publication S54-041660 (JP, Y1)

Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991

(58) Searched Fields (Int. Cl.[7], Name of Data Base)

H01L 33/00

Savant Technologies LLC - 1004.955

BJ

(19) Japanese Patent Office (JP)

(11) Laid Open Patent Application Publication No.

(12) **Laid Open Patent Application Publication (A)** P2003-234513A

(43) Publication Date: August 22, 2003

(51) Int. Cl.[7]	Identification Symbols	FI		Theme Codes (for references)	
H01L 33/00		H01L 33/00	N	5F041	
			C		

Examination Request: Requested

Number of Claims: 1 document (Total of 3 pages)

(21) Patent Application No.: P2003-67318

(62) Indication of Division: Division of P2001-313286

(22) Application Date: November 25, 1991

(71) Applicant: 000226057

Nichia Corporation

491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Yoshiaki Tadatsu

c/o Nichia Corporation

491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(72) Inventor: Shuji Nakamura

c/o Nichia Corporation

491-100 Oka, Kaminaka-Cho, Anan-Shi, Tokushima

(74) Agent: 100074354

Patent Attorney: Yasuhiro Toyosu (and another)

F Terms (for references) 5F041 AA11 AA14 CA40 CA46 DA16

DA43 DA55 DB01 EE25

(54) [Invention Title] Resin for Wavelength-Variable Light Emitting Diodes to which a Fluorescent Dye or Pigment is Added

(57) [Abstract]

[Issue] To improve the luminosity factor and brightness of an LED having a light emission device which is made of gallium nitride related compound semiconductor materials.

Savant Technologies LLC - 1004.956

[Resolution Means] A resin for wavelength-variable light emitting diodes to which a fluorescent dye or pigment is added for converting light from a light emitting device which is named of stacked n-type and p-type gallium nitride related compound semiconductor materials; wherein the fluorescent dye or pigment in said resin for wavelength-variable light emitting diode is excited with blue visible light from the light emitting device, and emits visible light with wavelengths longer than those of the excitation light, thereby improving the luminosity factor of the light emitting diodes.

Savant Technologies LLC - 1004.957

[What is Claimed is:]

[Claim 1] A resin for wavelength-variable light emitting diodes to which a fluorescent dye or pigment is added for converting light from a light emitting device which is named of stacked n-type and p-type gallium nitride related compound semiconductor materials;

wherein the fluorescent dye or pigment in said resin for wavelength-variable light emitting diode is excited with blue visible light from the light emitting device, and emits visible light with wavelengths longer than those of the excitation light, thereby improving the luminosity factor of the light emitting diodes.

[Detailed Explanation of Invention]

[0001]

[Field of Industrial Application]

The present invention relates to a light emitting diode (hereafter referred to as an LED) in which a light emitting device is surrounded with a resin mold. In particular, the present invention relates to a light emitting diode which can emit a variety of light emissions using one type of light emitting device, further which is bright, and which can vary the emission wavelength.

[0002]

[Conventional Technologies]

In general, an LED has a structure as illustrated in Figure 1. The numeral designator 1 represents a light emitting device which is cut to a piece of 1mm square or smaller and which is made of materials such as GaAlAs and GaP, the numeral designator 2 represents a metal stem, the numeral designator 3 represents a metal post and the numeral designator 4 represents a resin mold which surrounds the light emitting device. The back surface electrode of the light emitting device 1 is attached on the metal stem 2 using a material such as silver paste, thereby electrically connecting it thereto. A gold wire coming from the metal post 3, which is the other electrode, is bonded to the surface of the front surface electrode of the light emitting device 1. Further, the light emitting device 1 is molded using the transparent resin mold 4.

[0003]

Ordinarily, a resin with a large index of refraction and a high transparency is selected for the resin mold 4, so that the emission light from the light emitting device is efficiently emitted to the air. In other cases, an inorganic or organic pigment is mixed as a coloring agent in the resin mold 4 in order to convert or correct the emission color of the light emitting device. For instance, when a red pigment is added to a resin mold around a green light emitting device having GaP semiconductor materials, its emission color turns into white.

Savant Technologies LLC - 1004.958

[0004]

[Issues to be Resolved by Invention]

Conventionally, however, most of technologies to convert the wavelength by adding a coloring agent to a resin mold are not put into practical use and only handful technologies to employ a coloring agent for color correction are utilized. This is because adding an enough amount of a coloring agent, which is a non-light-emission material, to realize the wavelength conversion greatly reduces the brightness of an LED.

[0005]

In addition, currently realized LED's are infrared, red, yellow and green light emitting ones. Blue and ultraviolet LED's are not yet realized. Research is being conducting with semiconductors such as ZnSe which is a II-VI group material, SiC which is a IV-IV group material, and GaN which is a III-V group material. Recently, among these materials, gallium nitride related compound semiconductors which are expressed with a general formula of $Ga_XAl_{1-X}N$ (where $0 \leq X \leq 1$) are attracting attentions because it was found that they exhibit relatively superior light emission at normal temperatures. Moreover, LED's employing gallium nitride related compound semiconductors in which a pn junction was realized for the first time were reported (Oyo Butsuri, vol. 60, No. 2, pp163-166, 1991). According to this publication, LED's employing gallium nitride related compound semiconductors have a main emission peak at around 430nm and also have another emission peak in the ultraviolet range of around 370nm. These wavelengths are the shortest among those for the above semiconductor materials. Such LED's, however, have a disadvantage in that their luminosity factor is poor because the emission color is close to violet, as their emission wavelength indicates.

[0006]

The present invention was conceived with considerations being given to such circumstances. Its purpose is to improve the luminosity factor and brightness of LED's having a light emission device which is made of gallium nitride related compound semiconductors whose emission peaks are in the vicinities of 430nm and 370nm.

[0007]

[Means to Resolve Issues]

The present invention provides a resin for wavelength-variable light emitting diodes to which a fluorescent dye or pigment is added for converting light from a light emitting device which is named of stacked n-type and p-type gallium nitride related compound semiconductor materials; wherein the fluorescent dye or pigment in said resin for wavelength-variable light emitting diode is excited with blue visible light from the light

Savant Technologies LLC - 1004.959

emitting device, and emits visible light with wavelengths longer than those of the excitation light, thereby improving the luminosity factor of the light emitting diodes.

[0008]

[Embodiment to Implement Invention]

Figure 2 illustrate an example to depict the structure of an LED according to the present invention. The numeral designator 11 represents a blue light emitting device in which n-type and p-type GaAlN layers are stacked on a sapphire substrate, the numeral designators 2 and 3 represent a metal stem and a metal post, respectively, in the same manner as in Figure 1, and the numeral designator 4 represents a resin mold surrounding the light emitting device. There is the sapphire insulating substrate on the back surface of the light emitting device 11 and an electrode can not be made on the back surface. Therefore, in order to electrically connect an n-electrode on the GaAlN layer to the metal stem 2, a method is employed in which the GaAlN layers are etched to expose the surface of the n-type layer, upon which an ohmic electrode is attached. The ohmic electrode and the metal stem 2 are electrically connected using a gold wire. Moreover, the other electrode is wire-bonded to the surface of the p-type layer using a gold wire coming from the metal post 3 in the same manner as in Figure 1. Further, a fluorescent dye 5 which is excited with light with a wavelength near 420 to 440nm and which emits light with an emission peak near 480nm is added to the resin mold 4.

[0009]

[Advantages of Invention]

A fluorescent dye or pigment is generally excited with a short-wavelength light and emits light with a longer wavelength than that of the excitation light. Contrarily, there are fluorescent pigments which are excited with a long-wavelength light and which emit light with a shorter wavelength than that of the excitation light. Such materials, however, have a very poor energy efficiency and provides a very week emission light. As discussed above, gallium nitride related compound semiconductors have emission peaks in the shortest wavelength range among semiconductor materials which are employed for LED's. Moreover, they have an emission peak in the ultraviolet range. Therefore, when they are employed as materials for a light emitting device and when a fluorescent dye or pigment is added to a resin mold surrounding the light emitting device, the fluorescent material can be most optimally excited. Therefore, different types of a fluorescent dye or pigment can not only correct color of blue LED's but also convert light into a variety of wavelengths. Further, light with a shorter wavelength is converted to one with a longer wavelength with a good energy efficiency and hence, the amount of a fluorescent dye or pigment can be small and the invention is very excellent from the view point of reducing the degradation of luminosity factor.

Savant Technologies LLC - 1004.960

[Brief Explanation of Figures]

[Figure 1] A schematic cross section to illustrate the structure of a conventional LED.

[Figure 2] A schematic cross section to illustrate the structure of an example of an LED according to the present invention.

[Explanation of Numeral Designators]

11 Light emitting device

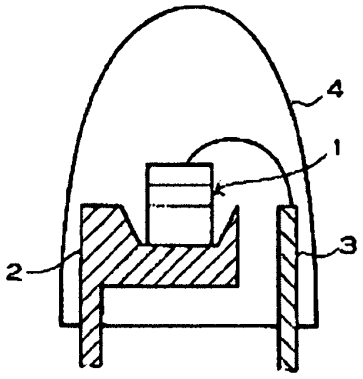
2 Metal stem

3 Metal post

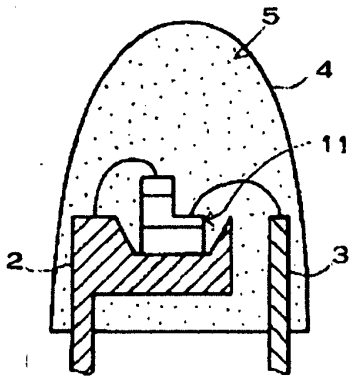
4 Resin mold

5 Fluorescent dye

[Figure 1]



[Figure 2]



Savant Technologies LLC - 1004.961

Utility Model Patent Application Publication No. S50-79379

Utility Model Patent Application

November 24, 1973

To: Patent Office Commissioner: Mr. Hideo Saito

1. Invention Title: Light Emitting Semiconductor Apparatus

2. Inventor: Address: c/o Fujitsu, LTD.
1015 Kami-Kodanaka, Nakahara-ku
Kawasaki-shi, Kanagawa-kenn
Name: Sei-ichi Tabuchi

3. Applicant: Address: 1015 Kami-Kodanaka, Nakahara-ku
Kawasaki-shi, Kanagawa-kenn
(522) Name: Fujitsu, LTD.
Representative: Yoshimitu Koura

4. Agent: Address: 1015 Kami-Kodanaka, Nakahara-ku
Kawasaki-shi, Kanagawa-kenn, 211
(6433) Name: Patent Attorney: Hiroshirou Matsuoka
Tel: 044-77-1111 ex. 2671

5. List of Attached Documents

1)	Specification	One copy
2)	Figures	One set
3)	Power of Attorney	One copy

48 135849

Savant Technologies LLC - 1004.962

Specification

1. Invention Title: Light Emitting Semiconductor Apparatus

2. What is Claimed is:

A light emitting semiconductor apparatus which is equipped with a light emitting semiconductor device and a transparent cover which covers said light emitting semiconductor device across a gap, wherein there is a phosphor layer on a surface of said transparent cover which faces said light emitting semiconductor device.

3. Detailed Explanation of the Utility Model Invention

The present utility model invention relates to a light emitting semiconductor apparatus which employs a phosphor to produce a visible light emission.

Recently, semiconductor light emitting diodes are frequently utilized as compact display devices with a long life. Their emission wavelengths are determined by the band gap which is specific to the semiconductor materials employed. For example, light emitting diodes utilizing gallium arsenide which is relatively inexpensive have an emission wavelength in the infrared region. Therefore, they can not be utilized as display devices without modification, although they exhibit high emission efficiency. Thus, light emitting semiconductor apparatuses in which a visible light conversion phosphor is applied on the surface of such infrared light emission diodes are produced. For example, Examined Patent Publication No. S46-9194 discloses such a light emitting semiconductor apparatus.

These light emitting semiconductor apparatuses have high brightness. Semiconductor materials, however, are expensive and light emitting devices are made very small. Therefore, they have a disadvantage in that they are almost a point light source. On the other hand, techniques are employed in order to obtain a large light emission area, such as providing a transparent lens in from of a light emitting device, and covering a light emitting device with a resin containing a light scattering agent. Such light emitting apparatuses, however, have complex structures and are expensive. Moreover, they have a disadvantage in that intense emission is observed only in the

Savant Technologies LLC - 1004.963

vicinity of a light emitting device although such a light scattering agent has an effect to reduce the overall light emitting intensity.

On the other hand, as disclosed in the aforementioned Examined Patent Publication No. S46-9194, a light emission area can be made larger if a binding agent in which a phosphor is dispersed is formed into a hemisphere covering a large region including a light emitting device, instead of applying the binding agent in a thin film on the surface of the light emitting device. A phosphor, however, is rather more expensive than semiconductor materials. Therefore, a structure which requires a large amount of phosphor is not preferred in terms of cost.

Upon giving reflections to the above points, the present utility model invention is intended to provide a light emitting semiconductor apparatus with a large light emitting area at low cost.

A light emitting semiconductor apparatus of the present utility model invention is equipped with a light emitting semiconductor device and a transparent cover which covers said light emitting semiconductor device across a gap, wherein there is a phosphor layer on a surface of said transparent cover which faces said light emitting semiconductor device.

Below, the present utility model invention is explained according to an example.

Figure 1 depicts a light emitting semiconductor apparatus of an example of the present utility model invention. In the example, the present utility model invention is applied to a light emitting semiconductor apparatus which employs a so-called TO-5 stem. Figure 1, glass 2 fixes leads 3 in a TO-5 metal stem 1. A light emitting semiconductor device 4 is conductively connected to stem 1. A transparent cover 6 according to the present utility model invention is fixed on stem 1. A phosphor layer 7 is provided by applying a binding agent in which a phosphor to convert the radiation from light emitting semiconductor device 4 to visible light is dispersed on the inner surface of transparent cover 6. Transparent cover 6 is made of a material such as glass or an epoxy resin is preferably fixed to stem 1 so that it can also function as a cap for hermetic sealing.

In the light emitting apparatus of the present utility model invention, phosphor layer 7 converts infrared or UV emitted from light emitting semiconductor device 4 to visible light which is radiated in random directions. Therefore, the light emitting

Savant Technologies LLC - 1004.964

semiconductor apparatus can produce an emission with a uniform intensity over a large area. Further, the light emitting semiconductor apparatus utilizes a relatively small quantity of phosphor and hence, is inexpensive.

Another example of a light emitting semiconductor apparatus of the present utility model is illustrated in Figure 2. In this example, the present utility model invention is applied to a mold-type light emitting semiconductor apparatus. In Figure 2, leads 9 are fixed on an insulating base 8. On a tip of one lead 9, a light emitting semiconductor device 10 is electrically connected. Further, light emitting semiconductor device 10 and the other lead 9 are electrically connected through a lead wire 11. A transparent resin 12 forms a hemispherical mold around light emitting semiconductor device 10. A phosphor layer 13 is formed on the surface of transparent resin 12. Further, a transparent cover 14 made of a material such as a transparent resin is provided on phosphor layer 13. In the present example, a ceramic material or a resin can be utilized for insulating base 8. Moreover, insulating base 8 may be formed at the same time when hemispherical transparent resin 12 is molded after light emitting semiconductor device 10 is fixed on lead 9 and lead wire 11 is connected. It is known that transparent resin 12 protects light emitting semiconductor device 10 and that at the same time, it improves apparent light emission efficiency of light emitting semiconductor device 10. In other words, providing transparent resin 12 reduces a difference in the index of diffraction between inside and outside of light emitting semiconductor device 10, thereby preventing light generated in the device from being totally reflected and enabling the light to efficiently exit the device. Because of these purposes, in general, an epoxy resin with a large index of diffraction is frequently employed for transparent resin 12.

Phosphor layer 13 and transparent cover 14 can be formed by sequentially applying a fluorescent conversion paint and a transparent resin. In the present example, transparent cover 14 does not play a role as a cap for hermetic sealing, but is merely intended to protect phosphor layer 13.

As explained above, the present example of a light emitting semiconductor apparatus of the present utility model invention facilitate an emission over a large area. It does not require a large amount of phosphor and hence, can be produced in an inexpensive manner.

Savant Technologies LLC - 1004.965

A light emitting semiconductor apparatus of the present utility model invention is not limited to the structures and materials illustrated in the above examples. For example, it goes without saying that a near UV light emitting devices with GaN can be employed and that an ordinary UV-visible light conversion phosphor can be utilized.

4. Brief Explanation of the Figures

Figures 1 and 2 are a cross sections of examples of a light emitting semiconductor device of the present utility model invention, respectively.

In the figures, numeral 1 denotes a stem, numerals 3 and 9 denote leads, numerals 4 and 10 denote a light emitting semiconductor device, numerals 6 and 14 denote a transparent cover and numerals 7 and 13 denote a phosphor layer.

Patent Attorney: Hiroshirou Matsuoka

Savant Technologies LLC - 1004.966

Figure 1

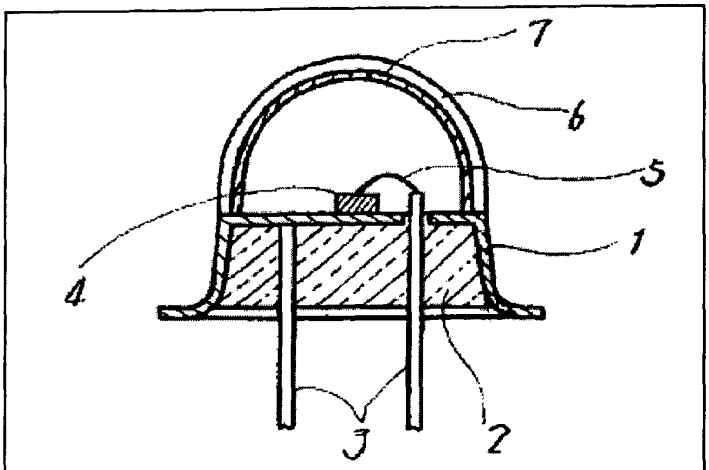
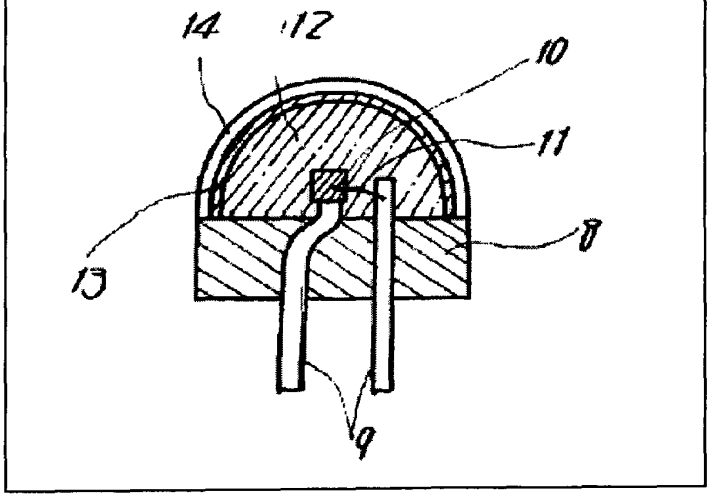


Figure 2



BEST AVAILABLE COPY

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:	WO 91/08508
G02F 1/133, H04N 9/12	A1	(43) International Publication Date:	13 June 1991 (13.06.91)

(21) International Application Number: PCT/GB90/01833

(22) International Filing Date: 26 November 1990 (26.11.90)

(30) Priority data:

8926547.4	24 November 1989 (24.11.89)	GB
9001543.9	23 January 1990 (23.01.90)	GB

(71) Applicant *(for all designated States except US)*: INNOVARE LIMITED [GB/GB]; Southpoint, 8 Paston Place, Brighton, East Sussex BN2 1HA (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)* : STONOR, John, Anthony [GB/GB]; SILSBY, Paul, Alistair [GB/GB]; Southpoint, 8 Paston Place, Brighton, East Sussex BN2 1HA (GB).

(74) Agent: STURT, Clifford, Mark; Marks & Clerk, 57-60 Lincoln's Inn Fields, London WC2A 3LS (GB).

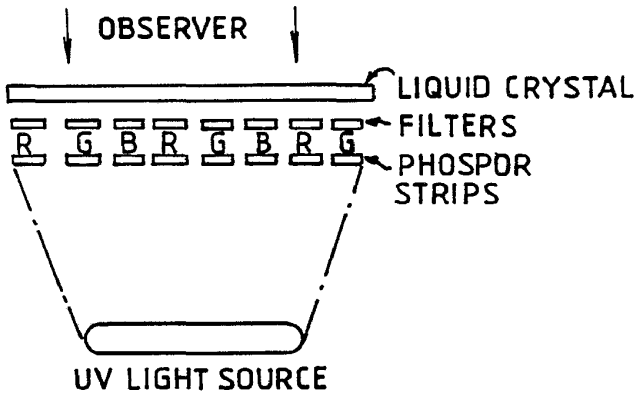
(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A DISPLAY DEVICE



(57) Abstract

A display device comprising one or more sources of UV radiation (50); an LCD panel and two aligned tri-colour arrays. One array comprises filter elements (70) on one surface of the LCD panel, the other comprises phosphor elements (72) on the filter elements. The filter elements (70) each consist of one of three colour filters. The phosphor elements (72), when excited by UV radiation, each emit visible light in one of three colours. Filter and phosphor elements associated with the same colour are aligned with each other. The elements are preferably arranged so that ambient light falling on the front of the devices is at least partially reflected by the filters and/or phosphors. This can be achieved by controlling the spacing between filter and phosphor elements in relation to the width of an element. The arrangement can be used to provide a large scale colour display device comprising a plurality of modules (12).

Savant Technologies LLC - 1004.968

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**FI**	Finland	**ML**	Mali
AU	Australia	**FR**	France	**MN**	Mongolia
BB	Barbados	**GA**	Gabon	**MR**	Mauritania
BE	Belgium	**GB**	United Kingdom	**MW**	Malawi
BF	Burkina Faso	**GN**	Guinea	**NL**	Netherlands
BG	Bulgaria	**GR**	Greece	**NO**	Norway
BJ	Benin	**HU**	Hungary	**PL**	Poland
BR	Brazil	**IT**	Italy	**RO**	Romania
CA	Canada	**JP**	Japan	**SD**	Sudan
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SE**	Sweden
CG	Congo			**SN**	Senegal
CH	Switzerland	**KR**	Republic of Korea	**SU**	Soviet Union
CI	Côte d'Ivoire	**LI**	Liechtenstein	**TD**	Chad
CM	Cameroon	**LK**	Sri Lanka	**TG**	Togo
DE	Germany	**LU**	Luxembourg	**US**	United States of America
DK	Denmark	**MC**	Monaco		
ES	Spain	**MG**	Madagascar		

Savant Technologies LLC - 1004.969

A DISPLAY DEVICE

The present invention relates to a colour display device.

The display device of the present invention makes use of phosphors excited by a source of UV radiation with filtering of the phosphor output and image generation by the use of an LCD panel as an electro-optical shutter. This arrangement differs from common conventional arrangements because of its use of a UV source separate from the phosphors, in contrast to fluorescent tube type arrangements. A common conventional arrangement is illustrated in figure 1. Colour filters (red, green, blue) are provided on the face of the LCD panel opposite the fluorescent light sources. With such an arrangement only a small portion of the light generated by the fluorescent tubes is transmitted to an observer, a much larger portion of the input light is filtered out. This arrangement has been improved upon by the use of special fluorescent tubes which emit light in three narrow spectral bands, which correspond to the maximum transmission of the three colour filters. However, approximately two-thirds of the light from the tubes is still lost since all of the incident light is filtered by each of the three colour filter systems.

Savant Technologies LLC - 1004.970

According to the present invention there is provided a colour display device comprising one or more sources of UV radiation; an LCD panel; a tri-colour array of filter elements with the filter elements each consisting of one of three colour filters; and a tri-colour phosphor array consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other.

The present invention is such as to enable large scale colour displays typically of a size of between 1 and 10 sq. m. to be constructed readily and reliably. The invention is also applicable to small size displays.

Embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings in which: -

Figure 1 is a diagrammatic representation of a conventional colour LCD display device,

Figure 2 is a diagrammatic representation of a module of a display device in accordance with the present invention,

Savant Technologies LLC - 1004.971

Figure 3 is a graph illustrating the wavelengths of the light emitted by the phosphor elements and the corresponding filter transmission wavelengths,

Figure 4 is diagrammatic representation of a large scale display device fabricated from a number of separate modules, in accordance with the present invention,

Figure 5 is a diagrammatic cross-section of a sealing strip to be inserted between the modules,

Figure 6 is a diagrammatic perspective view of a module housing,

Figure 7 represents a vertical section through the housing of Figure 6 with a screen component secured to the display surface thereof,

Figure 8 represents the flat arrangement of the remaining screen component and its associated circuit boards,

Figure 9 illustrates the components shown in Figure 8 when folded to match the configuration of the housing,

Figure 10 is a diagrammatic vertical section showing the

Savant Technologies LLC - 1004.972

components in place on the housing, effectively being a combination of Figures 7 and 9,

Figure 11 is an enlarged diagrammatic section through the LCD panel shown in Figures 8 and 9,

Figure 12 is a plan view of the LCD panel shown in Figure 11,

Figure 13 is a diagrammatic vertical section through the filter and phosphor panel illustrated in Figure 7,

Figure 14 illustrates a back or underneath view of an assembled module, showing in particular the mechanical means for interconnecting modules,

Figure 15 is a side view of the back plate of the module.

Figure 16 is a diagrammatic sectional view of a display device according to the present invention suitable for use in a miniature television receiver.

Figure 17 is a diagrammatic sectional view of a component of a display device in accordance with the present invention,

Figure 18 is a view similar to that of figure 10 and

Savant Technologies LLC - 1004.973

illustrating a variation of the internal structure of the module,

Figure 19 is a diagrammatic sectional view of an arrangement which enables the use of a phosphor binder to be avoided, and

Figure 20 illustrates a device for loading phosphor particles into channels in a plate.

One particular embodiment of the present invention is illustrated in figures 2-15 of the accompanying drawings.

The large scale colour display device 10 is formed from a plurality of modules 12. This is illustrated in figure 4. A typical large scale display may consist of one hundred and twenty eight modules arranged in a 4 x 32 matrix. The modules 12 are held, in a manner described hereinafter, closely adjacent each other. The columns of the modules are separated from each other by a rubber sealing member 14, the cross-section of which is shown in figure 5. The strips 14 are inserted between the modules subsequent to the mechanical interlocking of the modules.

Each module 12 is based on a housing 16 which has a configuration as illustrated in figure 6 and may, for

Savant Technologies LLC - 1004.974

example, be formed of aluminium. The housing 16 comprises two side panels 18 joined together by end plates 20. End plates 20 each have the shape of a trapezium. Side plates 18 each have a respective flange 22 which projects outwardly to extend in the plane defined by the shorter edges of end plates 20. Housing 16 thus defines a trough shaped hollow enclosure, the large open surface of which will become the front of the display module. This surface may typically measure 400 mm x 100 mm.

The longitudinal edges of the front (or as illustrated, upper) edge of the housing 16 are provided with respective stepped shoulders 24 which provide keying for an adhesive 26 which is used to secure a number of screen components 28 to the front of the display module. The screen components 28 have the form of a square shaped plate and four such plates are located along the length of each housing 16. The plates are spaced from each other by a narrow strip of silicon rubber. Each screen component or plate 28 carries the filter and phosphor arrays and will be described in more detail hereinafter with reference to figure 13.

The remaining screen component of the display, essentially the LCD panel 30, is manufactured separately from the screen plate 28 and is subsequently bonded

Savant Technologies LLC - 1004.975

thereto. The flat-plan arrangement of the LCD panel 30 and its associated components is shown in figure 8. The LCD panel 30 is basically the same shape and size as the screen plate 28. A vertical cross-section through the LCD panel 30 is illustrated in figure 11. The electrode pins 32 of panel 30 are connected to respective conductors 34 on a flexible strip connector 36. One such connector 36 is provided along each of two opposite sides of panel 30. They may be attached using known "thermal" conductive adhesives. Conductors 34 connect respective LCD electrode pins 32 to terminals 38 on printed circuit boards 40. Each printed circuit board 40 carries two LCD driver integrated circuits 42 which are interconnected between terminals 38 and a connector socket 44. That is, one connector socket 44 is provided on each circuit board 40. Each driver integrated circuit 42 has forty-eight outputs each of which is connected to a respective electrode pin 32 of the LCD panel 30. Thus, each LCD panel 30 comprises one hundred and ninety two pixels, as can be seen from the plan view of the panel 30 shown in figure 12. In practice, the smallest independently driven area is that associated with one driver circuit 42, i.e. one quarter of the LCD panel 30.

Figure 9 illustrates the configuration of the components shown in figure 8 when in place on housing 16. The

Savant Technologies LLC - 1004.976

assembled module is illustrated, in vertical section, in figure 10. It will be apparent that the trapezium shape cross-section of housing 16 enables components 42 and 44 to be accommodated between the modules. In practice a small longitudinally spacing is left between adjacent modules. This spacing accommodates expansion of the modules with temperature and is preferably of the order of 1 mm. Horizontally the modules may be buffered from each other, e.g. by neoprene coatings on end plates 20. As indicated by reference numeral 46 in figure 10, a reflective coating is provided on the inner walls of housing 16. Figure 10 also indicates the module back-plate 48 which carries the UV lamps 50.

The basic arrangement of the display screen modules is shown in Figure 2.

A diagrammatic cross-section through LCD panel 30 is illustrated in figure 11. The relative dimensions have been grossly distorted for the purposes of illustration. Panel 30 essentially comprises two glass plates 52 and 54 with a liquid crystal material, preferably of the Twisted Nematic type, encapsulated therebetween. A matrix of transparent electrodes 58 is provided on the inner surface of glass plate 52 and a back-plane electrode 60 is provided on the inner surface of the glass plate 54. Along two edges of the panel 30,

Savant Technologies LLC - 1004.977

glass plate 54 extends beyond plate 52 so as to provide ledges 62 which support the electrode pins 32. The glass plates 52 and 54 might typically have a thickness of 1mm with a separation therebetween, accommodating the liquid crystal material, of a few microns.

Where a Twisted Nematic material is used, respective linear polarisers 64 and 66 are provided on the front and rear surfaces of panel 30. Preferably, the polarisers are aligned in the same polarizing plane, to provide a so-called "negative" arrangement, i.e. dark when off. The polorisers may be formed of iodine doped long chain polymers and should preferably be of the low transmission type. Low transmission (38% or less) provides a significant improvement in contrast - higher contrast ratio. The materials and manufacturing techniques used to fabricate the panels 30 are otherwise essentially conventional and will therefore not be described in further detail. The illustrated panels provide an excellent angle of view of upto 140° or more.

Figure 13 is a diagrammatic representation of a section through screen component 28. Component 28 comprises a glass plate 68, the front surface of which supports an array of colour filters 70 and the rear face of which supports an array of colour phosphors 72. The arrays 70 and 72 consist of adjacent bands of red, green and blue

Savant Technologies LLC - 1004.978

elements with the filter and phosphor elements aligned with each other by colour, red opposite red etc. Of course, the colours red, green and blue relate to the colours of the light concerned, that is the phosphor bands when excited by UV radiation emit red, green and blue light respectively. The phosphor emissions and corresponding filters are indicated on the wavelength graph of figure 3. The filters can be implemented by silk screening of appropriate inks. As indicated in figure 3, the filters are selected to have maximum transmission corresponding as closely as possible with the peak of the respective phosphor emission. Yttrium oxide: Europium can be used for the red phsophor, producing a peak emission at 611nm. Cerium Terbium Magnesium Aluminate: Tb: Ce can be used for the green phosphor, producing a peak emission at 545 nm. Barium Magnesium Aluminate: Europium can be used for the blue phosphor, producing a peak emission at 450nm. The materials and method of manufacturing the filter and phosphor arrays are otherwise essentially conventional and will therefore not be described in further detail herein. However, it should be noted that the phosphors will typically be applied to the glass plate 68 using a binder. Such a binder should be resistant to long term degradation caused by the UV light which is used to excite the phosphors. The UV lamps preferably have a radiation peak output at about 254nm.

Savant Technologies LLC - 1004.979

It will be recalled that this embodiment of the present invention is concerned with large scale colour displays and that an important feature of this embodiment is that fact that ambient light passing through the LCD panel is at least partially reflected by the filters and/or phosphors. Such reflection enables a "dual mode" functionality to be achieved by the display device of this embodiment of the present invention. By "dual mode" is meant the following. The display modules can operate by the UV lamp 50 exciting the phosphors 72. Additionally or alternatively, in strong ambient lights the display can operate without the use of the UV lamp, as a result of the ambient light being reflected from the filters and/or phosphors. The effect is such that a high contrast saturated colour display can be provided even in strong sunlight. The requisite reflection is achieved by the absolute and relative dimensions of the components of plate 28.

The absolute and relative dimensions of the phosphor and filter elements which would be used to implement a display screen for a computer monitor or the like are such that the required reflection for dual mode operation would be absent. Such dual mode operation is not known to have previously been proposed for displays incorporating colour LCD panels. Clearly, there is a

Savant Technologies LLC - 1004.980

range of values within which satisfactory reflection can be obtained so as to implement the dual mode operation of a large scale display device. Values within such ranges which have been found to achieve particularly satisfactorily results are: a band width of 2mm for the filter and phosphor strips with a separation between, that is the thickness of glass plate 68, of 1mm. It is the ratio of band width to phosphor/filter separation which is believed to be the more critical factor. As to absolute values, the dual mode operation appears to disappear rapidly as the width of the phosphor and filter elements decreases below 1mm. The required effect also appears to diminish rapidly as the thickness of glass plate 68 increases beyond 6mm.

To obtain maximum benefit from the dual mode operation a photosensor set with an appropriate threshold can be used to switch off the UV lamps when the ambient light is sufficiently high, and vice versa.

The rear face of each module is closed by a back-plate 48 which supports two UV lamps 50, as indicated in figures 10 and 15. The lamps 50 are held within the module and the external surface of back-plate 48 carries the associated starter and driving circuits 74, one associated with each lamp 50. Back-plate 48 also supports two further integrated circuits 76 associated

Savant Technologies LLC - 1004.981

with the addressing of pixels in the LCD panels 30. Adjacent the top and bottom ends of each back-plate 48 are respective sockets 78 which are connected to integrated circuits 76 and from there to the integrated circuits 42 on each of the circuit boards 40. Sockets 78, and connectors 44, supply power and data to the LCD drivers and pixels.

As previously mentioned, direct drive of the LCD pixels is used in contrast to the conventional multiplex drive normally adopted for LCD panels. Thus, in the final display the modules may conveniently be grouped into sections for pixel addressing. For example, a display comprising one hundred and twenty eight modules may be split into eight sections each two modules deep and eight modules across - each section thus defining a display area of approximately 0.8sq.m. Serial drive signals for the LCD panels are applied to each section and the serial signals are daisy chained from one module to another within the section, via the connectors 78. The control signals are passed in serial form down to individual integrated circuits 42, at which point the serial information is converted to a parallel output and applied to the individual electrode pins 32. It is important to note that the direct drive of the LCD pixels enables grey scaling to be implemented within the LCD panels 30. Direct drive enables improved contrast

Savant Technologies LLC - 1004.982

to be obtained. Also, individual parts of the displayed image can be updated without the need for a complete "refresh" of the whole display. The speed with which the display can be updated depends upon the characteristics of the LCD panels 30 - which will usually be temperature dependent. However, it has been found that a speed of 25 frames per second can be achieved at 50°C.

The mechanical interlinking of the modules to form the large display device will be explained with reference to figure 14. Each module is held in place with the adjacent modules by the use of square linking plates 80, a variation of the plates being used at the edges of the device. The square plates 80 carry an aperture in each corner through which the plate is screwed or bolted to a respective corner of the back-plate 48 of each module. A threaded aperture 82 is provided centrally in each plate 80. The purpose of the threaded aperture 82 is to receive a threaded support strut (not shown). The support struts can be used to secure the display in position, for example on the side of a building. The support struts can also extend between the modules and can be configured so as to provide additional rigidity to the matrix of display modules. Moreover, the support struts can project a short distance in front of the display modules (passing through strip 14) so as to

Savant Technologies LLC - 1004.983

support a protective screen over the front of the display. A perspex sheet could be used for this purpose. Of course, the spacing between the screen and the front of the display should be as small as possible, and the material of the struts and their mode of connection to the screen should be carefully considered, to avoid degradation of the displayed image as viewed by the observer. Additionally or alternatively, an anti-reflection coating can be provided on the front of the display - either overall or on the separate LCD panels.

The embodiment described with reference to figures 2-15 of the drawings is concerned with a large scale, modular colour display. Various aspects of the invention are also applicable to displays which are neither necessarily large scale nor modular. For example, variations of components already described can be used in implementing a miniature, flat screen television receiver. A suitable arrangmenet is illustrated in figure 16.

In figure 16, the LCD panel 84 is of the Thin Film Transistor type with a respective poloriser 86 on each face of the panel. The tri-colour filters 88 are provided on a separate substrate which is placed in contact with the poloriser on the rear of the LCD

Savant Technologies LLC - 1004.984

panel. In contact with the other face of the filter substrate is a fine mesh 90 of reflective material. The arrangement is completed by a tri-colour phosphor element 92 provided on a substrate 94 and a short-wave UV light source 96.

Substrate 94 is preferably formed of UV transparent glass or quartz with a transmissivity of the order of 80%. Phosphor element 92 may be in the form of 1mm tri-colour pixels coated onto substrate 94. The pixels may be in the form of spots or a matrix. Mesh 90 is preferably no thicker than 1mm. The mesh reduces scatter of light produced by the phosphors and also acts as a guide for ambient light passing through the LCD and reflected from the phosphors.

A mesh can also be used in the above described large scale display device.

The arrangements described have included a poloriser in contact with the rear surface of the LCD panel. The requirement for this poloriser can be avoided by providing the phosphors in crystaline form and aligning them to emit light in the required plane of polorisation. This can be achieved by growing phosphor crystals on a glass substrate or by growing the crystals in suspension and subsequently bonding them onto the

Savant Technologies LLC - 1004.985

substrate.

Figure 17 illustrates a modified component which may beneficially be incorporated in a display device according to the present invention. The component is based on a moulded or machined substrate 98 of a material such as glass. The moulding or machining provides a grooved surface 100. A phosphor coating 102 is applied to the grooved surface 100. This has the advantge of considerably increasing the surface area on which the phosphor is coated. Reflective strips 104 are embedded in the opposite surface of the substrate and are aligned with respective ridges between the grooves of surface 100. These reflective strips act to guide light passing through the substrate. Typically, the substrate 98 might be of the order of 3mm deep, the groove 1mm deep and the reflective strips 2mm deep - for use in the embodiment of figures 2-15.

Some of the benefits of the component illustrated in figure 17 can be gained by use of a simple flat glass plate having parallel reflective strips embedded in and passing through the plate. The reflective strips should be aligned with the phosphor strips. Such an arrangement can, to some extent, obviate the criticality of the dimension ratios discussed above in achieving optimum results.

Savant Technologies LLC - 1004.986

The quality of the display can be enhanced by careful consideration of the effective distribution of radiation from the UV source. Proximity of the UV source to the phosphors can present a difficulty since, typically the radiation will emenate from a narrow core within the tube. A simple expedient for achieving improved distribution is to abrade the surface of the UV tube. A more sophisticated solution is to introduce a separate diffuser. Of course, the closer the UV source to the phosphors and LCD, the greater the ultimate light output from the display device.

Another alternative for improving the distribution of radiation from the UV source is shown in figure 18. Figure 18 is similar to figure 10 but includes a "cold mirror" 106 and an associated heat sink 108. Mirror 106 is parabolic with the UV tube(s) 96 locates so as to optimise even distribution of the UV radiation. A plastics material is used to fabricate mirror 106. The characteristics of the material are such that heat generated by the UV tubes is transmitted to heat sink 108 instead of being reflected towards the phosphors and LCD, hence the designation "cold". Heat which is not travelling in the direction of heat sink 108 when it passes through mirror 106 is redirected by the matt black anodised aluminium casing 110. Mirror 106 will

Savant Technologies LLC - 1004.987

absrob much less of the UV than diffraction grating or filter diffusers, thus providing improved efficiency.

Efficiency can also be improved by the use of a so-called "cold cathode" UV source. Such a source using a mercury/crypton mixture is beneficial.

