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Inventor(s):	Seung Ryeol Ryu et al.	Confirmation No.
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For:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR	

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PRELIMINARY AMENDMENT

Prior to Examination, please amend the application as follows.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 6 of this paper.

IPR2025-00335
Samsung Electronics Co., Ltd. v. Sinotechnix, LLC.
Samsung's Exhibit 1015 Vol. 1
EX1015, Page 1

IN THE CLAIMS

1. (Original) A backlight panel, comprising:

a light guide plate for emitting light incident from a side direction, the light guide emitting light through a top surface thereof;

white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and

a diffusion plate positioned over the top surface of the light guide plate,

wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

2. (Original) The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

3. (Original) A backlight panel, comprising:

a diffusion plate having a top surface and a bottom surface;

white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and

a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,

wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

4. (Original) The backlight panel as claimed in claim 3, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

5. (Currently amended) The backlight panel as claimed in ~~any one of~~ claims 1 ~~to 4~~, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; $z=x+2$; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

6. (Currently amended) The backlight panel as claimed in ~~any one of~~ claims 1 ~~to 4~~, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

7. (Currently amended) The backlight panel as claimed in ~~any one of~~ claims 1 ~~to 4~~, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; $z=x+2$; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

8. (New) The backlight panel as claimed in claim 2, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; $z=x+2$; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

9 (New) The backlight panel as claimed in claim 3, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; $z=x+2$; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

10. (New) The backlight panel as claimed in claim 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

11. (New) The backlight panel as claimed in claim 2, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

12. (New) The backlight panel as claimed in claim 3, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

13. (New) The backlight panel as claimed in claim 4, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

14. (New) The backlight panel as claimed in claim 2, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

15. (New) The backlight panel as claimed in claim 3, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

16. (New) The backlight panel as claimed in claim 4, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

REMARKS

Claims 5, 6, and 7 have been amended to remove multiple dependencies.

New claims 8-16 have been added.

No new matter has been added.

The Examiner is requested to call the undersigned if any questions arise concerning the above-mentioned application.

Respectfully submitted,

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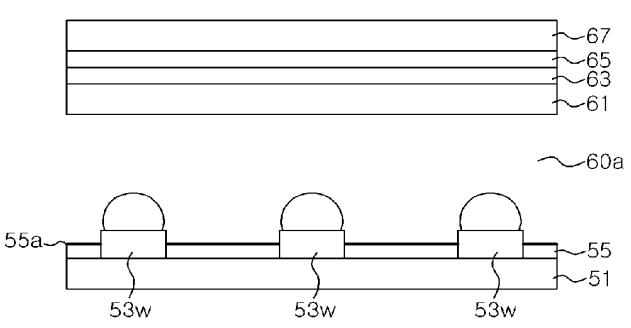
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(54) Title: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR



(57) Abstract: Disclosed is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Accordingly, since the backlighting can be performed using white light with distinct red, green and blue wavelengths, the color reproducibility can be enhanced. Further, since the white light can be implemented with a single light emitting diode, the manufacturing costs and thickness of the backlight panel can also be reduced.

Description

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Technical Field

[1] The present invention relates to a backlight panel for backlighting a display panel, and more particularly, to a backlight panel employing a white light emitting diode with red and green phosphors as a light source to enhance color reproducibility and luminance.

Background Art

[2] A passive display device such as a liquid crystal display (LCD) reflects or absorbs ambient sunlight or indoor light to display images on an LCD panel. Thus, the ambient sunlight or indoor light is required for a user to view the displayed image. However, in a case where intensity of the ambient sunlight or indoor light is not sufficient to illuminate a display panel, there is a problem in that the user cannot view the displayed image. As an alternative to such a problem, a backlight panel for backlighting a display panel is generally employed.

[3] A backlight panel includes a light source such as an incandescent lamp, fluorescent lamp or light emitting diode (LED). Light emitted from the light source illuminates the LCD panel, and thus, images are implemented. Meanwhile, since the LED has superior reproducibility, it has been frequently used as a backlight source. In addition, since the LED is environmentally friendly, it is expected that its use will be further increased in the future.

[4] Fig. 1 is a partial sectional view illustrating a conventional backlight panel for backlighting an LCD panel 17 using light emitting diodes (LEDs).

[5] Referring to Fig. 1, an LED array is arranged on a printed circuit board 1. The LED array is an array in which red, green and blue LEDs 3r, 3g and 3b are arranged at a predetermined interval. The LEDs are arranged on the printed circuit board 1 in a regular order and constructed into an LED module, and a plurality of LED modules are used to backlight the LCD panel 17.

[6] Each of the LEDs employs a lens designed for side-luminescence such that major light can be radiated almost in a side direction.

[7] A reflection sheet 5 is positioned below light exit surfaces of the LEDs. The reflection sheet may be formed with a reflection layer 5a on the top thereof. The reflection sheet reflects light emitted from the LEDs in an upward direction.

[8] Furthermore, a light transmission layer 7 is positioned above the LEDs. The light transmission layer is a layer through which light emitted from the LED can be

transmitted. The light transmission layer is generally made of a transparent resin such as PMMA (poly methyl methacrylate). The light transmission layer 7 is provided with light shielding patterns 9 at positions corresponding to the LEDs. The light shielding patterns function to prevent light emitted upward from the LEDs from penetrating the light transmission layer and then traveling toward the LCD panel 17. The light shielding patterns may be formed through an ESR (eletroslag remelting) process.

[9] The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a first gap 6a which is an air layer. The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are mixed with one another.

[10] A diffusion plate 11 is positioned above and spaced apart from the light transmission layer 7. The diffusion plate 11 diffuses light incident thereon to make the light uniform. The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a second gap 10a which is an air layer. Thus, the light transmitted through the light transmission layer 7 is again mixed within the second gap 10a and the mixed light is then incident onto the diffusion plate 11.

[11] A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film-embossed (DBEF-E) is positioned on a top surface of the BEF 13. The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

[12] Since the red, green and blue LEDs are used as light sources according to a prior art, the color reproducibility can be enhanced. However, it is necessary to mix light emitted from the LEDs in order to obtain the uniform light. Accordingly, it is necessary to prevent light emitted from the LEDs from transmitting directly through the light transmission layer 7 and traveling toward the diffusion plate 11 by using the light shielding pattern 9. Further, air layers such as the first and second gaps 6a and 10a are required. These result in an increase in thickness of a backlight panel.

[13] Further, while light emitted from the LEDs is mixed, light loss is generated. Thus, such light loss should be compensated by increasing an amount of current supplied to the LEDs, by using a larger number of LEDs or by using the BEF 13, the DBEF 15 and the like. However, in a case where the amount of current is increased or a large number of LEDs are used, power consumption is increased. In particular, the increase in the amount of current leads to an increase of heat generated from the LEDs, and the light

shielding layer may be deteriorated. In addition, the use of the BEFs causes the total thickness of the backlight panel to be further increased and the manufacturing costs of the backlight panel to be increased.

Disclosure of Invention

Technical Problem

[14] An object of the present invention is to provide a backlight panel which has smaller thickness and reduced manufacturing costs as compared with a conventional backlight panel.

[15] Another object of the present invention is to provide a backlight panel capable of enhancing its luminance as compared with a conventional backlight panel.

Technical Solution

[16] In order to achieve the above objects of the present invention, there is provided a backlight panel employing a white light emitting diode with red and green phosphors. A backlight panel according to an aspect of the present invention comprises a light guide plate for emitting light incident from a side direction. The light guide plate emits light through a top surface thereof. The white light emitting diodes are arranged at a side of the light guide plate to emit white light into the light guide plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a diffusion plate is positioned over the top surface of the light guide plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and the thickness of the backlight panel can also be reduced, by employing the white light emitting diode with three red, green and blue wavelengths

[17] Further, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate. The brightness enhancement films can enhance the luminance of the backlight panel.

[18] A backlight panel according to another aspect of the present invention comprises a diffusion plate having a top surface and a bottom surface. White light emitting diodes are arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a reflection sheet is positioned below light exit surfaces of the white light emitting diodes and also allows light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and spaces or gaps where light is mixed can also be reduced, so that the thickness of the backlight panel can be reduced. Further, since the luminance can be enhanced with the use of a light

source for upward emitting light, brightness enhancement films can be omitted.

[19] In addition, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate to further increase the luminance of the backlight panel.

[20] Preferably, the red phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate red light. The red phosphor may be an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

[21] Preferably, the green phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate green light. The green phosphor may be a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y <1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

Advantageous Effects

[22] According to the embodiments of the present invention, there is provided a backlight panel which has smaller thickness and reduced manufacturing costs as compared with the coventional backlight panel. Further, there is provided a backlight panel having enhanced luminance as compared with the conventional backlight panel.

[23] Meanwhile, in a case where the red, green and blue LEDs are used as described in the prior art, the life spans and degrees of deterioration of the LEDs are different from one another. Thus, a color sensor should be installed on the LCD panel to detect the deterioration of the LEDs and to perform a compensation work. However, since the white LEDs of the same kinds are used in the embodiments of the present invention, the life spans and deterioration of the LEDs are generally similar to one another. Therefore, it is less necessary to use the color sensor and perform the compensation work. Accordingly, an operation circuit of the LCD panel can be further simplified.

Brief Description of the Drawings

[24] Fig. 1 is a sectional view illustrating a conventional backlight panel.

[25] Fig. 2 is a sectional view illustrating a backlight panel according to an aspect of the present invention.

[26] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel

according to the aspect of the present invention.

[27] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[28] Fig. 5 is a sectional view illustrating a white light emitting diode of the present invention.

Mode for the Invention

[29] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided only for illustrative purposes so that those skilled in the art can fully understand the spirit of the present invention. Therefore, the present invention is not limited to the following embodiments but may be implemented in other forms. In the drawings, the widths, lengths, thicknesses and the like of components may be exaggerated for convenience of illustration. Like reference numerals indicate like elements throughout the specification and drawings.

[30] Fig. 2 is a sectional view illustrating a backlight panel for backlighting a liquid crystal display panel 37 (hereinafter, referred to as "LCD panel") according to an aspect of the present invention.

[31] Referring to Fig. 2, a light guide plate 27 is positioned below the LCD panel 37. The light guide plate converts light emitted from a light source 23w into surface light and then emits the surface light upward toward the LCD panel. The light guide plate 27 may be made of glass, a transparent resin such as a transparent acryl resin or a polycarbonate or epoxy resin, or the like. Both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Further, a reflection sheet 25 may be positioned on a bottom surface of the light guide plate.

[32] White light emitting diodes (hereinafter, referred to as "LEDs") are positioned adjacent to a side of the light guide plate. Each of the white LEDs emits white light toward the side of the light guide plate 27. The white LED may be mounted on a printed circuit board 21, and a plurality LEDs may be mounted on the printed circuit board 21 as an LED module. The LEDs 23w mounted on the printed circuit board 21 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 27. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[33] The white LED 23w includes a blue LED chip, and green and red phosphors which are positioned over the blue LED chip to convert a portion of blue light into green and red light, respectively. The white LED 23w will be described in detail later with reference to Fig. 5.

[34] Meanwhile, light shielding walls 29 are positioned above and below the white LED 23w, respectively. The light shielding walls prevent light emitted from the white LED 23w from traveling toward regions other than the side of the light guide plate 27. A reflection layer is coated on an inner wall of the light shielding wall 29 to enable light incident onto the light shielding wall to be reflected. Such a reflection layer may be also formed on a top surface of the printed circuit board 21.

[35] A diffusion plate 31 is positioned over top surface of the light guide plate 27. The diffusion plate 31 may be a thin sheet. The diffusion plate 31 diffuses light incident from the light guide plate 27 into uniform light. Moreover, a brightness enhancement film (BEF) 33 and/or a dual brightness enhancement film (DBEF) 35 may be interposed between the diffusion plate 31 and the LCD panel 37. The BEFs 33 and 35 collect light emitted from the light guide plate 27 within a certain showing angle to increase the luminance of light.

[36] Since the backlight panel according to the aspect of the present invention is mounted with the white LED to enable uniform white light to be emitted from the LED, an air layer used for mixing the red, green and blue light with one another is not necessary, as compared with the prior art. Thus, the thickness of the backlight panel can be decreased. Further, since light emitted from the white LED is incident directly onto the light guide plate 27, the light emitting luminance can be enhanced. Thus, the BEFs 33 and 35 may be omitted. Furthermore, in a case where the BEFs are used, the luminance can be further enhanced. Thus, the number of LEDs used can also be reduced.

[37] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel according to the aspect of the present invention.

[38] Referring to Fig. 3, the diffusion plate 31, the BEFs 33 and 35, and the LCD panel 37 are provided in the same manner as described with reference to Fig. 2. Hereinafter, only differences between the backlight panels of Figs. 2 and 3 will be described in detail.

[39] A light guide plate 47 is positioned below the diffusion plate 31. The light guide plate 47 is formed with a receiving groove 47a at a side thereof to accommodate LEDs in the receiving groove. As described with reference to Fig. 2, the light guide plate 47 may be made of glass, a transparent resin such as a transparent acryl resin or a poly-carbonate or epoxy resin, or the like. Further, both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Furthermore, the reflection sheet 25 can be positioned on a bottom surface of the light guide plate. The reflection sheet 25 may be attached to the bottom surface of the light guide plate 47 to extend to the side thereof and have a through-hole through which the LEDs can be received in the receiving

groove 47a of the light guide plate 47.

[40] A white LED 43w is accommodated in the receiving groove 47a. The white LED is a side-view LED which emits light almost in parallel with top and bottom surfaces of the light guide plate 47, i.e. perpendicular to the side surfaces thereof. The side-view LED can adjust a showing angle of emitted light to be smaller than that of an LED emitting light upward, so that the thickness of the light guide plate 47 can be reduced.

[41] The white LED may be mounted on a printed circuit board 41, and a plurality LEDs may also be mounted on the printed circuit board 41 as an LED module. The LEDs 43w mounted on the printed circuit board 41 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 47. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[42] According to this embodiment, the side-view LED capable of adjusting a showing angle to be smaller is mounted such that the thickness of the light guide plate can be reduced.

[43] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[44] Referring to Fig. 4, a diffusion plate 61 is positioned below an LCD panel 67. The diffusion plate has a top surface and a bottom surface. BEF 63 and/or DBEF 65 may be interposed between the diffusion plate and the LCD panel 67.

[45] Meanwhile, white LEDs 53w are arranged below the bottom surface of the diffusion plate 61 at a certain interval from the diffusion plate 61. Each of the white LEDs 53w includes a blue LED chip, and green and red phosphors positioned over the blue LED chip. The white LEDs 53w will be described in detail later with reference to Fig. 5.

[46] Each of the white LEDs 53w emits white light toward the diffusion plate 61. The white LED may be mounted on a printed circuit board 51, and a plurality LEDs may be mounted on the printed circuit board 51 as an LED module. The LEDs 53w mounted on the printed circuit board 51 may be simultaneously driven through a circuit printed on the printed circuit board. A plurality of LED modules may be arranged below the diffusion plate 61 to uniformly backlight the LCD panel 67.