It is possible to implement the present invention without using a binder to hold the phosphors in place. This is beneficial because some binders degrade rapidly when exposed to shortwave UV radiation. An advantageous arrangement is shown in figure 19. A quartz plate 112 and a glass plate 114 are each machined on one surface with complementary, rectangular section channels. One of the plates is placed with the machined surface uppermost. Phosphor particles are placed in the channels and the othr plate located in the first plate so as to sandwich the phosphor particles at the bottom of the channels of the first plate. The plates are bolted together and act as a high pressure clamp on the phosphor particles. A device for depositing phosphor particles in the channels is illustrated in figure 20. The device comprises a suction head 116 connected to a suction pump (not shown) by connector 118. Head 116 has a peripheral rim 120 within which phosphor particles are held by suction, when the head is placed in contact with a supply of particles. A membrane 122 prevents the

Savant Technologies LLC - 1004.988

particles from entering connector 118. After loading with particles, device 116 is located over a channel and the suction released. The particles thus fall into the channel. Although illustrated as a "single channel" device, device 116 can readily be extended so as to load several channels - if not an entire plate - in one operation. Adjustment of the suction can be used to control the size of particle picked up by the device, thus performing a grading operation at the time of loading the channels.

Particularly for smaller sizes of display, machining of the plates with phosphor receiving channels can be difficult. As an alternative to machining the plates, one of the plates can be coated with a UV resistant material in which "channels" are subsequently etched. The phosphor particles are loaded in the manner described and the channels sealed by clamping of the other flat plate over them.

Polorisers used on the rear face of LCD panels in previous proposals can absorb and scatter as much as 50-60% of incident light. This problem can be mitigated by the use of layers of material such as melenex or glass to change the plane of polorisation of the light. Use of a Woolastone Prism can be particularly beneficial.

Savant Technologies LLC - 1004.989

Finally, the colour range of the LCD panel can be improved either by varying the electrode voltage or by varying the duty cycle of the drive signals.

Embodiments of the invention have been described in detail with reference to the accompanying drawings. It will be readily apparent to a person skilled in the art that many modifications can be made and alternative embodiments implemented without departing from the scope of the inventive concept.

Savant Technologies LLC - 1004.990

CLAIMS: -

1. A colour display device comprising one or more sources of UV radiation; an LCD panel, a tri-colour array of filter elements with the filter elements each consisting of one of three colour filters; and a tri-colour phosphor array consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other.

2. A large scale colour display device having one or more sources of UV radiation and a plurality of modules each comprising: an LCD panel; a tri-colour array of filter elements adjacent one surface of the panel with the filter elements each consisting of one of three colour filters; a tri-colour phosphor array adjacent the filter array and consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other; the arrangement being such that ambient light passing through the LCD panel is at least partially reflected by the filters and/or phosphors.

Savant Technologies LLC - 1004.991

3. A display device as claimed in claim 2 wherein said elements are arranged side by side and the filter elements are spaced from the phosphor elements by a distance no greater than the width of individual elements.

4. A display device as claimed in claim 3 wherein the width of individual elements is at least twice said spacing distance.

5. A display device as claimed in claim 3 or claim 4 wherein the elements are arranged in opposite surfaces of a transparent panel, the filter elements on one surface and the phosphor elements on the other.

6. A display device as claimed in any one of claims 3 to 5 wherein the width of individual elements is at least 1 millimetre.

7. A display device as claimed in any one of claims 3 to 6 wherein the spacing distance is less than 6 millimetres.

8. A display device as claimed in any one of the preceding claims comprising means for driving the LCD panel, said driving means being arranged to drive

Savant Technologies LLC - 1004.992

individual pixels of the panel directly.

9. A display device as claimed in claim 1, wherein the LCD panel is of the thin film transistor type.

10. A display device as claimed in claim 1, further comprising a respective polariser located on each face of the LCD panel.

11. A display device as claimed in claim 1, further comprising a mesh of reflective material located between the filter elements and the phosphor elements.

12. A display device as claimed in claim 1, wherein the phosphor elements comprise phosphors in crystalline form aligned to provide a predetermined plane of polarisation of light emitted therefrom.

13. A display device as claimed in claim 1, wherein the phosphor elements are applied to a non-planar surface.

14. A display device as claimed in claim 1, further comprising reflective strips embedded in a substrate on which the phosphor elements are located so as to guide light from the phosphor elements through the substrate.

Savant Technologies LLC - 1004.993

15. A display device as claimed in any preceding claim, further comprising a diffuser of UV radiation located between the source or sources of UV radiation and phosphor elements.

16. A display device as claimed in any preceding claim, further comprising a reflector which reflects UV radiation towards the phosphor elements.

17. A display device as claimed in claim 16, wherein the reflector is a cold mirror.

18. A display device as claimed in claim 16, wherein the reflector is parabolic.

19. A display device as claimed in any preceding claim, wherein the source of UV radiation comprises a cold cathode UV source.

20. A display device as claimed in claim 1, wherein the phosphor elements are held between two substrates so as to avoid the use of a binder.

21. A display device substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Savant Technologies LLC - 1004.994

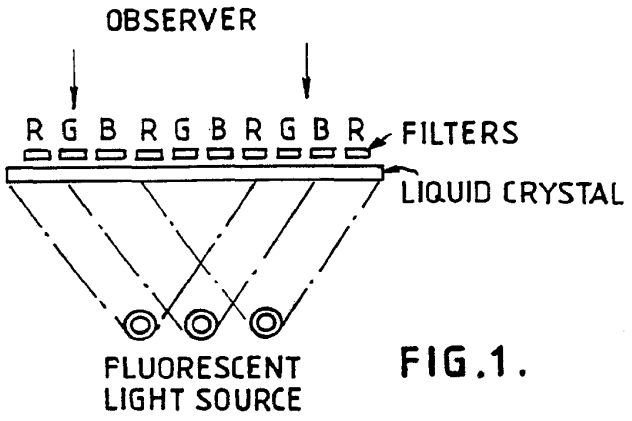


FIG.1.

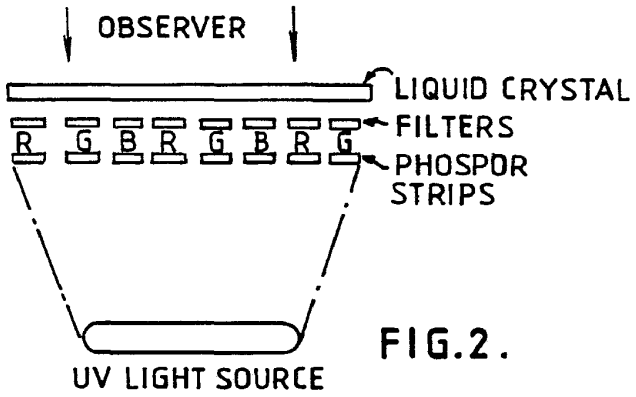


FIG.2.

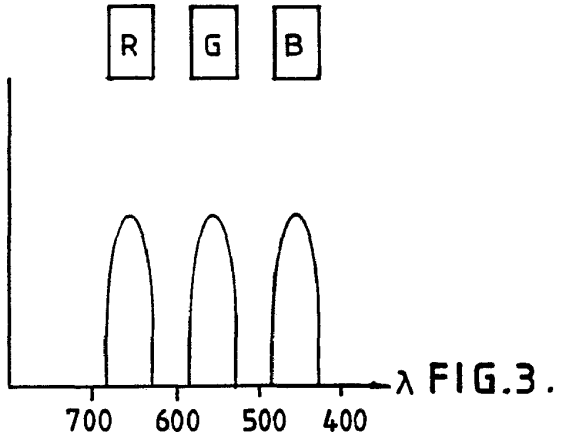


FIG.3.

Savant Technologies LLC - 1004.995

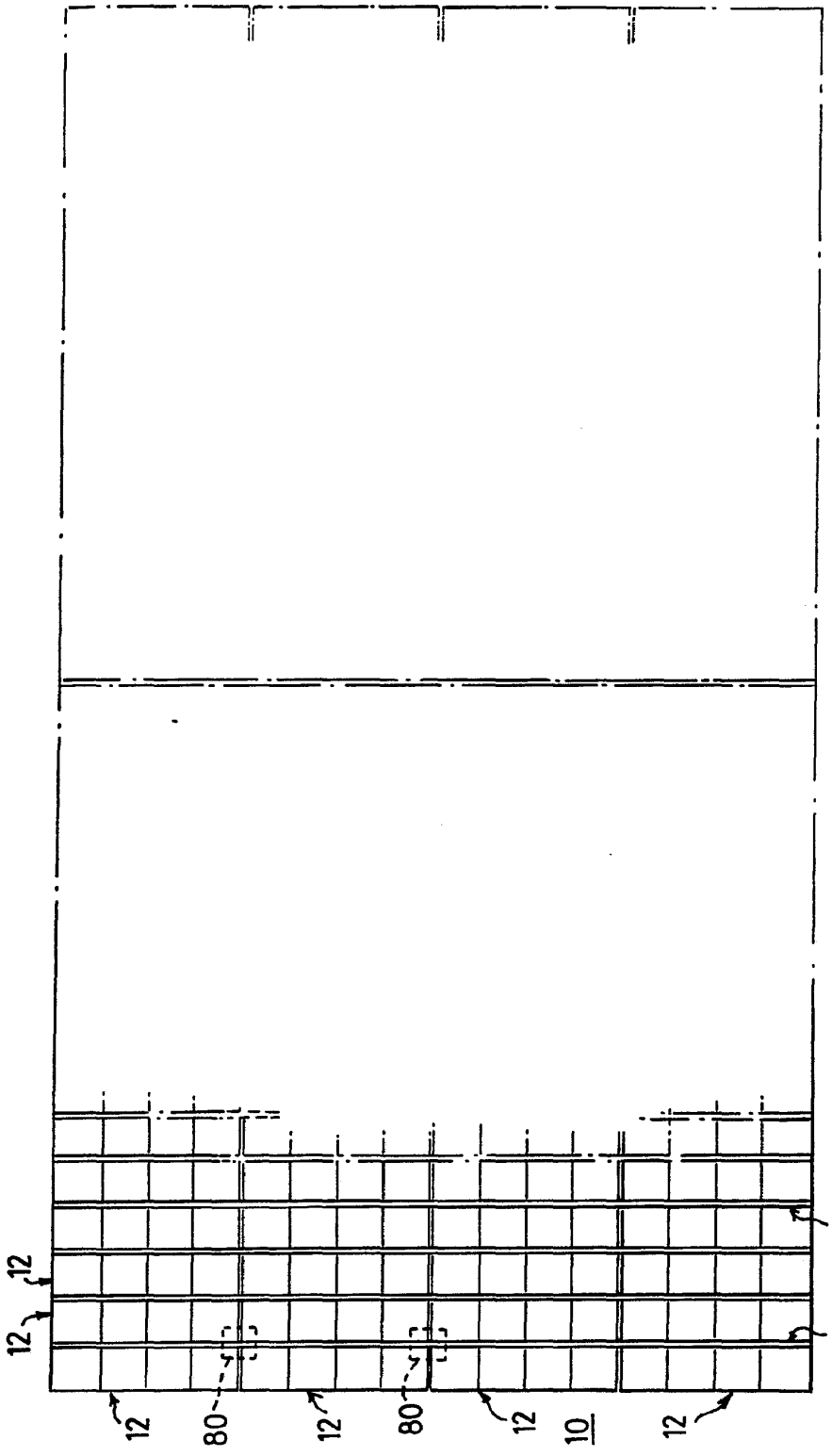


FIG. 4.

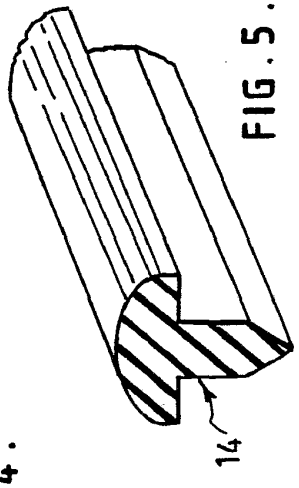


FIG. 5.

Savant Technologies LLC - 1004.996

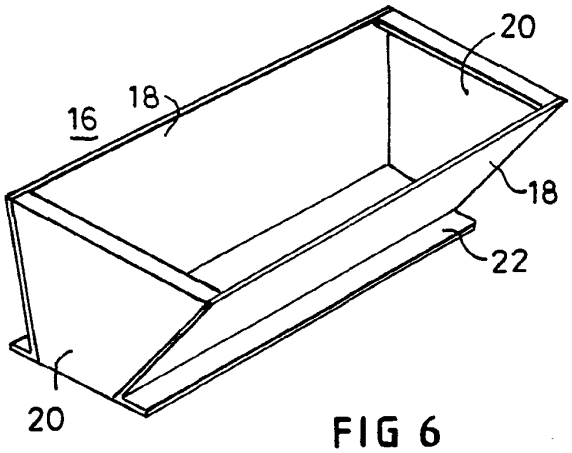


FIG 6

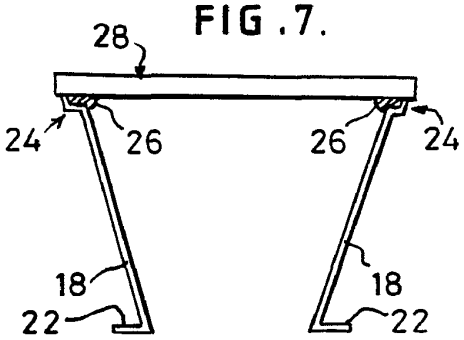


FIG .7.

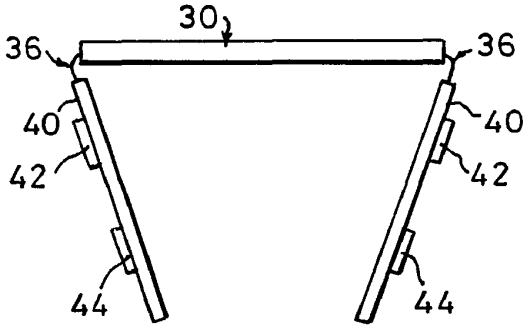


FIG .9

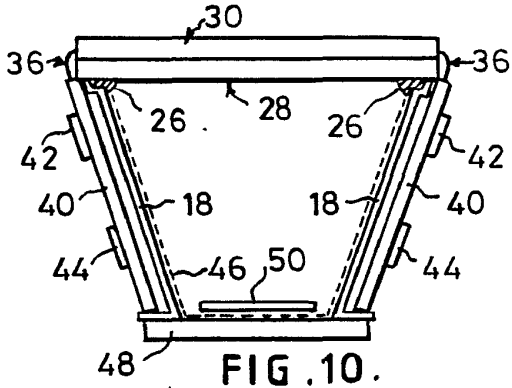


FIG .10.

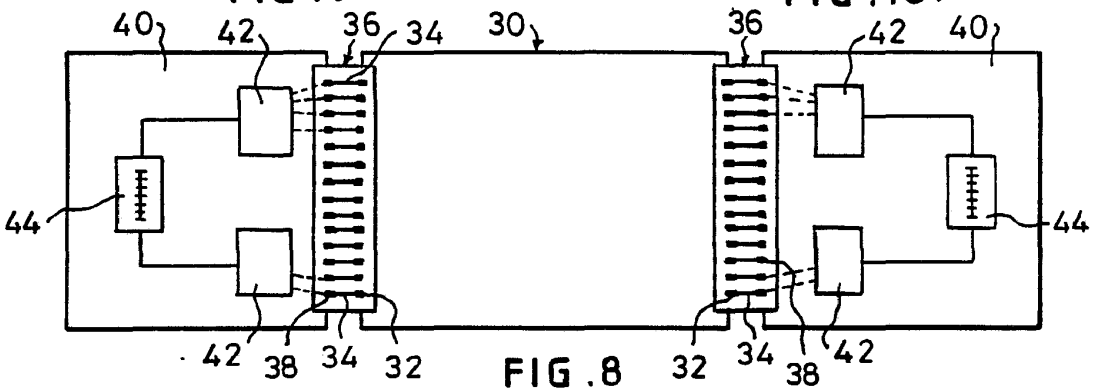


FIG .8

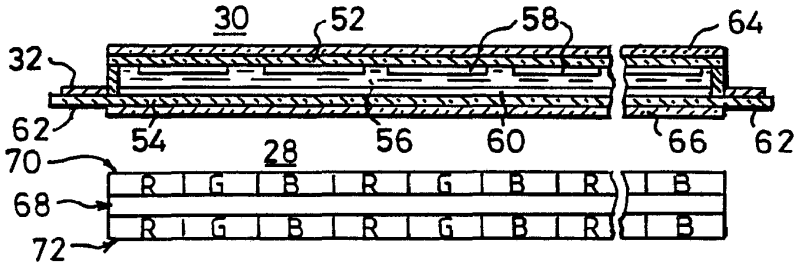


FIG.11

FIG.13.

Savant Technologies LLC - 1004.997

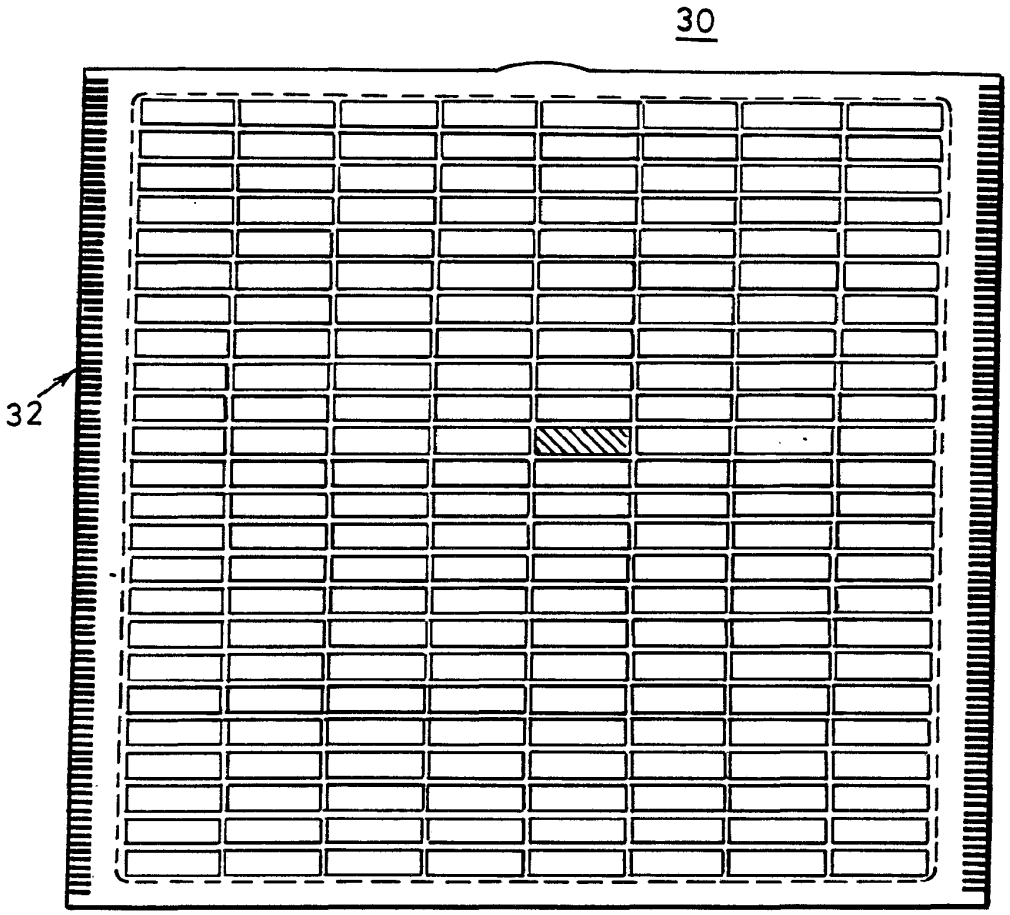


FIG.12.

Savant Technologies LLC - 1004.998

FIG.15.

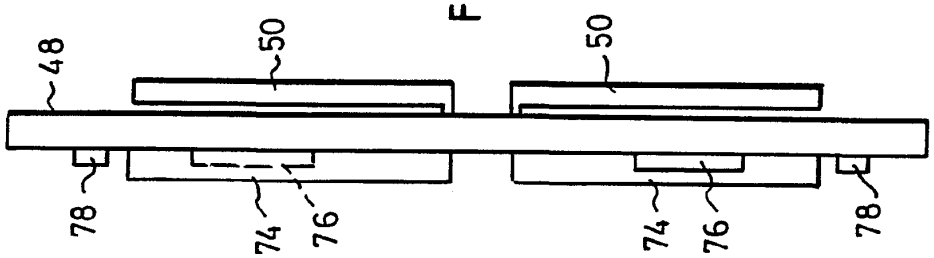
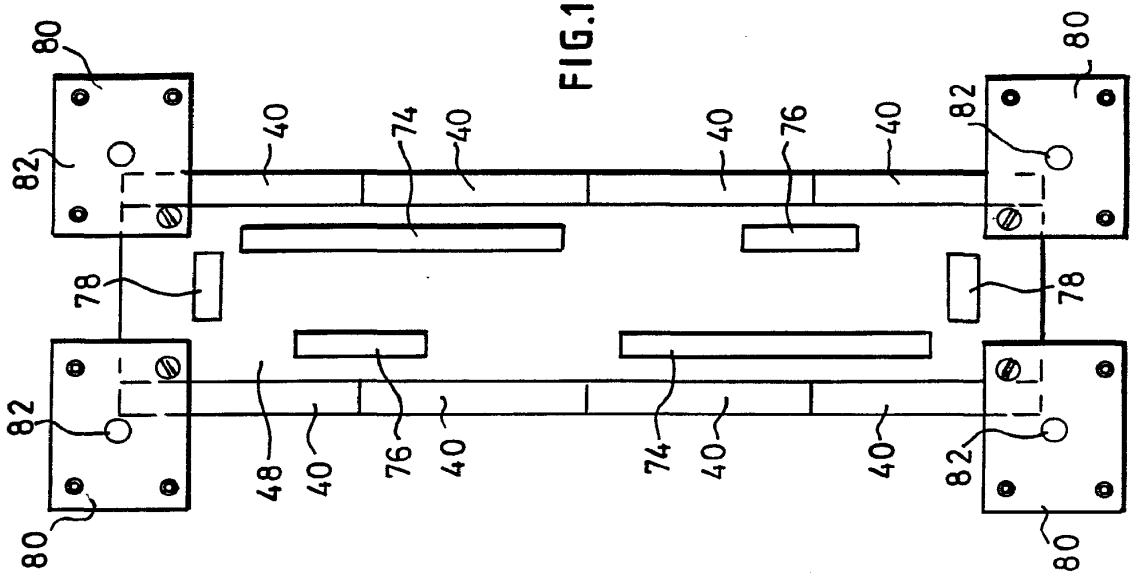


FIG.14.



Savant Technologies LLC - 1004.999

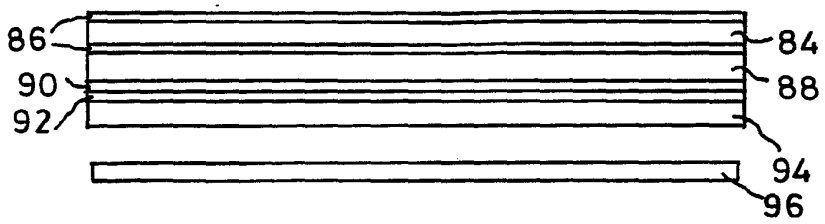


FIG.16.

FIG.17.

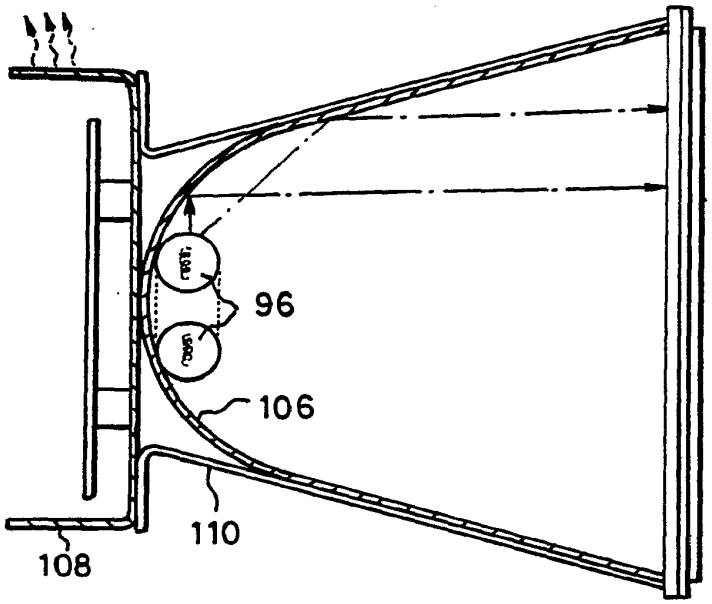


FIG.18.

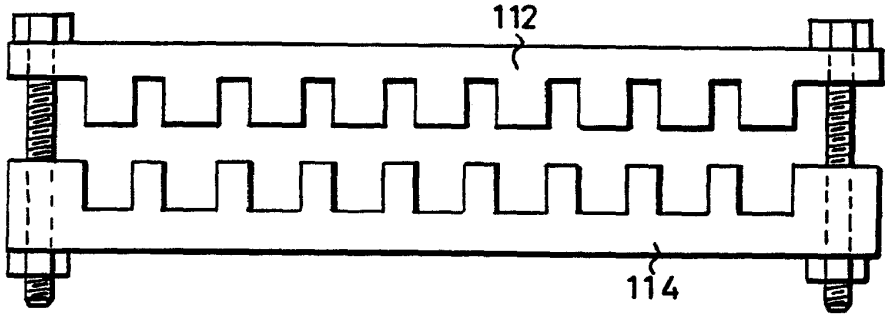


FIG.19.

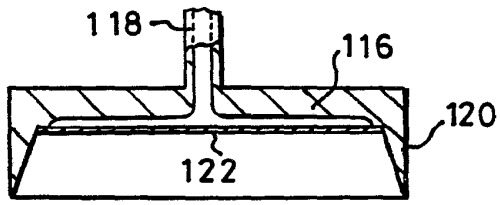


FIG. 20.

Savant Technologies LLC - 1004.1000

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01833

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 02 F 1/133, H 04 N 9/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 02 F, H 04 N, G 09 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	GB, A, 2154355 (RICOH COMPANY LTD) 4 September 1985 see page 4, line 46 - page 5, line 45; page 6, line 45 - page 7, line 40	1-5,8-10
A	--	6,7,11-21
A	EP, A, 0179913 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD) 7 May 1986 see page 10, line 5 - page 11, line 21	2
	---	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
3rd April 1991	17. 05. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	F.W. HECK

Form PCT/ISA/210 (second sheet) (January 1985)

Savant Technologies LLC - 1004.1001

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9001833 SA 42277

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 24/04/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A- 2154355	04-09-85	JP-A-	60149028	06-08-85
		JP-A-	60263186	26-12-85
		JP-A-	61091629	09-05-86
		JP-A-	61103185	21-05-86
		JP-A-	61103186	21-05-86
		DE-A-	3501006	07-11-85
		US-A-	4678285	07-07-87
EP-A- 0179913	07-05-86	JP-A-	60203915	15-10-85
		WO-A-	8504505	10-10-85
		US-A-	4874227	17-10-89

Savant Technologies LLC - 1004.1002

Electronic Acknowledgement Receipt

EFS ID:	15973731
Application Number:	13273212
International Application Number:	
Confirmation Number:	8795
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Customer Number:	101130
Filer:	Peter C. Mei/Tony Nguyen
Filer Authorized By:	Peter C. Mei
Attorney Docket Number:	ITMX-00318US1
Receipt Date:	06-JUN-2013
Filing Date:	13-OCT-2011
Time Stamp:	18:54:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	JPP3724498.pdf	230960 a2a44a4e14315c400f1d413e28bea65ebe501255	no	6

Warnings:	
Information:	

2	Foreign Reference	JPP2003234513.pdf	211323 75bc702db415b13b74779a06d233da07f96a29da	no	6
Warnings:					
Information:					
3	Foreign Reference	JPS5079379.pdf	212564 cd987620cf3988a881811d45e398ae55aa644bed	no	6
Warnings:					
Information:					
4	Foreign Reference	WO9108508.pdf	1108415 fca00ce9eeb53e9c15d51ed53d3727fb417d2d52	no	35
Warnings:					
Information:					
			Total Files Size (in bytes):	1763262	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

101130 7590 06/17/2013

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

EXAMINER	
BOWMAN, MARY ELLEN	
ART UNIT	**PAPER NUMBER**
2879	

NOTIFICATION DATE	DELIVERY MODE
06/17/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@viplawgroup.com
ttn@viplawgroup.com

Savant Technologies LLC - 1004.1005

Office Action Summary	Application No. 13/273,212	Applicant(s) DAI ET AL.	
	Examiner MARY ELLEN BOWMAN	Art Unit 2879	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *5 June 2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-29* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-29* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some * c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Interim copies:

a)☐ All b)☐ Some c)☐ None of the: Interim copies of the priority documents have been received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *11/16/12,6/5/13,6/6/13*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

Savant Technologies LLC - 1004.1006

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on June 5, 2013 has been entered.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-6, 9-14, 16-19, 21, 22, 25 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh, US 2001/0000622 (hereinafter “Reeh”) in view of McNulty et al., US 2002/0180351 A1, published December 5, 2002 (hereinafter referred to as "McNulty”).

Regarding claim 1, Reeh teaches a solid state light emitter emitting a blue light and having a phosphor conversion layer above said LED ([0053-0055]).

Further, in the same field of endeavor of LEDs, McNulty teaches a wavelength conversion component for a light emitting device comprising a wavelength conversion layer comprising particles of at least one photoluminescence material; and a light diffusing layer comprising particles of a light scattering material (Abstract, [0022-0024] and claim 5). McNulty further teaches the average particle size of the light scattering material is selected to improve an

OFF state white appearance of the light emitting device and to obtain substantially uniform color for emitted light from the light emitting device for emission angles over a 60 degree range from an emission axis (see explanation regarding claim 1 above, the scattering particles are of the same material and same size as those used by Applicant, therefore it is the position of the Examiner that the light scattering layer would function in a similar manner).

Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to provide the scattering particles of McNulty into the LED device of Reeh in order to ensure effective and efficient scattering of the blue excitation light in order to reduce the common halo and penumbra effect of such devices and to solve the same problem anticipated by Reeh.

Regarding claim 2, Reeh and McNulty teach the invention as explained above and McNulty further teaches the wavelength conversion layer and the light diffusing layer are in direct contact with each other ([0022] and Figure 2, layers 40 and 42). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 3, Reeh and McNulty teach the invention as explained above and McNulty further teaches the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder ([0021-0022]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claims 4 and 5, Reeh and McNulty teach the invention as explained above and McNulty further teaches the wavelength conversion layer further comprises a second light scattering material ([0022-0024], one scattering material in the wavelength conversion layer and

one in a separate layer), and wherein the first and second light scattering material have different properties ([0026]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 6, Reeh and McNulty teach the invention as explained above and McNulty further teaches the light transmissive binder comprises a curable liquid polymer selected from the group consisting of a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer ([0021]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 9, Reeh and McNulty teach the invention as explained above and McNulty teaches the invention as explained above. Further, the process limitations of claim 9 lend weight to the claim only in so far as they affect the structure of the device. It is the position of the Examiner that the structure of McNulty is capable of being manufactured by said method, and therefore meets the limitations of the claim. It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 10, Reeh and McNulty teach the invention as explained above and McNulty further teaches the light scattering material is silica ([0023-0024] and Table 1). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claims 11 and 12, Reeh and McNulty teach the invention as explained above and McNulty further teaches a light scattering material wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more, at least twice as much as the light

scattering material will scatter light generated by the at least one photoluminescence material (Abstract, [0022-0024] and claim 5; Note: The average particle size of the scattering material is around 1/10 of the wavelength of the light emitted from the LED light source, which is within the range taught by Applicant, therefore the particles would perform in the same manner). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 13, Reeh further teaches the excitation light comprises blue light ([0053-0055]).

Regarding claim 14, Reeh and McNulty teach the invention as explained above and McNulty further teaches the light scattering material has an average particle size that is less than about 150 nm (Abstract and [0022-0024]; Average particle size of between 30-42nm). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 19, Reeh and McNulty teach the invention as explained above and McNulty teaches the invention as explained above regarding claim 1 and further teaches a light emitting device comprising a solid state light emitter operable to generate excitation light (LED 20, Figure 2). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claims 16 and 25, Reeh and McNulty teach the invention as explained above and McNulty further teaches the wavelength conversion layer and the light diffusing layer comprises planar shapes (Figure 2 and [0022]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claims 17 and 26, Reeh and McNulty teach the invention as explained above and McNulty further teaches the light diffusing layer comprises a dome or elongated dome shape (Figure 2 and [0022]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claim 18, Reeh and McNulty teach the invention as explained above and McNulty further teaches the wavelength conversion layer fills a volume formed beneath the dome or elongated dome shape (Figure 2 and [0022]). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Regarding claims 21 and 22, Reeh and McNulty teach the invention as explained above and McNulty further teaches the average particle size of the light scattering material is selected to improve an OFF state white appearance of the light emitting device and to obtain substantially uniform color for emitted light from the light emitting device for emission angles over a 60 degree range from an emission axis (see explanation regarding claim 1 above, the scattering particles are of the same material and same size as those used by Applicant, therefore it is the position of the Examiner that the light scattering layer would function in a similar manner). It would have been obvious to combine the references for the reasons set forth above regarding claim 1.

Claims 7 and 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh and McNulty in view of Cairns et al., US 4191943, published March 4, 1980 (hereinafter referred to as “Cairns”).

Regarding claims 7 and 23, Reeh and McNulty teach the inventions as explained above, but are silent as to the loading of scattering material into the transmissive binder.

In the same field of endeavor of LEDs, Cairns teaches a light scattering material should be employed in the amount claimed in order to achieve optimum light scattering (col 3, lines 60-62). Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize the light scattering particles of McNulty in the amount taught by Cairns in order to achieve optimum light scattering without loss due to absorption.

Claims 8, 15 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh and McNulty in view of Chakraborty et al., US 2009/0272996, filed May 2, 2008 (hereinafter referred to as "Chakraborty").

Regarding claims 8 and 24, Reeh and McNulty teach the invention as explained above but are silent as to the particles being from 1 to 50 micrometers in size.

However, in the same field of endeavor of LEDs, Chakraborty teaches light scattering particles of the claimed size in a light transmissive binder ([0084]). Chakraborty further teaches that said particle size optimizes the light scattering effect of the layer (id). Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize light scattering particles in the claimed range in order to optimize the light scattering effect of the layer.

Regarding claim 15, Reeh and McNulty teach the invention as explained above but are silent as to the substrate upon which the LED and phosphor layer are formed.

In the same field of endeavor of LEDs, Chakraborty teaches the LED and phosphor layer are formed on a substrate having a reflective film thereon ([0097-0098]). Further, it was well known to those of ordinary skill in the art at the time the invention was made that materials such as glass make excellent device substrates due to their electrical insulation properties and ease of

manufacturing. Therefore, in light of the state of the art as well as the teaching in Chakraborty, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize a light transmissive substrate such as glass in order to form the LED and phosphor layers of an LED lighting device.

Claims 20 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh and McNulty in view of Robertson et al., US 6860628 B2, published March 1, 2005 (hereinafter referred to as "Robertson").

Regarding claim 20, Reeh and McNulty teach the invention as explained above but are silent as to the myriad of uses for an LED.

In the same field of endeavor of LEDs, Robertson teaches an LED may be used in a linear lamp as a replacement for a fluorescent bulb (Figure 3A). Further, it was well known to those of ordinary skill in the art at the time the invention was made that LEDs have many applications in the lighting field including several different types of bulbs with and without reflectors. Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize the LED taught by McNulty in several different ways, including as a linear lamp, such as the lighting device in Robertson.

Regarding claim 27, Reeh and McNulty teach the invention as explained above, but are silent as to the LED being used in a linear lamp.

In the same field of endeavor of LEDs, Robertson teaches a linear lamp comprising an elongate housing and a plurality of LEDs housed within the housing and configured along the length of the housing and an elongate wavelength conversion component (Figure 3A). Further, it was well known to those of ordinary skill in the art at the time the invention was made that LEDs

have many applications in the lighting field including several different types of bulbs with and without reflectors. Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize the LED taught by McNulty in several different ways, including as a linear lamp, such as the lighting device in Robertson.

Claim 28 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh and McNulty in view of Soules et al, US 2007/0120135 A1, published May 31, 2007 (hereinafter referred to as "Soules").

Regarding claim 28, Reeh and McNulty teach the invention as explained above but are silent as to the LED being used in a downlight.

In the same field of endeavor of LEDs, Soules teaches a downlight comprising a body comprising one or more LEDs, and the body is configured within a downlighting fixture ([0052]). Further, it was well known to those of ordinary skill in the art at the time the invention was made that LEDs have many applications in the lighting field including several different types of bulbs with and without reflectors. Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize the LED taught by McNulty in several different ways, including in a downlight, such as the lighting device in Soules.

Claim 29 is rejected under 35 U.S.C. 103(a) as being unpatentable over Reeh and McNulty in view of Negley et al., US 2008/0130285 A1, published June 5, 2008 (hereinafter referred to as "Negley").

Regarding claim 29, Reeh and McNulty teach the invention as explained above but are silent as to the LED being used in a light bulb.