[47] Furthermore, a reflection sheet 55 is positioned below light exit surfaces of the white LEDs 53w. The reflection sheet 55 may be formed with a reflection layer 55a thereon. The reflection sheet may be made of an aluminum sheet and coated with the reflection layer 55a thereon. Further, the reflection sheet 55 may be attached onto the printed circuit board 51 as shown in this figure.

[48] The reflection sheet 55 and the diffusion plate 61 are spaced apart from each other by a predetermined interval to define a gap 60a corresponding to an air layer. White

light emitted from the white LEDs 53w are mixed with one another in the gap 60a and then incident onto the diffusion plate 61.

[49] The backlight panel according to this aspect does not use an additional light guide plate. Thus, the diffusion plate 61 may be thicker than the diffusion plate 31 of Fig. 2 or 3 such that light emitted from the white LEDs 53w can be uniform.

[50] In the meantime, since the backlight panel according to this aspect employs top-view white LEDs contrary to the prior art, the light transmission layer 7 (Fig. 1) formed with the light shielding pattern 9 (Fig. 1) may be omitted. Further, since light emitted from the white LEDs 53w is incident directly onto the diffusion plate 61, the light loss can be reduced so that the luminance of the LCD panel 67 can be enhanced. Accordingly, since the BEF 63 and the DBEF 65 can be omitted, the thickness of the backlight panel can also be reduced.

[51] Fig. 5 is a sectional view illustrating the white LED 23w, 43w or 53w used in the embodiments of the present invention.

[52] Referring to Fig. 5, the white LED includes a package body 71. The package body may be formed using an injection molding, pressing or machining technique, and particularly injection-molded using a plastic resin. The package body is formed with a cavity which exposes lead terminals 73. Further, a sidewall of the cavity may be an inclined surface inclined at a certain angle.

[53] The lead terminals 73 extend outward to protrude out of the package body 71. The lead terminals 73 protruding to the outside are connected to a printed circuit board and electrically connected to an external power source. The lead terminals 73 may be bent from the outside such that they can be surface mounted.

[54] Meanwhile, a heat sink 75 may be attached to the bottom of the package body 71. The heat sink is provided to easily dissipate heat generated from an LED chip 77 to the outside. The heat sink 75 may be formed with a base and a projection protruding upward from a center portion of the base. The projection is inserted into the package body and then exposed to the cavity. After the package body 71 has been formed with a through-hole, the heat sink can be inserted into the through-hole of the package body and mounted to the package body. Alternatively, the heat sink 75 can be attached to the package body 71 by positioning the lead terminals 73 and the heat sink 75 and then forming the package body using an insert-molding technique. The heat sink 75 may be electrically isolated from the lead terminals 75, or electrically connected to any one of the lead terminals.

[55] A blue LED chip 77 for emitting blue light is mounted on the heat sink 75. The LED chip 77 is a GaN, InGaN or AlGaInN-based light emitting diode and radiates blue light with a wavelength of 420 to 480 nm. The LED chip 77 has two electrodes for the connection with an external source. The electrodes may be positioned on the same side

or opposite sides of the LED 77. The electrodes may be electrically connected to the lead terminals through an adhesive or bonding wires as shown in this figure. In a case where the electrodes are formed on the same side of the LED chip, the LED chip 77 and the lead terminals are connected through the two bonding wires, respectively, so that they can be electrically connected as shown in this figure. On the other hand, in a case where the electrodes are positioned on the opposite sides, one of the electrodes is connected to the heat sink 75 using a conductive adhesive and one of the lead terminals is connected to the heat sink 75 through the bonding wire, so that the lead terminals and the LED chip 77 can be electrically connected with each other.

[56] Over the blue LED chip 77 is positioned red and green phosphors 81r and 81g which are excited by blue light to radiate red and green light, respectively, such that the radiated light is mixed with a portion of blue light emitted from the LED chip 77 to become white light. The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.

[57] For example, the red phosphor 81r may be an alkali earth metal sulfide-based red phosphor, while the green phosphor 81g may be a thiogallate-based green phosphor. More specifically, the alkali earth metal sulfide-based red phosphor is expressed as general formula $A_{x-a}Eu_aGeS_z$, where A is Ca and/or Sr, z=x+2, x is set within a range of 2 to 5, and a/x is set within a range of 0.0005 to 0.02.

[58] Further, the thiogallate-based green phosphor is expressed as general formula $(A_{1-x-y}Eu_x(M^I_{0.5}M^{III}_{0.5})_y)B_2S_4$, where A is at least one element selected from the group consisting of Ba, Sr and Ca, B is at least one element selected from the group consisting of Al, Ga and In, and $0<x, y, x+y<1$. Preferably, x is set within a range of 0.01 to 0.1. Meanwhile, M^I is at least one element selected from the group consisting of Li, Na and K, and M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La. Preferably, y is set within a range of 0.2 to 0.8.

[59] Such red and green phosphors 81r and 81g are obtained in the following manners. That is, phosphor raw materials and an activator raw material are weighted to have a predetermined mixing ratio in accordance with a desired composition and sufficiently mixed into a uniform mixture by using a ball milling or a mixer such as agate mortar within an alcohol solvent for effective mixing. Then, the mixture is dried in an oven at a temperature of 100 to 150°C for 1 to 2 hours. The dried mixture is heat-treated in a high-purity alumina boat at a temperature of 800 to 1300°C under the atmosphere of H_2S using an electric furnace to synthesize phosphor powder and then sufficiently pulverize the synthesized phosphor powder.

[60] According to the results of measuring photoluminescence (PL) of the powder, the

thiogallate-based green phosphor of a typical composition expressed as $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$ exhibits strong photoluminescence spectrum throughout a region of 470 to 630 nm while the alkali earth metal sulfide-based red phosphor expressed as $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ exhibits strong photoluminescence spectrum throughout a region of 520 to 780 nm. Accordingly, white light with distinct red, green and blue wavelengths can be radiated using the blue LED chip 77 and the phosphors, and thus, the color reproducibility of the LCD panel can be enhanced.

[61] Meanwhile, the LED chip 77 and the phosphors 81r and 81g are covered with a lens 83. The lens may be formed into a variety of shapes. For example, to implement a top-view LED according to the aspects of the present invention, the lens may take the shape of a convex lens as shown in this figure. At this time, the curvature of the lens is determined depending on a desired showing angle. Meanwhile, to implement a side-view LED shown in Fig. 2, the lens is designed to emit light from the LED chip 77 in a side direction. An example of such a side-view LED is shown in Fig. 1, and the other side-view LEDs can be implemented into a variety of lens shapes.

Claims

[1] A backlight panel, comprising:
a light guide plate for emitting light incident from a side direction, the light guide emitting light through a top surface thereof;
white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and
a diffusion plate positioned over the top surface of the light guide plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[2] The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[3] A backlight panel, comprising:
a diffusion plate having a top surface and a bottom surface;
white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and
a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[4] The backlight panel as claimed in claim 3, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[5] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

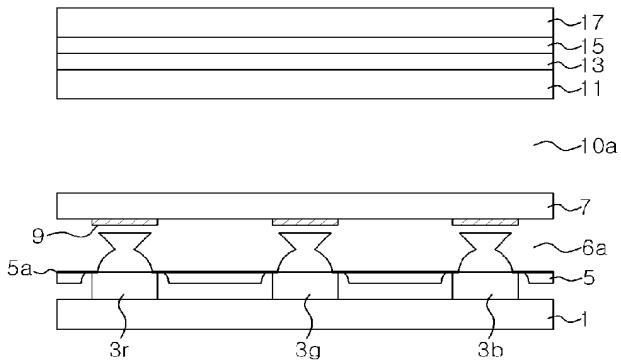
[6] The backlight panel as claimed in any one of claims 1 to 4, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li,

Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

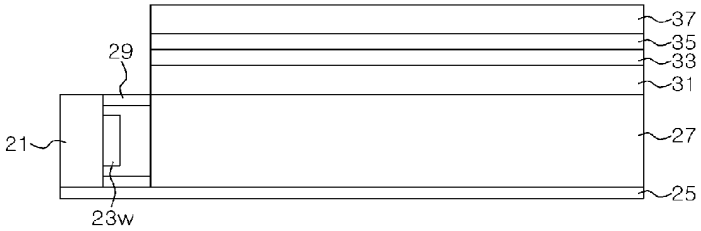
[7] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

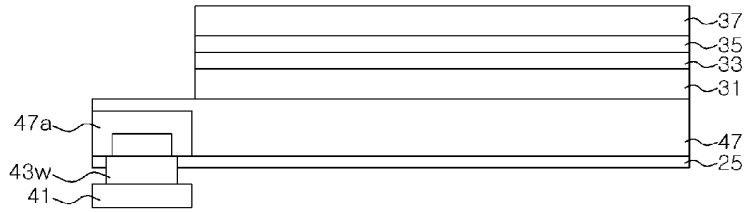
[Fig. 1]



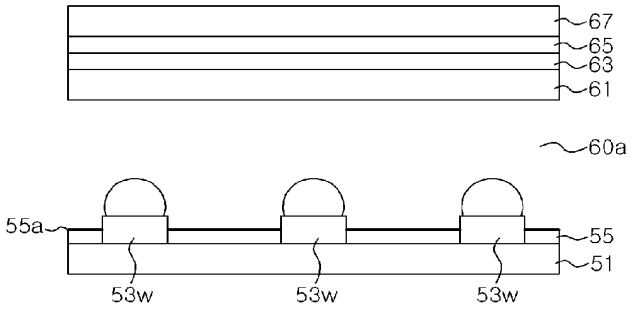
[Fig. 2]



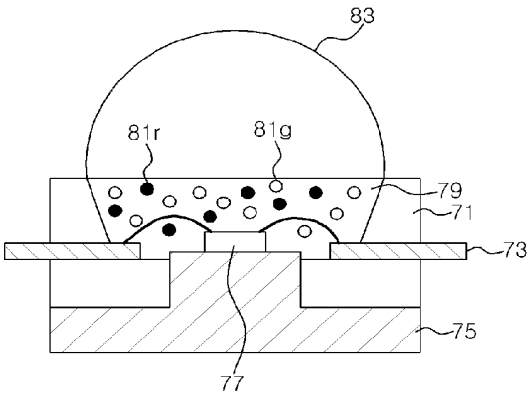
[Fig. 3]



[Fig. 4]



[Fig. 5]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/000885

A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/13357(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)
IPC8 G02F 1/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
Korean Utility Models and applications for Utility Models since 1975
Japanese Utility Models and applications for Utility Models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2001-97147 A (LS TECH CO., LTD.) 08.11.2001 see the Page 2-3, Fig2,6	1
A	WO 98/05078 A (NICHIA KAGAKU KOGYO KABUSHIKI KAISHA) 05.02.1998 see the whole document	1-7
A	JP 2004-296830 A (SOLIDLITE CORP) 21.10.2004 see the whole document	1-7
A	JP 2004-119743 A (CITIZEN ELECTRONICS CO LTD.) 15.04.2004 see the whole document	1-7

☐ 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
20 JUNE 2006 (20.06.2006)	**21 JUNE 2006 (21.06.2006)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	CHANG, Kyung Tae Telephone No. 82-42-481-5769

Form PCT/ISA/210 (second sheet) (April 2005)

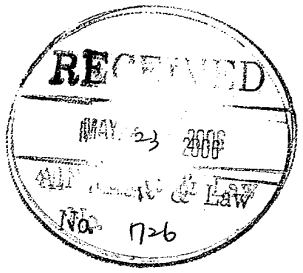
INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2006/000885

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 2001-97147A	08.11.2001	NONE	
WO9805078A1	05.02.1998	US6608332BB	19.08.2003
		EP00936682B1	23.08.2000
		JP2003179259A2	27.06.2003
		KR1020030097609A	31.12.2003
		US05998925B	07.12.1999
JP 2004-296830A	21.10.2004	NONE	
JP 2004-119743A	15.04.2004	CN1501519A	02.06.2004
		EP1403936A2	31.03.2004
		JP2004119743A2	15.04.2004
		KR1020040027378A	01.04.2004
		US6858456BB	22.02.2005

Form PCT/ISA/210 (patent family annex) (April 2005)



PATENT COOPERATION TREATY

PCT/KR2006/000885

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

LEE, Soo Wan
1901-ho, Keungil Tower 19F, 677-25 Yeoksam-dong
Gangnam-gu
Seoul 135-914
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 27 April 2006 (27.04.2006)	
Applicant's or agent's file reference P06-5004	**IMPORTANT NOTIFICATION**
International application No. PCT/KR2006/000885	International filing date *(day/month/year)* 13 March 2006 (13.03.2006)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 31 March 2005 (31.03.2005)
Applicant SEOUL SEMICONDUCTOR CO., LTD. et al	

1. By means of this Form, which replaces any previously issued notification concerning submission or transmittal of priority documents, the applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to a date of receipt, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. *(If applicable)* The **letters "NR"** appearing in the right-hand column denote **a priority document which, on the date of mailing of this Form, had not yet been received by the International Bureau** under Rule 17.1(a) or (b). Where, under Rule 17.1(a), the priority document must be submitted by the applicant to the receiving Office or the International Bureau, but the applicant fails to submit the priority document within the applicable time limit under that Rule, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

3. *(If applicable)***An asterisk (*)** appearing next to a date of receipt, in the right-hand column, denotes **a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b)** (the priority document was received after the time limit prescribed in Rule 17.1(a) or the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b)). Even though the priority document was not furnished in compliance with Rule 17.1(a) or (b), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
31 March 2005 (31.03.2005)	10-2005-0027133	KR	07 April 2006 (07.04.2006)

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Gijsbertus Beijer Facsimile No. +41 22 338 82 70 Telephone No. +41 22 338 95 61

Form PCT/IB/304 (October 2005) CTWR5WKB

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

SECOND AND SUPPLEMENTARY NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

LEE, Soo Wan
1901-ho, Keungil Tower 19F, 677-25 Yeoksam-dong
Gangnam-gu
Seoul 135-914
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 02 August 2007 (02.08.2007)	
Applicant's or agent's file reference P06-5004	**IMPORTANT NOTICE**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/KR2006/000885	13 March 2006 (13.03.2006)	31 March 2005 (31.03.2005)

Applicant: SEOUL SEMICONDUCTOR CO., LTD. et al

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does not apply**, please see Form PCT/IB/308(First Notice) issued previously.

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
05 October 2006 (05.10.2006)

   AU, AZ, BY, CN, CO, DZ, EP, HU, KG, KP, MD, MK, MZ, NA, NG, PG, RU, SY, TM, US

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   AE, AG, AL, AM, AP, AT, BA, BB, BG, BR, BW, BZ, CA, CR, CU, CZ, DE, DK, DM, EA, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, ID, IL, IN, IS, JP, KE, KM, KN, KZ, LC, LK, LR, LS, LT, LV, LY, MA, MG, MN, MW, MX, NI, NO, NZ, OA, OM, PH, PL, PT, RO, SC, SD, SG, SK, SL, SM, TJ, TN, TR, TT, UA, UZ, VC, VN, YU, ZA, ZM, ZW

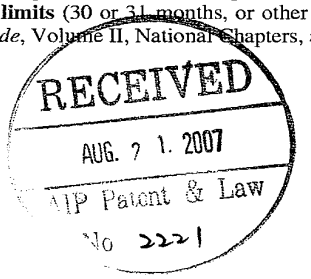
   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated or elected Office(s) listed above, the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **30 MONTHS** from the priority date.

   In practice, **time limits other than the 30-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated or elected Office(s) listed above. For **regular updates on the applicable time limits** (30 or 31 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, Volume II, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.



The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Becamel

e-mail: pt12.pct@wipo.int

Form PCT/IB/308(Second and Supplementary Notice) (January 2004)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
P06-5004		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/KR2006/000885	**13 MARCH 2006 (13.03.2006)**	31 MARCH 2005 (31.03.2005)
Applicant		
SEOUL SEMICONDUCTOR CO., LTD. et al		

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. ☐ 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(b), 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. 4
      ☒ as suggested by the applicant.
      ☐ because the applicant failed to suggest a figure.
      ☐ because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/000885

A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/13357(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)
IPC8 G02F 1/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
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Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2001-97147 A (LS TECH CO., LTD.) 08.11.2001 see the Page 2-3, Fig2,6	1
A	WO 98/05078 A (NICHIA KAGAKU KOGYO KABUSHIKI KAISHA) 05.02.1998 see the whole document	1-7
A	JP 2004-296830 A (SOLIDLITE CORP) 21.10.2004 see the whole document	1-7
A	JP 2004-119743 A (CITIZEN ELECTRONICS CO LTD.) 15.04.2004 see the whole document	1-7

☐ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 JUNE 2006 (20.06.2006)	**21 JUNE 2006 (21.06.2006)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	CHANG, Kyung Tae Telephone No. 82-42-481-5769

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2006/000885

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 2001-97147A	08.11.2001	NONE	
WO9805078A1	05.02.1998	US6608332BB	19.08.2003
		EP00936682B1	23.08.2000
		JP2003179259A2	27.06.2003
		KR1020030097609A	31.12.2003
		US05998925B	07.12.1999
JP 2004-296830A	21.10.2004	NONE	
JP 2004-119743A	15.04.2004	CN1501519A	02.06.2004
		EP1403936A2	31.03.2004
		JP2004119743A2	15.04.2004
		KR1020040027378A	01.04.2004
		US6858456BB	22.02.2005

PTO/SB/08a (08-03)
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	Art Unit	
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	1	WO9805078	WO		1998-02-05	Nichia Kagaku Kogyo Kabushiki Kaisha		☐
	2	1020010097147	KR		2001-11-08	LS Tech Co., Ltd.		☐
	3	JP2004296830	JP		2004-10-21	Solidlite Corp.		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	
	Filing Date	
	First Named Inventor	Seung Ryeol Ryu
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	4	JP2004119743	JP		2004-04-15	Citizen Electronics		☐

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	Application Number	
	Filing Date	
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	
	Examiner Name	
	Attorney Docket Number	1226-021

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☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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Signature	/Hosoon Lee/	Date (YYYY-MM-DD)	2007-09-25
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WO9805078

Publication Title:

LIGHT EMITTING DEVICE AND DISPLAY DEVICE

Abstract:

1690 Abstract of WO9805078

A light emitting device provided with a light emitting element having a semiconductor light emitting layer and a photoluminescence fluorophor which absorbs part of the light emitted from the light emitting element and emits light having a wavelength which is different from that of the absorbed light. The light emitting layer of the light emitting element is composed of a nitride compound semiconductor and the photoluminescence fluorophor contains a garnet-based fluorophor activated with cerium containing at least one element selected from among the elements of Y, Lu, Sc, La, Gd, and Sm and at least one element selected from among the elements of Al, Ga and In. As a result, a white light emitting diode having high luminance and a light emitting characteristic which is not deteriorated even when the diode is used for a long period of time is obtained.

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(51) 国際特許分類6 **H01L 33/00**	**A1**	(11) 国際公開番号	**WO98/05078**
		(43) 国際公開日	1998年2月5日(05.02.98)

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特願平8/244339	1996年9月17日(17.09.96)	JP
特願平8/245381	1996年9月18日(18.09.96)	JP
特願平8/359004	1996年12月27日(27.12.96)	JP
特願平9/81010	1997年3月31日(31.03.97)	JP

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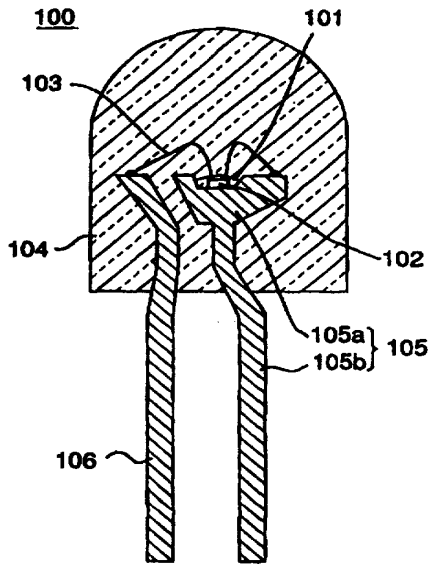
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国際調査報告書

(54)Title: **LIGHT EMITTING DEVICE AND DISPLAY DEVICE**

(54)発明の名称 発光装置と表示装置

(57) **Abstract**

A light emitting device provided with a light emitting element having a semiconductor light emitting layer and a photoluminescence fluorophor which absorbs part of the light emitted from the light emitting element and emits light having a wavelength which is different from that of the absorbed light. The light emitting layer of the light emitting element is composed of a nitride compound semiconductor and the photoluminescence fluorophor contains a garnet-based fluorophor activated with cerium containing at least one element selected from among the elements of Y, Lu, Sc, La, Gd, and Sm and at least one element selected from among the elements of Al, Ga and In. As a result, a white light emitting diode having high luminance and a light emitting characteristic which is not deteriorated even when the diode is used for a long period of time is obtained.



（５７）要約

本発明は、発光層が半導体である発光素子と、該発光素子によって発光された光の一部を吸収して、吸収した光の波長と異なる波長を有する光を発光するフォトルミネセンス蛍光体とを備えた発光装置において、前記発光素子の発光層が窒化物系化合物半導体からなり、かつ前記フォトルミネセンス蛍光体が、Ｙ、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍからなる群から選ばれた少なくとも１つの元素と、Ａｌ、Ｇａ及びＩｎからなる群から選ばれる少なくとも１つの元素とを含んでなるセリウムで付活されたガーネット系蛍光体を含むことを特徴とし、これによって、高輝度で、長時間の使用によっても発光特性の劣化が少ない白色系の発光ダイオードを提供する。

参考情報

ＰＣＴに基づいて公開される国際出願のパンフレット第一頁に記載されたＰＣＴ加盟国を同定するために使用されるコード

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明　細　書

発光装置と表示装置

技術分野

本願発明は、ＬＥＤディスプレイ、バックライト光源、信号機、照光式スイッチ及び各種インジケータなどに利用される発光ダイオードに関し、特に発光素子が発生する光の波長を変換して発光するフォトルミネセンス蛍光体を備えた発光装置及びそれを用いた表示装置に関する。

背景技術

発光ダイオードは、小型で、効率が良く鮮やかな色の光の発光が可能で、半導体素子であるため、球切れの心配がなく、初期駆動特性及び耐震性に優れ、さらにＯＮ／ＯＦＦ点灯の繰り返しに強いという特長を有する。そのため、各種インジケータや種々の光源として広く利用されている。また、最近では、超高輝度、高効率なＲＧＢ(赤、緑、青色)の発光ダイオードがそれぞれ開発され、これらの発光ダイオードを用いた大画面のＬＥＤディスプレーが使用されるようになった。このＬＥＤディスプレーは、少ない電力で動作させることができ、軽量でしかも長寿命であるという優れた特性を有し、今後益々使用されるものと期待される。

さらに、最近では、発光ダイオードを用いて、白色発光光源を構成する試みが種々なされている。発光ダイオードを用いて白色光を得るためには、発光ダイオードが単色性ピーク波長を有するので、例えば、Ｒ、Ｇ、Ｂの３つの発光素子を近接して設けて発光させて拡散混色する必要がある。このような構成によって白色光を発生させようとした場合、発光素子の色調や輝度等のバラツキにより所望の白色を発生させることができないという

問題点があった。また、発光素子がそれぞれ異なる材料を用いて形成されている場合、各発光素子の駆動電力などが異なり個々に所定の電圧を印加する必要があり、駆動回路が複雑になるという問題点があった。さらに、発光素子が半導体発光素子であるため、個々に温度特性や経時変化が異なり、色調が使用環境によって変化したり、各発光素子によって発生される光を均一に混色させる事ができずに色むらを生ずる場合がある等の多くの問題点を抱えていた。すなわち、発光ダイオードは、個々の色を発光させる発光装置としては有効であったが、発光素子を用いて白色光を発生させることができる満足な光源は得られていなかった。

そこで、本出願人は先に発光素子によって発生された光が、蛍光体で色変換されて出力される発光ダイオードを、特開平５－１５２６０９号公報、特開平７－９９３４５号公報、特開平７－１７６７９４号公報、特開平８－８６１４号公報などにおいて発表した。これらに開示された発光ダイオードは、１種類の発光素子を用いて白色系など他の発光色を発光させることができるというものであり、以下のように構成される。

上記公報に開示された発光ダイオードは、具体的には、発光層のエネルギーバンドギャップが大きい発光素子をリードフレームの先端に設けられたカップ上に配置し、発光素子を被覆する樹脂モールド部材中に発光素子からの光を吸収して、吸収した光と波長の異なる光を発光する（波長変換）蛍光体を含有させて構成する。

上述の開示された発光ダイオードにおいて、発光素子として、青色系の発光が可能な発光素子を用いて、該発光素子をその発光を吸収して黄色系の光を発光する蛍光体を含有した樹脂によってモールドすることにより、混色により白色系の光が発光可能な発光ダイオードを作製することができる。

しかしながら、従来の発光ダイオードは、蛍光体の劣化によって色調がずれたり、あるいは蛍光体が黒ずみ光の外部取り出し効率が低下する場合があるという問題点があった。ここで、黒ずむというのは、例えば、（Ｃｄ，Ｚｎ）Ｓ蛍光体等の無機系の蛍光体を用いた場合には、この蛍光体を構成する金属元素の一部が析出したり変質したりして着色することであり、また、有機系の蛍光体材料を用いた場合には、２重結合が切れる等により着色することをいう。特に、発光素子である高エネルギーバンドギャップを有する半導体を用い、蛍光体の変換効率を向上させた場合（すなわち、半導体によって発光される光のエネルギーが高くなり、蛍光体が吸収することができるしきい値以上の光が増加し、より多くの光が吸収されるようになる。）、又は蛍光体の使用量を減らした場合（すなわち、相対的に蛍光体に照射されるエネルギー量が多くなる。）等においては、蛍光体が吸収する光のエネルギーが必然的に高くなるので、蛍光体の劣化が著しい。また、発光素子の発光強度を更に高め長期にわたって使用すると、蛍光体の劣化がさらに激しくなる。

また、発光素子の近傍に設けられた蛍光体は、発光素子の温度上昇や外部環境（例えば、屋外で使用された場合の太陽光によるもの等）によって高温にもさらされ、この熱によって劣化する場合がある。

さらに、蛍光体によっては、外部から侵入する水分や、製造時に内部に含まれた水分と、上記光及び熱とによって、劣化が促進されるものもある。

またさらに、イオン性の有機染料を使用すると、チップ近傍では直流電界により電気泳動を起こし、色調が変化する場合がある。

発明の開示

したがって、本願発明は上記課題を解決し、より高輝度で、長時間の使

用環境下においても発光光度及び発光光率の低下や色ずれの極めて少ない発光装置を提供することを目的とする。

本発明者らは、この目的を達成するために、発光素子と蛍光体とを備えた発光装置において、

（１）発光素子としては、高輝度の発光が可能で、かつその発光特性が長期間の使用に対して安定していること、

（２）蛍光体としては、上述の高輝度の発光素子に近接して設けられて、該発光素子からの強い光にさらされて長期間使用した場合においても、特性変化の少ない耐光性及び耐熱性等に優れていること（特に発光素子周辺に近接して配置される蛍光体は、我々の検討によると太陽光に比較して約３０倍～４０倍に及ぶ強度を有する光にさらされるので、発光素子として高輝度のものを使用すれば使用する程、蛍光体に要求される耐光性は厳しくなる）、

（３）発光素子と蛍光体との関係としては、蛍光体が発光素子からのスペクトル幅をもった単色性ピーク波長の光を効率よく吸収すると共に効率よく異なる発光波長が発光可能であること、が必要であると考え、鋭意検討した結果、本発明を完成させた。

すなわち、本発明の発光装置は、発光層が半導体である発光素子と、該発光素子によって発光された光の一部を吸収して、吸収した光の波長と異なる波長を有する光を発光するフォトルミネセンス蛍光体とを備えた発光装置において、

前記発光素子の発光層が窒化物系化合物半導体からなり、かつ前記フォトルミネセンス蛍光体が、Ｙ、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍからなる群から選ばれた少なくとも１つの元素と、Ａｌ、Ｇａ及びＩｎからなる群から選ばれる少なくとも１つの元素とを含み、かつセリウムで付活された

ガーネット系蛍光体を含むことを特徴とする。

ここで、窒化物系化合物半導体（一般式$In_iGa_jAl_kN$、ただし、$0 \leqq i$，$0 \leqq j$，$0 \leqq k$，$i+j+k=1$）としては、ＩｎＧａＮや各種不純物がドープされたＧａＮを始め、種々のものが含まれる。

また、前記フォトルミネセンス蛍光体としては、$Y_3Al_5O_{12}$：Ｃｅ、$Gd_3In_5O_{12}$：Ｃｅを始め、上述のように定義される種々のものが含まれる。

この本願発明の発光装置は、高輝度の発光が可能な窒化物系化合物半導体からなる発光素子を用いているので、高輝度の発光をさせることができる。また、該発光装置において、使用している前記フォトルミネッセンス蛍光体は、長時間、強い光にさらされても蛍光特性の変化が少ない極めて耐光性に優れている。これによって、長時間の使用に対して特性劣化を少なくでき、発光素子からの強い光のみならず、野外使用時等における外来光（紫外線を含む太陽光等）による劣化も少なくでき、色ずれや輝度低下が極めて少ない発光装置を提供できる。また、この本願発明の発光装置は、使用している前記フォトルミネッセンス蛍光体が、短残光であるため、例えば、１２０ｎｓｅｃという比較的速い応答速度が要求される用途にも使用することができる。

本発明の発光ダイオードにおいては、前記フォトルミネセンス蛍光体が、ＹとＡｌを含むイットリウム・アルミニウム・ガーネット系蛍光体を含むことが好ましく、これによって、発光装置の輝度を高くできる。

本発明の発光装置においては、前記フォトルミネセンス蛍光体として、一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}$：Ｃｅで表される蛍光体を用いることができ（ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇｄから選択される少なくとも一種である。）、イットリウム・アルミニウ