In the same field of endeavor of LEDs, Negley teaches a light bulb comprising a connector base and a body comprising one or more LEDs ([0022]). Further, it was well known to those of ordinary skill in the art at the time the invention was made that LEDs have many applications in the lighting field including several different types of bulbs with and without reflectors. Therefore, it would have been obvious for one of ordinary skill in the art at the time the invention was made to utilize the LED taught by McNulty in several different ways, including in a light bulb, such as the lighting device in Negley.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARY ELLEN BOWMAN whose telephone number is (571)270-5383. The examiner can normally be reached on Monday-Friday, 5:30-8:30a.m. and 12:00-5:00 p.m. EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nimesh Patel can be reached on (571) 272-2457. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MARY ELLEN BOWMAN/
Primary Examiner, Art Unit 2879

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	Art Unit
	MARY ELLEN BOWMAN	2879

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
313257438	112, 498, 501, 5129827	9/18/129/18/129/ 18/12	MBMBMB

SEARCH NOTES		
Search Notes	Date	Examiner
inventor search in eDan	9/18/12	MB

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/MARY ELLEN BOWMAN/ Primary Examiner, Art Unit 2879

Savant Technologies LLC - 1004.1017

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	13273212
	Filing Date	2011-10-13
	First Named Inventor	Bing Dai
	Art Unit	2879
	Examiner Name	Bowman, Mary Ellen
	Attorney Docket Number	ITMX-00318US1

U.S.PATENTS							Remove
Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1						
If you wish to add additional U.S. Patent citation information please click the Add button.							Add

U.S.PATENT APPLICATION PUBLICATIONS							Remove
Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	
	1						
If you wish to add additional U.S. Published Application citation information please click the Add button.							Add

FOREIGN PATENT DOCUMENTS								Remove
Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐
If you wish to add additional Foreign Patent Document citation information please click the Add button								Add

NON-PATENT LITERATURE DOCUMENTS			Remove
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Receipt date: 11/16/2012	Application Number	13273212 13273212 - GAU: 2879
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)	Filing Date	2011-10-13
	First Named Inventor	Bing Dai
	Art Unit	2879
	Examiner Name	Bowman, Mary Ellen
	Attorney Docket Number	ITMX-00318US1

	1	Docket No. ITMX-00318US2; Non-Final Office Action dated Sep. 24, 2012 for U.S. Appln. No. 13/273,215	☐
	2	Docket No. ITMX-00318US3; Non-Final Office Action dated Sep. 24, 2012 for U.S. Appln. No. 13/273,217	☐

If you wish to add additional non-patent literature document citation information please click the Add button **Add**

EXAMINER SIGNATURE

Examiner Signature	/Mary Ellen Bowman/	Date Considered	01/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	"20090272996"	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/17 14:20
S2	2	"20070240346"	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/17 14:28
S3	356	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle with (size nanometer micrometer))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 14:34
S4	215	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle with (concentration weight percent$3 amount))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 15:37
S5	9	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (down$light) and (base near4 socket)	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:20
S6	2	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (down$light) and ((housing envelope bulb) with (elongat$2 linear))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:30
S7	46	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((housing envelope bulb) with (elongat$2 linear))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:31
S8	50	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (downlight)	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:33

EAST Search History (Interference)

<This search history is empty>

9/ 18/ 2012 2:26:07 PM
C:\ Users\ mbowman\ Documents\ EAST\ Workspaces\ 13273212.wsp

Savant Technologies LLC - 1004.1020

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
				Application Number	13/273,212
				Filing Date	10-13-2011
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	11	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	5371434	12-06-1994	Rawlings, Keith C.	
	2	5947587	09-07-1999	Keuper, et al.	
	3	5998925	12-07-1999	YOSHINORI SHIMIZU	
	4	6147367	11-14-2000	Yang et al.	
	5	6255670	07-03-2001	Srivastava et al.	
	6	6538375	03-25-2003	Duggal et al.	
	7	6555958	04-29-2003	Srivastava, et al.	
	8	6576930	06-10-2003	Reeh et al.	
	9	6580097	06-17-2003	Soules et al.	
	10	6614170	09-02-2003	Wang et al.	
	11	6680569	01-20-2004	Meueller-Mach et al.	
	12	6717353	04-06-2004	Mueller et al.	
	13	6834979	12-28-2004	Cleaver et al.	
	14	7029935	04-18-2006	Negley et al.	
	15	7220022	05-22-2007	Allen et al.	
	16	7311858	12-25-2007	Ning Wang	
	17	7390437	06-24-2008	Yi Dong	
	18	7575697	08-18-2009	Yi-Qun Li	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 5 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	19	7601276	10-13-2009	Yi-Qun Li	
	20	7655156	02-02-2010	Shifan Cheng	
	21	7663315	02-16-2010	Hulse, George R.	
	22	7686478	03-30-2010	Hulse et al.	
	23	7943951	05-17-2011	Kim et al.	
	24	7972030	07-05-2011	Li, Yi-Qun	
	25	8274215	09-25-2012	Shengfeng Liu	
	26	20010000622	05-01-2001	Reeh et al.	
	27	20020047516	04-25-2002	Iwasa et al.	
	28	20030038596	02-27-2003	Ho, Wen-Chih	
	29	20030052595	03-20-2003	Ellens et al.	
	30	20030102810	06-05-2003	Cross et al.	
	31	20040016908	01-29-2004	Hohn et al.	
	32	20040104391	06-03-2004	Maeda et al.	
	33	20040183081	09-23-2004	Alexander Shishov	
	34	20040227465	11-18-2004	Menkara et al.	
	35	20040239242	12-02-2004	Yasuhisa Mano	
	36	20050051782	03-10-2005	Negley et al.	
	37	20050052885	03-10-2005	Wu, Han Wen	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 6 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	38	20050057917	03-17-2005	Yatsuda et al.	
	39	20050093430	05-05-2005	Ibbertson et al.	
	40	20050168127	08-04-2005	Shei et al.	
	41	20060001352	01-05-2006	Maruta et al.	
	42	20060027786	02-09-2006	Dong,et al.	
	43	20060028122	02-09-2006	Wang, et al.	
	44	20060028837	02-09-2006	Mrakovich	
	45	20060124947	06-15-2006	Mueller et al.	
	46	20060158090	07-20-2006	Wang, et al.	
	47	20060261309	11-23-2006	Li, et al.	
	48	20060262532	11-23-2006	Blumel	
	49	20070029526	02-08-2007	Cheng, et al.	
	50	20070091601	04-26-2007	Hsieh, et al.	
	51	20070170840	07-26-2007	Chang-Hae et al.	
	52	20070240346	10-18-2007	Li et al.	
	53	20080111472	05-15-2008	Shengfeng Liu	
	54	20080218992	09-11-2008	Yi-Qun Li	
	55	20080246044	10-09-2008	Siew It Pang	
	56	20080308825	12-18-2008	Chakraborty et al.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	7	of	11	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	57	20090026908	01-29-2009	Bechtel et al.	
	58	20090050911	02-26-2009	Chakraborty	
	59	20090283721	11-19-2009	Shengfeng Liu	
	60	20110147778	06-23-2011	Ichikawa, Masatsugu	
	61	20120086034	04-12-2012	Xianglong Yuan	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Receipt date: 06/05/2013

13273212 GAU 2879

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	8	of	11	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1	CA 2466979	11/18/2005	Prodanov D.		
	2	JP 07094785	04/07/1995	Stanley Electric CO. LTD		
	3	JP 2003101078	04/04/2003	Toyoda Gosei Co Ltd		
	4	JP 2005011953	01/13/2005	Toyoda Gosei Co Ltd		
	5	RU 214492	06/27/1998	Abramov V. S., et al.		
	6	TW 200527664	08/16/2005	Cree, Inc. US		
	7	KR 10-2007-0065486 A	06/25/2007	Samsung Electro-Mechanics Co., Ltd.		
	8	KR 10-2009-0017346 A	02/29/2009	Seoul Semiconductor Co., Ltd.		
	9	WO 2002007228	01/24/2002	Elliiott C. T et al.		
	10	WO 2004077580	09/10/2004	James, IBBETSON et al.		
	11	WO 2005025831	03/24/2005	Gerald NEGLEY et al.		
	12	WO 2006022792	03/02/2006	Wang et al.		
	13	WO 2008043519 A1	04/17/2008	Lexedis Lighting GMBH		
	14	WO 2010074963	01/07/2010	LIU, Shengfeng		
	15					

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	9	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	BARRY, T., Flurrescence of EU2+ Activated Phases in Bunary Alkaline Earth Orthosilicate Systems, Journal of the Electrochemical Society, November 1968, pp. 1181-1184, Vol. 115, No. 1.	
	2	Docket No. ITMX-00116CN0; First Office Action for Chinese Patent Application No. 200780032995.8 Issued on March 19, 2010	
	3	Docket No. ITMX-00116CN0; Foreign Office Action dated Oct. 29, 2012 for Chinese Appln. No. 200780032995.8	
	4	Docket No. ITMX-00116CN0; Second Office Action for Chinese Patent Application No. 200780032995.8 Issued on August 10, 2011	
	5	Docket No. ITMX-00116CN0; Third Office Action for Chinese Patent Application No. 200780032995.8 Issued on December 12, 2011	
	6	Docket No. ITMX-00116CN1; Foreign Office Action dated Apr. 24, 2012 for Chinese Appln. No. 201010525492.8	
	7	Docket No. ITMX-00116EP0; Foreign Office Action dated July 5, 2012 for European Appln. No. 07811039.2	
	8	Docket No. ITMX-00116JP0; Foreign Office Action for Japanese Application No. 2009-522877 mailed on April 16, 2013	
	9	Docket No. ITMX-00116JP0; Foreign Office Action for Japanese Application No. 2009-522877 mailed on April 24, 2012	
	10	Docket No. ITMX-00116TW0; Taiwanese Office Action and Search Report for ROC (Taiwan) Patent Applicatoin No. 096128666 mailed on September 1, 2011	
	11	Docket No. ITMX-00116US06; Non-Final Office Action dated Sep. 27, 2012 for U.S. Appln. No. 13/436,471	
	12	Docket No. ITMX-00116US1; Final Office Action Mailed on June 23, 2009 for U.S. Application No. 11/640,533	
	13	Docket No. ITMX-00116US1; Final Office Action Mailed on September 23, 2011 for U.S. Application No. 11/640,533	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 10 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	14	Docket No. ITMX-00116US1; Final Office Action Mailed on September 9, 2010 for U.S. Application No. 11/640,533	
	15	Docket No. ITMX-00116US1; Non-Final Office Action Mailed on January 20, 2010 for U.S. Application No. 11/640,533	
	16	Docket No. ITMX-00116US1; Non-Final Office Action Mailed on March 3, 2011 for U.S. Application No. 11/640,533	
	17	Docket No. ITMX-00116US1; Non-Final Office Action Mailed on October 27, 2008 for U.S. Application No. 11/640,533	
	18	Docket No. ITMX-00116US2; Notice of Allowance Mailed on August 12, 2011 for U.S. Application No. 12/624,839	
	19	Docket No. ITMX-00116US2; Notice of Allowance Mailed on September 26, 2011 for U.S. Application No. 12/624,839	
	20	Docket No. ITMX-00116US3; Final Office Action dated Jan. 11, 2013 for U.S. Appln. No. 12/624,900	
	21	Docket No. ITMX-00116US3; Final Office Action Mailed on December 19, 2011 for U.S. Application No. 12/624,900	
	22	Docket No. ITMX-00116US3; Non-Final Office Action Mailed on June 25, 2012 for U.S. Application No. 12/624,900	
	23	Docket No. ITMX-00116US3; Non-Final Office Action Mailed on March 24, 2011 for U.S. Application No. 12/624,900	
	24	Docket No. ITMX-00116US4; Final Office Action dated Jan. 30, 2013 for U.S. Appln. No. 13/087,615	
	25	Docket No. ITMX-00116US4; Non-Final Office Action dated September 21, 2012 for U.S. Appln. No. 13/087,615	
	26	Docket No. ITMX-00116US6; Advisory Action dated May 15, 2013 for U.S. Appln. No. 13/436,471	
	27	Docket No. ITMX-00116US6; Final Office Action dated Mar. 1, 2013 for U.S. Appln. No. 13/436,471	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
				Application Number	13/273,212
				Filing Date	10-13-2011
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	11	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	28	Docket No. ITMX-00116US8; Final Office Action dated Apr. 5, 2013 for U.S. Appln. No. 13/441,714	
	29	Docket No. ITMX-00116US8; Non-Final Office Action dated September 19, 2012 for U.S. Appln. No. 13/441,714	
	30	Docket No. ITMX-00116WO0; International Search Report and the Written Opinion dated August 15, 2008 for PCT International Application No. PCT/US2007/017299	
	31	Docket No. ITMX-00307US1; Final Office Action dated Mar. 1, 2013 for U.S. Appln. No. 13/253,031	
	32	Docket No. ITMX-00307US1; Non-Final Office Action dated Oct. 16, 2012 for U.S. Appln. No. 13/253,031	
	33	Docket No. ITMX-00318US2; Final Office Action dated Mar. 1, 2013 for U.S. Appln. No. 13/273,215	
	34	Docket No. ITMX-00307WO0; International Search Report and Written Opinion for PCT Application No. PCT/US11/54827	
	35	Docket No. ITMX-00318US3; Final Office Action dated Mar. 1, 2013 for U.S. Appln. No. 13/273,217	
	36	Docket No. ITMX-00318WO0; International Search Report and Written Opinion dated Mar. 28, 2013 for PCT/US2012/0598292	
	37	PARK J.K., et al., Optical Properties of Eu2+ Activated Sr2Sio4 Phosphor for Light-Emitting Diodes, Electrochemical and Solid-State Letters, February 25, 2004, pp. H15-H17, Vol. 7, No. 5.	
	38	Supplementary European Search Report for EP 07811039.2, April 15, 2011, 15 pages; Docket No. ITMX-00116EP0	
	39	YOO, J.S., et al., Control of Spectral Properties of Strontium-Alkaline Earth-Silicate-Europiem Phosphors for LED Applications, Journal of the Electrochemical Society, April 1, 2005 pp.G382-G385, Vol. 152, No. 5.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 4 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	3290255	12-06-1966	Smith, I.	
	2	3593055	07-13-1971	Geusic, Joseph E., et al.	
	3	3670193	06-13-1972	Thorington, L., et al.	
	4	3676668	07-11-1972	Collins, N., et al.	
	5	3691482	09-01-1972	Pinnow et al.	
	6	3709685	01-09-1973	Hercock, R., et al.	
	7	3743833	07-01-1973	Martie et al.	
	8	3763405	10-02-1973	Mitsuhata, Teruhisa	
	9	3793046	02-01-1974	Wanmaker et al.	
	10	3819973	06-25-1974	Hosford, A.	
	11	3819974	06-25-1974	Stevenson, David A., et al.	
	12	3849707	11-19-1974	Braslau, N., et al.	
	13	3875456	04-01-1975	Kana, Tsuyoshi, et al.	
	14	3932881	01-13-1976	Mita, Yah, et al.	
	15	3937998	02-10-1976	Verstegen, J., et al.	
	16	3972717	08-03-1976	Wiedemann, W.	
	17	4047075	09-06-1977	Schober!, W.	
	18	4081764	03-28-1978	Christmann, M.H., et al.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 5 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	19	4104076	08-01-1978	Pons, A.	
	20	4143394	03-06-1979	Schoeberl, W.	
	21	4176294	11-27-1979	Thornton, Jr., W.	
	22	4176299	11-27-1979	Thornton, W.	
	23	4211955	07-08-1980	Ray, S.	
	24	4305019	12-08-1981	Graff, E.A., et al.	
	25	4315192	02-09-1982	Skwirut, H., et al.	
	26	4443532	04-17-1984	Joy, David C., et al.	
	27	4559470	12-17-1985	Murakami, K. et al.	
	28	4573766	03-04-1986	Bournay, Jr. et al.	
	29	4618555	10-21-1986	Suzuki, T., et al.	
	30	4638214	01-20-1987	Beers, W., et al.	
	31	4667036	05-19-1987	Iden, Ruediger, et al.	
	32	4678285	07-07-1987	Ohta, W., et al.	
	33	4727003	02-23-1988	Ohseto, S. et al.	
	34	4772885	09-20-1988	Uehara, K., et al.	
	35	4845223	07-04-1989	Seybold, Guenther, et al.	
	36	4859539	08-22-1989	Tomko, Donna L., et al.	
	37	4915478	04-01-1990	Lenko et al.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 6 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	38	4918497	04-01-1990	Edmond, John A.	
	39	4946621	08-07-1990	Fouassier, C. et al.	
	40	4992704	02-12-1991	Stinson, John W.	
	41	5077161	12-31-1991	Law, Kock-Yee	
	42	5110931	05-05-1992	Dietz, Erwin, et al.	
	43	5126214	06-30-1992	Tokailin, Hiroshi, et al.	
	44	5131916	07-21-1992	Eichenauer, Herbert, et al.	
	45	5143433	09-01-1992	Farrell, J.	
	46	5143438	09-01-1992	Giddens, L. et al.	
	47	5166761	11-24-1992	Olson, Jerry M., et al.	
	48	5208462	05-04-1993	O'Connor, James M., et al.	
	49	5210051	05-11-1993	Carter, Jr., C.	
	50	5211467	05-18-1993	Seder, Thomas A.	
	51	5237182	08-17-1993	Kitagawa, Masahiko, et al.	
	52	5264034	11-23-1993	Dietz, Erwin, et al.	
	53	5283425	02-01-1994	Imamura, M.	
	54	5369289	11-29-1994	Tamaki, M., et al.	
	55	5405709	04-11-1995	Littman, Jon E., et al.	
	56	5439971	08-08-1995	Hyche, K.W.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 7 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	57	5518808	05-21-1996	Bruno, Salvatore A., et al.	
	58	5535230	07-09-1996	Abe, Tadashi	
	59	5557168	09-17-1996	Nakajima, Fumio, et al.	
	60	5563621	10-08-1996	Silsby, Alastair P.	
	61	5578839	11-26-1996	Nakamura, Shuji, et al.	
	62	5583349	12-10-1996	Norman, Michael P., et al.	
	63	5585640	12-17-1996	Huston, A.L., et al.	
	64	5619356	04-08-1997	Kozo, Nakamura, et al.	
	65	5660461	08-26-1997	Ignatius, Ronald W., et al.	
	66	5677417	10-14-1997	Muellen, Klaus, et al.	
	67	5679152	10-21-1997	Tischler. Michael A., et al.	
	68	5763901	06-09-1998	Komoto, S., et al.	
	69	5770887	06-23-1998	Tadatomo, Kazuyuki, et al.	
	70	5771039	06-23-1998	Ditzik, Richard J.	
	71	5777350	07-07-1998	Nakamura, Shuji, et al.	
	72	5869199	02-09-1999	Kido, Junji	
	73	5959316	09-28-1999	Lowery, Christopher Haydn	
	74	5962971	10-05-1999	Chen, H.	
	75	6137217	10-24-2000	Pappalardo, Romano G., et al.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 8 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	76	6340824	01-22-2002	Komoto, S., et al.	
	77	6504301	01-07-2003	Lowery, C.H.	
	78	6576488	06-10-2003	Collins, W.O., et al.	
	79	6600175	07-29-2003	Baretz, Bruce, et al.	
	80	6642618	11-04-2003	Yagi, T., et al.	
	81	6642652	11-04-2003	Collins, W.O., et al.	
	82	6869812	03-22-2005	Liu, H.	
	83	7153015	12-26-2006	8rukilacchio, T.J.	
	84	7479662	01-20-2009	Soules, T.F., et al.	
	85	7615795	11-10-2009	Baretz, B., et al.	
	86	7943945	05-17-2011	Baretz, B., et al.	
	87	20040016938	01-29-2004	Baretz, Bruce, et al.	
	88	20060049416	03-09-2006	Baretz, Bruce, et al.	
	89	20080224597	09-18-2008	Baretz, Bruce, et al.	
	90	20080224598	09-18-2008	Baretz, Bruce, et al.	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 9 of 11

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1	EP 647694	04-12-1995	Kido, J.		
	2	GB 2 017 409	10-03-1979	Bayraktaroglu, Burhan, et al.		
	3	JP 01-260707	10-18-1989	Shoji, Usuda, et al.		
	4	JP 04-289691	10-14-1992	Toshiyuki, Baba		
	5	JP 05-152609	06-18-1993	Tadatsu, Y. et al.		
	6	JP 07-099345	04-11-1995	Matoba Kosuka, et al.		
	7	JP 07-235207	09-05-1995	Sekine, Mitsuharu		
	8	JP 2900928	03-19-1999	Tadatsu, Yoshiaki, et al.		
	9	JP 4010665	01-14-1992	Manabe, K. et al.		
	10	JP 4010666	01-14-1992	Manabe, K. et al.		
	11	JP 4-321280	11-11-1992	Shuji, N.		
	12	JP 60170194	09-03-1985	Shiina, Y.		
	13	JP 6207170	07-26-1994	Matsuura, M. et al.		
	14	JP 6-267301	09-22-1994	Menda, K.		
	15	JP 6283755	10-07-1994	Mimura, S. et al.		
	16	JP 8-250281	09-27-1996	Menda, K.		
	17	JP 862-189770	08-19-1987	Inaba, Fumio, et al.		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				**Complete if Known**	
				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	10	of	11	Attorney Docket Number	ITMX-00318US1

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Use as many sheets as necessary)

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	18	JP H01-1794 71	07-17-1989	Mishima, Osamu, et al.		
	19	JP H02-91980	03-30-1990	Nakamoto, Masayuki, et al.		
	20	JP H07-176794	07-14-1995	Shimizu, Yoshinori		
	21	JP H08-7614	01-12-1996	Shimizu, Yoshinori		
	22	JP H3-24692	03-14-1991	Fujii, Kentaro		
	23	JP H7-282609	10-27-1995	Abe, Tadashi		
	24	JP P2003-234513	08-22-2003	Tadatsu, Yoshiaki, et al.		
	25	JP P3724490	09-30-2005	Tadatsu, Yoshiaki, et al.		
	26	JP P3724498	09-30-2005	Tadatsu, Yoshiaki, et al.		
	27	JP S50-79379	11-24-1973	Tabuchi, Sei-ichi		
	28	WO 9108508	06-13-1991	Stonor, John Anthony, et al.		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	11	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	"Fraunhofer-Gesellschafl: Research News Special1997", http://www.fhg.de/press/md-e/md1997/sondert2.hlm,(accessed on July 23, 1998), January 1997, Publisher: Fraunhofer Institute	
	2	ADACHI, C. ET AL., "Blue light-emitting organic electroluminescent devices", "Appl. Phys. Lett.", 2/26/1990, Page(s) 799-801, Volume 56, Number 9	
	3	AKASAKI, ISAMU, ET AL., "Photoluminescence of Mg-doped p-type GaN and electroluminescence of GaN p-n junction LED", "Journal of Luminescence", Jan-Feb 1991, Page(s) 666-670, Volume 48-49 pt. 2	
	4	AMANO, H., ET AL., "UV and blue electroluminescence from Al/GaN:Mg/GaN LED treated with low-energy electron beam irradiation (LEEBI)", "Institute of Physics: Conference Series", 1990, Pages 725-730, Volume 106, Number 10	
	5	April 14, 2010 Office Action in U.S. Patent Application No. 11/264,124, issued by Examiner Abu I Kalam (Art Unit 2814)	
	6	April 15, 2009 Office Action in U.S. Patent Application No. 11/264.124, issued by Abu I Kalam (Art Unit 2814)	
	7	ARMAROLI, N. ET AL., "Supramolecular Photochemistry and Photophysics. ", "J. Am. Chern. Soc.", 1994, Page(s) 5211-5217, Volume 116	
	8	August 21, 2006 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	
	9	August 24, 2007 Office Action in U.S. Patent Application No. 11/264,124, issued by Thao X. Le (Art Unit 2814)	
	10	August 26, 2010 Office Action in U.S. Patent Application No. 12/131,118, issued by Examiner Abul Kalam (Art Unit 2814)	
	11	BERGGREN, M. ET AL., "Light-emitting diodes with variable colours from polymer blends", "Nature", 12/1/1994, Page(s) 444-446, Volume 372	
	12	BERGGREN, M., ET AL., "White light from an electroluminescent diode made from poly[3(4-octylphenyl)-2,2'-bithiophene] and an oxadiazole ... ", "Journal of Applied Physics", December 1994, Page(s) 7530-7534, Volume 76, Number 11	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	12	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	13	BOONKOSUM, W. ET AL., "Novel Flat Panel display made of amorphous SiN:H/SiC:H thin film LED", "Physical Concepts and Materials for Novel Optoelectronic Device Applications II", 1993, Page(s) 40-51, Volume 1985	
	14	BRADFIELD, P.L., ET AL., "Electroluminescence from sulfur impurities in a p-n junction formed in epitaxial silicon", "Appl. Phys. Lett", 07110/1989, Page(s)·10D-102, Volume 55, Number 2	
	15	CHAO, ZHANG JIN, ET AL., "White light emitting glasses", "Journal of Solid State Chemistry", 1991, Page(s) 17-29, Volume 93	
	16	COMRIE, M. , "Full Color LED Added to Lumex's Lineup", "EBN", 6/19/1995, Page(s) 28	
	17	CRC Handbook, 63rd Ed., (1983) p. E-201	
	18	DAS, N.C., ET AL., "Luminescence spectra of ann-channel metal-oxide-semiconductor field-effect transistor at breakdown", 1990, Page(s) 1152-1153, Volume 56, Number 12	
	19	December 16. 2004 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	
	20	Dictionary Definition of Phosphor, Oxford English Dictionary Online, March 9, 2012 (Only partial available due to corrupt file as provided by Examiner, Steven Y. Horikoshi, on March 22, 2012 in U.S. Patent Application No. 12/131, 119; Request for Full Reference filed)	
	21	EL JOUHARI, N., ET AL., "White light generation using fluorescent glasses activated by Ce3+, Tb3+ and Mn2+ ions", "Journal De Physique IV, Colloque C2", October 1992, Page(s) 257-260, Volume 2	
	22	February 21, 2012 Office Action in U.S. Patent Application 12/131,118, issued by Abul Kalam (Art Unit 2814)	
	23	February 26, 2008 Office Action in U.S. Patent Application No. 11/264,124, issued by Abu I Kalam (Art Unit 2814)	
	24	February 4, 2005 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	
	25	February 7, 2007 Office Action in U.S. Patent Application No. 11/264,124, issued by Thao X. Le (Art Unit 2814)	
	26	FORREST, S. ET AL. , "Organic emitters promise a new generation of displays", "Laser Focus World ", Feb. 1995, Page(s) 99-107	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	13	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	27	HAMADA, Y. ET AL. , "Blue-Light-Emitting Organic Electroluminescent Devices with Oxadiazole Dimer Dyes as an Emitter", "Jpn. J. Appl. Physics", June 1992, Page(s) 1812-1816, Volume 31	
	28	HAMAKAWA, YOSHIHIRO, ET AL., "Toward a visible light display by amorphous SiC:H alloy system", "Optoelectronics--Devices and Technologies", December 1989, Page(s) 281-294, Volume 4, Number 2	
	29	HIRANO, MASAO, ET AL., "Various performances of fiber-optical temperature sensor utilizing infrared-to-visible conversion phosphor", "Electrochemisty (JP)", February 1987, Page(s) 158-164, Volume 55, Number 2, Publisher: Electrochemical Society of Japan	
	30	JANG, S., "Effect of Avalanche-Induced Light Emission on the Multiplication Factor in Bipolar Junction Transistors", "Solid-State Electronics", 1991, Page(s) 1191-1196, Volume 34, Number 11	
	31	January 29, 2007 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	
	32	January 30, 2006 Office Action in U.S. Patent Application No. 11/264,124, issued by Thao X. Le (Art Unit 2814)	
	33	January 7, 2011 Office Action in U.S. Patent Application No. 12/131,119, issued by Steven Y. Horikoshi (Art Unit 2879)	
	34	July 10, 2008 Office Action in U.S. Patent Application No. 11/264,124, issued by Abu I Kalam (Art Unit 2814)	
	35	July 14, 2005 Notice of Allowance, Notice of Allowability, and Examiner's Statement of Reasons for Allowance in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	
	36	July 14, 2011 Office Action in U.S. Patent Application No. 12/131,119, issued by Steve Horikoshi (Art Unit 2879)	
	37	July 7, 2011 Office Action in U.S. Patent Application No. 12/131,118, issued by Abu I Kalam (Art Unit 2814)	
	38	June 14, 2006 Office Action in U.S. Patent Application No. 11/264,124, issued by Thao X. Le (Art Unit 2814)	
	39	June 26, 2007 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	14	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	40	KIDO, J. ET AL. , "1,2,4-Triazole Derivative as an Electron Transport Layer in Organic Luminescent Devices", "Jpn. J. Appl. Phys. ", 7/1/1993, Page(s) L917-L920, Volume 32	
	41	KIDO, J. ET AL. , "Bright blue electroluminescence from poly(N-vinylcarbazole)", "Appl. Phys. Letters", 11/8/1993, Page(s) 2627-2629, Volume 63, Number 19	
	42	KIDO, J., ET AL., "White light-emitting organic electroluminescent devices using the poly(N-vinylcarbazole) emitter layer doped with ... ", "Appl. Phys. Lett.", February 14, 1994, Page(s) 815-817, Volume 64, Number 7	
	43	KRAMES, M., ET AL., "Status and Future of High-Power Light-Emitting Diodes for Solid-Slate Lighting", "Journal of Display Technology", June 2007, Page(s) 160-175, Volume 3, Number 2	
	44	KUDRYASHOV, V., ET AL., "Spectra of Superbright Blue and Green InGaN/AlGaN/GaN Light-Emitting diodes", "Journal of the European Ceramic Society", May 1996, Page(s) 2033-2037, Volume 17	
	45	LARACH, S., ET AL., "Blue emitting luminescent phosphors: Review and status", "Int'l Workshop on Electroluminescence", 1990, Page(s) 137-143	
	46	LEDs and Laser Diodes, Electus Distribution, copyright 2001, available at URL:http://www .jaycar.com.au/images_uploaded/ledlaser.Pdf	
	47	LESTER, S., ET AL., "High dislocation densities in high efficiency GaN-based light-emitting diodes", "Appl. Phys. Lett.", March 6, 1995, Page(s) 1249-1251, Volume 66, Number 10	
	48	Lumogen® F Violet 570 Data Sheet; available at the BASF Chemical Company website Lumogen® F Violet 570 Data Sheet; available at the BASF Chemical Company website URL,http://worldaccount.basf.com/wa/EUen_GB/Catalog/Pigments/doc4/BASF/PRD/30048274/.pdt?title=Technicai%20Datasheet&asset_type=pds/pdf&language=EN&urn=urn:documentum:eCommerce_soi_EU :09007bb280021e27.pdf :09007bb280021e27.pdf	
	49	March 2, 2009 Office Action in U.S. Patent Application No. 10/623,198, issued by Abu I Kalam (Art Unit 2814)	
	50	March 22, 2012 Office Action in U.S. Patent Application No. 12/131,119, issued by Steven Y. Horikoshi (Art Unit 2879)	
	51	March 28, 2006 Office Action in U.S. Patent Application No. 10/623,198, issued by Thao X. Le (Art Unit 2814)	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	15	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	52	March 4, 2011 Notice of Allowance, Notice of Allowability, Examiner's Interview Summary, Examiner's Amendment/ Comment and Examiner's Statement of Reason for Allowance in U.S. Patent Application No. 11/264,124, issued by Abu I Kalam (Art Unit 2814)	
	53	March 7, 2008 Office Action in U.S. Patent Application No. 10/623,198, issued by Abu I Kalam (Art Unit 2814)	
	54	MARUSKA, H.P., "Gallium nitride light-emitting diodes (dissertation)", "Dissertation Submitted to Stanford University", November 1973	
	55	MARUSKA, H.P., ET AL., "Violet luminescence of Mg-doped GaN", "Appl. Phys. Lett.", March 15, 1973, Page(s) 303-305, Volume 22, Number 6	
	56	May 4, 2010 Office Action in U.S. Patent Application No. 12/131,119, issued by Examiner Steven Horikoshi (Art Unit 2879)	
	57	MCGRAW-HILL, "McGraw-Hill Dictionary of Scientific and Technical Terms, Third Edition", "McGraw-Hill Dictionary of Scientific and Technical Terms", 1984, Page(s) 912 and 1446, Publisher: McGraw-Hill	
	58	MCGRAW-HILL, "McGraw-Hill Encyclopedia of Science and Technology, Sixth Edition", "McGraw-Hill Encyclopedia of Science and Technology", 1987, Page(s) 582 and 60-63, Volume 9-10, Publisher: McGraw-Hill	
	59	MIMURA, HIDENORI, ET AL., "Visible electroluminescence from uc-SiC/porous Si/c-Si p-n junctions", "Int. J. Optoelectron.", 1994, Page(s) 211-215, Volume 9, Number 2	
	60	MIURA, NOBORU, ET AL., "Several Blue-Emitting Thin-Film Electroluminescent Devices", "Jpn. J. Appl. Phys.", January 15, 1992, Page(s) L46-L48, Volume 31, Number Part 2, No. 1A IB	
	61	Morkoc et al., "Large-band-gap SIC, 111-V nitride, and II-VI ZnSe-based semiconductor device technologies", J. Appl. Phys. 76(3), 1; March 17, 1994; Illinois University.	
	62	MUENCH, W.V., ET AL., "Silicon carbide light-emitting diodes with epitaxial junctions", "Solid-State Electronics", October 1976, Page(s) 871-874, Volume 19, Number 10	
	63	MUKAI, T., ET AL., "Recent progress of nitride-based light emitting devices", "Phys. Stat. Sol.", September 2003, Page (s) 52-57, Volume 200, Number 1	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	16	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	64	NAKAMURA, S., ET AL., "High-power InGaN single-quantum-well-structure blue and violet light-emitting diodes", "Appl. Phys. Lett.", September 25, 1995, Page(s) 1868-1870, Volume 67, Number 13	
	65	NAKAMURA, S., ET AL., "The Blue Laser Diode: GaN Based Light Emitters and Lasers", March 21, 1997, Page 239, Publisher: Springer-Verlag	
	66	NAKAMURA, S., ET AL., "The Blue Laser Diode: The Complete Story, 2nd Revised and Enlarged Edition", October 2000, Page(s) 237-240, Publisher: Springer-Verlag	
	67	November 30. 2010 Office Action in U.S. Patent Application No. 12/131/118. issued by Examiner Abu I Kalam (Art Unit 2814)	
	68	October 20, 2008 Office Action in U.S. Patent Application No. 10/623,198, issued by Abu I Kalam (Art Unit 2814)	
	69	PANKOVE, J.I., ET AL., "Scanning electron microscopy studies of GaN", "Journal of Applied Physics", April 1975, Page(s) 1647-1652, Volume 46, Number 4	
	70	PAVAN, P., ET AL., "Explanation of Current Crowding Phenomena Induced by Impact Ionization in Advanced Si Bipolar Transistors by Means of...", "Microelectronic Engineering", 1992, Page(s) 699-702, Volume 19	
	71	PEI, Q, ET AL., "Polymer Light-Emitting Electrochemical Cells", "Science", August 25, 1995, Page(s) 1086-1088, Volume 269, Number 5227	
	72	Reexam Advisory Action dated September 28, 2012 for U.S. Appln. No. 90/010,940	
	73	Reexam Final Office Action dated May 24, 2012 for U.S. Appln. No. 90/010,940	
	74	Reexam Final Office Action dated November 7, 2011 for U.S. Appln. No. 90/010,940	
	75	Reexam Non-Final Office Action dated January 26, 2012 for U.S. Appln. No. 90/010,940	
	76	Reexam Non-Final Office Action dated March 3, 2011 for U.S. Appln. No. 90/010,940	
	77	Reexam Non-Final Office Action dated September 20, 2010 for U.S. Appln. No. 90/010,940	
	78	ROMAN. D., "LEDs Turn A Brighter Blue", "Electronic Buyers' News", June 19, 1995, Pages 28 and 35, Volume 960, Publisher: CMP Media LLC	
	79	Saleh and Teich, Fundamentals of Photonics, New York: John Wiley & Sons, 1991, pp. 592-594	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	17	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	80	SATO, YUICHI, ET AL., "Full-color fluorescent display devices using a near-UV light-emitting diode", "Japanese Journal of Applied Physics", July 1996, Page(s) L838-L839, Volume 35, Number ?A	
	81	September 17, 2009 Notice of Allowance, Notice of Allowability, Examiner's Amendmeni/Comment, and Examiner's Statement of Reasons for Allowance in U.S. Patent Application No. 10/623,198, issued by Abul Kalam (Art Unit 2814)	
	82	September 29, 2009 Office Action in U.S. Patent Application No. 11/264,124, issued by Abu I Kalam (Art Unit 2814)	
	83	TANAKA, SHOSAKU, ET AL., "Bright white-light electroluminescence based on nonradiative energy transfer in Ce-and Eu-doped SrS thin films", "Applied Physics Letters", November 23, 1987, Page(s) 1661-1663, Volume 51, Number 21	
	84	TANAKA, SHOSAKU, ET AL., "White Light Emitting Thin-Film Electroluminescent Devices with SrS:Ce,Cl/ZnS:Mn Double Phosphor Layers", "Jpn. J. Appl. Phys.", March 20, 1986, Page(s) L225-L227, Volume 25, Number 3	
	85	The Penguin Dictionary of Electronics, 3rd edition, pp. 315,437-438, 509-510, copyright 1979, 1988, and 1998	
	86	URA, M. , "Recent trends of development of silicon monocarbide blue-light emission diodes", "Kinzoku ", 1989, Page (s) 11-15, Volume 59, Number 9	
	87	WERNER, K. , "Higher Visibility for LEDs", "IEEE Spectrum", July 1994, Page(s) 30-39	
	88	WOJCIECHOWSKI, J. ET AL. , "INFRARED-TO-BLUE UP-CONVERTING PHOSPHOR", "Electron Technology", 1978, Page(s) 31-47, Volume 11, Number 3	
	89	YAMAGUCHI, Y. ET AL., "HIGH-BRIGHTNESS SiC BLUE LEDS AND THEIR APPLICATION TO FULL COLOR LED LAMPS", "OPTOELECTRONICS-Devices and Technologies", June 1992, Page(s) 57-67, Volume 7, Number 1	
	90	YANG, Y., ET AL., "Voltage controlled two color light-emitting electrochemical cells", "Appl. Phys. Lett.", 1996, Volume 68, Number 19	
	91	YOSHIMI, MASASHI, ET AL., "Amorphous carbon basis blue light electroluminescent device", "Optoelectronics- Devices and Technologies", June 1992, Page(s) 69-81, Volume 7, Number 1	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	18	of	11	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	92	ZANONI, E., ET AL., "Impact ionization, recombination, and visible light emission in ALGaAs/GaAs high electron mobility transistors", "J. Appl. Phys.", 1991, Page(s) 529-531, Volume 70, Number 1	
	93	ZANONI, E., ET AL., "Measurements of Avalanche Effects and Light Emission in Advanced Si and SiGe Bipolar Transistors", "Microelectronic Engineering", 1991, Page(s) 23-26, Volume 15	
	94	ZDANOWSKI, MAREK, "Pulse operating up-converting phosphor LED", "Electron Technol. ", 1978, Page(s) 49-61, Volume 11, Number 3	
	95	ZHIMING, CHEN, ET AL., "Amorphous thin film white-LED and its light-emitting mechanism", "Conference Record of the 1991 International Display Research Conference", October 1991, Page(s) 122-125	

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	**Art Unit**
	MARY ELLEN BOWMAN	2879

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/18/2012	02/25/2013	06/10/2013						
	1	✓	✓	✓						
	2	✓	✓	✓						
	3	✓	✓	✓						
	4	✓	✓	✓						
	5	✓	✓	✓						
	6	✓	✓	✓						
	7	✓	✓	✓						
	8	✓	✓	✓						
	9	✓	✓	✓						
	10	✓	✓	✓						
	11	✓	✓	✓						
	12	✓	✓	✓						
	13	✓	✓	✓						
	14	✓	✓	✓						
	15	✓	✓	✓						
	16	✓	✓	✓						
	17	✓	✓	✓						
	18	✓	✓	✓						
	19	✓	✓	✓						
	20	✓	✓	✓						
	21	✓	✓	✓						
	22	✓	✓	✓						
	23	✓	✓	✓						
	24	✓	✓	✓						
	25	✓	✓	✓						
	26	✓	✓	✓						
	27	✓	✓	✓						
	28	✓	✓	✓						
	29	✓	✓	✓						

Savant Technologies LLC - 1004.1044

UNITED STATES PATENT AND TRADEMARK OFFICE
COMMISSIONER FOR PATENTS
P.O.BOX 1450
ALEXANDRIA VA 22313-1451

PRESORTED
FIRST-CLASS MAIL
U.S. POSTAGE PAID
POSTEDIGITAL
NNNNN

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

Courtesy Reminder for
Application Serial No: 13/273,212

Attorney Docket No: ITMX-00318US1
Customer Number: 101130
Date of Electronic Notification: 06/17/2013

This is a courtesy reminder that new correspondence is available for this application. If you have not done so already, please review the correspondence. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

An email notification regarding the correspondence was sent to the following email address(es) associated with your customer number:
docketing@viplawgroup.com
ttn@viplawgroup.com

To view your correspondence online or update your email addresses, please visit us anytime at **https://sportal.uspto.gov/secure/myportal/privatepair.** If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov or call 1-866-217-9197.

PATENT
Attorney Docket No.: ITMX-00318US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	Group Art Unit: 2879
Bing Dai et al.	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	Confirmation No.: 8795
Filed: October 13, 2011	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	

RESPONSE TO OFFICE ACTION

Mail Stop AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir/Madam:

In response to the Office action dated June 17, 2013, Applicants request that this application be amended in accordance with the following sheets.

Listing of the Claims begins on page 2.

Remarks begin on page 8.

Savant Technologies LLC - 1004.1046

LISTING OF THE CLAIMS

Claims 1-29 are pending. No new matter has been added. A complete listing of the pending claims is provided below and supersedes all previous claim lists.

1. (Previously Presented) A wavelength conversion component for a light emitting device comprising:

a wavelength conversion layer comprising particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

2. (Original) The component of Claim 1, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.

3. (Original) The component of Claim 1, wherein the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder.

4. (Original) The component of Claim 3, wherein the wavelength conversion layer further comprises a second light scattering material.

5. (Original) The component of Claim 4, wherein the light scattering material and the second light scattering material have different material properties.

Savant Technologies LLC - 1004.1047

6. (Original) The component of Claim 3, wherein the light transmissive binder comprises a curable liquid polymer selected from the group consisting of: a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer.

7. (Original) The component of Claim 2, wherein the weight loading of light scattering material to binder selected from the group consisting of: 7% to 35% and 10% to 20%.

8. (Original) The component of Claim 1, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

9. (Original) The component of Claim 1, wherein the wavelength conversion and light diffusing layers are deposited using a method selected from the group consisting of: screen printing, slot die coating, spin coating, roller coating, drawdown coating and doctor blading.

10. (Original) The component of Claim 1, wherein the light scattering material is selected from the group consisting of: titanium dioxide, barium sulfate, magnesium oxide, silicon dioxide and aluminum oxide.

11. (Previously Presented) The component of Claim 1, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter the excitation light relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

12. (Original) The component of Claim 11, wherein the light scattering material scatters the excitation light at least twice as much as light generated by the at least one photoluminescence material.

13. (Original) The component of Claim 11, wherein the excitation light comprises blue light.

14. (Original) The component of Claim 13, wherein the light scattering material has an

Savant Technologies LLC - 1004.1048

average particle size that is less than about 150nm.

15. (Original) The component of Claim 1, wherein the light diffusing layer is deposited on a light transmissive substrate, and the light transmissive substrate is selected from the group consisting of: a polycarbonate, an acrylic and a glass.

16. (Original) The component of Claim 1 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

17. (Original) The component of Claim 1 in which the light diffusing layer comprises a dome or elongated dome shape.

18. (Original) The component of claim 17 in which the wavelength conversion layer fills a volume formed beneath the dome or elongated dome shapes.