ム・ガーネット系蛍光体用いた場合と同様の優れた特性が得られる。

また、本発明の発光装置では、発光特性（発光波長や発光強度等）の温度依存性を小さくするために、前記フォトルミネセンス蛍光体として、一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3(Al_{1-s}Ga_s)_5O_{12}$で表される蛍光体（ただし、$0 \leqq p \leqq 0.8$、$0.003 \leqq q \leqq 0.2$、$0.0003 \leqq r \leqq 0.08$、$0 \leqq s \leqq 1$）を用いることが好ましい。

また、本発明の発光装置において、前記フォトルミネッセンス蛍光体は、それぞれＹとＡｌとを含んでなる互いに組成の異なる２以上の、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を含むようにしてもよい。これによって、発光素子の特性（発光波長）に対応して、フォトルミネッセンス蛍光体の発光スペクトルを調整して、所望の発光色の発光をさせることができる。

さらに、本発明の発光装置では、発光装置の発光波長を所定の値に設定するために、前記フォトルミネッセンス蛍光体は、それぞれ一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$（ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇｄから選択される少なくとも一種である。）で表され、互いに組成の異なる２以上の蛍光体を含むことが好ましい。

また、本発明の発光装置においては、発光波長を調整するために前記フォトルミネッセンス蛍光体は、一般式$Y_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表される第１の蛍光体と、一般式$Re_3Al_5O_{12}:Ce$で表される第２の蛍光体とを含んでもよい。

但し、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇａ、Ｌａから選択される少なくとも一種である。

また、本発明の発光装置においては、発光波長を調整するために、前記フォトルミネッセンス蛍光体は、それぞれイットリウム・アルミニウム・

ガーネット系蛍光体において、イットリウムの一部がガドリニウムに置換され、互いに置換量が異なる第１の蛍光体と第２の蛍光体とを含むようにしてもよい。

さらに、本発明の発光装置において、前記発光素子の発光スペクトルの主ピークが４００ｎｍから５３０ｎｍの範囲内に設定し、かつ前記フォトルミネッセンス蛍光体の主発光波長が前記発光素子の主ピークより長くなるように設定することが好ましい。これによって、白色系の光を効率よく発光させることができる。

またさらに、前記発光素子において、該発光素子の発光層がＩｎを含む窒化ガリウム系半導体を含んでなり、前記フォトルミネセンス蛍光体が、イットリウム・アルミニウム・ガーネット系蛍光体において、Ａｌの一部がＧａによってＧａ：Ａｌ＝１：１から４：６の範囲内の比率になるように置換されかつＹの一部がＧｄによってＹ：Ｇｄ＝４：１から２：３の範囲内の比率になるように置換されていることがさらに好ましい。このように調整されたフォトルミネセンス蛍光体の吸収スペクトルは、発光層としてＩｎを含む窒化ガリウム系半導体を有する発光素子の発光する光の波長と非常によく一致し、変換効率（発光効率）を良くできる。また、該発光素子の青色光と該蛍光体の蛍光光との混色による光は、演色性のよい良質な白色となり、その点で極めて優れた発光装置を提供できる。

本発明の１つの態様の発光装置は、その一側面に前記フォトルミネセンス蛍光体を介して前記発光素子が設けられ、かつその一主表面を除く表面が実質的に反射部材で覆われた略矩形の導光板を備え、前記発光素子が発光した光を前記フォトルミネセンス蛍光体と導光板とを介して面状にして、前記導光板の前記一主表面から出力することを特徴とする。

本発明の別の態様の発光装置は、その一側面に前記発光素子が設けられ、

その一主表面に前記フォトルミネセンス蛍光体が設けられかつ該一主表面を除く表面が実質的に反射部材で覆われた略矩形の導光板を備え、前記発光素子が発光した光を導光板と前記フォトルミネセンス蛍光体とを介して面状にして、前記導光板の前記一主表面から出力することを特徴とする。

また、本発明のＬＥＤ表示装置は、本発明の発光装置をマトリックス状に配置したＬＥＤ表示器と、該ＬＥＤ表示器を入力される表示データに従って駆動する駆動回路とを備える。これによって、高精細表示が可能でかつ視認角度によって色むらの少ない、比較的安価なＬＥＤ表示装置を提供できる。

本発明の一態様の発光装置は、カップ部とリード部とを有するマウント・リードと、

前記マウント・リードのカップ内に載置されかつ一方の電極がマウント・リードに電気的に接続されたＬＥＤチップと、

該ＬＥＤチップの他方の電極に電気的に接続させたインナー・リードと、

前記ＬＥＤチップを覆うように前記カップ内に充填された透光性のコーティング部材と、

前記マウント・リードのカップ部と、前記インナーリードと該ＬＥＤチップの他方の電極との接続部分とを含み、前記コーティング部材で覆われたＬＥＤチップを被覆するモールド部材とを有する発光ダイオードであって、

前記ＬＥＤチップが窒化物系化合物半導体であり、かつ前記コーティング部材が、Ｙ、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍからなる群から選ばれた少なくとも１つの元素と、Ａｌ、Ｇａ及びＩｎからなる群から選ばれる少なくとも１つの元素とを含み、セリウムで付活されたガーネット系蛍光体からなるフォトルミネッセンス蛍光体を含むことを特徴とする。

本発明の発光ダイオードにおいては、前記フォトルミネッセンス蛍光体

が、YとAlを含むイットリウム・アルミニウム・ガーネット系蛍光体を含むことが好ましく。

また、本発明の発光ダイオードでは、前記フォトルミネッセンス蛍光体として、一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表される蛍光体（ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Reは、Y、Gdから選択される少なくとも一種である。）を用いても良い。

また、本発明の発光ダイオードでは、前記フォトルミネッセンス蛍光体として、一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3(Al_{1-s}Ga_s)_5O_{12}$で表される（ただし、$0 \leqq p \leqq 0.8$、$0.003 \leqq q \leqq 0.2$、$0.0003 \leqq r \leqq 0.08$、$0 \leqq s \leqq 1$）蛍光体を用いることもできる。

本発明の発光ダイオードにおいては、発光波長を所望の波長に調整するために、前記フォトルミネッセンス蛍光体は、それぞれYとAlとを含んでなる互いに組成の異なる２以上のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を含むようにすることが好ましい。

本発明の発光ダイオードでは同様に、発光波長を所望の波長に調整するために、前記フォトルミネッセンス蛍光体として、それぞれ一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表され（ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Reは、Y、Gdから選択される少なくとも一種である。）、互いに組成の異なる２以上の蛍光体を用いてもよい。

本発明の発光ダイオードでは同様に、発光波長を所望の波長に調整するために、前記フォトルミネッセンス蛍光体として、一般式$Y_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表される第１の蛍光体と、一般式$Re_3Al_5O_{12}:Ce$で表される第２の蛍光体とを用いてもよい。ここで、$0 \leqq s \leqq 1$、Reは、Y、Ga、Laから選択される少なくとも一種である。

本発明の発光ダイオードでは同様に、発光波長を所望の波長に調整する

ために、前記フォトルミネッセンス蛍光体は、それぞれイットリウム・アルミニウム・ガーネット系蛍光体において、それぞれイットリウムの一部がガドリニウムに置換されてなり、互いに置換量が異なる第１の蛍光体と第２の蛍光体とを用いてもよい。

また、一般的に蛍光体では、短波長の光を吸収して長波長の光を発光するものの方が、長波長の光を吸収して短波長の光を発光するものに比較して効率がよい。発光素子としては、樹脂（モールド部材やコーティング部材等）を劣化させる紫外光を発光するものより可視光を発光するものを用いる方が好ましい。従って、本発明の発光ダイオードにおいては、発光効率の向上及び長寿命化のために、前記発光素子の発光スペクトルの主ピークを、可視光のうちで比較的短波長の４００ｎｍから５３０ｎｍの範囲内に設定し、かつ前記フォトルミネッセンス蛍光体の主発光波長を前記発光素子の主ピークより長く設定することが好ましい。また、このようにすることにより、蛍光体により変換された光は、発光素子が発光する光よりも長波長であるため、蛍光体等により反射された変換後の光が発光素子に照射されても、発光素子によって吸収されることはない（バンドギャップエネルギーより変換された光のエネルギーの方が小さいため）。このように、蛍光体等により反射された光は、発光素子を載置したカップにより反射され、さらに効率のよい発光が可能になる。

図面の簡単な説明

図１は、本発明に係る実施の形態のリードタイプの発光ダイオードの模式的断面図である。

図２は、本発明に係る実施の形態のチップタイプの発光ダイオードの模式的断面図である。

図３Ａは実施形態１のセリウムで付活されたガーネット系蛍光体の励起スペクトルを示すグラフである。

図３Ｂは実施形態１のセリウムで付活されたガーネット系蛍光体の発光スペクトルを示すグラフである。

図４は、実施の形態１の発光ダイオードの発光スペクトルを示すグラフである。

図５Ａは実施形態２のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体の励起スペクトルを示すグラフである。

図５Ｂは実施形態２のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体の発光スペクトルを示すグラフである。

図６は、実施形態２の発光ダイオードの発光色を説明するための色度図であり、図中、Ａ及びＢ点は発光素子が発光する光の発光色を示し、Ｃ点、Ｄ点は、それぞれ２種類のフォトルミネッセンス蛍光体からの発光色を示す。

図７は、本発明に係る別の実施形態の面状発光光源の模式的な断面図である。

図８は、図７とは異なる面状発光光源の模式的な断面図である。

図９は、図７及び図８とは異なる面状発光光源の模式的な断面図である。

図１０は、本願発明の応用例である表示装置のブロック図１０である。

図１１は、図１０の表示装置のＬＥＤ表示器の平面図である。

図１２は、本願発明の発光ダイオード及びＲＧＢの４つの発光ダイオードを用いて一絵素を構成したＬＥＤ表示器の平面図である。

図１３Ａは、実施例１及び比較例１の発光ダイオードの寿命試験の結果を示すグラフであって、２５℃における結果であり、図１３Ｂは、実施例１及び比較例１の発光ダイオードの寿命試験の結果を示すグラフであって、

６０℃，９０％ＲＨにおける結果である。

図１４Ａは、実施例９及び比較例２の耐候性試験の結果を示すグラフであり、経過時間に対する輝度保持率を示す。

図１４Ｂは、実施例９及び比較例２の耐候性試験の結果を示すグラフであり、試験前後の色調の変化を示す。

図１５Ａは、実施例９及び比較例２の発光ダイオードの信頼性試験における輝度保持率と時間との関係を示すグラフであり、図１５Ｂは、実施例９及び比較例２の発光ダイオードの信頼性試験における色調と時間との関係を示したグラフである。

図１６は、表１に示した蛍光体とピーク波長４６５ｎｍの青色ＬＥＤとを組み合わせた発光ダイオードにより実現できる色再現範囲を示す色度図である。

図１７は、表１に示した蛍光体とピーク波長４６５ｎｍの青色ＬＥＤとを組み合わせた発光ダイオードにおける蛍光体の含有量を変化させたときの発光色の変化を示す色度図である。

図１８Ａは、$(Y_{0.6}Gd_{0.4})_3Al_5O_{12}$：Ｃｅで表される実施例２のフォトルミネセンス蛍光体の発光スペクトルを示す。

図１８Ｂは、発光ピーク波長４６０ｎｍを有する実施例２の発光素子の発光スペクトルを示す。

図１８Ｃは、実施例２の発光ダイオードの発光スペクトルを示す。

図１９Ａは、$(Y_{0.2}Gd_{0.8})_3Al_5O_{12}$：Ｃｅで表される実施例５のフォトルミネセンス蛍光体の発光スペクトルを示す。

図１９Ｂは、発光ピーク波長４５０ｎｍを有する実施例５の発光素子の発光スペクトルを示す。

図１９Ｃは、実施例５の発光ダイオードの発光スペクトルを示す。

図２０Ａは、$Y_3Al_5O_{12}$：Ｃｅで表される実施例６のフォトルミネセンス蛍光体の発光スペクトルを示す。

図２０Ｂは、発光ピーク波長４５０ｎｍを有する実施例６の発光素子の発光スペクトルを示す。

図２０Ｃは、実施例６の発光ダイオードの発光スペクトルを示す。

図２１Ａは、$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表される実施例７のフォトルミネセンス蛍光体の発光スペクトルを示す。

図２１Ｂは、発光ピーク波長４５０ｎｍを有する実施例７の発光素子の発光スペクトルを示す。

図２１Ｃは、実施例７の発光ダイオードの発光スペクトルを示す。

図２２Ａは、$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}$：Ｃｅで表される実施例１１のフォトルミネセンス蛍光体の発光スペクトルを示す。

図２２Ｂは、$(Y_{0.4}Gd_{0.6})_3Al_5O_{12}$：Ｃｅで表される実施例１１のフォトルミネセンス蛍光体の発光スペクトルを示す。

図２２Ｃは、発光ピーク波長４７０ｎｍを有する実施例１１の発光素子の発光スペクトルを示す。

図２３は、実施例１１の発光ダイオードの発光スペクトルを示す。

発明を実施するための最良の形態

以下、図面を参照して本発明の実施形態の説明をする。

図１の発光ダイオード１００は、マウント・リード１０５とインナーリード１０６とを備えたリードタイプの発光ダイオードであって、マウント・リード１０５のカップ部１０５ａ上に発光素子１０２が設られ、カップ部１０５ａ内に、発光素子１０２を覆うように、所定のフォトルミネッセンス蛍光体を含むコーティング樹脂１０１が充填された後に、樹脂モールド

されて構成される。ここで、発光素子１０２のｎ側電極及びｐ側電極はそれぞれ、マウント・リード１０５とインナーリード１０６とにワイヤー１０３を用いて接続される。

以上のように構成された発光ダイオードにおいては、発光素子（ＬＥＤチップ）１０２によって発光された光（以下、ＬＥＤ光という。）の一部が、コーティング樹脂１０１に含まれたフォトルミネッセンス蛍光体を励起してＬＥＤ光と異なる波長の蛍光を発生させて、フォトルミネッセンス蛍光体が発生する蛍光と、フォトルミネッセンス蛍光体の励起に寄与することなく出力されるＬＥＤ光とが混色されて出力される。その結果、発光ダイオード１００は、発光素子１０２が発生するＬＥＤ光とは波長の異なる光も出力する。

また、図２に示すものはチップタイプの発光ダイオードであって、筐体２０４の凹部に発光素子（ＬＥＤチップ）２０２が設けられ、該凹部に所定のフォトルミネッセンス蛍光体を含むコーティング材が充填されてコーティング部２０１が形成されて構成される。ここで、発光素子２０２は、例えばＡｇを含有させたエポキシ樹脂等を用いて固定され、該発光素子２０２のｎ側電極とｐ側電極とをそれぞれ、筐体２０４に設けられた端子金属２０５に、導電性ワイヤー２０３を用いて接続される。　以上のように構成されたチップタイプの発光ダイオードにおいて、図１のリードタイプの発光ダイオードと同様に、フォトルミネッセンス蛍光体が発生する蛍光と、フォトルミネッセンス蛍光体に吸収されることなく伝搬されたＬＥＤ光とが混色されて出力され、その結果、発光ダイオード２００は、発光素子１０２が発生するＬＥＤ光とは波長の異なる光も出力する。

以上説明したフォトルミネセンス蛍光体を備えた発光ダイオードは、以下のような特徴を有する。

１．通常、発光素子（ＬＥＤ）から放出される光は、発光素子に電力を供給する電極を介して放出される。放出された光は、発光素子に形成された電極の陰となり、特定の発光パターンを有し、そのために全ての方向に均一に放出されない。しかしながら、蛍光体を備えた発光ダイオードは、蛍光体により発光素子からの光を散乱させて光を放出するので、不要な発光パターンを形成することなく、広い範囲に均一に光を放出することができる。

２．発光素子（ＬＥＤ）からの光は、単色性ピークを有するといっても、ある程度のスペクトル幅をもつので演色性が高い。このことは、比較的広い範囲の波長を必要とする光源として使用する場合には欠かせない長所になる。例えば、スキャナーの光源等に用いる場合は、スペクトル幅が広いほうが好ましい。

以下に説明する実施形態１，２の発光ダイオードは、図１又は図２に示す構造を有する発光ダイオードにおいて、可視光域における光エネルギーが比較的高い窒化物系化合物半導体を用いた発光素子と、特定のフォトルミネッセンス蛍光体とを組み合わせたことを特徴とし、これによって、高輝度の発光を可能にし、長時間の使用に対して発光効率の低下や色ずれが少ないという良好な特性を有する。

一般的に蛍光体においては、短い波長の光を吸収して長い波長の光を放出する蛍光体の方が、長い波長の光を吸収して短い光を放出する蛍光体に比較して変換効率が優れているので、本発明の発光ダイオードにおいては、短い波長の青色系の発光が可能な窒化ガリウム系半導体発光素子（発光素子）を用いることが好ましい。また、高い輝度の発光素子を用いることが好ましいことは言うまでもない。

このような窒化ガリウム系半導体発光素子と組み合わせて用いるのに適

したフォトルミネセンス蛍光体としては、

1．発光素子１０２，２０２に近接して設けられ、太陽光の約３０倍から４０倍にもおよぶ強い光にさらされることになるので、強い強度の光の照射に対して長時間耐え得るように、耐光性に優れていること。

2．発光素子１０２，２０２によって励起するために、発光素子の発光で効率よく発光すること。特に、混色を利用する場合、紫外線ではなく青色系発光で効率よく発光すること。

3．青色系の光と混色されて白色になるように、緑色系から赤色系の光が発光可能なこと。

4．発光素子１０２，２０２に近接して設けられ、該チップを発光させる際の発熱による温度変化の影響を受けるので、温度特性が良好であること。

5．色調が組成比あるいは複数の蛍光体の混合比を変化させることにより、連続的に変化させることができること。

6．発光ダイオードが使用される環境に応じた耐候性があること、

などの特性が要求される。

実施の形態１．

本願発明に係る実施の形態１の発光ダイオードは、発光層に高エネルギーバンドギャップを有し、青色系の発光が可能な窒化ガリウム系化合物半導体素子と、黄色系の発光が可能なフォトルミネセンス蛍光体である、セリウムで付活されたガーネット系フォトルミネッセンス蛍光体とを組み合わせたものである。これによって、この実施形態１の発光ダイオードにおいて、発光素子１０２，２０２からの青色系の発光と、その発光によって励起されたフォトルミネセンス蛍光体からの黄色系の発光光との混色によ

り白色系の発光が可能になる。

また、この実施形態１の発光ダイオードに用いた、セリウムで付活されたガーネット系フォトルミネッセンス蛍光体は耐光性及び耐候性を有するので、発光素子１０２，２０２から放出された可視光域における高エネルギー光を長時間その近傍で高輝度に照射した場合であっても発光色の色ずれや発光輝度の低下が極めて少ない白色光が発光できる。

以下、本実施形態１の発光ダイオードの各構成部材について詳述する。

（フォトルミネセンス蛍光体）

本実施形態１の発光ダイオードに用いられるフォトルミネセンス蛍光体は、半導体発光層から発光された可視光や紫外線で励起されて、励起した光と異なる波長を有する光を発光するフォトルミネセンス蛍光体である。具体的にはフォトルミネセンス蛍光体として、Ｙ、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍから選択された少なくとも１つの元素と、Ａｌ、Ｇａ及びＩｎから選択された少なくとも１つの元素とを含み、セリウムで付活されたガーネット系蛍光体である。本発明では、該蛍光体として、ＹとＡｌを含みセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体、又は、一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$（但し、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇｄから選択される少なくとも一種）であらわされる蛍光体を用いることが好ましい。窒化ガリウム系化合物半導体を用いた発光素子が発光するＬＥＤ光と、ボディーカラーが黄色であるフォトルミネセンス蛍光体が発光する蛍光光が補色関係にある場合、ＬＥＤ光と、蛍光光とを混色して出力することにより、全体として白色系の光を出力することができる。

本実施形態１において、このフォトルミネセンス蛍光体は、上述したように、コーテイング樹脂１０１，コーテイング部２０１を形成する樹脂（詳

細は後述する）に混合して使用されるので、窒化ガリウム系発光素子の発光波長に対応させて、樹脂などとの混合比率、若しくはカップ部１０５又は筐体２０４の凹部への充填量を種々調整することにより、発光ダイオードの色調を、白色を含め電球色など任意に設定できる。

このフォトルミネセンス蛍光体の含有分布は、混色性や耐久性にも影響する。例えば、フォトルミネセンス蛍光体が含有されたコーティング部やモールド部材の表面側から発光素子に向かってフォトルミネセンス蛍光体の分布濃度を高くした場合は、外部環境からの水分などの影響をより受けにくくでき、水分による劣化を防止することができる。他方、フォトルミネセンス蛍光体を、発光素子からモールド部材等の表面側に向かって分布濃度が高くなるように分布させると、外部環境からの水分の影響を受けやすいが発光素子からの発熱、照射強度などの影響をより少なくでき、フォトルミネセンス蛍光体の劣化を抑制することができる。このような、フォトルミネセンス蛍光体の分布は、フォトルミネセンス蛍光体を含有する部材、形成温度、粘度やフォトルミネセンス蛍光体の形状、粒度分布などを調整することによって種々の分布を実現することができ、発光ダイオードの使用条件などを考慮して分布状態が設定される。

実施形態１のフォトルミネセンス蛍光体は、発光素子１０２，２０２と接したり、あるいは近接して配置され、照射強度（Ｅｅ）として、３Ｗ・ｃｍ$^{-2}$以上１０Ｗ・ｃｍ$^{-2}$以下においても高効率でかつ十分な耐光性を有するので、該蛍光体を用いることにより、優れた発光特性の発光ダイオードを構成することができる。

また、実施形態１のフォトルミネセンス蛍光体は、ガーネット構造を有するので、熱、光及び水分に強く、図３Ａに示すように、励起スペクトルのピークを４５０ｎｍ付近にすることができる。また、発光ピークも図３

Bに示すように、５８０ｎｍ付近にあり７００ｎｍまで裾を引くブロードな発光スペクトルを持つ。また、実施形態１のフォトルミネッセンス蛍光体は、結晶中にＧｄを含有することにより、４６０ｎｍ以上の長波長域における励起発光効率を高くすることができる。Ｇｄの含有量の増加により、発光ピーク波長が、長波長に移動し、全体の発光波長も長波長側にシフトする。すなわち、赤みの強い発光色が必要な場合、Ｇｄによる置換量を多くすることで達成することができる。一方、Ｇｄが増加するするとともに、青色光によるフォトルミネッセンスの発光輝度は低下する傾向にある。

特に、ガーネット構造を有するＹＡＧ系蛍光体の組成の内、Ａｌの一部をＧａで置換することで、発光波長が、短波長側にシフトするまた組成のＹの一部をＧｄで置換することにより、発光波長が長波長側にシフトする。

表１に一般式 $(Y_{1-a}Gd_a)_3(Al_{1-b}Ga_b)_5O_{12}:Ce$ で表されるＹＡＧ系蛍光体の組成とその発光特性を示す。

表１

Ｎｏ.	Gd含有量	Ga含有量	ＣＩＥ色度座標		輝度	効率
	a（ﾓﾙ比）	b（ﾓﾙ比）	x	y	Y	
①	０．０	０．０	０．４１	０．５６	１００	１００
②	０．０	０．４	０．３２	０．５６	６１	６３
③	０．０	０．５	０．２９	０．５４	５５	６７
④	０．２	０．０	０．４５	０．５３	１０２	１０８
⑤	０．４	０．０	０．４７	０．５２	１０２	１１３
⑥	０．６	０．０	０．４９	０．５１	９７	１１３
⑦	０．８	０．０	０．５０	０．５０	７２	８６

表１に示した各特性は、４６０ｎｍの青色光で励起して測定した。又表１における輝度と効率は①の材料を１００として相対値で示している。

ＡｌをＧａによって置換する場合、発光効率と発光波長を考慮してＧａ：Ａｌ＝１：１から４：６の間の比率に設定することが好ましい。同様に、Ｙの一部をＧｄで置換する場合は、Ｙ：Ｇｄ＝９：１～１：９の範囲の比率に設定することが好ましく、４：１～２：３の範囲に設定することがより好ましい。Ｇｄの置換量が２割未満では、緑色成分が大きく赤色成分が少なくなるからであり、Ｇｄの置換量が６割以上になると、赤み成分を増やすことができるが、輝度が急激に低下する。特に、発光素子の発光波長によるがＹＡＧ系蛍光体中のＹとＧｄとの比率を、Ｙ：Ｇｄ＝４：１～２：３の範囲に設定することにより、１種類のイットリウム・アルミニウム・ガーネット系蛍光体を用いて黒体放射軌跡にほぼ沿った白色光の発光が可能な発光ダイオードを構成することができる。また、ＹＡＧ系蛍光体中のＹとＧｄとの比率を、Ｙ：Ｇｄ＝２：３～１：４の範囲に設定すると、輝度は低いが電球色の発光が可能な発光ダイオードを構成することができる。尚、Ｃｅの含有量（置換量）は、０．００３～０．２の範囲に設定することにより、発光ダイオードの相対発光光度を７０％以上にできる。含有量が０．００３未満では、Ｃｅによるフォトルミネッセンスの励起発光中心の数が減少することにより光度が低下し、逆に０．２より大きくなると濃度消光が生じる。

以上のように、組成のＡｌの一部をＧａで置換することにより発光波長を短波長にシフトさせることができ、また、組成のＹの一部をＧｄで置換することで、発光波長を長波長へシフトさせることができる。このように組成を変化することで発光色を連続的に調節することが可能である。また、波長が２５４ｎｍや３６５ｎｍであるＨｇ輝線ではほとんど励起されず４

５０ｎｍ付近の青色系発光素子からのＬＥＤ光による励起効率が高い。さらに、ピーク波長がＧｄの組成比で連続的に変えられるなど窒化物半導体発光素子の青色系発光を白色系発光に変換するための理想条件を備えている。

また、実施形態１では、窒化ガリウム系半導体を用いた発光素子と、セリウムで付活されたイットリウム・アルミニウム・ガーネット蛍光体（ＹＡＧ）に希土類元素のサマリウム（Ｓｍ）を含有させたフォトルミネセンス蛍光体とを組み合わせることにより、発光ダイオードの発光効率をさらに向上させることができる。

このようなフォトルミネセンス蛍光体は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍ、Ａｌ及びＧａの原料として酸化物、又は高温で容易に酸化物になる化合物を使用し、それらを所定の化学量論比で十分に混合して混合原料を作製し、作製された混合原料に、フラックスとしてフッ化アンモニウム等のフッ化物を適量混合して坩堝に詰め、空気中１３５０～１４５０℃の温度範囲で２～５時間焼成して焼成品を得、次に焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通すことにより作製できる。

上述の作製方法において、混合原料は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈したものを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムとを混合することにより作製してもよい。

一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3Al_5O_{12}$で表すことができるフォトルミネセンス蛍光体は、結晶中にＧｄを含有することにより、特に４６０ｎｍ以上の長波長域の励起発光効率を高くすることができる。また、ガドリニウムの含有量を増加させることにより、発光ピーク波長を、５３０ｎｍから５７０ｎｍまで長波長に移動させ、全体の発光波長も長波長側に

シフトさせることができる。赤みの強い発光色が必要な場合、Ｇｄの置換量を多くすることで達成できる。一方、Ｇｄが増加すると共に、青色光によるフォトルミネセンスの発光輝度は徐々に低下する。したがって、ｐは０．８以下であることが好ましく、０．７以下であることがより好ましい。さらに好ましくは０．６以下である。

また、一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3Al_5O_{12}$で表されるＳｍを含むフォトルミネセンス蛍光体は、Ｇｄの含有量を増加させても温度特性の低下を少なくできる。すなわち、Ｓｍを含有させることにより、高温度におけるフォトルミネセンス蛍光体の発光輝度の劣化は大幅に改善される。その改善される程度はＧｄの含有量が多くなるほど、大きくなる。特に、Ｇｄの含有量を増加させてフォトルミネセンスの発光の色調に赤みを付与した組成の蛍光体は、温度特性が悪くなるので、Ｓｍを含有させて温度特性を改善することが有効である。なお、ここで言う温度特性とは、４５０ｎｍの青色光による常温(２５℃)における励起発光輝度に対する、同蛍光体の高温（２００℃)における発光輝度の相対値（％）のことである。

Ｓｍの含有量ｒは０．０００３≦ｒ≦０．０８の範囲であることが好ましく、これによって温度特性を６０％以上にすることができる。この範囲よりｒが小さいと、温度特性の改良効果が小さくなる。また、この範囲よりｒが大きくなると温度特性は逆に低下してくる。また、Ｓｍの含有量ｒは０．０００７≦ｒ≦０．０２の範囲であることがさらに好ましく、これによって温度特性は８０％以上にできる。

Ｃｅの含有量ｑは、０．００３≦ｑ≦０．２の範囲であることが好ましく、これによって、相対発光輝度が７０％以上にできる。ここで、相対発光輝度とは、ｑ＝０．０３の蛍光体の発光輝度を１００パーセントとした場合における発光輝度のことをいう。

Ｃｅの含有量ｑが０．００３以下では、Ｃｅによるフォトルミネセンスの励起発光中心の数が減少するために輝度が低下し、逆に、０．２より大きくなると濃度消光が生ずる。ここで、濃度消光とは、蛍光体の輝度を高めるために付活剤の濃度を増加していくとある最適値以上の濃度では発光強度が低下することである。

本願発明の発光ダイオードにおいては、Ａｌ、Ｇａ、Ｙ及びＧｄやＳｍの含有量が異なる２種類以上の$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3Al_5O_{12}$フォトルミネセンス蛍光体を混合して用いてもよい。これによって、蛍光発光中のＲＧＢの波長成分を増やすことができ、これに、例えばカラーフィルターを用いることによりフルカラー液晶表示装置用としても利用できる。