19. (Previously Presented) A light emitting device, comprising:

at least one solid-state light emitter operable to generate excitation light; and

a wavelength conversion component comprising:

a wavelength conversion layer excitable by the excitation light, wherein the wavelength conversion layer comprises particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an OFF state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the at least one solid-state light emitter is emitted through the wavelength conversion component to contribute to a final visible emission product.

20. (Original) The device of claim 19, wherein the light emitting device is selected from the group consisting of: downlights, light bulbs, linear lamps, lanterns, wall lamps, pendant lamps,

Savant Technologies LLC - 1004.1049

chandeliers, recessed lights, track lights, accent lights, stage lighting, movie lighting, street lights, flood lights, beacon lights, security lights, traffic lights, headlamps, taillights, and signs.

21. (Previously Presented) The device of claim 19 in which the light scattering material within the light diffusing layer corresponds to an average particle size that improves the OFF state white appearance of the wavelength conversion component.

22. (Original) The device of claim 19 in which the light diffusing layer is configured to obtain substantially uniform color for emitted light from the light emitting device for emission angles over a $\pm 60^{o}$ range from an emission axis.

23. (Original) The device of claim 22, wherein a weight loading of the light scattering material to a binder selected from the group consisting of: 7% to 35% and 10% to 20%.

24. (Original) The device of Claim 19, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

25. (Original) The device of Claim 19 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

26. (Original) The device of Claim 19 in which the light diffusing layer comprises a dome or elongated dome shape.

27. (Previously Presented) A linear lamp comprising:

an elongate housing;

a plurality of solid-state light emitters housed within the housing and configured along the length of the housing; and

an elongate wavelength conversion component remote to the plurality of solid-state light emitters and configured to in part at least define a light mixing chamber,

Savant Technologies LLC - 1004.1050

wherein the elongate wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the elongate wavelength conversion component;

wherein the elongate wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the plurality of solid-state light emitters is emitted through the wavelength conversion component to contribute to a visible final emission product.

28. (Previously Presented) A downlight comprising:

a body comprising one or more solid-state light emitters, wherein the body is configured to be positioned within a downlighting fixture such that the downlight emits light in a downward direction; and

a wavelength conversion component remote to the one or more solid-state light emitters and configured to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

29. (Previously Presented) A light bulb comprising:

a connector base configured to be inserted in a socket to form an electrical connection for the light bulb;

a body comprising one or more solid-state light emitters;

Savant Technologies LLC - 1004.1051

a wavelength conversion component having a three dimensional shape that is configured to enclose the one or more solid-state light emitters and to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

Savant Technologies LLC - 1004.1052

REMARKS

Claims 1-29 are currently pending in the application. No new matter has been added.

I. Interview Summary

Applicants first wish to thank the Examiner of record, Ms. Mary Ellen Bowman, for granting and conducting a telephonic interview on September 11, 2013. During the telephonic interview, claim 1 and the McNulty reference were specifically discussed. Applicants and Examiner agreed that the McNulty reference cannot be combined to disclose the claimed limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product."

II. Claim Rejections under 35 U.S.C. §103

Claims 1-6, 9-14, 16-19, 21-22, 25 and 26 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable U.S. Patent Pub. No. 2002/0180351 (McNulty). Applicants respectfully traverse.

Claim 1 currently recites the following limitation. Claim 19 currently recites similar limitations.

> wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product

A. MPEP requires that the proposed modification cannot change the principle of operation of a reference, and that the suggested combination may not require a change in the basic principle under which the [primary reference] construction was designed to operate." MPEP §2143.01 citing *In re Ratti*, 270 F. 2d 810, 813, 123 USPQ 349, 352 (CCPA 1959) (emphasis added).

Applicants respectfully submit that permitting a modification of McNulty to possess the claimed aspect "wherein the wavelength conversion component is configured such that in

Savant Technologies LLC - 1004.1053

operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product" would frustrate the principle of operation in McNulty.

McNulty discloses UV reflectors incorporated in a UV LED-based light source to reduce the amount of UV excitation radiation emission into the surroundings and increase the efficiency of such light sources. *See abstract*. Figure 2 of McNulty illustrates an embodiment of a UV LED-based light source wherein a layer of phosphor material is applied to a surface of the UV LED and a layer of scattering material is applied on top of the phosphor layer. *See paragraph 22*. McNulty discloses that the scattering layer serves the purpose of reflecting UV excitation radiation of the UV LED light source back into the layer of phosphor material for further absorption such that the amount of unconverted UV excitation radiation is minimized and light output by the phosphor material is maximized. *See paragraphs 21-22*. This in turn allows for the significant reduction of UV radiation leakage to the surroundings. *See paragraph 22*.

Thus, the principle of operation in McNulty is to configure a layer of scattering material to maximize the reflection of excitation radiation back into the phosphor material in order to maximize the light output from the phosphor material, rather than allowing for a portion of excitation light to be emitted through to contribute to a final visible emission product. Nonetheless, claim 1 recites "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

It would therefore frustrate the principle of operation of McNulty to permit a modification of the scattering material to possess the claimed aspect "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

Savant Technologies LLC - 1004.1054

Therefore, Applicants respectfully submit that McNulty cannot be combined with other references to support claim rejections under 35 U.S.C. §103(a) as mandated by MPEP §2143.01 and the current 35 U.S.C. §103 jurisdprudence.

B. MPEP requires that "[a] prior art reference must be considered **in its entirety**, i.e., as a whole, including portions that would lead away from the claimed invention." MPEP §2141.03 citing *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F. 2d 1540, 220 USPQ 303 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) (emphasis added). The U.S. Court of Appeals for the Federal Circuit held that "[t]he Supreme Court went on to state that 'when a patent simply arranges old elements…the combination is obvious' (citation omitted)", and that "[t]he opposite conclusion would follow, however, if the prior art indicated that the invention would not have worked for its intended purpose or otherwise taught away from the invention. (Citation omitted.)" *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.* 567 F. 3d 1314, ____ (Fed. Cir. 2009) (emphasis added).

Claim 1 recites at least the limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

Applicants respectfully submit that McNulty in fact teaches away from at least the claimed limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

In contrast, McNulty discloses a component of a UV LED-based light source having a scattering layer and phosphor material, wherein the scattering layer is configured to reflect UV excitation radiation of the UV LED-based light source back into the layer of phosphor material for further absorption such that the amount of unconverted UV radiation is minimized and light output by the phosphor material is maximized. *See paragraphs 21-22.*

Savant Technologies LLC - 1004.1055

Thus, the layer of scattering material in McNulty is configured to maximize the reflection of excitation radiation back into the phosphor material in order to maximize the light output from the phosphor material, rather than being configured to allow for a portion of excitation light to be emitted through to contribute to a final visible emission product. As such, McNulty clearly teaches away from allowing a portion of excitation light generated to be emitted through a wavelength conversion component to contribute to a final visible emission product.

Therefore, Applicants respectfully submit that McNulty cannot be combined with other references to support claim rejections under 35 U.S.C. §103(a) as mandated by MPEP §2143.01 and the current 35 U.S.C. §103 jurisdprudence.

For at least these foregoing reasons, claim 1 and its dependent claims should be allowable over Reeh, McNulty and their combination. For at least these same reasons, claim 19 and its dependent claims should also be allowable over Reeh, McNulty and their combination.

III. Claim Rejections under 35 U.S.C. §103

Claims 7 and 23 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Patent No. 4,191,943 (Cairns). These claims are allowable for at least the same reason that their respective base claims are allowable.

IV. Claim Rejections under 35 U.S.C. §103

Claims 8, 15 and 24 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2009/0272996 (Chakraborty). These claims are allowable for at least the same reason that their respective base claims are allowable.

Savant Technologies LLC - 1004.1056

V. Claim Rejections under 35 U.S.C. §103

Claims 20 and 27 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Patent No. 6,860,628 (Robertson). These claims are allowable for at least the same reason that their respective base claims are allowable.

VI. Claim Rejections under 35 U.S.C. §103

Claim 28 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2007/0120135 (Soules). Applicants respectfully traverse.

This claim is allowable for at least the same reasons that claim 1 is allowable.

VII. Claim Rejections under 35 U.S.C. §103

Claim 29 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2008/0130285 (Negley). Applicants respectfully traverse.

This claim is allowable for at least the same reasons that claim 1 is allowable.

Savant Technologies LLC - 1004.1057

CONCLUSION

Based on the foregoing, all claims are believed allowable, and an allowance of the claims is respectfully requested. If the Examiner has any questions or comments, the Examiner is respectfully requested to contact the undersigned at the number listed below.

Applicant(s) hereby explicitly retracts and rescinds any and all of the arguments and disclaimers presented to distinguish the prior art of record during the prosecution of all parent and related application(s)/patent(s), and respectfully requests that the Examiner re-visit the prior art that such arguments and disclaimers were made to avoid.

The Commissioner is authorized to charge any fees due in connection with the filing of this document to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1. The Commissioner is authorized to credit any overpayment or to charge any underpayment to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1.

Respectfully submitted,

Dated: September 17, 2013

By: /Frederick Hsu /
Frederick Hsu
Registration No. 65,375

VISTA IP LAW GROUP LLP
2160 Lundy Ave., Suite 230
San Jose, CA 95131
Telephone: (408) 321-8663 x. 210
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1058

PATENT
Attorney Docket No.: ITMX-00318US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	Group Art Unit: 2879
Bing Dai et al.	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	Confirmation No.: 8795
Filed: October 13, 2011	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	

RESPONSE TO OFFICE ACTION

Mail Stop AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir/Madam:

In response to the Office action dated June 17, 2013, Applicants request that this application be amended in accordance with the following sheets.

Listing of the Claims begins on page 2.

Remarks begin on page 8.

Savant Technologies LLC - 1004.1059

LISTING OF THE CLAIMS

Claims 1-29 are pending. No new matter has been added. A complete listing of the pending claims is provided below and supersedes all previous claim lists.

1. (Previously Presented) A wavelength conversion component for a light emitting device comprising:

a wavelength conversion layer comprising particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

2. (Original) The component of Claim 1, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.

3. (Original) The component of Claim 1, wherein the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder.

4. (Original) The component of Claim 3, wherein the wavelength conversion layer further comprises a second light scattering material.

5. (Original) The component of Claim 4, wherein the light scattering material and the second light scattering material have different material properties.

Savant Technologies LLC - 1004.1060

6. (Original) The component of Claim 3, wherein the light transmissive binder comprises a curable liquid polymer selected from the group consisting of: a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer.

7. (Original) The component of Claim 2, wherein the weight loading of light scattering material to binder selected from the group consisting of: 7% to 35% and 10% to 20%.

8. (Original) The component of Claim 1, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

9. (Original) The component of Claim 1, wherein the wavelength conversion and light diffusing layers are deposited using a method selected from the group consisting of: screen printing, slot die coating, spin coating, roller coating, drawdown coating and doctor blading.

10. (Original) The component of Claim 1, wherein the light scattering material is selected from the group consisting of: titanium dioxide, barium sulfate, magnesium oxide, silicon dioxide and aluminum oxide.

11. (Previously Presented) The component of Claim 1, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter the excitation light relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

12. (Original) The component of Claim 11, wherein the light scattering material scatters the excitation light at least twice as much as light generated by the at least one photoluminescence material.

13. (Original) The component of Claim 11, wherein the excitation light comprises blue light.

14. (Original) The component of Claim 13, wherein the light scattering material has an

Savant Technologies LLC - 1004.1061

average particle size that is less than about 150nm.

15. (Original) The component of Claim 1, wherein the light diffusing layer is deposited on a light transmissive substrate, and the light transmissive substrate is selected from the group consisting of: a polycarbonate, an acrylic and a glass.

16. (Original) The component of Claim 1 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

17. (Original) The component of Claim 1 in which the light diffusing layer comprises a dome or elongated dome shape.

18. (Original) The component of claim 17 in which the wavelength conversion layer fills a volume formed beneath the dome or elongated dome shapes.

19. (Previously Presented) A light emitting device, comprising:

at least one solid-state light emitter operable to generate excitation light; and

a wavelength conversion component comprising:

a wavelength conversion layer excitable by the excitation light, wherein the wavelength conversion layer comprises particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an OFF state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the at least one solid-state light emitter is emitted through the wavelength conversion component to contribute to a final visible emission product.

20. (Original) The device of claim 19, wherein the light emitting device is selected from the group consisting of: downlights, light bulbs, linear lamps, lanterns, wall lamps, pendant lamps,

Savant Technologies LLC - 1004.1062

chandeliers, recessed lights, track lights, accent lights, stage lighting, movie lighting, street lights, flood lights, beacon lights, security lights, traffic lights, headlamps, taillights, and signs.

21. (Previously Presented) The device of claim 19 in which the light scattering material within the light diffusing layer corresponds to an average particle size that improves the OFF state white appearance of the wavelength conversion component.

22. (Original) The device of claim 19 in which the light diffusing layer is configured to obtain substantially uniform color for emitted light from the light emitting device for emission angles over a $\pm 60^{o}$ range from an emission axis.

23. (Original) The device of claim 22, wherein a weight loading of the light scattering material to a binder selected from the group consisting of: 7% to 35% and 10% to 20%.

24. (Original) The device of Claim 19, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

25. (Original) The device of Claim 19 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

26. (Original) The device of Claim 19 in which the light diffusing layer comprises a dome or elongated dome shape.

27. (Previously Presented) A linear lamp comprising:

an elongate housing;

a plurality of solid-state light emitters housed within the housing and configured along the length of the housing; and

an elongate wavelength conversion component remote to the plurality of solid-state light emitters and configured to in part at least define a light mixing chamber,

Savant Technologies LLC - 1004.1063

wherein the elongate wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the elongate wavelength conversion component;

wherein the elongate wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the plurality of solid-state light emitters is emitted through the wavelength conversion component to contribute to a visible final emission product.

28. (Previously Presented) A downlight comprising:

a body comprising one or more solid-state light emitters, wherein the body is configured to be positioned within a downlighting fixture such that the downlight emits light in a downward direction; and

a wavelength conversion component remote to the one or more solid-state light emitters and configured to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

29. (Previously Presented) A light bulb comprising:

a connector base configured to be inserted in a socket to form an electrical connection for the light bulb;

a body comprising one or more solid-state light emitters;

Savant Technologies LLC - 1004.1064

a wavelength conversion component having a three dimensional shape that is configured to enclose the one or more solid-state light emitters and to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

Savant Technologies LLC - 1004.1065

REMARKS

Claims 1-29 are currently pending in the application. No new matter has been added.

I. Interview Summary

Applicants first wish to thank the Examiner of record, Ms. Mary Ellen Bowman, for granting and conducting a telephonic interview on September 11, 2013. During the telephonic interview, claim 1 and the McNulty reference were specifically discussed. Applicants and Examiner agreed that the McNulty reference cannot be combined to disclose the claimed limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product."

II. Claim Rejections under 35 U.S.C. §103

Claims 1-6, 9-14, 16-19, 21-22, 25 and 26 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable U.S. Patent Pub. No. 2002/0180351 (McNulty). Applicants respectfully traverse.

Claim 1 currently recites the following limitation. Claim 19 currently recites similar limitations.

> wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product

A. MPEP requires that the proposed modification cannot change the principle of operation of a reference, and that the suggested combination may not require a change in the basic principle under which the [primary reference] construction was designed to operate." MPEP §2143.01 citing *In re Ratti*, 270 F. 2d 810, 813, 123 USPQ 349, 352 (CCPA 1959) (emphasis added).

Applicants respectfully submit that permitting a modification of McNulty to possess the claimed aspect "wherein the wavelength conversion component is configured such that in

Savant Technologies LLC - 1004.1066

operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product" would frustrate the principle of operation in McNulty.

McNulty discloses UV reflectors incorporated in a UV LED-based light source to reduce the amount of UV excitation radiation emission into the surroundings and increase the efficiency of such light sources. *See abstract*. Figure 2 of McNulty illustrates an embodiment of a UV LED-based light source wherein a layer of phosphor material is applied to a surface of the UV LED and a layer of scattering material is applied on top of the phosphor layer. *See paragraph 22*. McNulty discloses that the scattering layer serves the purpose of reflecting UV excitation radiation of the UV LED light source back into the layer of phosphor material for further absorption such that the amount of unconverted UV excitation radiation is minimized and light output by the phosphor material is maximized. *See paragraphs 21-22*. This in turn allows for the significant reduction of UV radiation leakage to the surroundings. *See paragraph 22*.

Thus, the principle of operation in McNulty is to configure a layer of scattering material to maximize the reflection of excitation radiation back into the phosphor material in order to maximize the light output from the phosphor material, rather than allowing for a portion of excitation light to be emitted through to contribute to a final visible emission product. Nonetheless, claim 1 recites "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

It would therefore frustrate the principle of operation of McNulty to permit a modification of the scattering material to possess the claimed aspect "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

Savant Technologies LLC - 1004.1067

Therefore, Applicants respectfully submit that McNulty cannot be combined with other references to support claim rejections under 35 U.S.C. §103(a) as mandated by MPEP §2143.01 and the current 35 U.S.C. §103 jurisdprudence.

B. MPEP requires that "[a] prior art reference must be considered **in its entirety**, i.e., as a whole, including portions that would lead away from the claimed invention." MPEP §2141.03 citing *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F. 2d 1540, 220 USPQ 303 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) (emphasis added). The U.S. Court of Appeals for the Federal Circuit held that "[t]he Supreme Court went on to state that 'when a patent simply arranges old elements…the combination is obvious' (citation omitted)", and that "[t]he opposite conclusion would follow, however, if the prior art indicated that the invention would not have worked for its intended purpose or otherwise taught away from the invention. (Citation omitted.)" *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.* 567 F. 3d 1314, ____ (Fed. Cir. 2009) (emphasis added).

Claim 1 recites at least the limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

Applicants respectfully submit that McNulty in fact teaches away from at least the claimed limitation "wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product".

In contrast, McNulty discloses a component of a UV LED-based light source having a scattering layer and phosphor material, wherein the scattering layer is configured to reflect UV excitation radiation of the UV LED-based light source back into the layer of phosphor material for further absorption such that the amount of unconverted UV radiation is minimized and light output by the phosphor material is maximized. *See paragraphs 21-22.*

Savant Technologies LLC - 1004.1068

Thus, the layer of scattering material in McNulty is configured to maximize the reflection of excitation radiation back into the phosphor material in order to maximize the light output from the phosphor material, rather than being configured to allow for a portion of excitation light to be emitted through to contribute to a final visible emission product. As such, McNulty clearly teaches away from allowing a portion of excitation light generated to be emitted through a wavelength conversion component to contribute to a final visible emission product.

Therefore, Applicants respectfully submit that McNulty cannot be combined with other references to support claim rejections under 35 U.S.C. §103(a) as mandated by MPEP §2143.01 and the current 35 U.S.C. §103 jurisdprudence.

For at least these foregoing reasons, claim 1 and its dependent claims should be allowable over Reeh, McNulty and their combination. For at least these same reasons, claim 19 and its dependent claims should also be allowable over Reeh, McNulty and their combination.

III. Claim Rejections under 35 U.S.C. §103

Claims 7 and 23 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Patent No. 4,191,943 (Cairns). These claims are allowable for at least the same reason that their respective base claims are allowable.

IV. Claim Rejections under 35 U.S.C. §103

Claims 8, 15 and 24 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2009/0272996 (Chakraborty). These claims are allowable for at least the same reason that their respective base claims are allowable.

Savant Technologies LLC - 1004.1069

V. Claim Rejections under 35 U.S.C. §103

Claims 20 and 27 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Patent No. 6,860,628 (Robertson). These claims are allowable for at least the same reason that their respective base claims are allowable.

VI. Claim Rejections under 35 U.S.C. §103

Claim 28 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2007/0120135 (Soules). Applicants respectfully traverse.

This claim is allowable for at least the same reasons that claim 1 is allowable.

VII. Claim Rejections under 35 U.S.C. §103

Claim 29 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Reeh and McNulty in view of U.S. Publication No. 2008/0130285 (Negley). Applicants respectfully traverse.

This claim is allowable for at least the same reasons that claim 1 is allowable.

Savant Technologies LLC - 1004.1070

CONCLUSION

Based on the foregoing, all claims are believed allowable, and an allowance of the claims is respectfully requested. If the Examiner has any questions or comments, the Examiner is respectfully requested to contact the undersigned at the number listed below.

Applicant(s) hereby explicitly retracts and rescinds any and all of the arguments and disclaimers presented to distinguish the prior art of record during the prosecution of all parent and related application(s)/patent(s), and respectfully requests that the Examiner re-visit the prior art that such arguments and disclaimers were made to avoid.

The Commissioner is authorized to charge any fees due in connection with the filing of this document to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1. The Commissioner is authorized to credit any overpayment or to charge any underpayment to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1.

Respectfully submitted,

Dated: September 17, 2013

By: /Frederick Hsu /
Frederick Hsu
Registration No. 65,375

VISTA IP LAW GROUP LLP
2160 Lundy Ave., Suite 230
San Jose, CA 95131
Telephone: (408) 321-8663 x. 210
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1071

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	)	Group Art Unit: 2879
	)	
Bing Dai et al.	)	Examiner: Bowman, Mary Ellen
	)	
Serial No.: 13/273,212	)	Confirmation No.: 8795
	)	
Filed: October 13, 2011	)	
	)	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	)	
	)	
	)	

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with 37 CFR §§ 1.97 and 1.98, the items identified in this Information Disclosure Statement (IDS) are being brought to the attention of the Office. The Examiner is requested to make these documents of record.

The items identified in this IDS may or may not be "material" pursuant to 37 CFR § 1.56. The submission thereof by Applicant(s) is not to be construed as an admission that any such patent, publication or other information referred to therein is material or considered to be material (37 CFR § 1.97(h)), or even qualifies as "prior art" under 35 USC § 102 with respect to this invention unless specifically designated by Applicant(s) as such.

1. Fee:

☐ Charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

☒ The fee due under 37 CFR § 1.17(p) is being concurrently submitted with the filing of an electronic IDS submission. Thus, no additional fee is required.

Savant Technologies LLC - 1004.1072

☐ Applicant believes that no fee is required for this submission. However, if Applicant is mistaken, then please charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

2. Statement Under 37 CFR § 1.97(e):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1); or

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

3. Copies of the Cited Items:

☒ Copies of all of the items listed under Foreign Patent Documents and/or Non Patent Literature Documents are enclosed.

☐ Copies of the following items listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are enclosed.

☐ Copies of the following documents listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are not supplied because they were previously cited by the Office or submitted in Information Disclosure Statements in parent U.S. Application No. _____, of which the current application is a _____ and relied upon in this application for an earlier filing date under 35 USC § 120. See 37 CFR § 1.98(d). The Examiner is requested to make these documents of record.

Savant Technologies LLC - 1004.1073

4. Conclusion:

Citation of the above documents shall not be construed as:

1. an admission that the documents are necessarily prior art with respect to the instant invention;
2. a representation that a search has been made, other than as described above; and
3. an admission that the information cited herein is, or is considered to be, material to patentability as defined in § 1.56(b).

It is respectfully requested that the Examiner indicate consideration of the cited references by returning a copy of the attached form with initials or other appropriate marks. If the U.S. Patent Office determines that an extension and/or other relief is required, Applicant(s) petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 501105**, referencing **Docket No. ITMX-00318US1**. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: 09-17-2013

By: /Peter C. Mei/
Peter C. Mei
Registration No. 39,768

Vista IP Law Group, LLP
2160 Lundy Ave., Ste. 230
San Jose, CA 95131
Telephone: (408) 321-8663 (Ext. 208)
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1074

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	6812500	11-02-2004	Reeh et al.	
	2	7029935	04-18-2006	Negley et al.	
	3	6903380	06-07-2005	Barnett et al.	
	4	20050243550	11-03-2005	Stekelenburg, Albert	
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	5	of	6	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1	JP 2001177153 A	06/29/2001	Sharp KK		
	2	JP 2002133910 A	05/10/2002	Toyoda Gosei KK		
	3	WO 2008019041 A2	02/14/2008	Li, Yi-Qun		
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
				Filing Date	10-13-2011
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116CN1; Foreign Office Action dated Mar. 19, 2013 for Chinese Appln. No. 201010525492.8	
	2	Docket No. ITMX-00307WO0; International Preliminary Report on Patentability dated Apr. 9, 2013 for PCT Application No. PCT/US11/54827	
	3	Docket No. ITMX-00116CN0; Fourth Office Action dated May 15, 2013 for Chinese Appln. No. 200780032995.8	
	4	Docket No. ITMX-00116US4; Non-Final Office Action dated May 16, 2013 for U.S. Appln. No. 13/087,615	
	5	Docket No. ITMX-00307US1; Non-Final Office Action dated Jun. 13, 2013 for U.S. Appln. No. 13/253,031	
	6	Docket No. ITMX-00318US3; Non-Final Office Action dated Jun. 13, 2013 for U.S. Appln. No. 13/273,217	
	7	Docket No. ITMX-00318US2; Non-Final Office Action dated Jun. 14, 2013 for U.S. Appln. No. 13/273,215	
	8	Docket No. ITMX-00116US6; Non-Final Office Action dated Jul. 18, 2013 for U.S. Appln. No. 13/436,471	
	9	Docket No. ITMX-00116US1; Non-Final Office Action Mailed on Jul. 25, 2013 for U.S. Application No. 11/640,533	
	10		
	11		
	12		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **2001-177153**
(43)Date of publication of application : **29.06.2001**

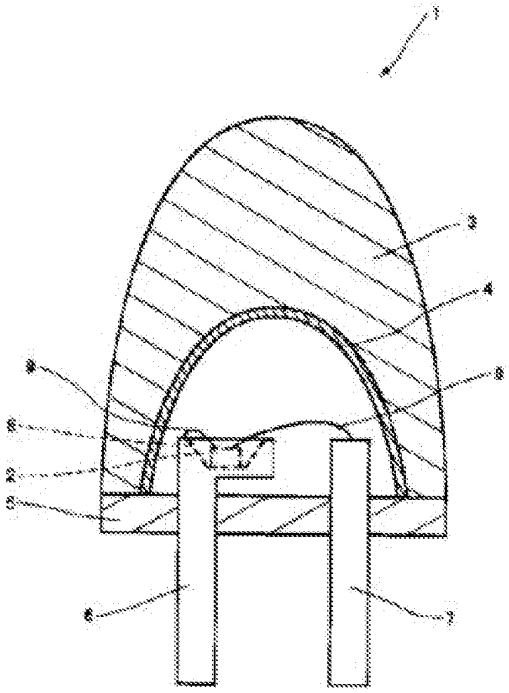
(51)Int.Cl. **H01L 33/00**

(21)Application number : **11-359330**
(22)Date of filing : **17.12.1999**

(71)Applicant : **SHARP CORP**
(72)Inventor : **OKAZAKI ATSUSHI**

(54) LIGHT EMITTING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a light emitting device having a wavelength conversion layer in an easily manufacturing form.
SOLUTION: The light emitting device comprises a light emitting diode chip, a transmissive member having a cavity for containing the chip, and a wavelength conversion layer formed on the inner wall surface of the cavity. In this case, the conversion layer is formed by coating it with a liquid wavelength conversion material.



Savant Technologies LLC - 1004.1078

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号
特開2001－177153
（P2001－177153A）
(43)公開日　平成13年６月29日(2001.6.29)

(51)Int.Cl.[7]	識別記号	ＦＩ	テーマコード(参考)
Ｈ０１Ｌ　33/00		Ｈ０１Ｌ　33/00	Ｆ　５Ｆ０４１ Ｃ Ｎ

審査請求　未請求　請求項の数４　ＯＬ　（全　４　頁）

(21)出願番号　特願平11－359330

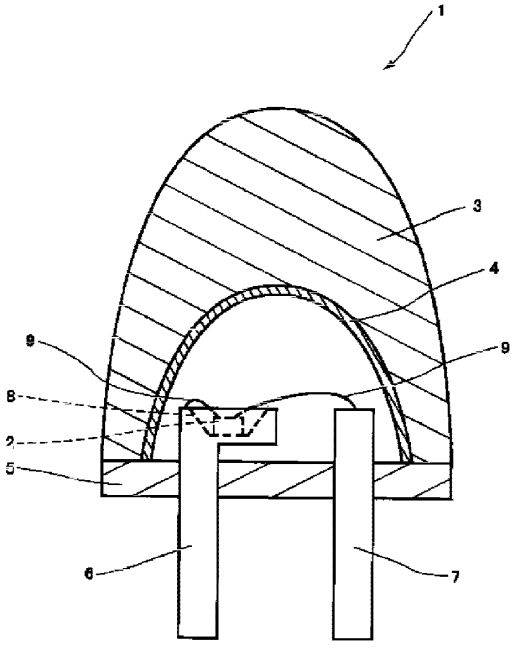
(22)出願日　平成11年12月17日(1999.12.17)

(71)出願人　000005049
シャープ株式会社
大阪府大阪市阿倍野区長池町22番22号
(72)発明者　岡崎　淳
大阪府大阪市阿倍野区長池町22番22号　シャープ株式会社内
(74)代理人　100065248
弁理士　野河　信太郎

Ｆターム(参考)　5F041 AA14 CA35 CA36 CA37 CA38
CA40 DA02 DA07 DA12 DA18
DA74 DA75 DA83 DB01 EE25

(54)【発明の名称】　発光装置

(57)【要約】
【課題】　波長変換層を備える発光装置を製造の容易な形態で提供すること。
【解決手段】　発光装置は、発光ダイオードチップと、前記チップを収容するための空洞を有する透光性部材と、空洞内壁面に形成された波長変換層とを備え、前記波長変換層は液状の波長変換材料を塗布することにより形成される。



Savant Technologies LLC - 1004.1079

【特許請求の範囲】
【請求項１】　発光ダイオードチップと、前記チップを収容するための空洞を有する透光性部材と、空洞内壁面に形成された波長変換層とを備え、前記波長変換層は液状の波長変換材料を塗布することにより形成された発光装置。
【請求項２】　発光ダイオードチップが紫外光を出射する紫外発光ダイオードチップであり、波長変換層を形成する波長変換材料は紫外光を受けて紫外光と波長が異なる光に変換する蛍光物質を含む請求項１に記載の発光装置。
【請求項３】　波長変換層が紫外光を黄色光に変換する請求項２に記載の発光装置。
【請求項４】　波長変換層が紫外光を赤色光と緑色光に変換する請求項２に記載の発光装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】この発明は、発光ダイオードチップの発光を蛍光物質によって波長変換して出射する発光装置に関するものである。
【０００２】
【従来の技術】従来より青色や青紫色等の紫外光を発光する発光ダイオードチップの波長を蛍光物質によって紫外光と波長が異なる光、例えば白色光等に変換して出射する発光装置が開発されている。白色光を出射する発光装置は、各種装置の表示部の照明や一般的な照明として広く用いられている。
【０００３】蛍光物質による波長変換機能を有する従来の発光装置としては、蛍光物質を分散含有するドーム状樹脂成型体を発光ダイオードチップに対して所定の距離を設けて装着し、さらに全体を透明樹脂で封止した発光装置が一般に知られている（例えば、特開平７－１９３２８１号公報参照）。
【０００４】
【発明が解決しようとする課題】従来の発光装置はその製造工程において、まず蛍光物質を分散含有するドーム状樹脂成型体を成型し、次に、成型されたドーム状樹脂成型体が発光ダイオードチップを覆うように配置した後、更に全体を透明樹脂で封止する必要がある。このため、従来の発光装置は製造工程が複雑であった。
【０００５】この発明は以上のような事情を考慮してなされたものであり、波長変換層を蛍光物質を含む液状の波長変換材料の塗布によって形成することにより、製造が容易な発光装置を提供するものである。
【０００６】
【課題を解決するための手段】この発明は、発光ダイオードチップと、前記チップを収容するための空洞を有する透光性部材と、空洞内壁面に形成された波長変換層とを備え、前記波長変換層は液状の波長変換材料を塗布することにより形成された発光装置を提供するものである。
【０００７】
【発明の実施の形態】この発明の発光装置においては、発光ダイオードチップが紫外光を出射する紫外発光ダイオードチップであり、波長変換層を形成する波長変換材料は紫外光を受けて紫外光と波長が異なる光に変換する蛍光物質を含むことが好ましい。
【０００８】なお、この発明において紫外光とは紫外線を含む青色光、青紫色光をさし、紫外発光ダイオードチップとは窒化ガリウム系化合物を材料とした発光強度のピークが約３６０ｎｍ～４３０ｎｍの範囲内にある発光ダイオードチップをさす。紫外発光ダイオードチップは上述のとおり短い波長を発するので蛍光物質を励起させて長波長の光を発光させる場合に都合がよい。
【０００９】この発明の発光装置においては、波長変換層が紫外光を黄色光に変換するようにしてもよい。波長変換層に入射する紫外光の全てが黄色光に変換されると発光装置から出射される光は黄色光となる。しかし、波長変換層に含まれる蛍光物質の量や波長変換層の厚さによっては、紫外光の一部のみが黄色光に変換され、発光装置からは紫外光（青色光）と黄色光とを混合した光が出射される。
【００１０】また、波長変換層が紫外光を赤色光と緑色光に変換するようにしてもよい。この場合にも、波長変換層に含まれる蛍光物質の量及び波長変換層の厚さによっては、紫外光の一部のみが赤色光と緑色光に変換され、発光装置からは赤色光と緑色光と紫外光（青色光）とを混合した光が出射される。つまり、青色光と黄色光とを混合、または赤色光と緑色光と青色光とを混合すれば様々な色の光、例えば白色光等を発光装置から出射することができる。
【００１１】紫外光を黄色光に変換する場合に好ましい蛍光物質としては、イットリウム・アルミニウム・ガーネット（以下、この明細書においてＹＡＧと称する）系の蛍光物質を挙げることができる。
【００１２】この発明の発光装置において、透光性部材の材料にはエポキシ樹脂、シリコン樹脂、ウレタン樹脂及びナイロン樹脂等を用いることができる。また、この発明の発光装置において波長変換材料とは、液状のエポキシ樹脂、シリコン樹脂又はウレタン樹脂等に蛍光物質を混合したものをさす。
【００１３】波長変換材料は成型された透光性部材に塗布されるが、具体的な塗布方法としては（１）液状吐出装置を用いて塗布するする方法、（２）噴霧装置を用いて噴霧する方法等を挙げることができる。
【００１４】なお、この発明の発光装置においては、上記の紫外発光ダイオードチップの他にもガリウムヒ素を材料とした赤外線発光ダイオード、ガリウム・アルミニウムヒ素を材料とした赤色発光ダイオード、ガリウムヒ素燐を材料とした橙色または黄色発光ダイオード、ガリ

Savant Technologies LLC - 1004.1080

ウム燐に窒素をドープした黄緑色発光ダイオード等の様々な発光ダイオードを用いることができる。

【００１５】また、蛍光物質についても上述のＹＡＧ等の他、基体として、亜鉛、カドミウム、マグネシウム、シリコン、イットリウム等の稀土類元素等の酸化物、硫化物、珪酸塩、バナジン酸塩等の無機蛍光物質、またはフルオレセイン、エオシン、油類（鉱物油）等の有機蛍光物質から選択し、付活体として、銀、銅、マンガン、クロム、ユウロピウム、亜鉛、アルミニウム、鉛、リン、砒素、金などから選択し、融剤として、塩化ナトリウム、塩化カリウム、炭酸マグネシウム、塩化バリウムなどから選択されたものを用いることができる。

【００１６】この発明の発光装置は、上述の発光ダイオードと蛍光物質の組み合わせ次第で、構造を変更することなく様々な色の光を出射することができる。

【００１７】

【実施例】以下に図面に示す実施例の基づいてこの発明を詳述する。なお、この実施例によってこの発明が限定されるものではない。

【００１８】実施例１

この発明の実施例１について図１に基づいて説明する。図１に示される発光装置１は、発光ダイオードチップ２と、発光ダイオードチップ２を収容するための透光性部材３と、空洞内壁面に形成された波長変換層４とを備え、波長変換層４は液状の波長変換材料を塗布することにより形成されている。

【００１９】透光性部材３の内壁面は半球状に成型されているので、波長変換層４も半球状に形成される。これにより、発光ダイオード２から出射された光が均一に波長変換層４を透過し、波長変換されるので、発光装置から出射される光の色は、見る方向によって色が異なる等の色ムラがない均一な色になる。

【００２０】また、樹脂成型体５は、第１、第２リードピン６、７が保持された金型内に熱硬化性樹脂を射出成型法によって注入して成型されたものである。なお、リードピン６、７の材料にはＣｕ又はＦｅ系の材料を用いている。発光ダイオードチップ２は窒化ガリウム系化合物を材料とし、波長約３６０～４３０ｎｍの紫外線を含む青色光（青紫色光）を出射する紫外発光ダイオードチップである。

【００２１】発光ダイオードチップ２は、第１リードピン６の凹状に窪んだカップ部８に銀ペースト（図示せず）を用いて設置されている。発光ダイオードチップ２の２つの電極（図示せず）は、金線９によって第１リードピン６と第２リードピン７にそれぞれ電気的に接続されている。

【００２２】また、発光装置１の製造手順は以下の通りである。

①透光性部材３を射出成型で成型する。

②成型された透光性部材３の内壁面に波長変換材料を噴霧して塗布し、波長変換層４を形成する。

③第１、第２リードピン６、７を金型内に保持した状態で樹脂成型体５を成型する。

④第１リードピン６のカップ部８に発光ダイオードチップ２を銀ペーストを用いて固定する。

⑤紫外発光ダイオードチップ２と第１、第２リードピン６、７に金線９をワイヤボンディングする。

⑥透光性部材３を樹脂成型体５にエポキシ接着剤で接着する。

【００２３】発光装置１は、発光ダイオードチップ２から出射される青色光の一部が波長変換層４を透過する際に黄色光に波長変換されるので、発光装置１から出射される光は青色光と黄色光とを混合した光、例えば白色光となる。

【００２４】また、発光装置１の波長変換層４は、上述のように波長変換材料を透光性部材３の内壁面に噴霧して塗布することにより形成されている。これにより、リードピン６、７及び発光ダイオード２がセットされた樹脂成型体５に波長変換層４が形成された透光性部材３をエポキシ接着剤で接着するだけで発光装置１を完成させることができる。従って、発光装置１は従来の発光装置よりも製造が容易になっている。

【００２５】実施例２

この発明の実施例１について図２に基づいて説明する。図２に示される発光装置２１は、図１に示される発光装置１の樹脂成型体５を上部が開口した箱型形状の樹脂成型体５ｂに変更してチップ部品型とし、それに伴い透光性部材３ｂ、第１、第２リードピン６ｂ、７ｂの形状にも変更を加えたものである。

【００２６】リードピン６ｂ、７ｂは樹脂成型体５ｂの底面にリードピン６ｂ、７ｂの一端が露出し、他端が樹脂成型体５ｂの壁部を貫通して裏側に回り込むように配置されている。これは、リードピン６ｂ、７ｂが保持された金型内に耐熱性樹脂を注入する射出成型法で製造することができる。また別の方法としては、樹脂成型体５ｂの成型時にリードピン６ｂ、７ｂ挿入用の穴を形成しておき、樹脂成型体５ｂの成型後にリードピン６ｂ、７ｂを挿入して適宜接着剤等で固定する方法等でもよい。

【００２７】透光性部材３ｂは樹脂成型体５ｂの内壁にぴったり嵌まる形状に成型され、樹脂成型体５ｂの内壁にエポキシ接着剤で接着されている。その他の構成及び製造手順は図１に示される実施例１の発光装置１と同じである。

【００２８】実施例３

この発明の実施例３について図３に基づいて説明する。図３に示される発光装置３１は、図１に示される発光装置１の樹脂成型体５と第１、第２リードピン６、７をプリント基板５ｃに変更し、更に透光性部材３ｃの形状も変更したものである。プリント基板５ｃはガラスエポキシ樹脂からなる基板上の必要箇所に無電解メッキ法によ

Savant Technologies LLC - 1004.1081

って銅のメッキ層からなる第１パターン６ｃ、第２パターン７ｃが形成されたものであるが、その他公知の基板材料を用いてもよい。プリント基板５ｃの表面には透光性部材３ｃがエポキシ接着剤で接着されている。その他の構成及び製造手順は図１に示される実施例１の発光装置１と同じである。

【００２９】以上、この発明の実施例１～３について説明したが、窒化ガリウム系化合物を材料とする発光ダイオードチップ２、２ｂ及び２ｃは、一般的に静電耐圧が１００Ｖ以下と低いので、サージ破壊から発光ダイオードチップ２、２ｂ及び２ｃを保護するためにツェナーダイオードを回路に組み入れてもよい。光源としては発光ダイオードチップ２、２ｂ及び２ｃ以外に半導体レーザチップを用いてもよい。この場合にはエポキシ樹脂にシリコンフィラーなどの分散剤を混ぜて透光性部材を成型し、半導体レーザチップから出射されるコヒーレント光を目に安全な非コヒーレント光に変換して出射することが好ましい。

【００３０】

【発明の効果】この発明によれば、液状の波長変換材料を塗布することにより波長変換層を形成するので、製造が容易な発光装置を提供することができる。

【図面の簡単な説明】

【図１】この発明の発光装置の実施例１の形態を示す部分断面図である。

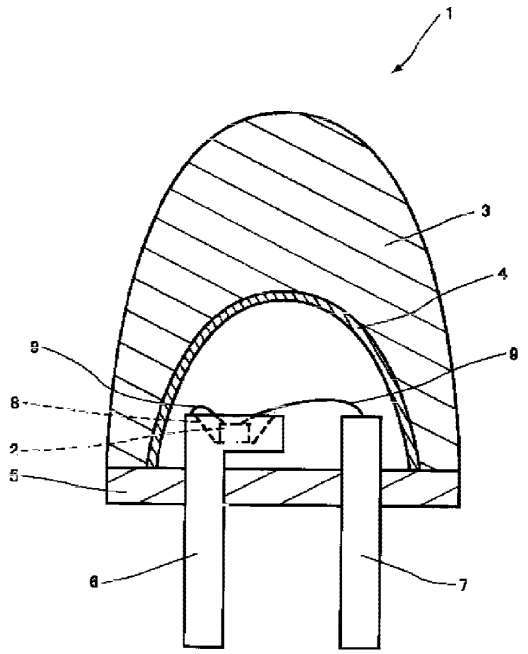
【図２】この発明の発光装置の実施例２の形態を示す部分断面図である。

【図３】この発明の発光装置の実施例２の形態を示す部分断面図である。

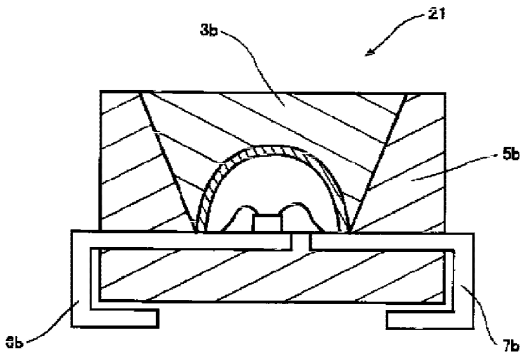
【符号の説明】

１・・・発光装置
２・・・発光ダイオードチップ
３・・・透光性部材
４・・・波長変換層
５・・・樹脂成型体
６・・・第１リードピン
７・・・第２リードピン
８・・・カップ部
９・・・金線

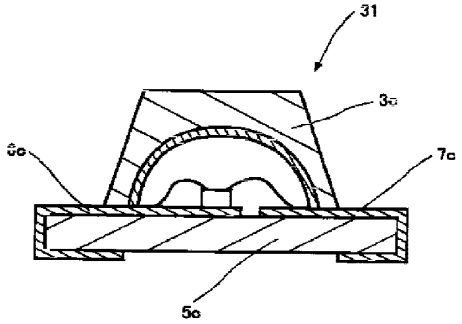
【図１】



【図２】



【図３】



Savant Technologies LLC - 1004.1082

PATENT ABSTRACTS OF JAPAN

(11)Publication number : **2002-133910**
(43)Date of publication of application : **10.05.2002**

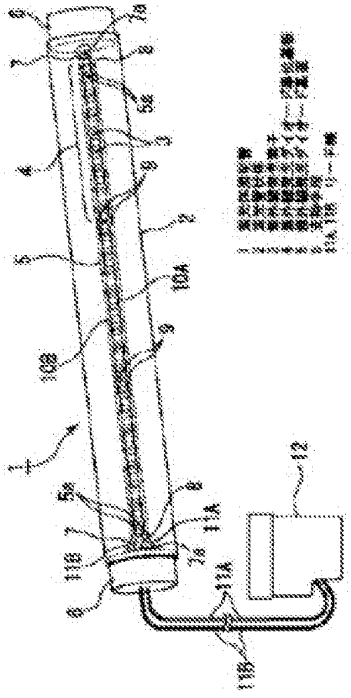
(51)Int.Cl. **F21S 8/04**
F21V 3/00
// F21Y101:02

(21)Application number : **2000-324129**
(22)Date of filing : **24.10.2000**

(71)Applicant : **TOYODA GOSEI CO LTD**
(72)Inventor : **IWASA TADANOBU**

(54) PHOSPHOR ILLUMINATION TUBE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an illumination appliance substituting for a fluorescent lamp, which can be produced easily and is durable under long usage, and by which the luminance of a variety of favorite colors can be enjoyed.
SOLUTION: The phosphor illumination tube comprises a fluorescent tube 2 consisting of a transparent glass tube, of which the inner surface is coated with a phosphor containing fluorescent material, and an ultraviolet rays LED substrate 5 inserted into the fluorescent tube 2, the LED substrate 5 having the length approximately equal to that of the fluorescent tube 2. The ultraviolet LED substrate 5 has 24 units of ultraviolet-rays-emitting element 3 having a long life, and a lead 11A and 11B for power supply, both connected to the substrate on its left end. When the ultraviolet rays are irradiated from 24 units of ultraviolet-rays-emitting element 3, the phosphor emits the light with a particular fluorescent color and the whole fluorescent tube 2 becomes luminous so that the surroundings is illuminated, thus the phosphor illumination tube 1 can be utilized as a illumination. The fluorescent material is available for a variety of colors, including the three primary colors, red, green, blue, which enables a desired luminance color.