（発光素子１０２、２０２）

発光素子は、図１及び図２に示すように、モールド部材に埋設されることが好ましい。本願発明の発光ダイオードに用いられる発光素子は、セリウムで付活されたガーネット系蛍光体を効率良く励起できる窒化ガリウム系化合物半導体である。窒化ガリウム系化合物半導体を用いた発光素子１０２，２０２は、ＭＯＣＶＤ法等により基板上にＩｎＧａＮ等の窒化ガリウム系半導体を発光層として形成することにより作製される。発光素子の構造としては、ＭＩＳ接合、ＰＩＮ接合やＰＮ接合などを有するホモ構造ヘテロ構造あるいはダブルヘテロ構成のものが挙げられる。半導体層の材料やその混晶度によって発光波長を種々選択することができる。また、半導体活性層を量子効果が生ずる程度に薄く形成した単一量子井戸構造や多重量子井戸構造とすることもできる。特に、本願発明においては、発光素子の活性層をＩｎＧａＮの単一量子井戸構造とすることにより、フォトルミネセンス蛍光体の劣化がなく、より高輝度に発光する発光ダイオードとして利用することができる。

窒化ガリウム系化合物半導体を使用した場合、半導体基板にはサファイヤ、スピネル、ＳｉＣ、Ｓｉ、ＺｎＯ等の材料が用いることができるが、結晶性の良い窒化ガリウムを形成させるためにはサファイヤ基板を用いることが好ましい。このサファイヤ基坂上にＧａＮ、ＡｌＮ等のバッファー層を介してＰＮ接合を形成するように窒化ガリウム半導体層を形成する。窒化ガリウム系半導体は、不純物をドープしない状態でＮ型導電性を示すが、発光効率を向上させるなど所望の特性（キャリヤ濃度等）のＮ型窒化ガリウム半導体を形成するためには、Ｎ型ドーパントとしてＳｉ、Ｇｅ、Ｓｅ、Ｔｅ、Ｃ等を適宜ドープすることが好ましい。一方、ｐ型窒化ガリウム半導体を形成する場合は、ｐ型ドーパンドであるＺｎ、Ｍｇ、Ｂｅ、Ｃａ、Ｓｒ、Ｂａ等をドープする。尚、窒化ガリウム系化合物半導体は、ｐ型ドーパントをドープしただけではｐ型化しにくいためｐ型ドーパント導入後に、炉による加熱、低速電子線照射やプラズマ照射等によりｐ型化させることが好ましい。エッチングなどによりｐ型及びＮ型の窒化ガリウム半導体の表面を露出させた後、各半導体層上にスパッタリング法や真空蒸着法などを用いて所望の形状の各電極を形成する。

次に、以上のようにして形成された半導体ウエハー等を、ダイシングソーにより直接フルカットする方法、又は刃先幅よりも広い幅の溝を切り込んだ後(ハーフカット)、外力によって半導体ウエハーを割る方法、あるいは、先端のダイヤモンド針が往復直線運動するスクライバーにより半導体ウエハーに極めて細いスクライブライン(経線)を例えば碁盤目状に引いた後、外力によってウエハーを割る方法等を用いて、半導体ウエハーをチップ状にカットする。このようにして窒化ガリウム系化合物半導体からなる発光素子を形成することができる。

本実施形態１の発光ダイオードにおいて白色系を発光させる場合は、フォ

トルミネセンス蛍光体との補色関係や樹脂の劣化等を考慮して発光素子の発光波長は４００ｎｍ以上５３０ｎｍ以下に設定することが好ましく、４２０ｎｍ以上４９０ｎｍ以下に設定することがより好ましい。発光素子とフォトルミネセンス蛍光体との効率をそれぞれより向上させるためには、４５０ｎｍ以上４７５ｎｍ以下に設定することがさらに好ましい。実施形態１の白色系発光ダイオードの発光スペクトルの一例を図４に示す。ここに例示した発光ダイオードは、図１に示すリードタイプのものであって、後述する実施例１の発光素子とフォトルミネッセンス蛍光体とを用いたものである。ここで、図４において、４５０ｎｍ付近にピークを持つ発光が発光素子からの発光であり、５７０ｎｍ付近にピークを持つ発光が発光素子によって励起されたフォトルミネセンスの発光である。

また、表１に示した蛍光体とピーク波長４６５ｎｍの青色ＬＥＤ（発光素子）とを組み合わせた白色系発光ダイオードで、実現できる色再現範囲を図１６に示す。この白色系発光ダイオードの発光色は、青色ＬＥＤ起源の色度点と蛍光体起源の色度点とを結ぶ直線上のいずれかに位置するので、表１の①～⑦の蛍光体を使用することにより、色度図中央部の広範な白色領域（図１６中斜線を付した部分）をすべてカバーすることができる。図１７は、白色系発光ダイオードにおける蛍光体の含有量を変化させた時の発光色の変化を示したものである。ここで、蛍光体の含有量は、コーティング部に使用する樹脂に対する重量パーセントで示している。図１７から明らかなように、蛍光体の量を増やせば蛍光体の発光色に近付き、減らすと青色ＬＥＤに近付く。

なお、本願発明では、蛍光体を励起する光を発生する発光素子に加えて、蛍光体を励起しない発光素子を一緒に用いることもできる。具体的には、蛍光体を励起可能な窒化物系化合物半導体である発光素子に加えて、蛍光

体を実質的に励起しない、発光層がガリウム燐、ガリウムアルミニウムひ素、ガリウムひ素燐やインジウムアルミニウム燐などである発光素子を一緒に配置する。このようにすると、蛍光体を励起しない発光素子からの光は、蛍光体に吸収されることなく外部に放出される。これによって、紅白が発光可能な発光ダイオードとすることができる。

以下、図１及び図２の発光ダイオードの他の構成要素について説明する。

（導電性ワイヤー１０３、２０３）

導電性ワイヤー１０３、２０３としては、発光素子１０２、２０２の電極とのオーミック性、機械的接続性、電気伝導性及び熱伝導性がよいものが求められる。熱伝導度としては０．０１ｃａｌ／（ｓ）（ｃｍ^2）（℃／ｃｍ）以上が好ましく、より好ましくは０．５ｃａｌ／（ｓ）（ｃｍ^2）（℃／ｃｍ）以上である。また、作業性を考慮すると導電性ワイヤーの直径は、１０μｍ以上、４５μｍ以下であることが好ましい。特に、蛍光体が含有されたコーティング部とモールド部材とをそれぞれ同一材料を用いたとしても、どちらか一方に蛍光体が入ることによる熱膨張係数の違いにより、それらの界面においては、導電性ワイヤーは断線し易い。そのために導電性ワイヤーの直径は、２５μｍ以上がより好ましく、発光面積や取り扱い易さの観点から３５μｍ以下が好ましい。導電性ワイヤーの材質としては、金、銅、白金、アルミニウム等の金属及びそれらの合金が挙げられる。このような材質、形状からなる導電性ワイヤーを用いることにより、ワイヤーボンディング装置によって、各発光素子の電極と、インナー・リード及びマウント・リードとを容易に接続することができる。

（マウント・リード１０５）

マウント・リード１０５は、カップ部１０５ａとリード部１０５ｂとからなり、カップ部１０５ａに、ダイボンディング装置で発光素子１０２を

載置する十分な大きさがあれば良い。また、複数の発光素子をカップ内に設け、マウント・リードを発光素子の共通電極として利用する場合においては、異なる電極材料を用いる場合があるので、それぞれに十分な電気伝導性とボンディングワイヤー等との接続性が求められる。また、マウント・リード上のカップ内に発光素子を配置すると共に蛍光体をカップ内部に充填する場合は、蛍光体からの光が当方的に放出されたとしても、カップにより所望の方向に反射されるので、近接して配置させた別の発光ダイオードからの光による疑似点灯を防止することができる。ここで、擬似点灯とは、近接して配置された別の発光ダイオードに電力を供給していなくても発光しているように見える現象のことをいう。

発光素子１０２とマウント・リード１０５のカップ部１０５ａとの接着は、エポキシ樹脂、アクリル樹脂やイミド樹脂等の熱硬化性樹脂などを用いて行うことができる。また、フェースダウン発光素子（基板側から発光を取り出すタイプであって、発光素子の電極をカップ部１０５ａに対向させて取り付けるように構成されたもの）を用いる場合は、該発光素子をマウント・リードと接着させると共に電気的に導通させるために、Ａｇペースト、カーボンペースト、金属バンプ等を用いることができる。さらに、発光ダイオードの光利用効率を向上させるために発光素子が配置されるマウント・リードのカップ部の表面を鏡面状とし、表面に反射機能を持たせても良い。この場合の表面粗さは、０．１Ｓ以上０．８Ｓ以下が好ましい。また、マウント・リードの具体的な電気抵抗としては３００μΩ・ｃｍ以下が好ましく、より好ましくは、３μΩ・ｃｍ以下である。また、マウント・リード上に複数の発光素子を積置する場合は、発光素子からの発熱量が多くなるため熱伝導度がよいことが求められ、その熱伝導度は、０．０１ｃａｌ／（ｓ）（ｃｍ^2）（℃／ｃｍ）以上が好ましく、より好ましく

は0．５ｃａｌ／（ｓ）（ｃｍ²）（℃／ｃｍ）以上である。これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅、メタライズパターン付きセラミック等が挙げられる。

（インナー・リード１０６）

インナー・リード１０６は、マウント・リード１０５上に配置された発光素子１０２の一方の電極に、導電性ワイヤー等で接続される。マウント・リード上に複数の発光素子を設けた発光ダイオードの場合は、インナーリード１０６を複数設け、各導電性ワイヤー同士が接触しないよう各インナーリードを配置する必要がある。例えば、マウント・リードから離れるに従って、各インナー・リードのワイヤーボンディングされる各端面の面積を順次大きくすることによって、導電性ワイヤー間の間隔を開けるようにボンディングし、導電性ワイヤー間の接触を防ぐことができる。インナーリードの導電性ワイヤーとの接続端面の粗さは、密着性を考慮して１．６Ｓ以上１０Ｓ以下に設定することが好ましい。

インナー・リードは、所望の形状になるように型枠を用いた打ち抜き加工等を用いて形成することができる。さらには、インナー・リードを打ち抜き形成後、端面方向から加圧することにより所望の端面の面積と端面高さを調整するようにしても良い。

また、インナー・リードは、導電性ワイヤーであるボンディングワイヤー等との接続性及び電気伝導性が良いことが求められる。具体的な電気抵抗としては、３００μΩ・ｃｍ以下であることが好ましく、より好ましくは３μΩ・ｃｍ以下である。これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅及び銅、金、銀をメッキしたアルミニウム、鉄、銅等が挙げられる。

（コーティング部１０１）

コーティング部１０１は、モールド部材１０４とは別にマウント・リードのカップに設けられるものであり、本実施の形態１では、発光素子の発光を変換するフォトルミネセンス蛍光体が含有されるものである。コーティング部の具体的材料としては、エポキシ樹脂、ユリア樹脂、シリコーンなどの耐侯性に優れた透明樹脂や硝子などが適する。また、フォトルミネセンス蛍光体と共に拡散剤を含有させても良い。具体的な拡散剤としては、チタン酸バリウム、酸化チタン、酸化アルミニウム、酸化珪素等を用いることが好ましい。さらに、蛍光体をスパッタリングにより形成する場合、コーティング部を省略することもできる。この場合、膜厚を調整したり蛍光体層に開口部を設けることで混色表示が可能な発光ダイオードとすることができる。

（モールド部材１０４）

モールド部材１０４は、発光素子１０２、導電性ワイヤー１０３、フォトルミネセンス蛍光体が含有されたコーティング部１０１などを外部から保護する機能を有する。本実施形態１では、モールド部材１０４にさらに拡散剤を含有させることが好ましく、これによって発光素子１０２からの指向性を緩和させることができ、視野角を増やすことができる。また、モールド部材１０４は、発光ダイオードにおいて、発光素子からの発光を集束させたり拡散させたりするレンズ機能を有する。従って、モールド部材１０４は、通常、凸レンズ形状、凹レンズ形状さらには、発光観測面から見て楕円形状やそれらを複数組み合わせた形状に形成される。また、モールド部材１０４は、それぞれ異なる材料を複数積層した構造にしてもよい。モールド部材１０４の具体的材料としては、主としてエポキシ樹脂、ユリア樹脂、シリコーン樹脂などの耐候性に優れた透明樹脂や硝子などが好適に用いられる。また、拡散剤としては、チタン酸バリウム、酸化チタン、

酸化アルミニウム、酸化珪素等を用いることができる。さらに、本願発明では、拡散剤に加えてモールド部材中にフォトルミネセンス蛍光体を含有させてもよい。すなわち、本願発明では、フォトルミネセンス蛍光体をコーティング部に含有させても良いし、モールド部材中に含有させてもよい。モールド部材にフォトルミネセンス蛍光体を含有させることにより、視野角をさらに大きくすることができる。また、コーティング部とモールド部材の双方に含有させてもよい。またさらに、コーティング部をフォトルミネセンス蛍光体が含有された樹脂とし、モールド部材を、コーティング部と異なる部材である硝子を用いて形成しても良く、このようにすることにより、水分などの影響が少ない発光ダイオードを生産性良く製造できる。また、用途によっては、屈折率を合わせるために、モールド部材とコーティング部とを同じ部材を用いて形成してもよい。本願発明においてモールド部材に拡散剤や着色剤を含有させることによって、発光観測面側から見た蛍光体の着色を隠すことができると共により混色性を向上させることができる。すなわち、蛍光体は強い外光のうち青色成分を吸収し発光し、黄色に着色しているように見える。しかしながら、モールド部材に含有された拡散剤はモールド部材を乳白色にし、着色剤は所望の色に着色する。これによって、発光観測面から蛍光体の色が観測されることはない。さらに、発光素子の主発光波長が４３０ｎｍ以上では、光安定化剤である紫外線吸収剤を含有させることがより好ましい。

発明の実施２.

本発明に係る実施の形態２の発光ダイオードは、発光素子として発光層に高エネルギーバンドギャップを有する窒化ガリウム系半導体を備えた素子を用い、フォトルミネセンス蛍光体として、互いに組成の異なる２種類

以上のフォトルミネセンス蛍光体、好ましくはセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を含む蛍光体を用いる。これにより実施の形態２の発光ダイオードは、発光素子によって発光されるＬＥＤ光の発光波長が、製造バラツキ等により所望値からずれた場合でも、２種類以上の蛍光体の含有量を調節することによって所望の色調を持った発光ダイオードを作製できる。この場合、発光波長が比較的短い発光素子に対しては、発光波長が比較的短い蛍光体を用い、発光波長が比較的長い発光素子には発光波長が比較的長い蛍光体を用いることで発光ダイオードから出力される発光色を一定にすることができる。

蛍光体に関して言うと、フォトルミネセンス蛍光体として、一般式（$Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}$：Ｃｅで表されるセリウムで付活された蛍光体を用いることもできる。但し、$0<r\leqq 1$、$0\leqq s\leqq 1$、Ｒｅは、Ｙ、Ｇｄ、Ｌａから選択される少なくとも一種である。これにより発光素子から放出された可視光域における高エネルギーを有する光が長時間高輝度に照射された場合や種々の外部環境の使用下においても蛍光体の変質を少なくできるので、発光色の色ずれや発光輝度の低下が極めて少なく、かつ高輝度の所望の発光成分を有する発光ダイオードを構成できる。

（実施の形態２のフォトルミネセンス蛍光体）

実施の形態２の発光ダイオードに用いられるフォトルミネセンス蛍光体について詳細に説明する。実施の形態２においては、上述したように、フォトルミネセンス蛍光体として組成の異なる２種類以上のセリウムで付活されたフォトルミネセンス蛍光体を使用した以外は、実施の形態１と同様に構成され、蛍光体の使用方法は実施の形態と同様である。

また、実施形態１と同様に、フォトルミネセンス蛍光体の分布を種々変える（発光素子から離れるに従い濃度勾配をつける等）ことによって耐候

性の強い特性を発光ダイオードに持たせることができる。このような分布はフォトルミネセンス蛍光体を含有する部材、形成温度、粘度やフォトルミネセンス蛍光体の形状、粒度分布などを調整することによって種々調整することができる。したがって、実施形態２では、使用条件などに対応させて、蛍光体の分布濃度が設定される。また、実施の形態２では、２種類以上の蛍光体をそれぞれ発光素子から出力される光に対応して配置を工夫（例えば、発光素子に近い方から順番に配置する等）することによって発光効率を高くすることができる。

以上のように構成された実施形態２の発光ダイオードは、実施形態１と同様、照度強度として（Ｅｅ）＝３Ｗ・ｃｍ$^{-2}$以上１０Ｗ・ｃｍ$^{-2}$以下の比較的高出力の発光素子と接する或いは近接して配置された場合においても高効率でかつ十分な耐光性を有する発光ダイオードを構成できる。

実施形態２に用いられるセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体（ＹＡＧ系蛍光体）は、実施形態１と同様、ガーネット構造を有するので、熱、光及び水分に強い。また、実施形態２のイットリウム・アルミニウム・ガーネット系蛍光体は、図５Ａの実線に示すように励起スペクトルのピークを４５０ｎｍ付近に設定でき、かつ発光スペクトルの発光ピークを図５Ｂの実線に示すように５１０ｎｍ付近に設定でき、しかも発光スペクトルを７００ｎｍまで裾を引くようにブロードにできる。これによって、緑色系の発光をさせることができる。また、実施形態２の別のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体は、励起スペクトルのピークを図５Ａの破線に示すように４５０ｎｍ付近にでき、かつ発光スペクトルの発光ピークを図５Ｂの破線に示すように６００ｎｍ付近に設定でき、しかも発光スペクトルを７５０ｎｍまで裾を引くブロードにできる。これによって、赤色系の発光が可能

となる。

ガーネット構造を持ったＹＡＧ系蛍光体の組成の内、Ａｌの一部をＧａで置換することで発光波長が短波長側にシフトし、また組成のＹの一部をＧｄ及び／又はＬａで置換することで、発光波長が長波長側へシフトする。ＡｌのＧａへの置換は、発光効率と発光波長を考慮してＧａ：Ａｌ＝１：１から４：６が好ましい。同様に、Ｙの一部をＧｄ及び／又はＬａで置換することは、Ｙ：Ｇｄ及び／又はＬａ＝９：１から１：９であり、より好ましくは、Ｙ：Ｇｄ及び／又はＬａ＝４：１から２：３である。置換が２割未満では、緑色成分が大きく赤色成分が少なくなる。また、６割以上では、赤み成分が増えるものの輝度が急激に低下する。

このようなフォトルミネセンス蛍光体は、Ｙ、Ｇｄ、Ｃｅ、Ｌａ、Ａｌ、Ｓｍ及びＧａの原料として酸化物、又は高温で容易に酸化物になる化合物を使用し、それらを化学量論比で十分に混合して原料を得る。又は、Ｙ、Ｇｄ、Ｃｅ、Ｌａ、Ｓｍの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈したものを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムとを混合して混合原料を得る。これにフラックスとしてフッ化アンモニウム等のフッ化物を適量混合して坩堝に詰め、空気中１３５０～１４５０℃の温度範囲で２～５時間焼成して焼成品を得、次に焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通すことで得ることができる。　本実施形態２において、組成の異なる２種類以上のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体は、混合して用いても良いし、それぞれ独立して配置（例えば、積層）して用いても良い。２種類以上の蛍光体を混合して用いた場合、比較的簡単に量産性よく色変換部を形成することができ、２種類以上の蛍光体を独立して配置した場合は、所望の色になるまで重ね合わせることにより、形成後に

色調整をすることができる。また、蛍光体をそれぞれ独立して配置して用いる場合、ＬＥＤ素子に近いほうに、光をより短波長側で吸収発光しやすい蛍光体を設け、ＬＥＤより離れた所に、それよりも長波長側で吸収発光しやすい蛍光体を配置することが好ましい。これによって効率よく吸収及び発光させることができる。

以上のように本実施形態２の発光ダイオードは、蛍光物質として、組成の異なる２種類以上のイットリウム・アルミニウム・ガーネット系蛍光体を用いている。これによって、所望の発光色が効率よく発光可能な発光ダイオードを構成することができる。即ち、半導体発光素子が発光する光の発光波長が、図６に示す色度図のＡ点からＢ点に至る線上に位置する場合、組成の異なる２種類以上のイットリウム・アルミニウム・ガーネット系蛍光体の色度点（Ｃ点及びＤ点）である図６のＡ点，Ｂ点，Ｃ点及びＤ点で囲まれた斜線内にある任意の発光色を発光させることができる。実施形態２では、ＬＥＤ素子、蛍光体の組成若しくはその量を種々選択することによって調節することができる。特に、ＬＥＤ素子の発光波長に対応して、所定の蛍光体を選択することによりＬＥＤ素子の発光波長のバラツキを補償することにより、発光波長のバラツキが少ない発光ダイオードを構成することができる。また、蛍光物質の発光波長を選択することにより、ＲＧＢの発光成分を高輝度に含んだ発光ダイオードを構成することができる。

さらに、実施形態２に用いるイットリウム・アルミニウム・ガーネット系（ＹＡＧ系）蛍光体は、ガーネット構造を有するので、実施形態２の発光ダイオードは、長時間高輝度に発光させることができる。また、実施形態１及び２の発光ダイオードは、発光観測面からみて蛍光体を介して発光素子を設ける。また、発光素子からの光よりもより長波長側に発光する蛍光物質を用いているので、効率よく発光させることができる。さらに、変

換された光は発光素子から放出される光よりも長波長側になっているために、発光素子の窒化物半導体層のバンドギャップよりも小さく、該窒化物半導体層に吸収されにくい。従って、蛍光体が等方的に発光するために発光された光はＬＥＤ素子にも向かうが、蛍光体によって発光された光はＬＥＤ素子に吸収されることはないので、発光ダイオードの発光効率を低下させることはない。

（面状発光光源）

本発明に係る別の実施形態である面状発光光源の例を図７に示す。

図７に示す面状発光光源では、実施形態１又は２で用いたフォトルミネセンス蛍光体が、コーティング部７０１に含有されている。これによって、窒化ガリウム系発光素子が発生する青色系の光を、コーティング部で色変換した後、導光板７０４及び散乱シート７０６を介して面状にして出力する。

詳細に説明すると、図７の面状発光光源において、発光素子７０２は、絶縁層及び導電性パターン（図示せず）が形成されたコの字形状の金属基板７０３内に固定される。発光素子の電極と導電性パターンとを導通させた後、フォトルミネセンス蛍光体をエポキシ樹脂と混合して発光素子７０２が積載されたコの字型の金属基板７０３の内部に充填する。こうして固定された発光素子７０２は、アクリル性の導光板７０４の一方の端面にエポキシ樹脂などで固定される。導光板７０４の一方の主面上の散乱シート７０６が形成されていない部分には、点状に発光する蛍現象防止のため白色散乱剤が含有されたフィルム状の反射部材７０７が形成される。

同様に、導光板７０４の他方の主表面（裏面側）全面及びや発光素子が配置されていない他方の端面上にも反射部材７０５を設け発光効率を向上させるように構成する。これにより、例えば、ＬＣＤのバックライト用と

して十分な明るさを有する面状発光の発光ダイオードを構成することができる。

この面状発光の発光ダイオードを用いた液晶表示装置は、例えば、導光板７０４の一方の主面上に、透光性導電性パターンが形成された硝子基板間（図示せず）に液晶が注入された液晶装置を介して偏光板を配し構成する。

本発明に係る別の実施形態である面状の発光装置の例を、図８、図９とに示す。図８に示す発光装置は、発光ダイオード７０２によって発生された青色系の光を、フォトルミネセンス蛍光体が含有された色変換部材７０１を介して白色系の光に変換した後、導光板７０４によって面状にして出力するように構成されている。

図９に示す発光装置は、発光素子７０２が発光する青色系の光を、導光板７０４によって面状にした後、導光板７０４の一方の主表面に形成された、フォトルミネッセンス蛍光体を有する散乱シート７０６によって白色光に変換して面状の白色光を出力するように構成されている。ここで、フォトルミネッセンス蛍光体は、散乱シート７０６に含有させても良いし、或いはバインダー樹脂と共に散乱シート７０６に塗布してシート状に形成してもよい。さらには、導光板７０４上にフォトルミネセンス蛍光体を含むバインダーを、シート状ではなく、ドット状に直接形成してもよい。

＜応用例＞

（表示装置）

次に、本願発明に係る表示装置について説明する。図１０は本願発明に係る表示装置の構成を示すブロック図である。該表示装置は、図１０に示すように、ＬＥＤ表示器６０１と、ドライバー回路６０２、画像データ記憶手段６０３及び階調制御手段６０４を備えた駆動回路６１０とからなる。

ここで、ＬＥＤ表示器６０１は、図１１に示すように、図１又は図２に示す白色系の発光ダイオード５０１が、筐体５０４にマトリクス状に配列され、白黒用のＬＥＤ表示装置として使用される。ここで、筐体５０４には遮光部材５０５が一体で成形されている。

駆動回路６１０は、図１０に示すように、入力される表示データを一時的に記憶する画像データ記憶手段（ＲＡＭ）６０３と、ＲＡＭ６０３から読み出したデータに基づいてＬＥＤ表示器６０１のそれぞれの発光ダイオードを所定の明るさに点灯させるための階調信号を演算して出力する階調制御手段６０４と、階調制御手段６０４から出力される信号によってスイッチングされて、発光ダイオードを点灯させるドライバー６０２とを備える。階調制御回路６０４は、ＲＡＭ６０３に記憶されるデータを取り出してＬＥＤ表示器６０１の発光ダイオード点灯時間を演算して点滅させるパルス信号をＬＥＤ表示器６０１に出力する。以上のように構成された表示装置において、ＬＥＤ表示器６０１は、駆動回路から入力されるパルス信号に基づいて表示データに対応した画像を表示することができ、以下のような利点がある。

すなわち、ＲＧＢの３つの発光ダイオードを用いて白色系の表示をさせるＬＥＤ表示器は、ＲＧＢの各発光ダイオードの発光出力を調節して表示させる必要があるため、各発光ダイオードの発光強度、温度特性などを考慮して各発光ダイオードを制御しなければならないので、該ＬＥＤ表示器を駆動する駆動回路は複雑になるという問題点があった。しかしながら、本願発明の表示装置においては、ＬＥＤ表示器６０１が、ＲＧＢの３種類の発光ダイオードを用いることなく、本願発明に係る白色系の発光が可能な発光ダイオード５０１を用いて構成されているので、駆動回路がＲＧＢの各発光ダイオードを個別に制御する必要がなく、駆動回路の構成を簡単

にでき、表示装置を安価にできる

また、ＲＧＢの３つの発光ダイオードを用いて白色系の表示をさせるＬＥＤ表示器は、１画素毎に、ＲＧＢの３つの発光ダイオードを組み合わせて白色表示させるためには、３つの各発光ダイオードをそれぞれ同時に発光させて混色する必要があり、一画素あたりの表示領域が大きくなり、高精細に表示させることができなかった。しかしながら、本願発明の表示装置におけるＬＥＤ表示器は、１個の発光ダイオードで白色表示できるので、より高精細に白色系表示させることができる。さらに、３つの発光ダイオードの混色によって表示するＬＥＤ表示器は、見る方向や角度によって、ＲＧＢの発光ダイオードのいずれかが部分的に遮光され表示色が変化する場合があるが、本願発明のＬＥＤ表示器ではそのようなことはない。

以上のように本願発明に係る白色系の発光が可能な発光ダイオードを用いたＬＥＤ表示器を備えた表示装置は、より高精細化が可能であり、安定した白色系の表示ができ、さらに、色むらを少なくできる特長がある。また、本願発明に係る白色表示が可能なＬＥＤ表示器は、従来の赤色、緑色のみを用いたＬＥＤ表示器に比べ人間の目に対する刺激が少なく長時間の使用に適している。

（本願発明の発光ダイオードを用いた他の表示装置の例）

本願発明の発光ダイオードを用いることにより、図１２に示すように、ＲＧＢの３つの発光ダイオードに本願発明の発光ダイオードを加えたものを１絵素とするＬＥＤ表示器を構成することができる。そして、このＬＥＤ表示器と所定の駆動回路とを接続することにより種々の画像を表示することができる表示装置を構成できる。この表示装置における駆動回路は、モノクロームの表示装置と同様に、入力される表示データを一時的に記憶する画像データー記憶手段（ＲＡＭ）と、ＲＡＭに記憶されたデータに基

づいて各発光ダイオードを所定の明るさに点灯させるための階調信号を演算する階調制御回路と、階調制御回路の出力信号でスイッチングされて、各発光ダイオードを点灯させるドライバーとを備える。ただし、この駆動回路は、ＲＧＢと白色系に発光する各発光ダイオードをそれぞれ制御する専用の回路を必要とする。階調制御回路は、ＲＡＭに記憶されるデータから、それぞれの発光ダイオードの点灯時間を演算して、点滅させるパルス信号を出力する。ここで、白色系の表示を行う場合は、ＲＧＢ各発光ダイオードを点灯するパルス信号のパルス幅を短く、あるいは、パルス信号のピーク値を低く、あるいは全くパルス信号を出力しないようにする。他方、それを補償するように（すなわち、パルス信号のパルス幅を短く、あるいは、パルス信号のピーク値を低く、あるいは全くパルス信号を出力しない分を補うように）白色系発光ダイオードにパルス信号を供給する。これにより、ＬＥＤ表示器の白色を表示する。

このように、ＲＧＢの発光ダイオードに白色発光ダイオードを追加することによって、ディスプレーの輝度を向上させることができる。また、ＲＧＢの組合せで白色を表示しようとすると、見る角度によってＲＧＢのうちのいずれか１つ又はいずれか２つの色が強調され、純粋な白を表現することができないが、本表示装置のように白色の発光ダイオードを追加することにより、そのような問題を解決することができる。

このような表示装置における駆動回路では、白色系発光ダイオードを所望の輝度で点灯させるためのパルス信号を演算する階調制御回路としてＣＰＵを別途備えることが好ましい。階調制御回路から出力されるパルス信号は、白色系発光ダイオードのドライバーに入力されてドライバをスイッチングさせる。ドライバーがオンになると白色系発光ダイオードが点灯され、オフになると消灯される。