Savant Technologies LLC - 1004.1083

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号
特開2002－133910
（P2002－133910A）
(43)公開日　平成14年５月10日(2002.5.10)

(51)Int.Cl.[7]	識別記号	ＦＩ		ﾃｰﾏｺｰﾄﾞ(参考)
Ｆ２１Ｓ　8/04		Ｆ２１Ｖ　3/00		Ｊ
Ｆ２１Ｖ　3/00		Ｆ２１Ｙ 101:02		
// Ｆ２１Ｙ 101:02		Ｆ２１Ｓ　1/02		Ｇ

審査請求　未請求　請求項の数７　ＯＬ　（全 ９ 頁）

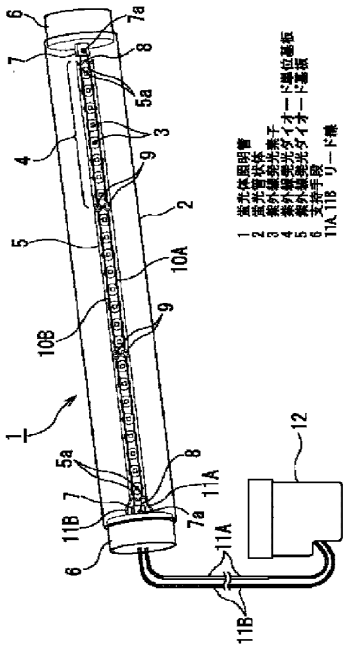
(21)出願番号　特願2000－324129(P2000－324129)

(22)出願日　平成12年10月24日(2000.10.24)

(71)出願人　000241463
豊田合成株式会社
愛知県西春日井郡春日町大字落合字長畑１番地
(72)発明者　岩佐　忠信
愛知県西春日井郡春日町大字落合字長畑１番地　豊田合成株式会社内
(74)代理人　100089738
弁理士　樋口　武尚

(54)【発明の名称】　蛍光体照明管

(57)【要約】
【課題】　製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、蛍光灯に代わる照明装置を提供すること。
【解決手段】　蛍光体照明管１は、透明なガラス管の内面に蛍光材料を含む蛍光体を塗布した蛍光管状体２の内部に、蛍光管状体２とほぼ同じ長さの紫外線ＬＥＤ基板５を挿入したものである。紫外線ＬＥＤ基板５は２４個の寿命の長い紫外線発光素子３を有しており、左端には電力を供給するリード線１１Ａ，１１Ｂが接続され、２４個の紫外線発光素子３から紫外線が照射されると蛍光体が独自の蛍光色で発光し、蛍光管状体２全体が発光して周囲を照らし、照明として使用することができる。蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがあるので、これらによって任意の発光色を出すことができる。



Savant Technologies LLC - 1004.1084

【特許請求の範囲】
【請求項１】　透明な管状部を有する本体に紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む蛍光体を内面または外面に塗布した蛍光管状体と、
前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、
前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、
前記複数の紫外線発光素子に電力を供給するリード線とを具備することを特徴とする蛍光体照明管。
【請求項２】　紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む透明な合成樹脂材料を管状に加工した蛍光管状体と、
前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、
前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、
前記複数の紫外線発光素子に電力を供給するリード線とを具備することを特徴とする蛍光体照明管。
【請求項３】　前記紫外線発光ダイオード基板は、複数の紫外線発光素子を基板上に線状に配置したものであることを特徴とする請求項１または請求項２に記載の蛍光体照明管。
【請求項４】　前記支持手段は、前記紫外線発光ダイオード基板を前記蛍光管状体の内部中心付近に位置するように支持するものであることを特徴とする請求項１乃至請求項３のいずれか１つに記載の蛍光体照明管。
【請求項５】　前記紫外線発光ダイオード基板は、１または２以上の紫外線発光素子を線状に配置した複数の紫外線発光ダイオード単位基板が連結されてなるものであることを特徴とする請求項１乃至請求項４のいずれか１つに記載の蛍光体照明管。
【請求項６】　前記蛍光管状体を文字・数字・記号・パターンのいずれかを表すように複数個配置して、その複数個の蛍光管状体の内部に前記紫外線発光ダイオード基板を電気的接続をとりながら配置したことを特徴とする請求項１乃至請求項５のいずれか１つに記載の蛍光体照明管。
【請求項７】　前記紫外線発光素子は、その発光波長が３６０ｎｍから４００ｎｍの範囲内であることを特徴とする請求項１乃至請求項６のいずれか１つに記載の蛍光体照明管。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、紫外線の照射によって発光する蛍光管状体に、その内部に挿入された複数個の紫外線発光ダイオード（以下、「紫外線ＬＥＤ」とも略する。）を照射することによって、従来の蛍光灯に代わって様々な照明や光表現を行うことができる蛍光体照明管に関するものである。
【０００２】なお、本明細書中においては、ＬＥＤチップそのものは「発光素子」と呼び、ＬＥＤチップを搭載したパッケージ樹脂またはレンズ系等の光学装置を含む発光装置全体を「発光ダイオード」または「ＬＥＤ」と呼ぶこととする。
【０００３】
【従来の技術】紫外線の照射によって発光する蛍光体には、種々の異なる色を発光するものがある。従来、これらの蛍光体を用いた照明装置としては、白色または昼光色の光を発する蛍光灯がある。蛍光灯は、両端に電極を備えたガラス管の内壁に紫外線で発光する蛍光材料を塗布し、内部を真空に近く減圧した状態で両電極間で放電を生じさせ、この放電によって生じた紫外エネルギーを蛍光材料によって光に変換する低圧水銀放電ランプである。明るい白色光が安定して得られるため、一般家庭用室内照明を始めとして、オフィス用照明、街灯等の幅広い分野で普及している。
【０００４】
【発明が解決しようとする課題】しかし、従来の蛍光灯は蛍光材を塗布したガラス管の内部の空気を抜いて密封しなければならず、またグロースターターランプを用いた複雑な点灯回路を必要とするため、製造工程が複雑となってしまう。さらに、放電の繰り返しによって蛍光管の端部が劣化して点灯しなくなるので、比較的短期間で寿命がきて交換しなければならないという問題点があった。
【０００５】そこで、本発明は、製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、蛍光灯に代わる照明装置の提供を課題とするものである。
【０００６】
【課題を解決するための手段】請求項１の発明にかかる蛍光体照明管は、透明な管状部を有する本体に紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む蛍光体を内面または外面に塗布した蛍光管状体と、前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、前記複数の紫外線発光素子に電力を供給するリード線とを具備するものである。
【０００７】ここで、「透明な管状部を有する本体」の材質としては、ガラスやアクリル樹脂、メタクリル樹脂、ポリカーボネート樹脂等の透明樹脂等を用いることができる。また、「管状部」の太さは５ｍｍ程度の小径のものから１０ｃｍ以上の大径のものまで、様々な太さのものが使用できる。さらに、「透明な管状部を有する本体」の形状としては、直管、曲管、円形、螺旋形、分岐形状、ビン、ボトル、ペットボトル等、種々の形状の

Savant Technologies LLC - 1004.1085

ものを用いることができる。また、「透明な管状部を有する本体」の断面形状としては、円形を始めとして、半円形、楕円形、三角形、四角形、それ以上の多角形、星形等、様々な断面形状のものが使用可能である。さらに、「基板」としてはガラスエポキシ基板のようなリジッドなものだけでなく、ポリイミドのフィルム基板のようなフレキシブルな基板をも用いることができる。

【０００８】かかる構成を有する蛍光体照明管においては、蛍光管状体の内部に挿入された紫外線ＬＥＤ基板上の複数の紫外線発光素子にリード線から電力を供給することによって、複数の紫外線発光素子から紫外線が照射される。照射された紫外線が蛍光管状体に塗布された蛍光体に当たると、蛍光体が独自の蛍光色で発光する。これによって、蛍光管状体全体が発光して周囲を照らし、照明として使用することができる。蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがあるので、これらの組み合わせによって白色のみでなく白色に近い発光色をも出すことができる。また、イルミネーション用照明として、白色以外の様々な発光色を楽しむこともできる。

【０００９】このような蛍光体照明管は、透明な管状部を有する本体に蛍光体を塗布してその内部に紫外線ＬＥＤ基板を挿入するだけで製造することができるから、従来の蛍光灯のような脱気・密封処理や複雑な点灯回路の取付けが不要であり、極めて容易に製作することができる。また、紫外線発光素子の寿命は長いので長期間交換の必要がなく、従来の蛍光灯と違って半永久的に使用することができる。

【００１０】このようにして、製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、従来の蛍光灯に代わる照明装置となる。

【００１１】請求項２の発明にかかる蛍光体照明管は、紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む透明な合成樹脂材料を管状に加工した蛍光管状体と、前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、前記複数の紫外線発光素子に電力を供給するリード線とを具備するものである。

【００１２】ここで、「透明な合成樹脂材料」としては、アクリル樹脂、メタクリル樹脂、ポリカーボネート樹脂等の透明樹脂を用いることができる。また、合成樹脂材料を管状に加工する方法としては、押し出し成形、射出成形等の成形法を用いることができる。また、「蛍光管状体」の太さは５ｍｍ程度の小径のものから１０ｃｍ以上の大径のものまで、様々な太さのものが使用できる。さらに、「蛍光管状体」の断面形状としては、円形を始めとして、半円形、楕円形、三角形、四角形、それ以上の多角形、星形等、様々な断面形状のものが使用可能である。また、「基板」としてはガラスエポキシ基板のようなリジッドなものだけでなく、ポリイミドのフィルム基板のようなフレキシブルな基板をも用いることができる。

【００１３】かかる構成を有する蛍光体照明管においては、蛍光管状体の内部に挿入された紫外線ＬＥＤ基板上の複数の紫外線発光素子にリード線から電力を供給することによって、複数の紫外線発光素子から紫外線が照射される。照射された紫外線が蛍光管状体中に含有される蛍光材料に当たると、蛍光材料が独自の蛍光色で発光する。これによって、蛍光管状体全体が発光して周囲を照らし、照明として使用することができる。蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがあるので、これらの組み合わせによって白色のみでなく白色に近い発光色をも出すことができる。また、イルミネーション用照明として、白色以外の様々な発光色を楽しむこともできる。

【００１４】このような蛍光体照明管は、蛍光材料を含む透明な合成樹脂材料を押し出し成形等によって管状に加工して、その内部に紫外線ＬＥＤ基板を挿入するだけで製造することができるから、従来の蛍光灯のような脱気・密封処理や複雑な点灯回路の取付けが不要であり、極めて容易に製作することができる。また、紫外線発光素子の寿命は長いので長期間交換の必要がなく、従来の蛍光灯と違って半永久的に使用することができる。

【００１５】このようにして、製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、従来の蛍光灯に代わる照明装置となる。

【００１６】請求項３の発明にかかる蛍光体照明管は、請求項１または請求項２の構成において、前記紫外線発光ダイオード基板は、複数の紫外線発光素子を基板上に線状に配置したものである。このように複数の紫外線発光素子が基板上に線状に配置されることによって、紫外線発光ダイオード基板を長尺の蛍光管状体の内部に挿入した場合でも蛍光管状体の全長に亘って均一に紫外線が照射されるため、長尺の蛍光管状体をも全長に亘って均一に発光させることができる。

【００１７】請求項４の発明にかかる蛍光体照明管は、請求項１乃至請求項３のいずれか１つの構成において、前記支持手段は、前記紫外線発光ダイオード基板を前記蛍光管状体の内部中心付近に位置するように支持するものである。このように紫外線ＬＥＤ基板は支持手段によって蛍光管状体の内部中心付近に位置するように支持されているため、紫外線は蛍光管状体の全周に亘って均一に照射される。したがって、蛍光管状体の全周に亘って均一に発光させることができる。

【００１８】請求項５の発明にかかる蛍光体照明管は、請求項１乃至請求項４のいずれか１つの構成において、前記紫外線発光ダイオード基板は、１または２以上の紫外線発光素子を線状に配置した複数の紫外線発光ダイオ

Savant Technologies LLC - 1004.1086

ード単位基板が連結されてなるものである。したがって、蛍光管状体の長さに合わせて紫外線ＬＥＤ単位基板を接続して紫外線ＬＥＤ基板を構成すれば良いので、様々な長さの蛍光管状体ごとに別々に専用の紫外線ＬＥＤ基板を製作する手間が省け、生産性の良い蛍光体照明管となる。

【００１９】請求項６の発明にかかる蛍光体照明管は、請求項１乃至請求項５のいずれか１つの構成において、前記蛍光管状体を文字・数字・記号・パターンのいずれかを表すように複数個配置して、その複数個の蛍光管状体の内部に前記紫外線発光ダイオード基板を電気的接続をとりながら配置したものである。したがって、各紫外線ＬＥＤ基板上の紫外線発光素子にリード線から電力を供給すると紫外線発光素子から紫外線が照射され、各蛍光管状体から蛍光が発せられる。すると、１または２以上の文字・数字・記号・パターンの形状に光って見えるため、室内用イルミネーションとして使用できるのは勿論、ネオンサインの代替品としても用いることができる。

【００２０】請求項７の発明にかかる蛍光体照明管は、請求項１乃至請求項６のいずれか１つの構成において、前記紫外線発光素子は、その発光波長が３６０ｎｍから４００ｎｍの範囲内であるものである。したがって、紫外線発光素子の中心発光波長は３８０ｎｍとなり、紫外線発光素子といってもその発する光は波長の長い近紫外線であり、人体、特に眼や皮膚に対する有害性は殆どない。これによって、照明として長時間紫外線発光素子を点灯させても健康への影響が全くない蛍光体照明管となる。

【００２１】

【発明の実施の形態】以下、本発明の実施の形態について説明する。

【００２２】図１は、本発明の実施の形態１にかかる蛍光体照明管の全体構成を示す斜視図である。図２（ａ）は本発明の実施の形態１にかかる蛍光体照明管に使用される紫外線ＬＥＤ単位基板の全体構成を示す平面図、（ｂ）は正面図、（ｃ）は内部回路図である。図３（ａ）は本発明の実施の形態１にかかる蛍光体照明管の蛍光管状体の構成を示す断面図、（ｂ）は本発明の実施の形態１の変形例にかかる蛍光体照明管の蛍光管状体の構成を示す断面図である。

【００２３】実施の形態１

まず、本発明の実施の形態１について、図１乃至図３を参照して説明する。図１に示されるように、本実施の形態１の蛍光体照明管１は、透明なガラス管の内面に蛍光材料を含む蛍光体を塗布した蛍光管状体２の内部に、蛍光管状体２とほぼ同じ長さの紫外線ＬＥＤ基板５を挿入したものである。なお、内面に蛍光体を塗布した蛍光管状体２は実際には不透明であるが、図１においては内部構造を分かり易くするため、あたかも透明であるかのように内部をも示している。

【００２４】紫外線ＬＥＤ基板５は、紫外線ＬＥＤ単位基板４が３個接続されて形成されており、紫外線ＬＥＤ単位基板４同士はハンダ付け９によって機械的及び電気的に接続されている。各紫外線ＬＥＤ単位基板４には８個の紫外線発光素子（以下、単に「発光素子」ともいう。）３が直線状に配置されており、したがって、紫外線ＬＥＤ基板５は全部で２４個の紫外線発光素子３を有している。

【００２５】この紫外線ＬＥＤ基板５は、蛍光管状体２の両端に嵌め込まれた支持手段としてのテフロン（登録商標）製の栓６の内部に突出した凸部７に穿設された支持孔７ａによって引っ張り支持されている。即ち、紫外線ＬＥＤ基板５の両端には、それぞれ２個の貫通孔５ａが穿設されており、この２個の貫通孔５ａに絶縁性の支持紐８が通され、支持紐８は前記支持孔７ａに通されて結ばれている。このようにして、紫外線ＬＥＤ基板５はその両端をテフロン製の栓６の支持孔７ａに結び付けられて、蛍光管状体２の内部中心付近に位置するように支持されている。

【００２６】さらに、紫外線ＬＥＤ基板５の左端には、２４個の紫外線発光素子３に電力を供給するための２本のリード線１１Ａ，１１Ｂがハンダ付けで接続されている。これらのリード線１１Ａ，１１Ｂは、紫外線ＬＥＤ基板５上に印刷されているプリント配線１０Ａ，１０Ｂにそれぞれ接続されており、プリント配線１０Ａが正（＋）極側で、プリント配線１０Ｂが負（－）極側である。したがって、左側のテフロン製の栓６を貫通して、リード線１１Ａは外部の電源１２の（＋）極側に接続されており、リード線１１Ｂは電源１２の（－）極側に接続されている。

【００２７】次に、本実施の形態１の紫外線ＬＥＤ単位基板４の構成について、図２を参照してさらに詳しく説明する。図２（ａ）に示されるように、紫外線ＬＥＤ単位基板４の８個の発光素子３は、間に抵抗１３を挟んで２個ずつ組になって配線されている。左側の発光素子３の一方の端子は、プリント配線１５によって（＋）極側のプリント配線１０Ａに接続され、この発光素子３の反対側の端子はプリント配線１５によって抵抗１３に接続されている。抵抗１３の反対側の端子は、プリント配線１５によって右側の発光素子３の左側の端子に接続され、この発光素子３の反対側の端子はプリント配線１５によって（－）極側のプリント配線１０Ｂに接続されている。

【００２８】このような回路が、ガラスエポキシ基板４ａの上に４組構成されている。さらに、図２（ｂ）に示されるように、８個の発光素子３は、透明なエポキシ樹脂１４によって封止されている。これによって、発光素子３の劣化が防止されるとともに、放射される紫外線の光量が多くなる。

Savant Technologies LLC - 1004.1087

【００２９】以上説明した紫外線ＬＥＤ単位基板４の構成を回路図にしたものが、図２（ｃ）である。図２（ｃ）に示されるように、４組の発光素子３と抵抗１３は、（＋）側のプリント配線１０Ａと（－）側のプリント配線１０Ｂの間に並列に接続されている。

【００３０】本実施の形態１の紫外線発光素子３の発光波長は３６０ｎｍから４００ｎｍまでであり、光出力強度のピークは中間波長の３８０ｎｍであって、光出力強度のパターンは３８０ｎｍを中心として左右対称となっている。したがって、紫外線発光素子といっても波長の長い近紫外線であり、人体、特に、眼や皮膚に対する有害性は殆どなく、照明として長時間紫外線発光素子を点灯させても健康への影響が全くない。なお、本発明の紫外線発光素子３とは、少なくとも波長の長い近紫外線を含むものであればよく、可視光の発光の有無を問うものではない。

【００３１】次に、本実施の形態１の蛍光管状体２の構造とその変形例について、図３を参照して説明する。図３（ａ）に示されるように、本実施の形態１の蛍光管状体２は、透明な円筒形のガラス管１８の内壁に蛍光材料を含む蛍光体２０を塗布したものである。蛍光体２０の塗布の方法としては、大径の管状体（パイプ）に塗布する場合には、液状にした蛍光体２０をエアスプレーで吹き付けて乾燥させれば良いが、本実施の形態１のようにガラス管１８がそれほど大径でない場合には、ガラス管１８の一端を液状にした蛍光体２０内に浸して他端から真空ポンプでガラス管１８内を減圧することによって、ガラス管１８の内壁に蛍光体２０が付着して、図３（ａ）のように塗布される。

【００３２】なお、本実施の形態１においては、ガラス管１８の内面に蛍光体２０を塗布しているが、ガラス管１８の外周面に蛍光体２０を塗布しても良い。この場合には、小径のガラス管であってもエアスプレーによる吹き付けで塗布することができる。

【００３３】また、直接塗布する以外の方法として、合成樹脂製のフィルムもしくはシートに蛍光体を塗布して乾燥させ、これらのフィルム、シートを透明パイプ内面に挿入するという方法も可能である。このように、フィルム、シートに蛍光体を塗布する場合には、異なる種類の蛍光体でストライプ模様を形成したり、その他様々な模様を描いたり、さらには絵画のようなものをシルク印刷することもできる。

【００３４】本実施の形態１の蛍光管状体２の変形例として、図３（ｂ）に示される蛍光管状体２２のようなものを用いることもできる。蛍光管状体２２は、蛍光材料２６を含む熱可塑性の透明な合成樹脂材料２４を押し出し成形によって、円筒形のパイプ形状としたものである。このようにして形成される蛍光管状体２２には、蛍光体を塗布するという工程を省くことができ、また蛍光材料２６を蛍光管状体２２中に均一に分散させられるという利点がある。

【００３５】かかる構成を有する本実施の形態１の蛍光体照明管１において、電源１２の図示しないスイッチを入れると、蛍光管状体２の内部に挿入された紫外線ＬＥＤ基板５上の２４個の紫外線発光素子３にリード線１１Ａ，１１Ｂから電力が供給されて、２４個の紫外線発光素子３から紫外線が照射される。紫外線ＬＥＤ基板５は支持手段６によって蛍光管状体２の内部中心付近に位置するように支持されているため、紫外線は蛍光管状体２の全周に亘って均一に照射される。照射された紫外線が蛍光管状体２の内面に塗布された蛍光体２０に当たると、蛍光体２０が独自の蛍光色で発光する。これによって、蛍光管状体２全体が発光して周囲を照らし、照明として使用することができる。

【００３６】蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがある。ここで、近紫外線の照射を受けて赤色を発光する赤色発光蛍光体の具体例としては、一般式：$(La_{1-x-y}Eu_xSm_y)_2O_2S$（式中、ｘ及びｙは、０．０１≦ｘ≦０．１５、０．０００１≦ｙ≦０．０３、を満足する数である）で実質的に表される３価のユーロピウム及びサマリウム付活酸硫化ランタン蛍光体が挙げられる。

【００３７】また、近紫外線の照射を受けて緑色を発光する緑色発光蛍光体の具体例としては、一般式：ａ（Ｍ１，Ｅｕ，Ｍｎ）Ｏ・ｂAl_2O_3　（式中、Ｍ１はＭｇ，Ｃａ，Ｓｒ，Ｂａ，Ｚｎ，Ｌｉ，Ｒｂ及びＣｓから選ばれる少なくとも１種の元素を示し、ａ及びｂは、ａ＞０，ｂ＞０，０．２≦ａ／ｂ≦１．５を満足する数である）で実質的に表される２価のユーロピウム及びマンガン付活アルミン酸塩蛍光体が挙げられる。

【００３８】さらに、近紫外線の照射を受けて青色を発光する青色発光蛍光体の具体例としては、一般式：（Ｍ２，Ｅｕ）$_{10}$（PO_4）$_6$・Cl_2　（式中、Ｍ２はＭｇ，Ｃａ，Ｓｒ及びＢａから選ばれる少なくとも１種の元素を示す）で実質的に表される２価のユーロピウム付活ハロ燐酸塩蛍光体、及び一般式：ａ（Ｍ１，Ｅｕ）Ｏ・ｂAl_2O_3　（式中、Ｍ１はＭｇ，Ｃａ，Ｓｒ，Ｂａ，Ｚｎ，Ｌｉ，Ｒｂ及びＣｓから選ばれる少なくとも１種の元素を示し、ａ及びｂは、ａ＞０，ｂ＞０，０．２≦ａ／ｂ≦１．５を満足する数である）で実質的に表される２価のユーロピウム付活アルミン酸塩蛍光体が挙げられる。

【００３９】したがって、これらの組み合わせによって白色を含めて白色に近い発光色をも出すことができる。また、イルミネーション用照明として、白色以外の様々な発光色を楽しむこともできる。

【００４０】このような蛍光体照明管１は、透明な管状部を有する本体１８の内面に蛍光体２０を塗布してその内部に紫外線ＬＥＤ基板５を挿入するだけで製造することができるから、従来の蛍光灯のような脱気・密封処理

Savant Technologies LLC - 1004.1088

や複雑な点灯回路の取付けが不要であり、極めて容易に製作することができる。また、発光素子３の寿命は長いので長期間交換の必要がなく、従来の蛍光灯と違って半永久的に使用することができる。このようにして、製作が容易で白色のみでなく好みの色の発光を楽しむことができ、長期間の使用に耐える、従来の蛍光灯に代わる照明装置となる。

【００４１】実施の形態２

次に、本発明の実施の形態２について、図４を参照して説明する。図４は、本発明の実施の形態２にかかる複数の蛍光管状体を用いた蛍光体照明管の全体構成を示す説明図である。図４に示されるように、本実施の形態２の蛍光体照明管３１は、アルファベットの「Ｌ」、「Ｅ」、「Ｄ」の３文字を表すように複数個（１０本）の蛍光管状体２を配置して、その１０本の蛍光管状体２の内部に紫外線ＬＥＤ基板５をリード線１１Ａ，１１Ｂで電気的接続をとりながら配置したものである。なお、蛍光管状体２は内面に蛍光体２０が塗布されているので実際は不透明であるが、図４では説明のし易さのためにあたかも透明で紫外線ＬＥＤ基板５が見えるように示している。

【００４２】まず、左側には同じ長さの２本の蛍光管状体２で「Ｌ」の文字が形作られている。一つ一つの蛍光体照明管の構造は実施の形態１と同様で、蛍光管状体２の両端に嵌め込んだテフロン製の栓６によって内部の紫外線ＬＥＤ基板５を支持しており、紫外線ＬＥＤ基板５の端部にハンダ付けしたリード線１１Ａ，１１Ｂをテフロン製の栓６を貫通させて外部に取り出している。次に、中央には、同じ長さの４本の蛍光管状体２で「Ｅ」の文字が形成されている。これら４本の蛍光体照明管も、リード線１１Ａ，１１Ｂによって順に電気的に接続されている。そして、右側には同じ長さの１本の蛍光管状体２とそれより短い３本の蛍光管状体２とで「Ｄ」の文字が描かれている。そして、右下の蛍光管状体２から出たリード線１１Ａ，１１Ｂは、電源３２に接続されている。

【００４３】なお、紫外線ＬＥＤ基板５における紫外線発光素子３の接続は、図２（ｃ）に示されるように並列接続なので、蛍光管状体２の列がいくら長くなっても紫外線発光素子３にかかる電圧は殆ど変化せず、同じ明るさの発光が得られる。

【００４４】これら合計１０本の蛍光管状体２は、図示しないガラス板にガラス用接着剤で接着されている。この図示しないガラス板は、さらに図示しない木製基板の上に垂直に固定支持されている。これによって、これら合計１０本の蛍光管状体２によって、アルファベットの「Ｌ」、「Ｅ」、「Ｄ」の３文字が空中に形成されている。なお、１０本の蛍光管状体２を支持する方法としては、他にも木板に針金等で縛りつけたり、網状の支持枠に紐で縛りつけたり等の様々な方法を用いることができる。

【００４５】かかる構成を有する複数の蛍光管状体２からなる蛍光体照明管３１において、電源３２の図示しないスイッチが入れられると、各紫外線ＬＥＤ基板５上の紫外線発光素子３にリード線１１Ａ，１１Ｂから電力が供給されて紫外線発光素子３から紫外線が照射され、各蛍光管状体２から蛍光が発せられる。すると、「Ｌ」、「Ｅ」、「Ｄ」の３文字の形状に光って見えるため、室内用イルミネーションとして使用できるのは勿論、ネオンサインの代替品としても用いることができる。なお、ネオンサイン等の屋外広告として用いる場合は、蛍光管状体２の長さと太さをもっと大きくする必要がある。また、イルミネーション、ネオンサインとして用いる場合には、単に点灯させるだけでなく、点滅、端から順番に点灯、部分的に時間帯を変えて点灯等の工夫を凝らす必要もある。さらに、色についても、一色ではなく数種類の蛍光材料を用いて数種類の発光色を出すことが望ましい。

【００４６】上記各実施の形態の蛍光体照明管は、その他にも種々の用途に応用することができる。例えば、照明としても室内照明のみでなく、自動車の車内ランプの代替品として、またブレーキランプ等の自動車の外回りの光源としても用いることができる。さらに、赤色の発光色を有する蛍光材料を透明な合成樹脂中に分散させて押し出し成形した蛍光管状体を用いた蛍光体照明管は、工事現場等の交通整理に用いる警棒や夜間老人が外出する際の杖等の交通安全用品として用いることができる。また、小型で多色の複数の蛍光体照明管は、オーディオ機器のグラフィックイコライザー等の表示やその他の表示器に応用できる。さらに、白色の発光色を有する蛍光体照明管は、ＬＣＤ（液晶表示）のバックライト光源としても応用が可能である。

【００４７】上記各実施の形態においては、透明な管状部を有する本体として、ガラス管１８を用いているが、アクリル樹脂、メタクリル樹脂、ポリカーボネート樹脂等の透明樹脂等をも用いることができる。また、管状部を有する本体の形状として直管のものを用いた場合について説明しているが、その他にも曲管、円形、螺旋形、分岐形状、ピン、ボトル、ペットボトル等、種々の形状のものを用いることができる。さらに、管状部を有する本体の断面形状としては円形のものを用いているが、半円形、楕円形、三角形、四角形、それ以上の多角形、星形等、様々な断面形状のものが使用可能である。

【００４８】さらに、基板としてはガラスエポキシ基板４ａを用いているが、このようなリジッドなものだけでなく、ポリイミドのフィルム基板のようなフレキシブルな基板をも用いることができる。これによって、蛍光体照明管で文字等を表す場合に、文字等のカーブ部分に曲管の蛍光管状体を用いて、その中に紫外線発光素子を搭載したフレキシブルな基板を曲げて挿入することによっ

Savant Technologies LLC - 1004.1089

て蛍光体照明管を構成することができ、文字等の形状がより自然になるとともに、文字等を構成する蛍光管状体の数を減らすことができる。

【００４９】また、紫外線発光素子として発光波長が３６０ｎｍから４００ｎｍの範囲内のものを使用しているが、蛍光材料を発光させられる紫外線であれば、どのような波長範囲のものを用いても良い。蛍光体照明管のその他の部分の構造、形状、数量、材質、大きさ、接続関係等についても、上記各実施の形態に限定されるものではない。

【００５０】

【発明の効果】以上説明したように、請求項１の発明にかかる蛍光体照明管は、透明な管状部を有する本体に紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む蛍光体を内面または外面に塗布した蛍光管状体と、前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、前記複数の紫外線発光素子に電力を供給するリード線とを具備するものである。

【００５１】かかる構成を有する蛍光体照明管においては、蛍光管状体の内部に挿入された紫外線ＬＥＤ基板上の複数の紫外線発光素子にリード線から電力を供給することによって、複数の紫外線発光素子から紫外線が照射される。照射された紫外線が蛍光管状体に塗布された蛍光体に当たると、蛍光体が独自の蛍光色で発光する。これによって、蛍光管状体全体が発光して周囲を照らし、照明として使用することができる。蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがあるので、これらの組み合わせによって白色のみでなく白色に近い発光色をも出すことができる。また、イルミネーション用照明として、白色以外の様々な発光色を楽しむこともできる。

【００５２】このような蛍光体照明管は、透明な管状部を有する本体に蛍光体を塗布してその内部に紫外線ＬＥＤ基板を挿入するだけで製造することができるから、従来の蛍光灯のような脱気・密封処理や複雑な点灯回路の取付けが不要であり、極めて容易に製作することができる。また、紫外線発光素子の寿命は長いので長期間交換の必要がなく、従来の蛍光灯と違って半永久的に使用することができる。このようにして、製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、従来の蛍光灯に代わる照明装置となる。

【００５３】請求項２の発明にかかる蛍光体照明管は、紫外線の照射によって発光する無機または有機材料の１以上からなる蛍光材料を含む透明な合成樹脂材料を管状に加工した蛍光管状体と、前記蛍光管状体の内部に挿入された複数の紫外線発光素子を基板上に配置した紫外線発光ダイオード基板と、前記紫外線発光ダイオード基板を前記蛍光管状体の内部に支持する支持手段と、前記複数の紫外線発光素子に電力を供給するリード線とを具備するものである。

【００５４】かかる構成を有する蛍光体照明管においては、蛍光管状体の内部に挿入された紫外線ＬＥＤ基板上の複数の紫外線発光素子にリード線から電力を供給することによって、複数の紫外線発光素子から紫外線が照射される。照射された紫外線が蛍光管状体中に含有される蛍光材料に当たると、蛍光材料が独自の蛍光色で発光する。これによって、蛍光管状体全体が発光して周囲を照らし、照明として使用することができる。蛍光材料には赤、緑、青の光の三原色を始めとして様々な発光色のものがあるので、これらの組み合わせによって白色のみでなく白色に近い発光色をも出すことができる。また、イルミネーション用照明として、白色以外の様々な発光色を楽しむこともできる。

【００５５】このような蛍光体照明管は、蛍光材料を含む透明な合成樹脂材料を押し出し成形等によって管状に加工して、その内部に紫外線ＬＥＤ基板を挿入するだけで製造することができるから、従来の蛍光灯のような脱気・密封処理や複雑な点灯回路の取付けが不要であり、極めて容易に製作することができる。また、紫外線発光素子の寿命は長いので長期間交換の必要がなく、従来の蛍光灯と違って半永久的に使用することができる。このようにして、製作が容易で様々な好みの色の発光を楽しむことができ、長期間の使用に耐える、従来の蛍光灯に代わる照明装置となる。

【００５６】請求項３の発明にかかる蛍光体照明管は、請求項１または請求項２の構成において、前記紫外線発光ダイオード基板は、複数の紫外線発光素子を基板上に線状に配置したものである。このように複数の紫外線発光素子が基板上に線状に配置されることによって、紫外線発光ダイオード基板を長尺の蛍光管状体の内部に挿入した場合でも蛍光管状体の全長に亘って均一に紫外線が照射されるため、長尺の蛍光管状体をも全長に亘って均一に発光させることができる。

【００５７】請求項４の発明にかかる蛍光体照明管は、請求項１乃至請求項３のいずれか１つの構成において、前記支持手段は、前記紫外線発光ダイオード基板を前記蛍光管状体の内部中心付近に位置するように支持するものである。このように紫外線ＬＥＤ基板は支持手段によって蛍光管状体の内部中心付近に位置するように支持されているため、紫外線は蛍光管状体の全周に亘って均一に照射される。したがって、蛍光管状体の全周に亘って均一に発光させることができる。

【００５８】請求項５の発明にかかる蛍光体照明管は、請求項１乃至請求項４のいずれか１つの構成において、前記紫外線発光ダイオード基板は、１または２以上の紫外線発光素子を線状に配置した複数の紫外線発光ダイオード単位基板が連結されてなるものである。したがっ

Savant Technologies LLC - 1004.1090

て、蛍光管状体の長さに合わせて紫外線ＬＥＤ単位基板を接続して紫外線ＬＥＤ基板を構成すれば良いので、様々な長さの蛍光管状体ごとに別々に専用の紫外線ＬＥＤ基板を製作する手間が省け、生産性の良い蛍光体照明管となる。

【００５９】請求項６の発明にかかる蛍光体照明管は、請求項１乃至請求項５のいずれか１つの構成において、前記蛍光管状体を文字・数字・記号・パターンのいずれかを表すように複数個配置して、その複数個の蛍光管状体の内部に前記紫外線発光ダイオード基板を電気的接続をとりながら配置したものである。したがって、各紫外線ＬＥＤ基板上の紫外線発光素子にリード線から電力を供給すると紫外線発光素子から紫外線が照射され、各蛍光管状体から蛍光が発せられる。すると、１または２以上の文字・数字・記号・パターンの形状に光って見えるため、室内用イルミネーションとして使用できるのは勿論、ネオンサインの代替品としても用いることができる。

【００６０】請求項７の発明にかかる蛍光体照明管は、請求項１乃至請求項６のいずれか１つの構成において、前記紫外線発光素子は、その発光波長が３６０ｎｍから４００ｎｍの範囲内であるものである。したがって、紫外線発光素子の中心発光波長は３８０ｎｍとなり、紫外線発光素子といってもその発する光は波長の長い近紫外線であり、人体、特に眼や皮膚に対する有害性は殆どない。これによって、照明として長時間紫外線発光素子を点灯させても健康への影響が全くない蛍光体照明管となる。

【図面の簡単な説明】

【図１】　図１は、本発明の実施の形態１にかかる蛍光体照明管の全体構成を示す斜視図である。

【図２】　図２（ａ）は本発明の実施の形態１にかかる蛍光体照明管に使用される紫外線ＬＥＤ単位基板の全体構成を示す平面図、（ｂ）は正面図、（ｃ）は内部回路図である。

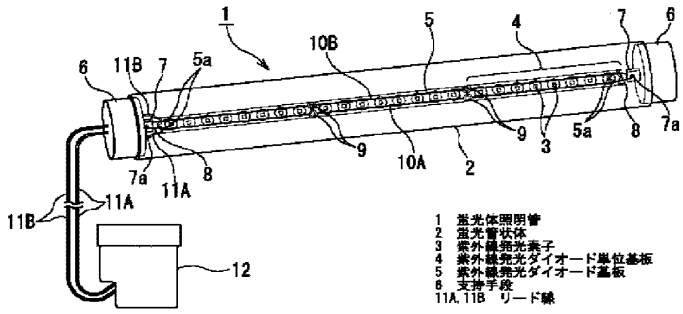
【図３】　図３（ａ）は本発明の実施の形態１にかかる蛍光体照明管の蛍光管状体の構成を示す断面図、（ｂ）は本発明の実施の形態１の変形例にかかる蛍光体照明管の蛍光管状体の構成を示す断面図である。

【図４】　図４は、本発明の実施の形態２にかかる複数の蛍光管状体を用いた蛍光体照明管の全体構成を示す説明図である。

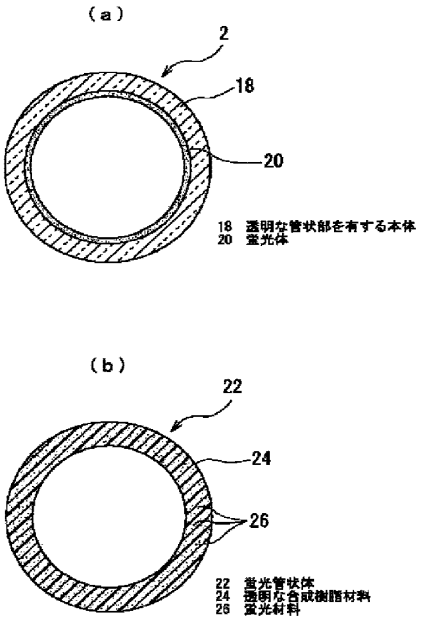
【符号の説明】

１，３１	蛍光体照明管
２，２２	蛍光管状体
３	紫外線発光素子
４	紫外線発光ダイオード単位基板
５	紫外線発光ダイオード基板
６	支持手段
１１Ａ，１１Ｂ	リード線
１８	透明な管状部を有する本体
２０	蛍光体
２４	透明な合成樹脂材料
２６	蛍光材料

【図１】

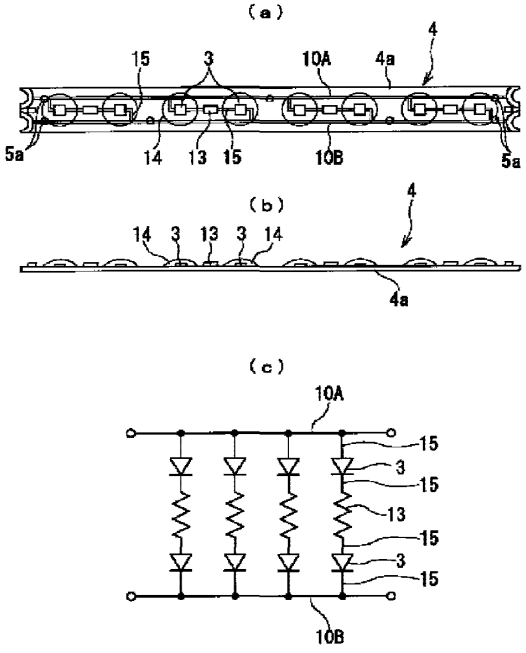


【図３】

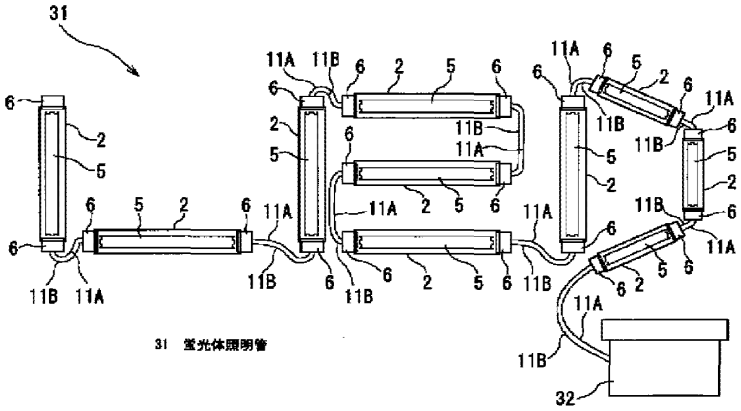


Savant Technologies LLC - 1004.1091

【図2】



【図4】



Savant Technologies LLC - 1004.1092

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 February 2008 (14.02.2008)

PCT

(10) International Publication Number
WO 2008/019041 A2

(51) International Patent Classification:
G21K 4/00 (2006.01)

(21) International Application Number:
PCT/US2007/017299

(22) International Filing Date: 2 August 2007 (02.08.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/835,601 3 August 2006 (03.08.2006) US
11/640,533 15 December 2006 (15.12.2006) US

(71) Applicant *(for all designated States except US)*: **INTEMATIX CORPORATION** [US/US]; 46410 S. Fremont Blvd., Fremont, CA 94538 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **LI, Yi-qun** [US/US]; 30 Trish Lane, Danville, CA 94506 (US).

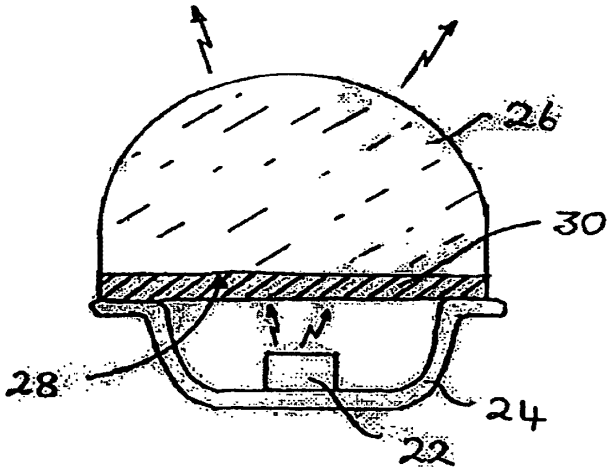
(74) Agent: **HAMRICK, Claude A.S.**; Buchanan Ingersoll, LLP, P.O. Box 1404, Alexandria, VA 22313-1404 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

(54) **Title:** LED LIGHTING ARRANGEMENT INCLUDING LIGHT EMITTING PHOSPHOR



(57) **Abstract:** A lighting arrangement (20) comprises: a radiation source, LED chip, (22) configured to emit radiation having a first wavelength range; a phosphor, photoluminescent material, (30) configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and an optical component, lens, (26) through which at least said first wavelength range radiation passes. The LED is characterized in that the phosphor is provided on a surface (28) of the optical component.

WO 2008/019041 A2

Savant Technologies LLC - 1004.1093

LED LIGHTING ARRANGEMENT INCLUDING LIGHT EMITTING PHOSPHOR

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to solid-state lighting applications which comprise light emitting diodes (LEDs) which include a light emitting phosphor, photoluminescent material, to generate light of a desired color, that is in a different part of the wavelength spectrum from the LEDs. In particular, although not exclusively, the invention concerns LED-based lighting arrangements which generate light in the visible part of the spectrum and in particular, although not exclusively white light. Moreover the invention provides an optical component for such a lighting arrangement and methods of fabricating a lighting arrangement and an optical component. Furthermore the invention provides a phosphor material for coating an optical component or as a part of optical designs in lighting arrangements.

STATE OF THE ART

In the context of this patent application light is defined as electromagnetic radiation in a wavelength range 300nm (Ultraviolet) to 1000nm (Infrared). Primarily, although not exclusively the invention concerns lighting arrangements which emit light in the visible part of the spectrum that is 380 to 750nm.

White light emitting diodes (LEDs) are known in the art and are a relatively recent innovation. It was not until LEDs emitting in the blue/ultraviolet of the electromagnetic spectrum were developed that it became practical to develop white light sources based on LEDs. As is known white light generating LEDs ("white LEDs") include a phosphor, that is a photoluminescent material, which absorbs a portion of the radiation emitted by the LED and re-emits radiation of a different color (wavelength). For example the LED emits blue light in the

Savant Technologies LLC - 1004.1094

visible part of the spectrum and the phosphor re-emits yellow light. Alternatively the phosphor can emit a combination of green and red light, green and yellow or yellow and red light. The portion of the visible blue light emitted by the LED which is not absorbed by the phosphor mixes with the yellow light emitted to provide light which appears to the eye as being white. A known yellow phosphor is a YAG-based phosphor having a main emission wavelength peak that varies in wavelength range from 530 to 590nm depending on the composition of the phosphors. Further examples of phosphors are described in our co-pending patent application US 2006/0028122 in which the photoluminescent materials have a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group consisting of Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N. Such phosphors emit light of intensities that are greater than either known YAG compounds or silicate-based phosphors.

It is predicted that white LEDs could potentially replace incandescent light sources due to their long operating lifetimes, typically many 100,000 of hours, and their high efficiency. Already high brightness LEDs are used in vehicle brake lights and indicators as well as traffic lights and flash lights.

To increase the intensity of light emitted from an LED it is known to include a lens made of a plastics material or glass to focus the light emission and to thereby increase intensity. Referring to Figure 1 a high brightness white LED 2 is shown. The LED 2 comprises an LED chip 4 which is mounted within a plastic or metal reflection cup 6 and the LED chip is then encapsulated within an encapsulating material, typically an epoxy resin 8. The encapsulation material includes the phosphor material for providing color conversion. Typically the inner surface of the cup 6 is silvered to reflect stray light towards a lens 10 which is mounted on the surface of the encapsulating epoxy resin 8.

The inventor has appreciated that such an arrangement has limitations and the present invention arose in an endeavor to mitigate, at least in part, these limitations. For example for

high intensity LEDs having a high intensity output larger than 1W, the high temperature at the output of the LED combined with its close proximity the phosphor material can give rise to a light characteristic which is temperature dependent and in some cases thermal degradation of the phosphor material can occur. Moreover the uniformity of color of light emitted by such LEDs can be difficult to maintain with the phosphor distributed within the epoxy resin since light passing through different path lengths will encounter and be absorbed by differing amounts of phosphor. Furthermore the fabrication of such LEDs is time consuming due to the encapsulation and subsequent placement of the lens.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a lighting arrangement comprising: a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and an optical component through which at least said first wavelength range radiation passes, characterized in that the phosphor is provided on a surface of the optical component. The invention provides the advantage of reducing the manufacturing steps and hence cost and also provides a more uniform color of output light.

Advantageously the phosphor is provided as a substantially uniform thickness layer on said surface of the optical component. Such an arrangement ensures a more uniform color of emitted light.

The optical component can have a number of forms and typically comprises a lens for focusing the radiation to increase the intensity of the emitted light. Alternatively the optical component can be for directing the radiation thus acting as a waveguide or as a window through which the radiation passes. The phosphor can be provided on inner or outer surfaces of the optical component and this will determine whether said second wavelength range radiation also

passes through the optical component. For example in one implementation the optical component has a substantially planar surface and the phosphor is provided on said substantially planar surface. An advantage of applying the phosphor to the planar surface is that it is easier to produce a uniform thickness layer. Alternatively the optical component can have a convex or concave surface and the phosphor is provided on said convex or concave surfaces.

In one implementation the optical component has a substantially hemispherical surface and the phosphor is provided on said hemispherical surface. Preferably, the optical component comprises a substantially hemispherical shell and the phosphor is provided on the inner hemispherical surface. Alternatively the phosphor can be provided on at least a part of the outer hemispherical surface. In a further alternative embodiment the optical component comprises a substantially spherical shell and the phosphor is provided on at least a part of the inner or outer spherical surfaces. Such a form finds particular application as a light source for replacing incandescent light sources. In yet a further embodiment the optical component comprises a hollow cylinder and the phosphor is provided on at least a part of the inner or outer surfaces.

Advantageously, the optical component is made of a plastics material such as a polycarbonate and silicone or a glass such as a silica-based glass. The optical component comprises a material which is at least substantially transparent to said first wavelength range radiation and where the phosphor is provided on an inner surface of the component the material is further substantially transparent to the second wavelength range radiation.

In a preferred implementation the phosphor comprises a powder which is incorporated within an epoxy resin, a silicone material or a polymer material to form a mixture and the phosphor mixture is then applied to the optical component to form a layer of phosphor on the optical component surface. To improve the uniformity of light emitted from the lighting arrangement the phosphor mixture advantageously further incorporates a light diffusing material such as titanium oxide, silica, alumina, etc. Such a light diffusing material has as low an

Savant Technologies LLC - 1004.1097

absorption of light as possible.

The phosphor advantageously comprises a phosphor which emits luminescent light when illuminated by radiation in wavelength range from 300nm to 550nm. One example of the phosphor advantageously comprises a YAG-based phosphor which comprises a photoluminescent material having a formula $(YA)_3(AlB)_5(OC)_{12}:Ce^{3+}$ where A is a trivalent metal selected from the group comprising Gd, Tb, La, Sm or divalent metal ions such as Sr, Ca, Ba, Mg, Zn and Cd, B comprising Si, B, P, and Ga and C is a dopant selected from the group comprising F, Cl, Br, I, P, S and N. In another implementation the phosphor comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group comprising Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group comprising F, Cl, Br, I, P, S and N.

In yet a further embodiment an orange-red silicate-based phosphor having a formula $(SrM1)_3Si(OD)_5$:Eu where M1 is selected from the group comprising Ba, Ca, Mg, Zn.. and where D is selected from the group comprising F, Cl, S, and N. Such a phosphor is advantageously used for emitting light in a wavelength range from green to yellow (580 to 630nm).

Alternatively the phosphor comprises a red silicon nitride based phosphor having a formula $(SrM1)Si_5N_8$ where M1 is selected from the group comprising Sr, Ca, Mg, and Zn.

In another embodiment the phosphor comprises a red sulfate based phosphor having a formula of (SrM1)S where M1 is selected from the group comprising Ca, Ba, and Mg.

In yet another embodiment the phosphor can comprise a green sulfate based phosphor having a formula of $(SrM1)(GaM2)_2S_4$:Eu where M1 is selected from the group comprising Ca, Ba, and Mg, and M2 is selected from the group comprising Al and In.

Preferably, the radiation source comprises a light emitting diode, advantageously a Gallium Nitride based LED.

The present invention finds particular application for white light sources and the radiation source is operable to emit radiation having a wavelength range of 300 to 500nm. Preferably, the phosphor composition is configured to emit radiation having a wavelength ranging from 450 to 700nm.

According to a second aspect of the invention there is provided an optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component configured such that at least said first wavelength range radiation passes through the optical component, and characterized in that said phosphor is provided on a surface of said optical component.

Such an optical component provides the advantages of reducing the manufacturing steps and hence cost and emits a more uniform color light. Moreover such an optical component can be used to provide direct color conversion in an LED arrangement.

To ensure the uniformity of color of light generated by the optical component, the phosphor is advantageously provided as a substantially uniform thickness layer on said surface of the optical component.

For ease of fabrication the optical component preferably has a substantially planar surface and the phosphor is provided on said substantially planar surface. Alternatively, the optical component has a convex or concave surface and the phosphor is provided on said convex or concave surfaces by for example spraying or printing related coating methods.

In one implementation the optical component has a substantially hemispherical surface and the phosphor is provided on said hemispherical surface. The optical component can comprise a substantially hemispherical shell and the phosphor is provided on the inner hemispherical surface. Such an arrangement provides environmental protection of the phosphor.

Savant Technologies LLC - 1004.1099

Alternatively, the phosphor is provided on the outer hemispherical surface. In a further embodiment the optical component comprises a substantially spherical shell and the phosphor is provided on at least a part of the inner or outer spherical surfaces. In yet a further implementation the optical component comprises a hollow cylinder and the phosphor is provided on at least a part of the inner or outer surfaces.

Preferably, the phosphor comprises a powder which is incorporated within an epoxy resin, a silicone material or a polymer material to form a mixture and then the phosphor mixture is applied to the optical component to form a layer of phosphor on the optical component surface. To ensure a uniform light intensity output the phosphor mixture advantageously further comprises a light diffusing material.

Preferably, the optical component is fabricated from a plastics material or a glass.

The phosphor advantageously comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group comprising Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group comprising F, Cl, Br, I, P, S and N.

According to third aspect of the invention there is provided a method of fabricating a lighting arrangement comprising: providing a radiation source configured to emit radiation having a first wavelength range and an optical component through which said radiation passes; and providing on a surface of the optical component a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range.

Advantageously the method further comprises providing the phosphor as a substantially uniform thickness layer on said surface of the optical component.

The optical component can have a substantially planar surface, convex or concave surfaces and the method comprises providing the phosphor on said substantially planar surface, convex or concave surfaces.

In one implementation the optical component has a substantially hemispherical surface and the method comprises providing the phosphor on said hemispherical surface. Preferably, the optical component comprises a substantially hemispherical shell and the method comprises providing the phosphor on the inner or outer hemispherical surfaces. Alternatively, the optical component can comprise a substantially spherical shell and the method comprises providing the phosphor on at least a part of the inner or outer spherical surfaces. In a further alternative arrangement the optical component comprises a hollow cylinder and the method comprises providing the phosphor on at least a part of the inner or outer surfaces.

The optical component is preferably fabricated from a plastics material or glass.

According to a further aspect of the invention there is provided a method of fabricating an optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component being configured such that at least said first wavelength range radiation passes through the optical component the method comprising providing said phosphor on a surface of the optical component.

To ensure uniform color conversion the method advantageously comprises providing the phosphor as a substantially uniform thickness layer.

When the optical component has a substantially planar surface the method preferably comprises providing the phosphor on said substantially planar surface.

Alternatively where the optical component has a convex or concave surface the method can comprise providing the phosphor on said convex or concave surfaces.

In yet a further alternative arrangement the optical component has a substantially hemispherical surface and the method comprises providing the phosphor on said hemispherical surface. Where the optical component comprises a substantially hemispherical shell the method

comprises providing the phosphor on the inner or outer hemispherical surfaces. Moreover where the optical component comprises a substantially spherical shell the method comprises providing the phosphor on at least a part of the inner or outer spherical surfaces. Alternatively the optical component can comprise a hollow cylinder and the method comprises providing the phosphor on at least a part of the inner or outer surfaces.

In a preferred method the phosphor comprises a powder and the method comprises incorporating the phosphor within an epoxy resin or silicone material or polymer material to form a mixture and then applying the phosphor mixture to the optical component to form a layer of phosphor on the optical component surface. The mixture can be applied by painting the mixture onto the surface of the optical component, spraying or other known deposition techniques. When the phosphor is to be applied to a planar surface the optical component is then advantageously spun or tape casting to distribute the mixture uniformly over the surface to thereby ensure a uniform thickness of phosphor forms.

Advantageously the method further comprises incorporating a light diffusing material, for example titanium oxide, silica, alumina in the phosphor mixture. Alternatively the light diffusing material can be provided as a separate layer.

Advantageously, the phosphor comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group comprising Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group comprising F, Cl, Br, I, P, S and N.

The method further comprises fabricating the optical component from a plastics material or glass.

For ease of fabrication, and in accordance with a particularly preferred method of the invention a plurality of optical components in the form of an array, said array of optical components having a common planar surface, and said phosphor is deposited on the planar surface. Advantageously, the phosphor is provided as a substantially uniform thickness layer on

said planar surface of the array of optical components.

In accordance with a further aspect of the invention there is provided a phosphor material for coating an optical component of an LED comprising a phosphor powder incorporated within an epoxy resin, a silicone material or a polymer material. Advantageously the phosphor material further incorporates a light diffusing material.

In accordance with yet a further aspect of the invention there is provided an optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component being configured such that at least said first wavelength range radiation passes through the optical component, and characterized in that said phosphor is incorporated in said optical component.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic representation of a known white LED as already described;

Figures 2 to 7 are schematic representations of LED lighting arrangements in accordance with the invention; and

Figure 8 is a schematic representation of a method of fabricating an optical component for an LED lighting arrangement in accordance with the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

In order that the present invention is better understood, embodiments of the invention will now be described by way of example only with reference to the accompanying drawings.

Referring to Figure 2 there is shown a LED lighting arrangement 20 in accordance with the invention. The LED lighting arrangement 20 is for generating light of a selected color for

example white light. The lighting arrangement comprises a LED chip 22, preferably a Gallium Nitride chip, which is operable to produce light, radiation, preferably of wavelength in a range 300 to 500nm. The LED chip 22 is mounted inside a stainless steel enclosure or reflection cup 24 which has metallic silver deposited on its inner surface to reflect light towards the output of the lighting arrangement. A convex lens 26 is provided to focus light output from the arrangement. In the example illustrated the lens 26 is substantially hemispherical in form. The lens 26 can be made of a plastics material such as polycarbonates or glass such as silica based glass or any material substantially transparent to the wavelengths of light generated by the LED chip 22.

In the embodiment in Figure 2 the lens 26 has a planar, substantially flat, surface 28 onto which there is provided a layer of phosphor 30 before the lens is mounted to the enclosure 22. The phosphor 30 preferably comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group comprising Sr (Strontium), Ca (Calcium), Ba (Barium), Mg (Magnesium), Zn (Zinc) and Cd (Cadmium) and D is a dopant selected from the group comprising F (Fluorine), Cl (Chlorine), Br (Bromine), I (Iodine), P (Phosphorous), S (Sulfur) and N (Nitrogen) as disclosed in our co-pending patent application US 2006/0028122 the content of which is hereby incorporated by way of reference thereto. The phosphor which is in the form of a powder is mixed with an adhesive material such as epoxy or a silicone resin, or a transparent polymer material and the mixture is then applied to the surface of the lens to provide the phosphor layer 30. The mixture can be applied by painting, dropping or spraying or other deposition techniques which will be readily apparent to those skilled in the art. Moreover the phosphor mixture preferably further includes a light diffusing material such as titanium oxide, silica or alumina to ensure a more uniform light output.

The color of light emitted from the lighting arrangement can be controlled by appropriate selection of the phosphor composition as well as the thickness of the phosphor layer which will

determine the proportion of output light originating from the phosphor. To ensure a uniform output color the phosphor layer is preferably of uniform thickness and has a typical thickness in a range 20 to 500 μm.

An advantage of the lighting arrangement of the invention is that no phosphor need be incorporated within the encapsulation materials in the LED package. Moreover the color of the light output by the arrangement can be readily changed by providing a different lens having an appropriate phosphor layer. This enables large scale production of a common laser package. Moreover such a lens provides direct color conversion in an LED lighting arrangement.

Referring to Figure 3 there is shown an LED lighting arrangement in accordance with a further embodiment in which the phosphor 30 is provided as a layer on the outer convex surface 32 of the lens 26. In this embodiment the lens 26 is dome shaped in form.

Figure 4 shows an LED lighting arrangement in accordance with a further embodiment in which the lens 26 comprises a substantially hemispherical shell and the phosphor 30 is provided on the inner surface 34 of the lens 26. An advantage of providing the phosphor on the inner surface is that the lens 26 then provides environmental protection for the LED and phosphor. Alternatively the phosphor can be applied as a layer of the outer surface of the lens 26 (not shown).

Figure 5 illustrates an LED arrangement in which the lens 26, optical component, comprises a substantially spherical shell and the phosphor 30 is deposited as a layer on at least a part of the inner 36 or outer spherical 38 surfaces and the LED chip 22 is mounted within the spherical shell. To ensure uniform emission of radiation a plurality of LED chips are advantageously incorporated in which the chip are oriented such that they each emit light in differing directions. Such a form is preferred as a light source for replacing existing incandescent light sources (light bulbs).

Referring to Figure 6 there is shown a further arrangement in which the optical

component 26 comprises a hollow cylindrical form and the phosphor is applied to the inner 40 or outer 42 curved surfaces. In such an arrangement the laser chip preferably comprises a linear array of laser chips that are arranged along the axis of the cylinder. Alternatively the lens 26 can comprise a solid cylinder (not shown).

Figure 7 shows an LED arrangement in which the optical component comprise a solid substantially spherical lens 26 and the phosphor is provided on at least a part of the spherical surface 44. In a preferred arrangement, as illustrated, the phosphor is applied to only a portion of the surface, which surface is then mounted within the volume defined by the enclosure. By mounting the lens 26 in this way this provides environmental protection of the phosphor 30.

Referring to Figure 8 there is shown a preferred method of fabricating lenses in accordance with the invention. An array of lenses 46 is provided in which the lenses have a common planar surface 48 onto which the phosphor 30 is provided. In the example illustrated the lenses 36 are substantially hemispherical in form. After the phosphor has been deposited the lenses can be separated and mounted to the LED assemblies. Such a method is found to be particularly advantageous for mass production of the optical components.

It will be appreciated that the present invention is not restricted to the specific embodiments described and that modifications can be made which are within the scope of the invention. For example although in the foregoing description reference is made to a lens the phosphor can be deposited onto other optical components such as for example a window through which light passes though is not necessarily focused or directed or a waveguide which guides, directs, light. Moreover the optical component can have many forms which will be readily apparent to those skilled in the art.

It will be appreciated that the phosphor and LED chip can be selected depending on the intended application to provide light of a desired color. It is also envisaged to provide two or more phosphor materials to achieve the desired color, spectral content, of emitted light. The

Savant Technologies LLC - 1004.1106

different phosphors can be provided by mixing the powdered material and incorporating them within a single layer or alternatively by providing multiple layers of different phosphors.

Examples of preferred phosphors are:

- YAG-based phosphors which comprising a photoluminescent material having a formula $(YA)_3(AlB)_5(OC)_{12}:Ce^{3+}$ where A is a trivalent metal selected from the group comprising Gd (Gadolinium), Tb (Terbium), La (Lanthanum), Sm (Samarium) or divalent metal ions such as Sr (Strontium), Ca (Calcium), Ba (Barium), Mg (Magnesium), Zn (Zinc) and Cd (Cadmium), B comprising Si (Silicon), B (Boron), P (phosphorous), and Ga (Gadolinium) and C is a dopant selected from the group comprising F (Fluorine), Cl (Chlorine), Br (Bromine), I (Iodine), P (phosphorous), S (Sulfur) and N (Nitrogen);
- orange-red silicate-based phosphors of general formula $(SrM1)_3Si(OD)_5:Eu$ where M1 is selected from the group comprising Ba, Ca, Mg, Zn.. and D is selected from the group comprising F, Cl, S, and N (such a phosphor can be used for emitting light in a wavelength range from green to yellow (580 to 630nm));
- red silicon nitride based phosphors of general formula of $(SrM1)Si_5N_8$ where M1 is selected from the group comprising Sr, Ca, Mg, and Zn;
- red sulfate based phosphors having a general formula (SrM1)S where M1 is selected from the group comprising Ca, Ba, and Mg; and
- green sulfate based phosphors having a general formula $(SrM1)(GaM2)_2S_4:Eu$ where M1 is selected from the group comprising Ca, Ba, and Mg, and where M2 is selected from the group comprising Al and In.

In addition to providing an LED lighting arrangement the invention further provides a novel optical component and method of fabrication thereof.

In a further embodiment it is also envisaged to incorporate the phosphor within material

comprising the optical component. Moreover the phosphor can be provided as a layer on the encapsulating material.

WHAT IS CLAIMED IS:

1. A lighting arrangement comprising: a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and an optical component through which at least said first wavelength range radiation passes, characterized in that the phosphor is provided on a surface of the optical component.

2. The lighting arrangement according to Claim 1, in which the phosphor is provided as a substantially uniform thickness layer on said surface of the optical component.

3. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component has a substantially planar surface and the phosphor is provided on said substantially planar surface.

4. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component has a convex surface and the phosphor is provided on said convex surface.

5. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component has a concave surface and the phosphor is provided on said concave surface.

Savant Technologies LLC - 1004.1109

6. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component has a substantially hemispherical surface and the phosphor is provided on said hemispherical surface.

7. The lighting arrangement according to Claim 6, in which the optical component comprises a substantially hemispherical shell and the phosphor is provided on the inner hemispherical surface.

8. The lighting arrangement according to Claim 6, in which the optical component comprises a substantially hemispherical shell and the phosphor is provided on at least a part of the outer hemispherical surface.

9. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component comprises a substantially spherical shell and the phosphor is provided on at least a part of the inner spherical surface.

10. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component comprises a substantially spherical shell and the phosphor is provided on at least a part of the outer spherical surface.

11. The lighting arrangement according to Claim 1 or Claim 2, in which the optical component comprises a hollow cylinder and the phosphor is provided on at least a part of the inner surface.

12. The lighting arrangement according to Claim 1 or Claim 2, in which the optical

Savant Technologies LLC - 1004.1110

component comprises a hollow cylinder and the phosphor is provided on at least a part of the outer surface.

13. The lighting arrangement according to Claim 1 to 2, in which the optical component is made from one of a plastics material, glass.

14. The lighting arrangement according to Claim 1, in which the phosphor comprises a powder which is incorporated within one of an epoxy resin, a silicone material and a polymer material to form a mixture and in which the phosphor mixture is applied to the optical component to form a layer of phosphor on the optical component surface.

15. The lighting arrangement according to Claim 14, and further comprising incorporating a light diffusing material with the phosphor powder.

16. The lighting arrangement according to any of claims 1, 2, 14 or 15, in which the phosphor comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group consisting of Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

17. The lighting arrangement according to any one of Claims1, 2, 14 or 15, in which the phosphor comprises a photoluminescent material having a formula $(YA)_3(AlB)_5(OC)_{12}:Ce^{3+}$ where A is a trivalent metal selected from the group consisting of Gd, Tb, La, Sm or divalent metal ions such as Sr, Ca, Ba, Mg, Zn

Savant Technologies LLC - 1004.1111

and Cd; B is selected from the group consisting of Si, B, P, and Ga; and C is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

18. The lighting arrangement according to any one of Claims1, 2, 14 or 15, in which the phosphor comprises an orange-red silicate-based phosphor having a formula $(SrM1)_3Si(OD)_5$:Eu where M1 is selected from the group consisting of Ba, Ca, Mg, Zn..; and D is selected from the group consisting of F, Cl, S, and N.

19. The lighting arrangement according to any one of Claims1,2 14 or 15, in which the phosphor comprises a red silicon nitride based phosphor having a formula $(SrM1)Si_5N_8$ where M1 is selected from the group consisting Sr, Ca, Mg, and Zn.

20. The lighting arrangement according to any one of Claims1, 2, 14 or 15, in which the phosphor comprises a red sulfate based phosphor having a formula (SrM1)S where M1 is selected from the group consisting of Ca, Ba, and Mg.

21. The lighting arrangement according to any one of Claims1,2 14 or 15, in which the phosphor comprises a green sulfate based phosphor having a formula $(SrM1)(GaM2)_2S_4$:Eu where M1 is selected from the group consisting of Ca, Ba, and Mg, and M2 is selected from the group consisting of Al and In.

22. The lighting arrangement according to Claim 1, in which the radiation source comprises a light emitting diode.

23. The lighting arrangement according to Claim 1, in which said LED chip

comprises a Gallium Nitride LED.

24. The lighting arrangement according to Claim 1, in which said radiation source is operable to emit radiation having a wavelength range of 300 to 500nm.

25. The lighting arrangement according to Claim 1, in which the phosphor is configured to emit radiation having a wavelength ranging from 450 to 700nm.

26. An optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component being configured such that at least said first wavelength range radiation passes though the optical component, and characterized in that said phosphor is provided on a surface of said optical component.

27. The optical component according to Claim 26, in which the phosphor is provided as a substantially uniform thickness layer on said surface of the optical component.

28. The optical component according to Claim 26 or Claim 27, in which the optical component has a substantially planar surface and the phosphor is provided on said substantially planar surface.

29. The optical component according to Claim 26 or Claim 27, in which the optical

component has a convex surface and the phosphor is provided on said convex surface.

30. The optical component according to Claim 26 or Claim 27, in which the optical component has a concave surface and the phosphor is provided on said concave surface.

31. The optical component according to Claim 26 or Claim 27, in which the optical component has a substantially hemispherical surface and the phosphor is provided on said hemispherical surface.

32. The optical component according to Claim 31, in which the optical component comprises a substantially hemispherical shell and the phosphor is provided on the inner hemispherical surface.

33. The optical component according to Claim 31, in which the optical component comprises a substantially hemispherical shell and the phosphor is provided on at least a part of the outer hemispherical surface.

34. The optical component according to Claim 26 or Claim 27, in which the optical component comprises a substantially spherical shell and the phosphor is provided on at least a part of the inner spherical surface.

35. The optical component according to Claim 26 or Claim 27, in which the optical component comprises a substantially spherical shell and the phosphor is provided

Savant Technologies LLC - 1004.1114

on at least a part of the outer spherical surface.

36. The optical component according to Claim 26 or Claim 27, in which the optical component comprises a hollow cylinder and the phosphor is provided on at least a part of the inner surface.

37. The optical component according to Claim 26 or Claim 27 in which the optical component comprises a hollow cylinder and the phosphor is provided on at least a part of the outer surface.

38. The optical component according to Claim 26 or 27, in which the phosphor comprises a powder which is incorporated within one of an epoxy resin, a silicone material and a polymer material to form a mixture and in which the phosphor mixture is applied to the optical component to form a layer of phosphor on the optical component surface.

39. The optical component according to Claim 38, and further comprising a light diffusing material with the phosphor powder.

40. The optical component according to Claim 26 or 27, in which the optical component is fabricated from one of a plastics material, a glass.

41. The optical component according to Claim 26 or 27 in which the phosphor comprises a photoluminescent material having a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group consisting of Sr, Ca, Ba, Mg, Zn and

Savant Technologies LLC - 1004.1115

Cd and D is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

42. The optical component according to Claim 26 or 27, in which the phosphor comprises a photoluminescent material having a formula $(YA)_3(AlB)_5(OC)_{12}:Ce^{3+}$ where A is a trivalent metal selected from the group consisting of Gd, Tb, La, Sm or divalent metal ions such as Sr, Ca, Ba, Mg, Zn and Cd; B is selected from the group Si, B, P, and Ga; and C is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

43. The optical component according to Claim 26 or 27, in which the phosphor comprises an orange-red silicate-based phosphor having a formula $(SrM1)_3Si(OD)_5:Eu$ where M1 is selected from the group consisting of Ba, Ca, Mg, and Zn, and D is selected from the group consisting of F, Cl, S, and N.

44. The lighting arrangement according to Claim 26 or 27, in which the phosphor comprises a red silicon nitride based phosphor having a formula $(SrM1)Si_5N_8$ where M1 is selected from the group consisting of Sr, Ca, Mg, and Zn.

45. The lighting arrangement according to Claim 26 or 27, in which the phosphor comprises a red sulfate based phosphor having a formula (SrM1)S where M1 is selected from the group consisting of Ca, Ba, and Mg.

46. The lighting arrangement according to Claim 26 or 27, in which the phosphor comprises a green sulfate based phosphor having a formula $(SrM1)(GaM2)_2S_4:Eu$

Savant Technologies LLC - 1004.1116

where M1 is selected from the group consisting of Ca, Ba, and Mg, and M2 is selected from the group consisting of Al and In.

47. A method of fabricating a lighting arrangement comprising: providing a radiation source configured to emit radiation having a first wavelength range and an optical component through which said radiation passes; and providing on a surface of the optical component a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range.

48. The method according to Claim 47, and comprising providing the phosphor as a substantially uniform thickness layer on said surface of the optical component.

49. The method according to Claim 47 or Claim 48, in which the optical component has a substantially planar surface and comprising providing the phosphor on said substantially planar surface.

50. The method according to Claim 47 or Claim 48, in which the optical component has a convex surface and comprising providing the phosphor on said convex surface.

51. The method according to Claim 47 or Claim 48, in which the optical component has a concave surface and comprising providing the phosphor on said concave surface.

Savant Technologies LLC - 1004.1117

52. The method according to Claim 47 or Claim 48, in which the optical component has a substantially hemispherical surface and comprising providing the phosphor on said hemispherical surface.

53. The method according to Claim 52, in which the optical component comprises a substantially hemispherical shell and comprising providing the phosphor on the inner hemispherical surface.

54. The method according to Claim 52, in which the optical component comprises a substantially hemispherical shell and comprising providing the phosphor on at least a part of the outer hemispherical surface.

55. The method according to Claim 47 or Claim 48, in which the optical component comprises a substantially spherical shell and comprising providing the phosphor on at least a part of the inner spherical surface.

56. The method according to Claim 47 or Claim 48, in which the optical component comprises a substantially spherical shell and comprising providing the phosphor on at least a part of the outer spherical surface.

57. The method according to Claim 47 or Claim 48, in which the optical component comprises a hollow cylinder and comprising providing the phosphor on at least a part of the inner surface.

58. The method according to Claim 47 or Claim 48, in which the optical component

Savant Technologies LLC - 1004.1118

comprises a hollow cylinder and comprising providing the phosphor on at least a part of the outer surface.

59. The method according to Claim 47 or 48 in which the optical component is fabricated from one of a plastics material, a glass.

60. A method of fabricating an optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component being configured such that at least said first wavelength range radiation passes through said optical component, the method comprising providing said phosphor on a surface of the optical component.

61. The method according to Claim 60, and comprising providing the phosphor as a substantially uniform thickness layer.

62. The method according to Claim 60 or Claim 61, in which the optical component has a substantially planar surface and comprising providing the phosphor on said substantially planar surface.

63. The method according to Claim 60 or Claim 61, in which the optical component has a convex surface and comprising providing the phosphor on said convex surface.

Savant Technologies LLC - 1004.1119

64. The method according to Claim 60 or Claim 61, in which the optical component has a concave surface and comprising providing the phosphor on said concave surface.

65. The method according to Claim 60 or Claim 61, in which the optical component has a substantially hemispherical surface and comprising providing the phosphor on said hemispherical surface.

66. The method according to Claim 65, in which the optical component comprises a substantially hemispherical shell and comprising providing the phosphor on the inner hemispherical surface.

67. The method according to Claim 65, in which the optical component comprises a substantially hemispherical shell and comprising providing the phosphor on at least a part of the outer hemispherical surface.

68. The method according to Claim 60 or 61, in which the optical component comprises a substantially spherical shell and comprising providing the phosphor on at least a part of the inner spherical surface.

69. The method according to Claim 60 or 61, in which the optical component comprises a substantially spherical shell and comprising providing the phosphor on at least a part of the outer spherical surface.

70. The method according to Claim 60 or 61, in which the optical component

Savant Technologies LLC - 1004.1120

comprises a hollow cylinder and comprising providing the phosphor on at least a part of the inner surface.

71. The method according to Claim 60 or 61, in which the optical component comprises a hollow cylinder and comprising providing the phosphor on at least a part of the outer surface.

72. The method according to Claim 60 or 61, in which the phosphor comprises a powder and comprising incorporating the phosphor within one of a epoxy resin, silicone material, polymer material to form a mixture and applying the phosphor mixture to the optical component to form a layer of phosphor on the optical component surface.

73. The method according to Claim 60, and further comprising incorporating a light diffusing material with the phosphor powder.

74. The method according to any one of Claims 60, 61 or 73, in which the phosphor comprises a photoluminescent materials have a formula $A_2SiO_4:Eu^{2+}D$ where A is a divalent metal selected from the group consisting of Sr, Ca, Ba, Mg, Zn and Cd and D is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

75. The lighting arrangement according to any one of Claims 60, 61 or 73, in which the phosphor comprises a photoluminescent material having a formula $(YA)_3(AlB)_5(OC)_{12}:Ce^{3+}$ where A is a trivalent metal selected from the group

Savant Technologies LLC - 1004.1121

consisting of Gd, Tb, La, Sm or divalent metal ions such as Sr, Ca, Ba, Mg, Zn and Cd; B is selected from the group consisting of Si, B, P, and Ga; and C is a dopant selected from the group consisting of F, Cl, Br, I, P, S and N.

76. The lighting arrangement according to any one of Claims 60, 61 or 73, in which the phosphor comprises an orange-red silicate-based phosphor having a formula $(SrM1)_3Si(OD)_5$:Eu where M1 is selected from the group consisting of Ba, Ca, Mg, and Zn, and D is selected from the group consisting of F, Cl, S, and N.

77. The lighting arrangement according to any one of Claims 60, 61 or 73, in which the phosphor comprises a red silicon nitride based phosphor having a formula $(SrM1)Si_5N_8$ where M1 is selected from the group consisting of Sr, Ca, Mg, and Zn.

78. The lighting arrangement according to any one of Claims 60, 61 or 73, in which the phosphor comprises a red sulfate based phosphor having a formula (SrM1)S where M1 is selected from the group consisting of Ca, Ba, and Mg.

79. The lighting arrangement according to any one of Claim 60, 61 or 73, in which the phosphor comprises a green sulfate based phosphor having a formula $(SrM1)(GaM2)_2S_4$:Eu where M1 is selected from the group consisting of Ca, Ba, and Mg, and M2 is selected from the group consisting of Al, and In.

80. The method according to any one of Claims 60, 61 or 73, and comprising fabricating the optical component from one of a plastics material, glass.

Savant Technologies LLC - 1004.1122

81. The method according to Claim 60 and further comprising providing a plurality of optical components in the form of an array said array of optical components having a common planar surface and depositing said phosphor on the planar surface.

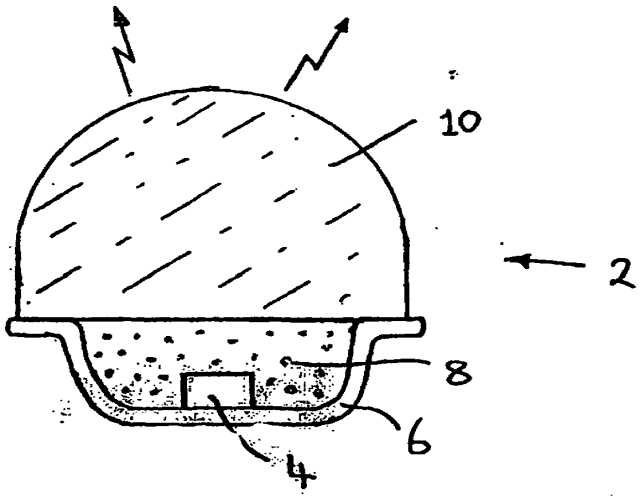
82. The method according to Claim 81, and comprising providing the phosphor as a substantially uniform thickness layer on said planar surface of the array of optical components.

83. A phosphor material for coating an optical component of an LED lighting arrangement comprising a phosphor powder incorporated within one of an epoxy resin, a silicone material and a polymer material.

84 The phosphor material according to Claim 83 and further comprising a light diffusing material.

85. An optical component for a lighting arrangement of a type comprising a radiation source configured to emit radiation having a first wavelength range; a phosphor configured to absorb at least a portion of said first wavelength range radiation and emit radiation having a second wavelength range; and said optical component being configured such that at least said first wavelength range radiation passes through said optical component, and characterized in that said phosphor is incorporated in said optical component.

Savant Technologies LLC - 1004.1123



PRIOR ART

Figure 1.

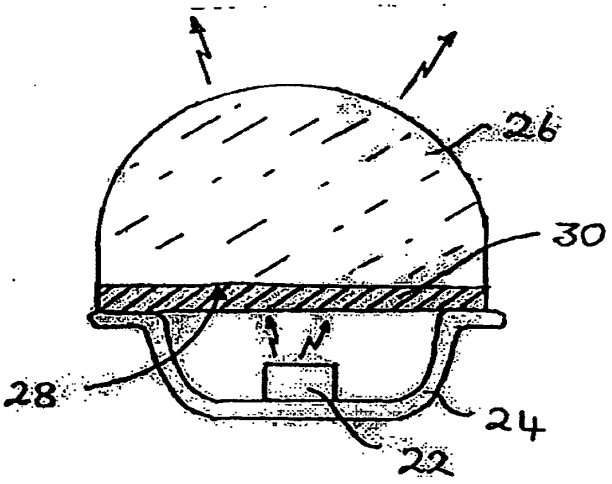


Figure 2.

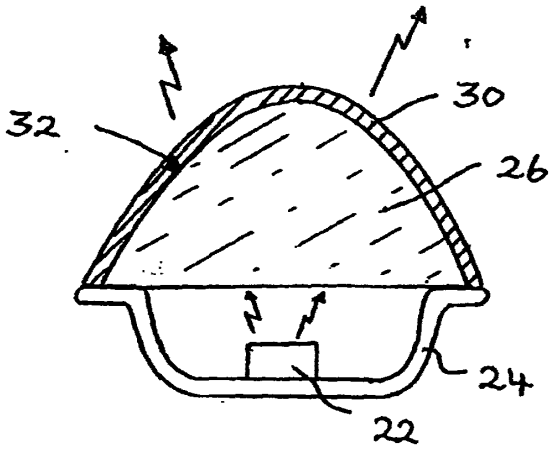


Figure 3

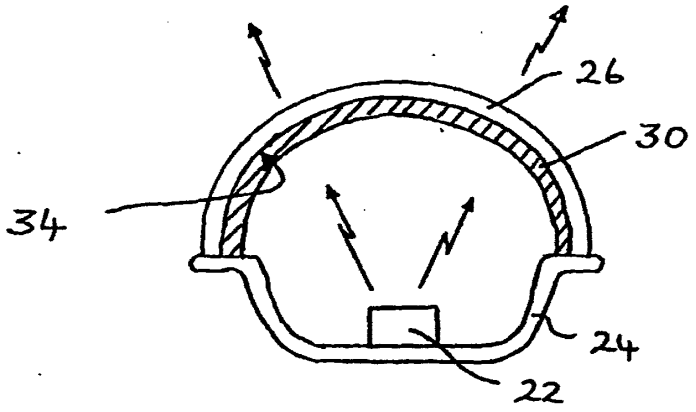


Figure 4

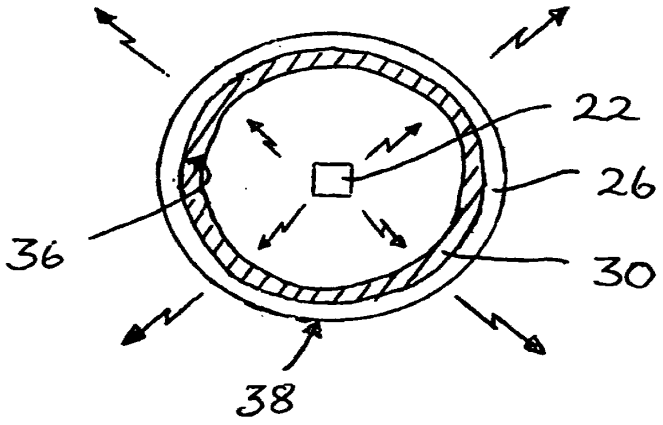


Figure 5.

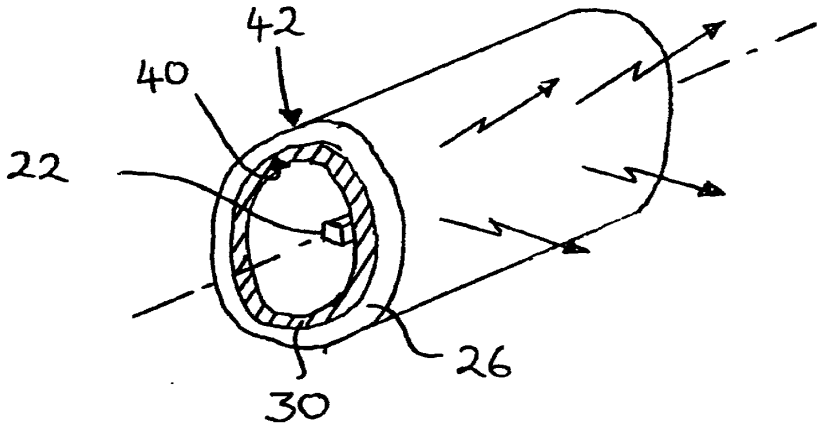


Figure 6.

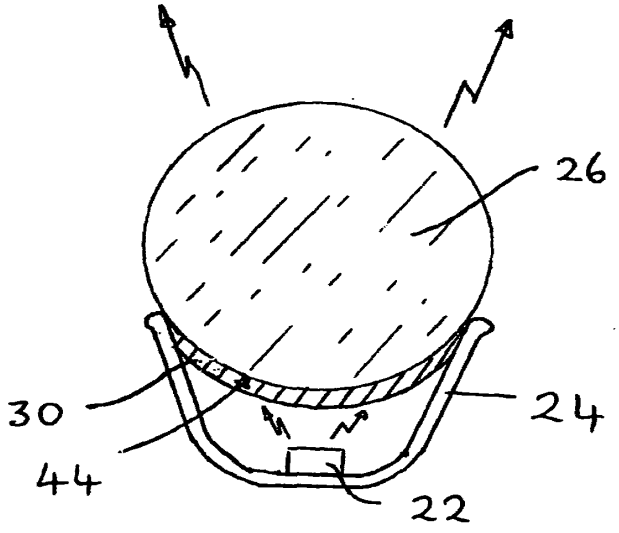


Figure 7.

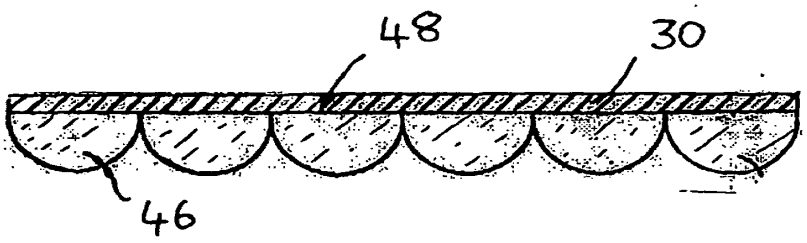


Figure 8.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)
(PCT Rule 44bis.1(c))

To:

ROBINSON, Ross, T.
Winstead PC
P.O. Box 131851
Dallas, TX 75313
ETATS-UNIS D'AMERIQUE

51626-P248WO

Date of mailing *(day/month/year)* 18 April 2013 (18.04.2013)	
Applicant's or agent's file reference ITMX00307WO0	IMPORTANT NOTICE

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2011/054827	04 October 2011 (04.10.2011)	05 October 2010 (05.10.2010)

Applicant
INTEMATIX CORPORATION et al

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

DOCKETED
MAY 01 2013
By:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Yolaine Cussac

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference ITMX00307WO0	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2011/054827	International filing date *(day/month/year)* 04 October 2011 (04.10.2011)	Priority date *(day/month/year)* 05 October 2010 (05.10.2010)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant INTEMATIX CORPORATION		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 09 April 2013 (09.04.2013)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Yolaine Cussac e-mail: pt05.pct@wipo.int

Form PCT/IB/373 (January 2004)

Savant Technologies LLC - 1004.1130

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: PETER C. MEI
VISTA IP LAW GROUP, LLP
1885 LUNDY AVE., STE. 108
SAN JOSE, CA 95131

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	26 JAN 2012
Applicant's or agent's file reference: ITMX00307WO0	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 11/54827	04 October 2011 (04.10.2011)	05 October 2010 (05.10.2010)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - G09G 3/34 (2011.01)
USPC - 345/84

Applicant INTEMATIX CORPORATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1 *bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Fom PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	10 January 2012 (10.01.2012)	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (July 2011)

Savant Technologies LLC - 1004.1131

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/54827

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Savant Technologies LLC - 1004.1132

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/54827

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	2, 3 and 15	YES
	Claims	1, 4-14 and 16-24	NO
Inventive step (IS)	Claims	none	YES
	Claims	1-24	NO
Industrial applicability (IA)	Claims	1-24	YES
	Claims	none	NO

2. Citations and explanations:

Claims 1, 4-14 and 16-24 lack novelty under PCT Article 33(2) as being anticipated by US 2009/0272996 A1 to Chakraborty.

Regarding claim 1, Chakraborty discloses a light emitting device (LED device 200, para. [0027], Fig. 2) comprising: at least one solid-state light emitter operable to generate excitation light (LED chip 202 is disposed on a mount surface; LED 202 can emit light of different colors and can also emit radiation outside the visible spectrum, such as infrared or ultraviolet, para. [0027]); and a photoluminescence wavelength conversion component (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032], [0055] through [0058], [0082], [0085], [0087], [0092] through [0095]) comprising a mixture of particles of at least one photoluminescence material (phosphor comprises many different compositions and phosphor materials alone or in combination, para. [0028] through [0041]) and particles of a light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]).

Regarding claim 4, Chakraborty discloses the light emitting device of claim 1, wherein the light reflective material has a particle size in a range selected from the group consisting of: 0.01u to 10un; 0.01un to 1un and 0.1um to 1um (nanoparticles and light scattering particles proximate to the light source. Nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]).

Regarding claim 5, Chakraborty discloses the light emitting device of claim 1, wherein a weight percent loading of light reflective material (light scattering particles (LSPs) 210) to the at least one photoluminescence material (phosphor) is in a range selected from the group consisting of: .01% to 10%; 0.01% to 1%; 0.1% to 1% and 0.5% to 1% (e.g.: if the conversion layer material has a RI of 1.5 and the target effective RI is 1.7, then the conversion layer 204 should comprise approximately 20% TiO.sub.2 nanoparticles by volume; other material combinations and compositions may also be used; e.g.: some embodiments may have greater than 5% nanoparticles by volume; other embodiments may have greater than 10% nanoparticles by volume; other embodiments may include 20-40% by volume nanoparticle loading; various percentages of composition of the LSPs 210 can be used as dictated by the application; depending on the materials used, the LSPs 210 will typically be found in concentrations ranging from 0.01% to 5% by volume; other concentrations can be used; however, the loss due to absorption increases with the concentration of the scattering particles; concentrations of the LSPs should be chosen in order to maintain an acceptable loss figure, para. [0057], [0083]).

See Continuation Sheet.

Savant Technologies LLC - 1004.1133

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/54827

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
Box V, item 2. Citations and explanations.

Regarding claim 6, Chakraborty discloses the light emitting device of claim 1, wherein the light reflective material (light scattering particles (LSPs) 210, para. [0060]) is selected from the group consisting of: titanium dioxide (para. [0060], [0065]), barium sulfate (para. [0060], [0066]) and combinations thereof (para. [0060], [0079]).

Regarding claim 7, Chakraborty discloses the light emitting device of claim 1, wherein the wavelength conversion component (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032], [0055] through [0058], [0082], [0085], [0087], [0092] through [0095]) is selected from the group consisting of:
a light transmissive substrate on which the mixture of photoluminescence material and light reflective material is provided as at least one layer (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082] and [0086]);
a light transmissive substrate configured as a light guide and wherein the mixture of photoluminescence material and light reflective material is provided on at least a part of a face of the light guide (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082] and [0086]); and
a light reflective surface on which the mixture of the photoluminescence material and light reflective material are provided as at least one layer (textured light emission surface 214, the LED chip 202 has a reflective element 216 such as a layer of reflective material; reflective element 216 redirects some of the light generated in the LED chip 202 back towards the textured light emission surface 214; reflective element 214 may comprise a thick silver mirror, para. [0086]).

Regarding claim 8, Chakraborty discloses the light emitting device of claim 1, wherein the at least one solid-state light emitter comprises an LED that is operable to generate blue excitation light having a peak wavelength in a wavelength range 440nm to 480nm (wavelength of light emitted from the LED chip 202 e.g., about.450 nm for a blue emitter, para. [0056]).

Regarding claim 9, Chakraborty discloses the light emitting device of claim 1, wherein the mixture of the photoluminescence material and the light reflective material is distributed over an area of at least 0.8cm^2 (LED devices can be formed from a single wafer; e.g.: when fabricating LED devices having a 1 millimeter (mm) square size, up to 4500 LED devices can be fabricated on a 3 inch wafer, para. [0096], [0098]).

Regarding claim 10, Chakraborty discloses the light emitting device of claim 1, wherein the particles of the light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]) corresponds to a particle size (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]) such that the particles scatter excitation light relatively more than light generated by the at least one phosphor material (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082]).

Regarding claim 11, Chakraborty discloses the light emitting device of claim 1, further comprising a light diffusing layer that is adjacent to the photoluminescence wavelength conversion component (LED chip 202 has a textured light emission surface 214 included to increase light extraction from the LED chip 202 by reducing total internal reflection (TIR), para. [0008], [0009], [0011], [0013], [0086] through [0090], [0099]).

See Continuation Sheet.

Savant Technologies LLC - 1004.1134

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box V, item 2. Citations and explanations.

Regarding claim 12, Chakraborty discloses the light emitting device of claim 11, in which the light diffusing layer (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032], [0055] through [0058], [0082], [0085], [0087], [0092] through [0095]) comprises particles of light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]) corresponding to a particle size (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]) such that the particles scatter excitation light relatively more than light generated by the at least one photoluminescence material (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082]).

Regarding claim 13, Chakraborty discloses the light emitting device of claim 12, wherein the light reflective material has a particle size in a range 100nm to 150nm (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]).

Regarding claim 14, Chakraborty discloses the light emitting device of claim 1, in which the at least one photoluminescence material comprises phosphor (phosphor comprises many different compositions and phosphor materials alone or in combination, para. [0028] through [0041], [0060] through [0079]).

Regarding claim 16, Chakraborty discloses a wavelength conversion component (conversion layer 204 phosphor particles are dispersed throughout a binder material 206 such as silicone; refractive index (RI) of the phosphor particles and the RI of the binder 206 can be the same, or they can be different, para. [0041] through [0058]) for a solid-state light emitting device (LED device 200; LED chip 202 is disposed on a mount surface; LED 202 can emit light of different colors and can also emit radiation outside the visible spectrum, such as infrared or ultraviolet, para. [0027], Fig. 2) comprising a mixture of particles of at least one photoluminescence material (phosphor comprises many different compositions and phosphor materials alone or in combination, para. [0028] through [0041]) and particles of a light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]).

Regarding claim 17, Chakraborty discloses the wavelength conversion component of claim 16, wherein the light reflective material has a particle size in a range selected from the group consisting of: 0.01um to 10un; 0.01un to 1um and 0.1 to 1um (nanoparticles and light scattering particles proximate to the light source. Nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]).

Regarding claim 18, Chakraborty discloses the wavelength conversion component of claim 16, wherein a weight percent loading of light reflective material (light scattering particles (LSPs) 210) to the at least one photoluminescence material (phosphor) is in a range selected from the group consisting of: 0.01% to 10%; 0.01% to 1%; 0.1% to 1% and 0.5% to 1% (e.g.: if the conversion layer material has a RI of 1.5 and the target effective RI is 1.7, then the conversion layer 204 should comprise approximately 20% TiO.sub.2 nanoparticles by volume; other material combinations and compositions may also be used; e.g.: some embodiments may have greater than 5% nanoparticles by volume; other embodiments may have greater than 10% nanoparticles by volume; other embodiments may include 20-40% by volume nanoparticle loading; various percentages of composition of the LSPs 210 can be used as dictated by the application; depending on the materials used, the LSPs 210 will typically be found in concentrations ranging from 0.01% to 5% by volume; other concentrations can be used; however, the loss due to absorption increases with the concentration of the scattering particles; concentrations of the LSPs should be chosen in order to maintain an acceptable loss figure, para. [0057], [0083]).

See Continuation Sheet.

Savant Technologies LLC - 1004.1135

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US 11/54827

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
Box V, item 2. Citations and explanations.

Regarding claim 19, Chakraborty discloses the wavelength conversion component of claim 16, wherein the wavelength conversion component (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032], [0055] through [0058], [0082], [0085], [0087], [0092] through [0095]) is selected from the group consisting of:
a light transmissive substrate on which the mixture of the at least one photoluminescence material and light reflective material are provided as at least one layer (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082] and [0086]);
a light transmissive substrate configured as a light guide and wherein the mixture of photoluminescence material and light reflective material is provided on at least a part of a face of the light guide (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082] and [0086]); and
a light reflective surface on which the mixture of the photoluminescence material and light reflective material are provided as at least one layer (textured light emission surface 214, the LED chip 202 has a reflective element 216 such as a layer of reflective material; reflective element 216 redirects some of the light generated in the LED chip 202 back towards the textured light emission surface 214; reflective element 214 may comprise a thick silver mirror, para. [0086]).

Regarding claim 20, Chakraborty discloses the wavelength conversion component of claim 16, wherein the mixture of the at least one photoluminescence material and the light reflective material are distributed over an area of at least 0.8cm^2 (LED devices can be formed from a single wafer; e.g.: when fabricating LED devices having a 1 millimeter (mm) square size, up to 4500 LED devices can be fabricated on a 3 inch wafer, para. [0096], [0098]).

Regarding claim 21, Chakraborty discloses the wavelength conversion component of claim 16, wherein the particles of the light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]) corresponds to a particle size (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]) such that the particles scatter excitation light relatively more than light generated by the at least one phosphor material (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082]).

Regarding claim 22, Chakraborty discloses the wavelength conversion component of claim 21, wherein the light reflective material has a particle size in a range 100nm to 150nm (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]).

Regarding claim 23, Chakraborty discloses the wavelength conversion component of claim 16, further comprising a light diffusing layer that is adjacent to the photoluminescence wavelength conversion component (LED chip 202 has a textured light emission surface 214 included to increase light extraction from the LED chip 202 by reducing total internal reflection (TIR), para. [0008], [0009], [0011], [0013], [0086] through [0090], [0099]).

See Continuation Sheet.

Savant Technologies LLC - 1004.1136

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Box V, item 2. Citations and explanations.

Regarding claim 24, Chakraborty discloses the wavelength conversion component of claim 23, in which the light reflective layer (conversion layer 204) comprises particles of light reflective material (light scattering particles; light extraction efficiency and the color temperature distribution uniformity are improved by the introduction of both nanoparticles and light scattering particles proximate to the light source; light scattering particles (LSPs) 210 are disposed proximate to the LED chip 202; strikes one or more of the scattering particles 210 the index of refraction differential between the medium and the particles 210 causes the light to refract and travel in a different direction, para. [0021], [0058] through [0084]) corresponding to a particle size (nanoparticles and light scattering particles proximate to the light source; nanoparticles having a high index of refraction are dispersed throughout a wavelength conversion layer to adjust the index of refraction of the layer for improved light extraction, para. [0021], [0056], [0057], [0089], [0093], [0095], [0103]) such that the particles scatter excitation light relatively more than light generated by the at least one phosphor material (LSPs 210 can be dispersed throughout various elements so long as they are proximate to the LED chip 202 such that substantially all of the emitted light has a probability of interacting with the LSPs 210; e.g. LSPs 210 are disposed throughout the binder material 206 along with the nanoparticles 208 and the phosphor; conversion layer 204 is disposed on the LED chip 202, substantially all of the emitted light travels through the conversion layer where the LSPs 210 are dispersed before being emitted from the device 200, para. [0082]).

Claims 2 and 3 lack an inventive step under PCT Article 33(3) as being obvious over Chakraborty.

Regarding claim 2, Chakraborty discloses the light emitting device of claim 1, wherein an area over which the mixture of photoluminescence material and light reflective material is distributed (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032]) is larger than the light emitting area of the light emitter (LED chip 202 is disposed on a mount surface; LED 202 can emit light of different colors and can also emit radiation outside the visible spectrum, such as infrared or ultraviolet, para. [0027], illustrated, Fig. 2, 5), yet fails to disclose wherein an area over which the mixture of photoluminescence material and light reflective material is distributed is at least fifty times the light emitting area of the light emitter. However, since the manufacturing methods used by Chakraborty include physical/chemical deposition techniques, electroplating, electrophoretic deposition, spin coating, spray coating, screen printing, and dispensing (para. [0101] through [0103]), it would have been obvious to one of skill in the art to size the area of distribution of the mixture of photoluminescence material and light reflective material to be least fifty times the light emitting area of the light emitter, since such a modification would have been a matter of routine experimentation. (Chakraborty: para. [0101] through [0103]).

Regarding claim 3, Chakraborty discloses the light emitting device of claim 1, wherein the wavelength conversion component (conversion process takes place in the conversion layer 204 which may be loaded with phosphors; wavelength conversion layer 204 converts a portion of the emitted light to a different wavelength; Yttrium aluminum garnet (YAG) is an example of a common phosphor that may be used, para. [0028] through [0032]) is locatable at a distance of at least 5mm from (conversion layer 708 has a thickness such that it may cover/bury the pedestal 706, para. [0103], [0104], [0105]) the at least one light emitter (LED chip 202 is disposed on a mount surface; LED 202 can emit light of different colors and can also emit radiation outside the visible spectrum, such as infrared or ultraviolet, para. [0027]), yet fails to disclose a distance of at least 5mm. However, it would have been obvious to one of skill in the art to size the distance between the wavelength conversion component and the light emitter to at least 5 mm, since such a modification would have been a matter of routine experimentation.

Claim 15 lacks an inventive step under PCT Article 33(3) as being obvious over Chakraborty in view of US 2007/0240346 A1 to Li et al. (hereinafter Li).

Regarding claim 15, Chakraborty discloses the light emitting device of claim 1, yet fails to disclose wherein the device is configured as a light emitting sign. Li discloses wherein a device configured as a light emitting sign (number of light emitting diodes (LEDs) 4 are provided within the light box 2 and are preferably blue LEDs which emit blue light in a wavelength range 410 to 470 nm; layer of phosphor material 6, photo luminescent material, is provided on an under surface, that is the surface facing the LEDs, excitable by the radiation emitted by the LEDs 4; para. [0040] through [0044], Fig. 1). Since both references are directed toward LED lighting, it would have been obvious to one of skill in the art to configure the device of Chakraborty into a light emitting sign as suggested by Li, since such a modification would result in an light emitting sign with greater color saturation. (Li: para. [0044]).

Claims 1-24 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

Savant Technologies LLC - 1004.1137

Electronic Patent Application Fee Transmittal	
Application Number:	13273212
Filing Date:	13-Oct-2011
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Filer:	Peter C. Mei/Tony Nguyen
Attorney Docket Number:	ITMX-00318US1
Filed as Small Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt	
EFS ID:	16874733
Application Number:	13273212
International Application Number:	
Confirmation Number:	8795
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Customer Number:	101130
Filer:	Peter C. Mei/Tony Nguyen
Filer Authorized By:	Peter C. Mei
Attorney Docket Number:	ITMX-00318US1
Receipt Date:	17-SEP-2013
Filing Date:	13-OCT-2011
Time Stamp:	14:14:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$90
RAM confirmation Number	518
Deposit Account	501105
Authorized User	VISTA IP LAW GR
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees) Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	ITMX-00318US1_OA_Response_due_09172013.pdf	137619 362b677a32da9b0993f1d4b7b65e1c765129a9e3	no	13
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	ITMX-00318US1_IDS-sb08-transmittal.pdf	164127 0d936eae7369310536a6070414c6da57693b4c86	no	6
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	JP2001177153A.pdf	376173 4858b622897b06caa852193a98fc9152d833d6d2	no	5
Warnings:					
Information:					
4	Foreign Reference	JP2002133910A.pdf	894536 bb2fc132541d731435b746c50d9abbd0f5e97aa1	no	10
Warnings:					
Information:					
5	Foreign Reference	WO2008019041A2.pdf	758416 c0e6cf3f719c07f4948036b93ac003851ee25530	no	35
Warnings:					
Information:					
6	Non Patent Literature	ITMX-00116CN1_OA_03-19-13.pdf	146411 a47e160b08ed1cae507023980f20fa72e6574acc	no	3
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
7	Non Patent Literature	ITMX-00307WO0_Int-Report-on-Patentability_04-09-13.pdf	311001 f08d4e0872fe6f552668dde0d9309fc1c3769f85	no	10
Warnings:					
Information:					
8	Non Patent Literature	ITMX-00116CN0_Office-Action_05-15-2013.pdf	294533 a17460683cabe3b4b66f5f8d3e6042dc9b7c1bc0	no	7

Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
9	Non Patent Literature	ITMX-00116US4_Non_Final_OA_05-16-13.pdf	1612902 5d9f5ba3bc9941d01b1f41aed5a415e493c0db40	no	32
Warnings:					
Information:					
10	Non Patent Literature	ITMX-00307US1_Non_Final_OA_06-13-13.pdf	843775 0a57211b6c6696c04507dca5e270b68b78e6d423	no	22
Warnings:					
Information:					
11	Non Patent Literature	ITMX-00318US3_Non_Final_OA_06-13-13.pdf	1977777 cc68519ebda4df5f52d7ce8b79c92c6183c30895	no	41
Warnings:					
Information:					
12	Non Patent Literature	ITMX-00318US2_Non_Final_OA_06-14-13.pdf	2073736 a5db0d5093a9858a8f8076ef2f1ffcf052d389b5	no	38
Warnings:					
Information:					
13	Non Patent Literature	ITMX-00116US6_NFOA_07_18_2013.pdf	660578 89ecbc1a18141e5070f89ca8be4b891466e34956	no	18
Warnings:					
Information:					
14	Non Patent Literature	ITMX-00116US1_NFOA_07_25_2013.pdf	2425223 9e1892fc2b167c91a1b0783b54a4fcf2bec54c50	no	48
Warnings:					
Information:					
15	Fee Worksheet (SB06)	fee-info.pdf	30458 f1b21d3272a52c4250f45dbd221b8ae21f1cacc1	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	12707265	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/273,212	Filing Date 10/13/2011	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/17/2013	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 29	Minus	** 29	= 0	X $40 =	0
	Independent (37 CFR 1.16(h))	* 5	Minus	***5	= 0	X $210 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/SONYA HILLIARD/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

101130 7590 09/24/2013

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

EXAMINER
BOWMAN, MARY ELLEN

ART UNIT	PAPER NUMBER
2879	

DATE MAILED: 09/24/2013

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

TITLE OF INVENTION: WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$890	$300	$0	$1190	12/24/2013

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

Savant Technologies LLC - 1004.1145

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

101130 7590 09/24/2013
Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

TITLE OF INVENTION: WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$890	$300	$0	$1190	12/24/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
BOWMAN, MARY ELLEN	2879	313-501000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

Savant Technologies LLC - 1004.1146

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29	NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
❑ Applicant asserting small entity status. See 37 CFR 1.27	NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
❑ Applicant changing to regular undiscounted fee status.	NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

101130 7590 09/24/2013

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

EXAMINER	
BOWMAN, MARY ELLEN	

ART UNIT	PAPER NUMBER
2879	

DATE MAILED: 09/24/2013

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

Savant Technologies LLC - 1004.1148

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 13/273,212	Applicant(s) DAI ET AL.	
	Examiner MARY ELLEN BOWMAN	Art Unit 2879	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *Amendment filed 9/17/13*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-29*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

Savant Technologies LLC - 1004.1150

The present application is being examined under the pre-AIA first to invent provisions.

The present application is being examined under the pre-AIA first to invent provisions.

Allowable Subject Matter

Claims 1-29 are allowed.

The following is an examiner's statement of reasons for allowance: The prior art fails to teach the presently claimed invention comprising the claimed wavelength conversion component and scattering particles. The reasons for allowance are clearly set forth in Applicant's remarks, filed September 13, 2013, and are therefore not herein repeated.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARY ELLEN BOWMAN whose telephone number is (571)270-5383. The examiner can normally be reached on Monday-Friday, 5:30-8:30a.m. and 12:00-5:00 p.m. EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nimesh Patel can be reached on (571) 272-2457. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MARY ELLEN BOWMAN/
Primary Examiner, Art Unit 2879

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	**Art Unit**
	MARY ELLEN BOWMAN	2879

| CPC | | |

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	**Art Unit**
	MARY ELLEN BOWMAN	2879

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
313	112	H	0	1	J	5 / 16 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
313	498				
257	98				

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	29	
/MARY ELLEN BOWMAN/ Primary Examiner.Art Unit 2879	09/18/2013	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Savant Technologies LLC - 1004.1154

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	**Art Unit**
	MARY ELLEN BOWMAN	2879

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17												
2	2	18	18												
3	3	19	19												
4	4	20	20												
5	5	21	21												
6	6	22	22												
7	7	23	23												
8	8	24	24												
9	9	25	25												
10	10	26	26												
11	11	27	27												
12	12	28	28												
13	13	29	29												
14	14														
15	15														
16	16														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 29	
/MARY ELLEN BOWMAN/ Primary Examiner.Art Unit 2879 (Primary Examiner)	09/18/2013 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

Savant Technologies LLC - 1004.1155

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1	"20090272996"	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/17 14:20
S2	2	"20070240346"	US-PGPUB; USPAT; USOCR	OR	OFF	2012/09/17 14:28
S3	356	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle with (size nanometer micrometer))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 14:34
S4	215	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle with (concentration weight percent$3 amount))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 15:37
S5	9	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (down$light) and (base near4 socket)	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:20
S6	2	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (down$light) and ((housing envelope bulb) with (elongat$2 linear))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:30
S7	46	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((housing envelope bulb) with (elongat$2 linear))	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:31
S8	50	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and (downlight)	US-PGPUB; USPAT; USOCR	OR	ON	2012/09/17 16:33
S9	968	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle) and blue	US-PGPUB; USPAT; USOCR	OR	ON	2013/02/21 10:28
S10	896	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle) and blue and (phosphor fluorescent)	US-PGPUB; USPAT; USOCR	OR	ON	2013/02/21 10:29

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp

Savant Technologies LLC - 1004.1156

L1	408	(257/98.ccls. 438/27.ccls. 313/498,501,512,112.ccls.) and ("light emitting diode" LED.U/C.) and ((scatter$3 reflect$3) with particle) and blue and (phosphor fluorescent)	USPAT; UPAD	OR	ON	2013/09/18 18:14

9/18/2013 6:15:05 PM
C:\Users\mbowman\Documents\EAST\Workspaces\13273217.wsp

Savant Technologies LLC - 1004.1157

Receipt date: 09/17/2013

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

13273212 GAU: 2879

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	6812500	11-02-2004	Reeh et al.	
	2	7029935	04-18-2006	Negley et al.	
	3	6903380	06-07-2005	Barnett et al.	
	4	20050243550	11-03-2005	Stekelenburg, Albert	
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				

Examiner Signature	/Mary Ellen Bowman/	Date Considered	09/18/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (10-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 5 of 6

Complete if Known	
Application Number	13/273,212
Filing Date	10-13-2011
First Named Inventor	Bing Dai
Art Unit	2879
Examiner Name	Bowman, Mary Ellen
Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1	JP 2001177153 A	06/29/2001	Sharp KK		
	2	JP 2002133910 A	05/10/2002	Toyoda Gosei KK		
	3	WO 2008019041 A2	02/14/2008	Li, Yi-Qun		
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature	/Mary Ellen Bowman/	Date Considered	09/18/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116CN1; Foreign Office Action dated Mar. 19, 2013 for Chinese Appln. No. 201010525492.8	
	2	Docket No. ITMX-00307WO0; International Preliminary Report on Patentability dated Apr. 9, 2013 for PCT Application No. PCT/US11/54827	
	3	Docket No. ITMX-00116CN0; Fourth Office Action dated May 15, 2013 for Chinese Appln. No. 200780032995.8	
	4	Docket No. ITMX-00116US4; Non-Final Office Action dated May 16, 2013 for U.S. Appln. No. 13/087,615	
	5	Docket No. ITMX-00307US1; Non-Final Office Action dated Jun. 13, 2013 for U.S. Appln. No. 13/253,031	
	6	Docket No. ITMX-00318US3; Non-Final Office Action dated Jun. 13, 2013 for U.S. Appln. No. 13/273,217	
	7	Docket No. ITMX-00318US2; Non-Final Office Action dated Jun. 14, 2013 for U.S. Appln. No. 13/273,215	
	8	Docket No. ITMX-00116US6; Non-Final Office Action dated Jul. 18, 2013 for U.S. Appln. No. 13/436,471	
	9	Docket No. ITMX-00116US1; Non-Final Office Action Mailed on Jul. 25, 2013 for U.S. Application No. 11/640,533	
	10		
	11		
	12		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	09/18/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	Art Unit
	MARY ELLEN BOWMAN	2879

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/18/2012	02/25/2013	06/10/2013	09/18/2013					
	1	✓	✓	✓	=					
	2	✓	✓	✓	=					
	3	✓	✓	✓	=					
	4	✓	✓	✓	=					
	5	✓	✓	✓	=					
	6	✓	✓	✓	=					
	7	✓	✓	✓	=					
	8	✓	✓	✓	=					
	9	✓	✓	✓	=					
	10	✓	✓	✓	=					
	11	✓	✓	✓	=					
	12	✓	✓	✓	=					
	13	✓	✓	✓	=					
	14	✓	✓	✓	=					
	15	✓	✓	✓	=					
	16	✓	✓	✓	=					
	17	✓	✓	✓	=					
	18	✓	✓	✓	=					
	19	✓	✓	✓	=					
	20	✓	✓	✓	=					
	21	✓	✓	✓	=					
	22	✓	✓	✓	=					
	23	✓	✓	✓	=					
	24	✓	✓	✓	=					
	25	✓	✓	✓	=					
	26	✓	✓	✓	=					
	27	✓	✓	✓	=					
	28	✓	✓	✓	=					
	29	✓	✓	✓	=					

Savant Technologies LLC - 1004.1161

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13273212	DAI ET AL.
	Examiner	Art Unit
	MARY ELLEN BOWMAN	2879

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
313	112, 498, 501, 512	9/18/12	MB
257	98	9/18/12	MB
438	27	9/18/12	MB

SEARCH NOTES		
Search Notes	Date	Examiner
inventor search in eDan	9/18/12	MB

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	same	9/18/13	MB

/MARY ELLEN BOWMAN/ Examiner.Art Unit 2879	/MARY ELLEN BOWMAN/ Primary Examiner.Art Unit 2879

Savant Technologies LLC - 1004.1162

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

101130 7590 09/24/2013
Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

TITLE OF INVENTION: WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$890	$300	$0	$1190	12/24/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
BOWMAN, MARY ELLEN	2879	313-501000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Vista IP Law Group, LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Intematix Corporation

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Fremont, California

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☒ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 501105 (enclose an extra copy of this form).

Savant Technologies LLC - 1004.1163

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29	NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
❑ Applicant asserting small entity status. See 37 CFR 1.27	NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
❑ Applicant changing to regular undiscounted fee status.	NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /Eric Zhou/ Date 10-25-2013

Typed or printed name Eric Zhou Registration No. 68,842

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT
Atty. Dkt. No(s).: ITMX-00318US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	Group Art Unit: 2879
Bing Dai et al.	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	Confirmation No.: 8795
Filed: October 13, 2011	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	

AFTER ALLOWANCE AMENDMENT PURSUANT TO 37 C.F.R. § 1.312

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sirs and Madams:

Applicants first wish to thank the Examiner for allowing the application. In the meantime, Applicants respectfully submit the after allowance amendment in response to the Examiner's amendment as listed in the Notice of Allowance dated October 2, 2013 pursuant to 37 C.F.R. §1.312 in accordance with the following sheets:

Amendment to the Claims begins on page 2 of this paper.

Remarks begin on page 3 of this paper.

Savant Technologies LLC - 1004.1165

AMENDMENT TO THE CLAIMS

Claims 1-29 are currently pending in the Application. Claim 7 is currently amended to correct a claim dependency error. A complete listing of the current pending claims is provided below and supersedes all previous claims listing(s). No new matter has been added.

1. (Previously Presented) A wavelength conversion component for a light emitting device comprising:

a wavelength conversion layer comprising particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

2. (Previously Presented) The component of Claim 1, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.

3. (Previously Presented) The component of Claim 1, wherein the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder.

4. (Previously Presented) The component of Claim 3, wherein the wavelength conversion layer further comprises a second light scattering material.

Savant Technologies LLC - 1004.1166

5. (Previously Presented) The component of Claim 4, wherein the light scattering material and the second light scattering material have different material properties.

6. (Previously Presented) The component of Claim 3, wherein the light transmissive binder comprises a curable liquid polymer selected from the group consisting of: a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer.

7. (Currently Amended) The component of Claim [[2]]3, wherein the weight loading of light scattering material to binder selected from the group consisting of: 7% to 35% and 10% to 20%.

8. (Previously Presented) The component of Claim 1, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

9. (Previously Presented) The component of Claim 1, wherein the wavelength conversion and light diffusing layers are deposited using a method selected from the group consisting of: screen printing, slot die coating, spin coating, roller coating, drawdown coating and doctor blading.

10. (Previously Presented) The component of Claim 1, wherein the light scattering material is selected from the group consisting of: titanium dioxide, barium sulfate, magnesium oxide, silicon dioxide and aluminum oxide.

11. (Previously Presented) The component of Claim 1, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter the

Savant Technologies LLC - 1004.1167

excitation light relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

12. (Previously Presented) The component of Claim 11, wherein the light scattering material scatters the excitation light at least twice as much as light generated by the at least one photoluminescence material.

13. (Previously Presented) The component of Claim 11, wherein the excitation light comprises blue light.

14. (Previously Presented) The component of Claim 13, wherein the light scattering material has an average particle size that is less than about 150nm.

15. (Previously Presented) The component of Claim 1, wherein the light diffusing layer is deposited on a light transmissive substrate, and the light transmissive substrate is selected from the group consisting of: a polycarbonate, an acrylic and a glass.

16. (Previously Presented) The component of Claim 1 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

17. (Previously Presented) The component of Claim 1 in which the light diffusing layer comprises a dome or elongated dome shape.

18. (Previously Presented) The component of claim 17 in which the wavelength conversion layer fills a volume formed beneath the dome or elongated dome shapes.

Savant Technologies LLC - 1004.1168

19. (Previously Presented) A light emitting device, comprising:

at least one solid-state light emitter operable to generate excitation light; and

a wavelength conversion component comprising:

a wavelength conversion layer excitable by the excitation light, wherein the wavelength conversion layer comprises particles of at least one photoluminescence material; and

a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an OFF state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the at least one solid-state light emitter is emitted through the wavelength conversion component to contribute to a final visible emission product.

20. (Previously Presented) The device of claim 19, wherein the light emitting device is selected from the group consisting of: downlights, light bulbs, linear lamps, lanterns, wall lamps, pendant lamps, chandeliers, recessed lights, track lights, accent lights, stage lighting, movie lighting, street lights, flood lights, beacon lights, security lights, traffic lights, headlamps, taillights, and signs.

21. (Previously Presented) The device of claim 19 in which the light scattering material within the light diffusing layer corresponds to an average particle size that improves the OFF state white appearance of the wavelength conversion component.

22. (Previously Presented) The device of claim 19 in which the light diffusing layer is configured to obtain substantially uniform color for emitted light from the light emitting device for emission angles over a $\pm 60^{o}$ range from an emission axis.

Savant Technologies LLC - 1004.1169

23. (Previously Presented) The device of claim 22, wherein a weight loading of the light scattering material to a binder selected from the group consisting of: 7% to 35% and 10% to 20%.

24. (Previously Presented) The device of Claim 19, wherein the light scattering material has an average particle size in a range selected from the group consisting of: 1μm to 50μm and 10μm to 20μm.

25. (Previously Presented) The device of Claim 19 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

26. (Previously Presented) The device of Claim 19 in which the light diffusing layer comprises a dome or elongated dome shape.

27. (Previously Presented) A linear lamp comprising:

an elongate housing;

a plurality of solid-state light emitters housed within the housing and configured along the length of the housing; and

an elongate wavelength conversion component remote to the plurality of solid-state light emitters and configured to in part at least define a light mixing chamber,

wherein the elongate wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the elongate wavelength conversion component;

wherein the elongate wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to

Savant Technologies LLC - 1004.1170

440 nm generated by the plurality of solid-state light emitters is emitted through the wavelength conversion component to contribute to a visible final emission product.

28. (Previously Presented) A downlight comprising:

a body comprising one or more solid-state light emitters, wherein the body is configured to be positioned within a downlighting fixture such that the downlight emits light in a downward direction; and

a wavelength conversion component remote to the one or more solid-state light emitters and configured to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

29. (Previously Presented) A light bulb comprising:

a connector base configured to be inserted in a socket to form an electrical connection for the light bulb;

a body comprising one or more solid-state light emitters;

a wavelength conversion component having a three dimensional shape that is configured to enclose the one or more solid-state light emitters and to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer

Savant Technologies LLC - 1004.1171

comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

Savant Technologies LLC - 1004.1172

REMARKS

Claims 1-29 are currently pending in the Application.

I. Amendment to the Claims

Claim 7 is currently amended to correct a claim dependency error. Applicants respectfully submit that the current amendment introduces no new matter.

Therefore, Applicants respectfully submit that the current amendment to the claims introduces no new matter and necessitates no new search. Applicants thus respectfully request entry of the after-allowance amendment pursuant to 37 C.F.R. § 1.312.

Savant Technologies LLC - 1004.1173

CONCLUSION

Based on the foregoing, all claims are believed allowable, and an allowance of the claims is respectfully requested. If the Examiner has any questions or comments, the Examiner is respectfully requested to contact the undersigned at the number listed below.

Applicant(s) hereby explicitly retracts and rescinds any and all of the arguments and disclaimers presented to distinguish the prior art of record during the prosecution of all parent and related application(s)/patent(s), and respectfully requests that the Examiner re-visit the prior art that such arguments and disclaimers were made to avoid.

The Commissioner is authorized to charge any fees due in connection with the filing of this document to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1. The Commissioner is authorized to credit any overpayment or to charge any underpayment to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1.

Respectfully submitted,

Date: October 25, 2013

By: /Eric Zhou/
Eric Zhou
Reg. No. 68,842

VISTA IP LAW GROUP LLP
2160 Lundy Ave., Suite 230
San Jose, CA 95131
Telephone: (408) 321-8663 x. 206
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1174

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	Group Art Unit: 2879
Bing Dai et al.	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	Confirmation No.: 8795
Filed: October 13, 2011	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sirs / Madams:

Applicants first wish to thank the Examiner of record, Ms. Mary Ellen Bowman, for allowing the above-identified application.

The October 2, 2013 Notice of Allowance provides that "*the prior art fails to teach the presently claimed invention comprising the claimed wavelength conversion component and scattering particles*". Examiner's Reasons for Allowance, p. 2, October 2, 2013 Notice of Allowability (Italics added.)

Savant Technologies LLC - 1004.1175

Applicants first respectfully submit that Applicants submitted the response to Office action to selectively respond to some of the basis for rejections. To the extent that Applicants did not respond to certain basis for rejections, Applicants respectfully submit that Applicants' silence on such certain basis for rejections does not explicitly or implicitly indicate Applicants' acquiescence in such certain basis for rejections.

Applicants further respectfully submit that the U.S. Patent Law jurisprudence requires that each of the currently pending claims is to be considered in its entirety. The application includes independent claims, where each independent claim may recite limitations that are different from or not present in other claims, and that the application includes more than just the independent claims but also numerous dependent claims, each of which recites one or more different claimed limitations. Therefore, Applicants respectfully submit that the independent claims and their respective dependent claims are allowable for what they respectively and actually recite rather than the alleged Reasons for Allowance stating that "*the prior art fails to teach the presently claimed invention comprising*" some but not all of the claimed limitations of an independent claim as purported by the Notice of Allowance on page 3.

Moreover, Applicants respectfully submit that the U.S. patent law jurisprudence does not find claims allowable merely because "*the prior art fails to teach the presently claimed invention comprising*" some but not all of the claimed limitations of an independent claim.

Rather, the U.S. patent law jurisprudence requires that the each of the pending claims and the prior art references are to be considered in their respective entireties, and that the claims are allowable over the prior art references if the prior art references, either alone or in combination, fail to anticipate and render obvious each of the claims that is considered as a whole, and that the

Savant Technologies LLC - 1004.1176

claims and all the other parts of the application meet various requirements of Title 35 of the U.S. Code together with the controlling case law and Title 37 of the Code of Federal Regulations before the application may be considered allowable. The Manual of Patent Examining Procedure (MPEP) similar requires the application to meet certain additional requirements other than those required by Title 35 of the U.S. Code and Title 37 of the Code of Federal Regulations.

As such, Applicants respectfully submit that the independent claims and their respective dependent claims are allowable for what they respectively and actually recite rather than "*the prior art fails to teach the presently claimed invention comprising*" some but not all of the claimed limitations of an independent claim as purported by the Notice of Allowance, and that the application is allowed by meeting all of the requirements of Title 35 of the U.S. Code together with the controlling case law, Title 37 of the Code of Federal Regulations, and the MPEP.

If the Examiner has any questions or comments, the Examiner is respectfully requested to contact the undersigned at the number listed below.

Savant Technologies LLC - 1004.1177

CONCLUSION

If the Examiner has any questions or comments, the Examiner is respectfully requested to contact the undersigned at the number listed below.

The Commissioner is authorized to charge any fees due in connection with the filing of this document to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1. The Commissioner is authorized to credit any overpayment or to charge any underpayment to Vista IP Law Group's Deposit Account No. 50-1105, referencing billing number ITMX-00318US1.

Respectfully submitted,

Dated: October 25, 2013

By: /Eric Zhou/
Eric Zhou
Reg. No. 68,842

Vista IP Law Group LLP
2160 Lundy Avenue, Suite 230
San Jose, CA 95131-1887
Telephone: (408) 321-8663 Ext. 206
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1178

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	)	Group Art Unit: 2879
Bing Dai et al.	)	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	)	Confirmation No.: 8795
Filed: October 13, 2011	)	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	)	

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with 37 CFR §§ 1.97 and 1.98, the items identified in this Information Disclosure Statement (IDS) are being brought to the attention of the Office. The Examiner is requested to make these documents of record.

The items identified in this IDS may or may not be "material" pursuant to 37 CFR § 1.56. The submission thereof by Applicant(s) is not to be construed as an admission that any such patent, publication or other information referred to therein is material or considered to be material (37 CFR § 1.97(h)), or even qualifies as "prior art" under 35 USC § 102 with respect to this invention unless specifically designated by Applicant(s) as such.

1. Fee:

☐ Charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

☒ The fee due under 37 CFR § 1.17(p) is being concurrently submitted with the filing of an electronic IDS submission. Thus, no additional fee is required.

Savant Technologies LLC - 1004.1179

☐ Applicant believes that no fee is required for this submission. However, if Applicant is mistaken, then please charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

2. Statement Under 37 CFR § 1.97(e):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1); or

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

3. Copies of the Cited Items:

☒ Copies of all of the items listed under Foreign Patent Documents and/or Non Patent Literature Documents are enclosed.

☐ Copies of the following items listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are enclosed.

☐ Copies of the following documents listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are not supplied because they were previously cited by the Office or submitted in Information Disclosure Statements in parent U.S. Application No. _____, of which the current application is a _____ and relied upon in this application for an earlier filing date under 35 USC § 120. See 37 CFR § 1.98(d). The Examiner is requested to make these documents of record.

Savant Technologies LLC - 1004.1180

4. Conclusion:

Citation of the above documents shall not be construed as:

1. an admission that the documents are necessarily prior art with respect to the instant invention;
2. a representation that a search has been made, other than as described above; and
3. an admission that the information cited herein is, or is considered to be, material to patentability as defined in § 1.56(b).

It is respectfully requested that the Examiner indicate consideration of the cited references by returning a copy of the attached form with initials or other appropriate marks. If the U.S. Patent Office determines that an extension and/or other relief is required, Applicant(s) petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 501105**, referencing **Docket No. ITMX-00318US1**. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: 10-25-2013

By: /Eric Zhou/
Eric Zhou
Registration No. 68,842

Vista IP Law Group, LLP
2160 Lundy Ave., Ste. 230
San Jose, CA 95131
Telephone: (408) 321-8663 (Ext. 208)
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1181

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
				Filing Date	10-13-2011
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	5	of	6	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116US3; Non-Final Office Action dated 09-27-2013 for U.S. Appln. No. 12/624,900	
	2	Docket No. ITMX-00307US1; Notice of Allowance dated 10-02-2013 for U.S. Appln. No.13/253,031	
	3	Docket No. ITMX-00318US2; Notice of Allowance dated 09-30-2013 for U.S. Appln. No. 13/273,215	
	4	Docket No. ITMX-00318US3; Notice of Allowance dated 09-24-2013 for U.S. Appln. No. 13/273,217	
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	7	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	21		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
ROBINSON ROSS T.

WINSTEAD PC P.O. BOX 131851 DALLAS TX 75313 USA

RECEIVED ON
OCT 10 2013
BY WINSTEAD

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing *(day/month/year)*	27 September 2013 (27.09.2013)
Applicant's or agent's file reference ITMX-00116WO1 51026-P286WO	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. **PCT/US2013/048354**	International filing date *(day/month/year)* **27 June 2013 (27.06.2013)**
Applicant **INTEMATIX CORPORATION**	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 . 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90bis.1 and 90bis.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the PCT Applicant's Guide, National Chapters.

Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-8755

DOCKETED ON
OCT 10 2013

Form PCT/ISA/220 (July 2010)

By:

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Services => PCT Services

ID : PCT international application number
PW : **7LMA2ADG**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com

Email: ipkc@ipkcenter.com

Savant Technologies LLC - 1004.1187

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference ITMX-00116WO1	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2013/048354**	International filing date *(day/month/year)* **27 June 2013 (27.06.2013)**	(Earliest) Priority Date *(day/month/year)* 28 June 2012 (28.06.2012)
Applicant **INTEMATIX CORPORATION**		

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **3** sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **8**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

DOCKETED ON
OCT 10 2013
By:

Form PCT/ISA/210 (first sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/048354

A. CLASSIFICATION OF SUBJECT MATTER

F21S 2/00(2006.01)i, F21V 5/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F21S 2/00; F21V 29/00; H01J 1/62; F21V 9/16; F21V 5/00; F21Y 101/02; H01J 9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: elongate lens, phosphor, solid-state light emitter, lamp, diffusing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005-0093430 A1 (JAMES IBBETSON et al.) 05 May 2005 See paragraphs [0005]-[0072]; and figures 1-18.	18-25
Y		1-17
Y	US 2011-0149548 A1 (HAITAO YANG et al.) 23 June 2011 See paragraphs [0039]-[0057]; and figures 2-12.	1-17
A	JP 2011-192793 A (NIIYAMA HEIJI) 29 September 2011 See paragraphs [0016]-[0045]; and figures 1-8.	1-25
A	US 2008-0062672 A1 (SIEW IT PENG et al.) 13 March 2008 See paragraphs [0008]-[0026]; and figures 1-5.	1-25
A	US 2009-0219713 A1 (DENNIS SIEMIET et al.) 03 September 2009 See paragraphs [0013]-[0032]; and figures 1-3.	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 2013 (27.09.2013)	**27 September 2013 (27.09.2013)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	Authorized officer KIM Do Weon Telephone No. +82-42-481-5560

Form PCT/ISA/210 (second sheet) (July 2009)

Savant Technologies LLC - 1004.1189

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2013/048354

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005-0093430 A1	05/05/2005	CA 2517009 A1	10/09/2004
		CN 1777999 A	24/05/2006
		CN 1777999 B	26/05/2010
		EP 1597777 A2	23/11/2005
		EP 1597777 B1	24/04/2013
		EP 2262006 A2	15/12/2010
		EP 2262006 A3	21/03/2012
		JP 2006-519500 A	24/08/2006
		JP 2011-061230 A	24/03/2011
		JP 2013-093595 A	16/05/2013
		KR 10-2005-0113200 A	01/12/2005
		KR 10-2011-0137403 A	22/12/2011
		MY 142684 A	31/12/2010
		TW 201225339 A	16/06/2012
		WO 2004-077580 A2	10/09/2004
		WO 2004-077580 A3	10/03/2005
US 2011-0149548 A1	23/06/2011	None	
JP 2011-192793 A	29/09/2011	JP 4792531 B2	12/10/2011
US 2008-0062672 A1	13/03/2008	US 2005-0248271 A1	10/11/2005
		US 2008-0064287 A1	13/03/2008
		US 7315119 B2	01/01/2008
		US 7727041 B2	01/06/2010
		US 7733021 B2	08/06/2010
US 2009-0219713 A1	03/09/2009	US 7815338 B2	19/10/2010
		WO 2009-111098 A2	11/09/2009
		WO 2009-111098 A3	29/10/2009

Savant Technologies LLC - 1004.1190

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
ROBINSON ROSS T.

WINSTEAD PC P.O. BOX 131851 DALLAS TX 75313 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**27 September 2013 (27.09.2013)**
Applicant's or agent's file reference: ITMX-00116WO1	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/048354	**27 June 2013 (27.06.2013)**	28 June 2012 (28.06.2012)

International Patent Classification (IPC) or both national classification and IPC

F21S 2/00(2006.01)i, F21V 5/00(2006.01)i

Applicant
INTEMATIX CORPORATION

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	27 September 2013 (27.09.2013)	KIM Do Weon Telephone No. +82-42-481-5560

DOCKETED ON
OCT 15 2013
By:

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/048354

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Savant Technologies LLC - 1004.1192

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/048354

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-25	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-25	NO
Industrial applicability (IA)	Claims	1-25	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2005-0093430 A1
D2: US 2011-0149548 A1
D3: JP 2011-192793 A
D4: US 2008-0062672 A1
D5: US 2009-0219713 A1

1. Novelty and Inventive Step

1.1. Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a lamp (an emitter 30; see paragraph [0049] and figure 4).

When comparison is made between claim 1 and D1, the following features of claim 1 differ from D1, but the features can be easily derived from the features of D1 or D2 as follows:

a co-extruded component, the co-extruded component comprising an elongate lens and a layer of a photoluminescent material, wherein the elongate lens and the layer of the photoluminescent material are co-extruded together to form the co-extruded component (a lens 36 includes an inside layer 38 with conversion particles 22 and an outside layer 40, where the layers 38 and 40 preferably have uniform thicknesses throughout in D1; see paragraph [0050] and figure 4);
the elongate lens for shaping light emitted from the lamp (a lens and caps can

Continued on Supplemental Box

Savant Technologies LLC - 1004.1193

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of: Box No. V

be shaped to adapt to the particular application and can be shaped to focus the emitted light in D1; see paragraph [0072]),
wherein the elongate lens comprises an elongate interior cavity (a filler material 19 can be positioned on a surface 11 to surround a light source 12 in D1; see paragraph [0050] and figures 1-4);
the layer of a photoluminescent material on an interior wall of the elongate interior cavity (an inside layer 38 with conversion particles 22 in D1; see paragraph [0050] and figure 4); and
an array of solid-state light emitters configured to emit light into the elongate interior cavity (linear array of LEDs 116 in D2; see paragraph [0054] and figure 11).

Accordingly, it would be obvious to a person skilled in the art to combine the disclosures of D1 and D2, thereby arriving at the claim. Therefore, claim 1 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2. Dependent Claims 2-17

Claims 2-17 are directly or indirectly dependent on claim 1.

1.2.1. The additional features of claims 2 and 3 can be easily derived from the feature of D1 (a dome shaped lens 76; see paragraph [0055] and figure 8). Therefore, claims 2 and 3 are novel under PCT Article 33(2) but lack an inventive step under PCT Article 33(3).

1.2.2. The additional feature of claim 4 can be easily derived from the feature of D1 (a filler material 19 can be positioned on a surface 11 to surround a light source 12; see paragraph [0050] and figures 1-4). Therefore, claim 4 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.3. The additional feature of claim 5 is merely a matter of design option in view of the feature of D1 (a lens 36 includes an inside layer 38 with conversion particles 22 and an outside layer 40, and the lens 36 is dome shaped; see paragraph [0050] and figure 3). Therefore, claim 5 is novel under PCT Article

Continued on The Next Page

Savant Technologies LLC - 1004.1194

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of: Previous Page

33(2) but lacks an inventive step under PCT Article 33(3).

1.2.4. The additional feature of claim 6 can be easily derived from the feature of D1 (a lens 36 includes an inside layer 38 with conversion particles 22 and an outside layer 40, and the lens 36 is dome shaped; see paragraph [0050] and figure 3). Therefore, claim 6 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.5. The additional feature of claim 7 can be easily derived from the feature of D2 (a cooperating portion 226 on the lens; see paragraph [0055] and figure 12). Therefore, claim 7 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.6. The additional feature of claim 8 can be easily derived from the feature of D1 (a layer 98 includes scattering particles 100 for redirecting some of the light; see paragraph [0057] and figure 10). Therefore, claim 8 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.7. The additional feature of claim 9 is merely a matter of design option in view of the feature of D1 (a layer 98 includes scattering particles 100 for redirecting some of the light; see paragraph [0057] and figure 10). Therefore, claim 9 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.8. The additional feature of claim 10 can be easily derived from the feature of D1 (a layer 98 includes scattering particles 100 for redirecting some of the light; see paragraph [0057] and figure 10). Therefore, claim 10 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.9. The additional features of claims 11 and 12 are merely a matter of design option in view of the feature of D1 (phosphor particles are generally too large to effectively scatter light; see paragraph [0062] and figures 11, 12). Therefore, claims 11 and 12 are novel under PCT Article 33(2) but lack an inventive step under PCT Article 33(3).

Continued on The Next Page

Savant Technologies LLC - 1004.1195

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Previous Page

1.2.10. The additional feature of claim 13 is merely a matter of design option in view of the feature of D1 (surfaces 101 and 115 are shaped, so light directed along a layer 118 reflects off surfaces 101 and/or 117 and is combined with the light emitted from a light source 12 that flows through the layer 118 to a surface 105; see paragraph [0062] and figure 12). Therefore, claim 13 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.11. The additional feature of claim 14 can be easily derived from the feature of D2 (a bi-pin connector cap 220; see paragraph [0054] and figure 11). Therefore, claim 14 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.2.12. The additional features of claims 15 and 16 can be easily derived from the feature of D1 (a filler material 19 is positioned on a surface 11 and surrounds a light source 12 so that a filler material 19 fills the volume within the cup; see paragraph [0033] and figure 2). Therefore, claims 15 and 16 are novel under PCT Article 33(2) but lack an inventive step under PCT Article 33(3).

1.2.13. The additional feature of claim 17 can be easily derived from the feature of D1 (a lens and caps can be shaped to adapt to the particular application and can be shaped to focus the emitted light; see paragraph [0072]). Therefore, claim 17 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.3. Independent Claim 18

D1, which is considered to be the closest prior art to the subject matter of claim 18, discloses a method of fabricating an optical component (an emitter fabrication method; see paragraph [0068]).

Claim 18 differs from D1 in that the claim comprises "co-extruding an elongated solid body having a wavelength conversion layer and an optical component layer, the wavelength conversion layer in contact with the optical component layer".

Continued on The Next Page

Savant Technologies LLC - 1004.1196

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Previous Page

However, it can be easily derived by a person skilled in the art from the feature of D1 (a lens 36 includes an inside layer 38 with conversion particles 22 and an outside layer 40, where the layers 38 and 40 preferably have uniform thicknesses throughout; see paragraph [0050]; and figure 4). Therefore, claim 18 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.4. Dependent Claims 19-25

Claims 19-25 are directly or indirectly dependent on claim 18.

1.4.1. The additional feature of claim 19 is merely a matter of design option in view of the feature of D1 (a material can be used to mass produce lenses using known methods such as injection molding or the conventional syringe manufacturing process; see paragraph [0041]). Therefore, claim 19 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.4.2. The additional feature of claim 20 is merely a matter of design option in view of the feature of D1 (a syringe mechanism is filled with an optically clear and curable material (e.g., epoxy, silicon, sol gel, etc.) with the conversion material mixed in the material, where the conversion material typically includes phosphor particles; see paragraph [0007]). Therefore, claim 20 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.4.3. The additional feature of claim 21 is merely a matter of design option in view of the feature of D1 (a layer 98 includes scattering particles 100 for redirecting some of the light; see paragraph [0057] and figure 10). Therefore, claim 21 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.4.4. The additional features of claims 22 and 23 can be easily derived from the feature of D1 (a dome shaped lens 76; see paragraph [0055], and figure 8). Therefore, claims 22 and 23 are novel under PCT Article 33(2) but lack an inventive step under PCT Article 33(3).

Continued on The Next Page

Savant Technologies LLC - 1004.1197

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Previous Page

1.4.5. The additional feature of claim 24 can be easily derived from the feature of D1 (a color emitted by a particular emitter 10 can change by using a lens which includes a different type of conversion particles to produce different light combinations; see paragraph [0043]). Therefore, claim 24 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

1.4.6. The additional feature of claim 25 can be easily derived from the feature of D1 (testing can be repeated until the emitter emits light at a sufficient color and intensity over a range of viewing angles before the cap is bonded to the LED; see paragraph [0071]). Therefore, claim 25 is novel under PCT Article 33(2) but lacks an inventive step under PCT Article 33(3).

2. Industrial Applicability

Claims 1-25 are industrially applicable under PCT Article 33(4).

Savant Technologies LLC - 1004.1198

Electronic Patent Application Fee Transmittal

Application Number:	13273212
Filing Date:	13-Oct-2011
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Filer:	Eric Zhou/Tony Nguyen
Attorney Docket Number:	ITMX-00318US1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	2501	1	890	890
Publ. Fee- Early, Voluntary, or Normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1190**

Electronic Acknowledgement Receipt	
EFS ID:	17237166
Application Number:	13273212
International Application Number:	
Confirmation Number:	8795
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Customer Number:	101130
Filer:	Eric Zhou/Tony Nguyen
Filer Authorized By:	Eric Zhou
Attorney Docket Number:	ITMX-00318US1
Receipt Date:	28-OCT-2013
Filing Date:	13-OCT-2011
Time Stamp:	04:10:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1190
RAM confirmation Number	7920
Deposit Account	501105
Authorized User	VISTA IP LAW GR
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees) Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	00318US1_Issue-fee-payment.pdf	982632 1a8df3220795ae7e85b50cdc94799ec99cb90d92	no	2
Warnings:					
Information:					
2	Amendment after Notice of Allowance (Rule 312)	00318US1_Amendment-sec-312.pdf	91413 f9e569478226c93ff36f846cd107c17fc0fc40d8	no	10
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	00318US1-comments-SRFA.pdf	79961 4d26f85883611bbb13f46197dd8c15168db4e2fc	no	4
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Form (SB08)	00318US1_IDS-sb08-transmittal.pdf	166782 cdd4f9aa2f94f9af7e0b9bf379a1cf169065e663	no	6
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
5	Information Disclosure Statement (IDS) Form (SB08)	00318US1_IDS-sb08-transmittal2.pdf	173860 fdf923e183faca9a843817152e86d4d21c4e10b8	no	7
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
6	Non Patent Literature	00116WO1_ISR-WO_09-27-13.pdf	235347 e8d9fa35444dfb4258d3214413b740d5b9651b49	no	13
Warnings:					
Information:					
7	Non Patent Literature	00116US3_NFOA_09-27-13.pdf	1047964 53c8267c233aaab32b740ea6ab4f647fd54feeb5	no	27
Warnings:					
Information:					
8	Non Patent Literature	00307US1_NOA_10-02-13.pdf	555935 02c9bb34ee04dea9ac7fb0ce83ddd631277dfdbd	no	11

Warnings:					
Information:					
9	Non Patent Literature	00318US2_NOA_09-30-13.pdf	695163 75e22ebf45695e717ec6489eadd800e07947d133	no	14
Warnings:					
Information:					
10	Non Patent Literature	00318US3_NOA_09-24-13.pdf	553283 d1277ee2ca7a41b1a1be50a0091c4765ab0c4b1d	no	11
Warnings:					
Information:					
11	Fee Worksheet (SB06)	fee-info.pdf	32112 d7086352f3e7c55706c525d53b5c94bde8723d77	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	4614452	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	)	Group Art Unit: 2879
Bing Dai et al.	)	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	)	Confirmation No.: 8795
Filed: October 13, 2011	)	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	)	

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In accordance with 37 CFR §§ 1.97 and 1.98, the items identified in this Information Disclosure Statement (IDS) are being brought to the attention of the Office. The Examiner is requested to make these documents of record.

The items identified in this IDS may or may not be "material" pursuant to 37 CFR § 1.56. The submission thereof by Applicant(s) is not to be construed as an admission that any such patent, publication or other information referred to therein is material or considered to be material (37 CFR § 1.97(h)), or even qualifies as "prior art" under 35 USC § 102 with respect to this invention unless specifically designated by Applicant(s) as such.

1. Fee:

☐ Charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

☒ The fee due under 37 CFR § 1.17(p) is being concurrently submitted with the filing of an electronic IDS submission. Thus, no additional fee is required.

Savant Technologies LLC - 1004.1204

☐ Applicant believes that no fee is required for this submission. However, if Applicant is mistaken, then please charge the fee due under 37 CFR § 1.17(p) to the deposit account referenced below.

2. Statement Under 37 CFR § 1.97(e):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1); or

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

3. Copies of the Cited Items:

☒ Copies of all of the items listed under Foreign Patent Documents and/or Non Patent Literature Documents are enclosed.

☐ Copies of the following items listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are enclosed.

☐ Copies of the following documents listed under Item Nos. ___ under Foreign Patent Documents and Item Nos. ___ under Non Patent Literature Documents are not supplied because they were previously cited by the Office or submitted in Information Disclosure Statements in parent U.S. Application No. _____, of which the current application is a _____ and relied upon in this application for an earlier filing date under 35 USC § 120. See 37 CFR § 1.98(d). The Examiner is requested to make these documents of record.

Savant Technologies LLC - 1004.1205

4. Conclusion:

Citation of the above documents shall not be construed as:

1. an admission that the documents are necessarily prior art with respect to the instant invention;
2. a representation that a search has been made, other than as described above; and
3. an admission that the information cited herein is, or is considered to be, material to patentability as defined in § 1.56(b).

It is respectfully requested that the Examiner indicate consideration of the cited references by returning a copy of the attached form with initials or other appropriate marks. If the U.S. Patent Office determines that an extension and/or other relief is required, Applicant(s) petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 501105**, referencing **Docket No. ITMX-00318US1**. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Respectfully submitted,

Dated: 10-25-2013

By: /Eric Zhou/
Eric Zhou
Registration No. 68,842

Vista IP Law Group, LLP
2160 Lundy Ave., Ste. 230
San Jose, CA 95131
Telephone: (408) 321-8663 (Ext. 208)
Facsimile: (408) 877-1662

Savant Technologies LLC - 1004.1206

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
				Filing Date	10-13-2011
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	5	of	6	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116WO1; International Search Report and Written Opinion dated 09-27-2013 for PCT Appln. No. PCT/US13/48354	
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Electronic Patent Application Fee Transmittal	
Application Number:	13273212
Filing Date:	13-Oct-2011
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Filer:	Eric Zhou/Tony Nguyen
Attorney Docket Number:	ITMX-00318US1
Filed as Small Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt	
EFS ID:	17237171
Application Number:	13273212
International Application Number:	
Confirmation Number:	8795
Title of Invention:	WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER
First Named Inventor/Applicant Name:	Bing Dai
Customer Number:	101130
Filer:	Eric Zhou/Tony Nguyen
Filer Authorized By:	Eric Zhou
Attorney Docket Number:	ITMX-00318US1
Receipt Date:	28-OCT-2013
Filing Date:	13-OCT-2011
Time Stamp:	04:13:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$90
RAM confirmation Number	7924
Deposit Account	501105
Authorized User	VISTA IP LAW GR
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees) Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	30519 4ca19509dd240a3d9e4bbb677174ace782cd41ab	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	30519		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	8795

101130 7590 11/12/2013

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

EXAMINER	
BOWMAN, MARY ELLEN	
ART UNIT	PAPER NUMBER
2879	

NOTIFICATION DATE	DELIVERY MODE
11/12/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

docketing@viplawgroup.com
ttn@viplawgroup.com

Savant Technologies LLC - 1004.1214

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Trademark Office
Address : COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
13/273,212	13 October, 2011	DAI ET AL.	ITMX-00318US1

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

EXAMINER	
MARY ELLEN BOWMAN	
ART UNIT	PAPER
2879	20131102

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Each of the two IDSs filed on October 28, 2013 have been considered. The reasons for allowance have not changed.

/MARY ELLEN BOWMAN/
Primary Examiner, Art Unit 2879

PTO-90C (Rev.04-03)

Response to Rule 312 Communication	Application No.	Applicant(s)
	13/273,212	DAI ET AL.
	Examiner	Art Unit
	MARY ELLEN BOWMAN	2879

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address –

1. ☒ The amendment filed on *28 October 2013* under 37 CFR 1.312 has been considered, and has been:

a) ☒ entered.

b) ☐ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.

/MARY ELLEN BOWMAN/
Primary Examiner, Art Unit 2879

Savant Technologies LLC - 1004.1216

Receipt date: 10/28/2013

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

13273212 GAU 2879

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number / Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				***Complete if Known***	
				Application Number	13/273,212
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	5	of	6	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (12-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116WO1; International Search Report and Written Opinion dated 09-27-2013 for PCT Appln. No. PCT/US13/48354	
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

OK TO ENTER: /M.B./

11/02/2013

PATENT

Atty. Dkt. No(s).: ITMX-00318US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:	Group Art Unit: 2879
Bing Dai et al.	Examiner: Bowman, Mary Ellen
Serial No.: 13/273,212	Confirmation No.: 8795
Filed: October 13, 2011	
For: WAVELENGTH CONVERSION COMPONENT WITH DIFFUSING LAYER	

AFTER ALLOWANCE AMENDMENT PURSUANT TO 37 C.F.R. § 1.312

Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sirs and Madams:

Applicants first wish to thank the Examiner for allowing the application. In the meantime, Applicants respectfully submit the after allowance amendment in response to the Examiner's amendment as listed in the Notice of Allowance dated October 2, 2013 pursuant to 37 C.F.R. §1.312 in accordance with the following sheets:

Amendment to the Claims begins on page 2 of this paper.

Remarks begin on page 3 of this paper.

Savant Technologies LLC - 1004.1220

Receipt date: 10/28/2013

13273212 GAU 2879

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	4	of	6	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12				
	13				
	14				
	15				
	16				
	17				
	18				

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Receipt date: 10/28/2013

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	5	of	6	Attorney Docket Number	ITMX-00318US1

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3] – Number[4] – Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Receipt date: 10/28/2013

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	6	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Docket No. ITMX-00116US3; Non-Final Office Action dated 09-27-2013 for U.S. Appln. No. 12/624,900	
	2	Docket No. ITMX-00307US1; Notice of Allowance dated 10-02-2013 for U.S. Appln. No.13/253,031	
	3	Docket No. ITMX-00318US2; Notice of Allowance dated 09-30-2013 for U.S. Appln. No. 13/273,215	
	4	Docket No. ITMX-00318US3; Notice of Allowance dated 09-24-2013 for U.S. Appln. No. 13/273,217	
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

PTO/SB/08a (02-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
(Use as many sheets as necessary)				Examiner Name	Bowman, Mary Ellen
Sheet	7	of	6	Attorney Docket Number	ITMX-00318US1

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	~~21~~		

Examiner Signature	/Mary Ellen Bowman/	Date Considered	11/02/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

Receipt date: 06/06/2013

PTO/SB/08a (07-09) (modified)
Approved for use through 07/31/2012. OMB 0651-0031

13273212 GAU 2879

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	13/273,212
				Filing Date	10-13-2011
				First Named Inventor	Bing Dai
				Art Unit	2879
				Examiner Name	Bowman, Mary Ellen
Sheet	8	of	11	Attorney Docket Number	ITMX-00318US1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	76	6340824	01-22-2002	Komoto, S., et al.	
	77	6504301	01-07-2003	Lowery, C.H.	
	78	6576488	06-10-2003	Collins, W.O., et al.	
	79	6600175	07-29-2003	Baretz, Bruce, et al.	
	80	6642618	11-04-2003	Yagi, T., et al.	
	81	6642652	11-04-2003	Collins, W.O., et al.	
	82	6869812	03-22-2005	Liu, H.	
	83	7153015	12-26-2006	~~8rukilacchio, T.J.~~	Brukilacchio
	84	7479662	01-20-2009	Soules, T.F., et al.	
	85	7615795	11-10-2009	Baretz, B., et al.	
	86	7943945	05-17-2011	Baretz, B., et al.	
	87	20040016938	01-29-2004	Baretz, Bruce, et al.	
	88	20060049416	03-09-2006	Baretz, Bruce, et al.	
	89	20080224597	09-18-2008	Baretz, Bruce, et al.	
	90	20080224598	09-18-2008	Baretz, Bruce, et al.	

Change(s) applied to document, /M.H.E./ 10/26/2013

Examiner Signature	/Mary Ellen Bowman/	Date Considered	06/10/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant's unique citation designation number (optional). 2 See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. 3 Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4 For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. 6 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.B./

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/273,212	12/10/2013	8604678	ITMX-00318US1	8795

101130 7590 11/20/2013

Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Bing Dai, Fremont, CA;
Xianglong Yuan, Fremont, CA;
Gang Wang, Milpitas, CA;
Charles Edwards, Pleasanton, CA;
James Caruso, Albuquerque, NM;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1	94704

Acknowledgement of Loss of Entitlement to Entity Status Discount

The entity status change request below filed through Private PAIR on 08/28/2019 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/Peter C. Mei/
Name:	Peter C. Mei
Registration Number:	39768

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☑ Practitioners associated with Customer Number: 00826

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☐ The address associated with Customer Number:

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: FEIT ELECTRIC COMPANY, INC.
4901 Gregg Road
Pico Rivera, California 90660-2108

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	7/17/2017
Name	ALAN FEIT	Telephone	562.463.2852
Title	EVP, of Feit Electric Company, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
13/273,212	**07/05/2022 05:10:37 PM ET**	**ITMX-00318US1**

Title of Invention

WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	8604678
CONFIRMATION #	8795	FILED BY	Lisa Rone
PATENT CENTER #	60761096	FILING DATE	10/13/2011
CUSTOMER #	101130	FIRST NAMED INVENTOR	Bing Dai
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Chris Lightner

Documents

TOTAL DOCUMENTS: 2

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
581180-POA-8795.pdf		3	-	122 KB
581180-POA-8795-R3.73.pdf	(1-2)	2	Assignee showing of ownership per 37 CFR 3.73	86 KB
581180-POA-8795-PA...pdf	(3-3)	1	Power of Attorney	46 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
581180-POA-8795.pdf	C06BE9BEBFA00716B43E69C35095C3CA93FC1A6CDAEF8641

	C8269D3DC6CDE80106FFEBCAC591E833F4A02994A774A9A7 219BDDFABA36A3ED8F2BD41F31760CA4
581180-POA-8795-R3.73.pdf	FEB0701D33EB2A05A6C7E020CFB184F066E184F6CC1816DF2 13769A13DF254095C2B316BA0344BCDE210ED5501C160B5D2 94B651B8D054358BC3583CAB779835
581180-POA-8795-PA...pdf	AAF1ABEAF8776034984243839 2BD7EA796CD6162D57444B470 D6774AC888D644E8C54642395E98A5049D4890CFD513B11C8 C132D28EE994485D609A3D37AE076

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/96 (08-12)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Feit Electric Company, Inc.

Application No./Patent No.: 8,604,678 Filed/Issue Date: 12/10/2013

Titled: WAVELENGTH CONVERSION COMPONENT WITH A DIFFUSING LAYER

Feit Electric Company, Inc., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Inventors To: Intematix Corporation

   The document was recorded in the United States Patent and Trademark Office at
   Reel 027448, Frame 0492, or for which a copy thereof is attached.

2. From: Intematix Corporation To: East West Bank

   The document was recorded in the United States Patent and Trademark Office at
   Reel 036967, Frame 0623, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313 1450**.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: East West Bank To: Intematix Corporation

The document was recorded in the United States Patent and Trademark Office at
Reel 059910, Frame 0304, or for which a copy thereof is attached.

4. From: Intematix Corporation To: Feit Electric Company, Inc.

The document was recorded in the United States Patent and Trademark Office at
Reel 060078, Frame 0465, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Christopher P. Lightner/	2022-07-05
Signature	Date
Christopher P. Lightner	62156
Printed or Typed Name	Title or Registration Number

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/273,212	10/13/2011	Bing Dai	

CONFIRMATION NO. 8795

826
ALSTON & BIRD LLP
ONE SOUTH AT THE PLAZA
101 SOUTH TRYON STREET
SUITE 4000
CHARLOTTE, NC 28280-4000

POA ACCEPTANCE LETTER

OC000000135014945

Date Mailed: 07/08/2022

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/05/2022.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/nrhayden/

Savant Technologies LLC - 1004.1233

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/273,212	10/13/2011	Bing Dai	ITMX-00318US1

CONFIRMATION NO. 8795

101130
Vista IP Law Group, LLP (Intematix)
2160 Lundy Avenue, Suite 230
San Jose, CA 95131

POWER OF ATTORNEY NOTICE

OC000000135014903

Date Mailed: 07/08/2022

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/05/2022.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/nrhayden/

Savant Technologies LLC - 1004.1234

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
13/273,212	10/13/2011	Bing Dai	060196/581180	170085

Acknowledgement of Change to Small Entity Status

The entity status change request below filed through Private PAIR on 07/13/2022 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant asserting small entity status. See 37 CFR 1.27.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/Christopher P. Lightner/
Name:	Christopher P. Lightner
Registration Number:	62156