（信号機）

本願発明の発光ダイオードを表示装置の１種である信号機として利用した場合、長時間安定して発光させることが可能であると共に発光ダイオードの一部が消灯しても色むらなどが生じないという特長がある。本願発明の発光ダイオードを用いた信号機の概略構成として、導電性パターンが形成された基坂上に白色系発光ダイオードを所定の配列に配置する。このような発光ダイオードを直列又は直並列に接続された発光ダイオードの回路を発光ダイオード群として扱う。発光ダイオード群を２つ以上用いそれぞれ渦巻き状に発光ダイオードを配置させる。全ての発光ダイオードが配置されると円状に全面に配置される。各発光ダイオード及び基板から外部電力と接続させる電源コードをそれぞれ、ハンダにより接続した後、鉄道信号用の匡体内に固定する。ＬＥＤ表示器は、遮光部材が付いたアルミダイキャストの匡体内に配置され表面にシリコーンゴムの充填材で封止されている。匡体の表示面は、白色レンズを設けてある。また、ＬＥＤ表示器の電気的配線は、筐体の裏面から筐体を密閉するためにゴムパッキンを介して通し、筐体内を密閉する。このようにして白色系信号機を形成することができる。本願発明の発光ダイオードを、複数の群に分け中心部から外側に向け輪を描く渦巻き状などに配置し、並列接続することでより信頼性が高い信号機を構成することができる。この場合、中心部から外側に向け輪を描くことにより、信頼性が高い信号機を構成することができる。中心部から外側に向け輪を描くことには、連続的に輪を描くものも断続的に配置するものの双方を含む。したがって、ＬＥＤ表示器の表示面積などを考慮して、配置される発光ダイオードの数や発光ダイオード群の数を種々選択することができる。この信号機により、一方の発光ダイオード群や一部の発光ダイオードが何らかのトラブルにより消灯したとしても他方の発光ダ

イオード群や残った発光ダイオードにより信号機を円形状に均一に発光させることが可能となるり、色ずれが生ずることもない。渦巻き状に配置してあることから中心部を密に配置することができ電球発光の信号と何ら違和感なく駆動させることができる。

＜実施例＞

以下、本願発明の実施例について説明するが、本願発明は、以下に示す実施例のみに限定されるものではないことを念のために言っておく。

（実施例１）

実施例１は、発光素子として、ＧａＩｎＮ半導体を用いた発光ピークが４５０ｎｍ、半値幅３０ｎｍの発光素子を用いた例である。実施例１の発光素子は、洗浄されたサファイ基板上にＴＭＧ（トリメチルガリウム)ガス、ＴＭＩ（トリメチルインジウム）ガス、窒素ガス及びドーバントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化ガリウム系化合物半導体を成膜することにより作製される。成膜時に、ドーパントガスとしてＳｉH_4とＣｐ$_2$Ｍｇと、を切り替えることによってＮ型導電性を有する窒化ガリウム半導体とＰ型導電性を有する窒化ガリウム半導体を形成する。実施例１のＬＥＤ素子は、Ｎ型導電性を有する窒化ガリウム半導体であるコンタクト層と、Ｐ型導電性を有する窒化ガリウムアルミニウム半導体であるクラッド層、Ｐ型導電性を有する窒化ガリウム半導体層であるコンタクト層を備え、Ｎ型導電性を有するコンタクト層とＰ型導電性を有するクラッド層との間に厚さ約３ｎｍの、単一量子井戸構造を構成するためのノンドープＩｎＧａＮからなる活性層が形成されている。尚、サファイア基板上には、バッファ層として低温で窒化ガリウム半導体層が形成されている。また、Ｐ型窒化ガリウム半導体は、成膜後４００℃以上の温度でアニールされている。

エッチングによりＰ型及びＮ型の各半導体表面を露出させた後、スパッタリングによりｎ側ｐ側の各電極がそれぞれ形成される。こうして作製された半導体ウエハーにスクライブラインを引いた後、外力を加えて個々の発光素子に分割した。

以上のようにして作製された発光素子を、銀メッキした鋼製のマウント・リードのカップ部にエポキシ樹脂でダイボンディングした後、発光素子の各電極とマウント・リード及びインナー・リードとをそれぞれ直径が３０μｍの金線を用いてワイヤーボンディングして、リードタイプの発光ダイオードを作製した。

一方、フォトルミネセンス蛍光体は、Ｙ、Ｇｄ、Ｃｅの希土類元素を所定の化学量論比で酸に溶解した溶解液を修酸で共沈させ、沈澱物を焼成して得られる共沈酸化物と、酸化アルミニウムを混合して、この混合原料にフラックスとしてフツ化アンモニウムを混合して坩堝に詰めて、空気中１４００℃の温度で３時間焼成した後、その焼成品をボールミルを用いて湿式粉砕して、洗浄、分離、乾燥後、最後に篩を通すことにより作製した。その結果、フォトルミネセンス蛍光体は、ＹがＧｄで約２割置換されたイットリウム・アルミニウム酸化物として$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}:Ce$が形成された。尚、Ｃｅの置換は０．０３であった。

以上のようにして作製した$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}:Ce$蛍光体８０重量部とエポキシ樹脂１００重量部とをよく混合してスラリーとし、このスラリーを発光素子が載置されたマウント・リードのカップ内に注入した後、１３０℃の温度で１時間で硬化させた。こうして発光素子上に厚さ１２０μｍのフォトルミネセンス蛍光体が含有されたコーティング部を形成した。なお、本実施例１では、コーティング部においては、発光素子に向かってフォトルミネセンス蛍光体が徐々に多く分布するように構成した。

照射強度は、約３．５Ｗ／ｃｍ^{2}である。その後、さらに発光素子やフォトルミネセンス蛍光体を外部応力、水分及び塵芥などから保護する目的でモールド部材として透光性エポキシ樹脂を形成した。ここで、モールド部材は、砲弾型の型枠の中に、リードフレームにボンディングされ、フォトルミネセンス蛍光体を含んだコーティング部に覆われた発光素子を挿入して、透光性エポキシ樹脂を注入した後、１５０℃５時間にて硬化させて形成した。

この要に形成した発光ダイオードは、発光観測正面から見ると、フォトルミネセンス蛍光体のボディーカラーにより中央部が黄色っぽく着色されていた。

こうして得られた白色系が発光可能な発光ダイオードの色度点、色温度、演色性指数を測定した結果、それぞれ、色度点は、（ｘ＝０．３０２、ｙ＝０．２８０）、色温度８０８０Ｋ、演色性指数（Ｒａ）＝８７．５と三波長型蛍光灯に近い性能を示した。また、発光効率は９．５１ｍ／ｗと白色電球並であった。さらに、温度２５℃６０ｍＡ通電、温度２５℃２０ｍＡ通電、温度６０℃９０％ＲＨ下で２０ｍＡ通電の各寿命試験においても蛍光体に起因する変化は観測されず通常の青色発光ダイオードと寿命特性に差がないことが確認できた。

(比較例1)

フォトルミネセンス蛍光体を$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}$：Ｃｅ蛍光体から（ＺｎＣｄ）Ｓ：Ｃｕ、Ａｌとした以外は、実施例１と同様にして発光ダイオードの形成及び寿命試験を行った。形成された発光ダイオードは通電直後、実施例１と同様、白色系の発光が確認されたが輝度は低かった。また、寿命試験においては、約１００時間で出力がゼロになった。劣化原因を解析した結果、蛍光体が黒化していた。

これは、発光素子の発光光と蛍光体に付着していた水分あるいは外部環境から進入した水分により光分解し蛍光体結晶表面にコロイド状亜鉛金属を析出し外観が黒色に変色したものと考えられる。温度２５℃２０ｍＡ通電、温度６０℃９０％ＲＨ下で２０ｍＡ通電の寿命試験結果を実施例１の結果と共に図１３に示す。輝度は初期値を基準にしそれぞれの相対値を示す。図１３において、実線が実施例１であり波線が比較例１を示す。

（実施例２）

実施例２の発光ダイオードは、発光素子における窒化物系化合物半導体のＩｎの含有量を実施例１の発光素子よりも増やすことにより、発光素子の発光ピークを４６０ｎｍとし、フォトルミネセンス蛍光体のＧｄの含有量を実施例１よりも増やし（$Y_{0.6}Gd_{0.4}$）$_3Al_5O_{12}$：Ｃｅとした以外は実施例１と同様にして発光ダイオードを作製した。

以上のようにして作製した発光ダイオードは、白色系の発光可能であり、その色度点、色温度、演色性指数を測定した。それぞれ、色度点（ｘ＝０．３７５、ｙ＝０．３７０）、色温度４４００Ｋ、演色性指数（Ｒａ）＝８６．０であった。

図１８Ａ、図１８Ｂ及び図１８Ｃにそれぞれ、実施例２のフォトルミネセンス蛍光体、発光素子及び発光ダイオードの各発光スペクトルを示す。

また、この実施例２の発光ダイオードを１００個作製し、初期の光度に対する１０００時間発光させた後における光度を調べた。その結果、初期（寿命試験前）の光度を１００％とした場合、１０００時間経過後における平均光度は、平均して９８．８％であり特性に差がないことが確認できた。

（実施例３）

実施例３の発光ダイオードは、フォトルミネセンス蛍光体としてＹ、Ｇ

ｄ、Ｃｅの希土類元素に加えＳｍを含有させた、一般式（$Y_{0.39}Gd_{0.57}Ce_{0.03}Sm_{0.01}$）$_3Al_5O_{12}$蛍光体を用いた以外は、実施例１と同様に作製した。この実施例３の発光ダイオードを１００個作製し、１３０℃の高温下において評価した結果、実施例１の発光ダイオードと比較して平均温度特性が８％ほど良好であった。

（実施例４）

実施例４のＬＥＤ表示器は、実施例１の発光ダイオードが、図１１に示すように銅パターンを形成したセラミックス基坂上に、１６×１６のマトリックス状に配列されて構成される。尚、実施例４のＬＥＤ表示器では、発光ダイオードが配列された基板は、フェノール樹脂からなり遮光部材５０５が一体で形成された筐体５０４内部に配置され、発光ダイオードの先端部を除いて筐体、発光ダイオード、基板及び遮光部材の一部をピグメントにより黒色に着色したシリコンゴム５０６が充填される。また、基板と発光ダイオードとの接続は、自動ハンダ実装装置を用いてハンダ付けを行った。

以上のように構成されたＬＥＤ表示器を、入力される表示データを一時的に記憶するＲＡＭ及びＲＡＭに記憶されるデータを取り出して発光ダイオードを所定の明るさに点灯させるための階調信号を演算する階調制御回路と階調制御回路の出力信号でスイッチングされて発光ダイオードを点灯させるドライバーとを備えた駆動手段によって駆動することにより白黒ＬＥＤ表示装置として使用できることを確認した。

（実施例５）

実施例５の発光ダイオードは、フォトルミネセンス蛍光体として一般式（$Y_{0.2}Gd_{0.8}$）$_3Al_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして作製した。この実施例５の発光ダイオードを１００個

作製して諸特性を測定した。

その結果、色度点（平均値）は（ｘ＝０．４５０，ｙ＝０．４２０）であり、電球色の光を発光することができた。

図１９Ａ、図１９Ｂ及び図１９Ｃにそれぞれ、実施例５のフォトルミネセンス蛍光体、発光素子及び発光ダイオードの各発光スペクトルを示す。

また、実施例５の発光ダイオードは、実施例１の発光ダイオードに比較して輝度が約４０％低かったが、寿命試験においては、実施例１と同様に優れた耐候性を示していた。

（実施例６）

実施例６の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Y_3Al_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして作製した。この実施例６の発光ダイオードを１００個作製して諸特性を測定した。

その結果、実施例１に比較してやや黄緑色がかった白色の光を発光することができた。

図２０Ａ、図２０Ｂ及び図２０Ｃにそれぞれ、実施例６のフォトルミネセンス蛍光体、発光素子及び発光ダイオードの各発光スペクトルを示す。

また、実施例６の発光ダイオードは、寿命試験においては、実施例１と同様に優れた耐候性を示していた。

（実施例７）

実施例７の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして作製した。この実施例７の発光ダイオードを１００個作製して諸特性を測定した。

その結果、実施例７の発光ダイオードは、輝度は低いが緑色がかった白

色の光を発光することができ、寿命試験においては、実施例１と同様に優れた耐候性を示していた。

図２１Ａ、図２１Ｂ及び図２１Ｃにそれぞれ、実施例７のフォトルミネセンス蛍光体、発光素子及び発光ダイオードの各発光スペクトルを示す。

（実施例８）

実施例８の発光ダイオードは、フォトルミネセンス蛍光体として、一般式$Gd_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表されるＹを含まない蛍光体を用いた以外は、実施例１と同様にして作製した。この実施例８の発光ダイオードを１００個作製して諸特性を測定した。

その結果、実施例８の発光ダイオードは、輝度は低いが、寿命試験においては、実施例１と同様に優れた耐候性を示していた。

（実施例９）

実施例９の発光ダイオードは、図７に示す構成を有する面状発光の発光装置である。

発光素子として発光ピークが４５０ｎｍの$In_{0.05}Ga_{0.95}N$半導体を用いた。発光素子は、洗浄させたサファイヤ基板上にＴＭＧ（トリメチルガリウム）ガス、ＴＭＩ（トリメチルインジュウム）ガス、窒素ガス及びドーパントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化ガリウム系化合物半導体を成膜することにより形成した。ドーパントガスとしてSiH_4とCp_2Mgと、を切り替えることによってＮ型導電性を有する窒化ガリウム半導体とＰ型導電性を有する窒化ガリウム半導体を形成しＰＮ接合を形成した。半導体発光素子としては、Ｎ型導電性を有する窒化ガリウム半導体であるコンタクト層、Ｎ型導電性を有する窒化ガリウムアルミニウム半導体であるクラッド層、Ｐ型導電性を有する窒化ガリウムアルミニウム半導体であるクラッド層、Ｐ型導電性を有する窒化ガリウム半導体で

あるコンタクト層を形成した。N型導電性を有するクラッド層とP型導電性を有するクラッド層との間にダブルヘテロ接合となるZnドープInGaNの活性層を形成した。なお、サファイア基板上には、低温で窒化ガリウム半導体を形成し、バッファ層として用いた。P型窒化物半導体層は、成膜後400℃以上の温度でアニールされている。

各半導体層を成膜した後、エッチングによりPN各半導体表面を露出させた後、スパッタリングにより各電極をそれぞれ形成し、こうして出来上がった半導体ウエハーをスクライブラインを引いた後、外力により分割させ発光素子として発光素子を形成した。

銀メッキした銅製リードフレームの先端にカップを有するマウント・リードに発光素子をエポキシ樹脂でダイボンディングした。発光素子の各電極とマウント・リード及びインナー・リードと、をそれぞれ直径が30μmの金線でワイヤーボンディングし電気的導通を取った。

モールド部材は、砲弾型の型枠の中に発光素子が配置されたリードフレームを挿入し透光性エポシキ樹脂を混入後、150℃5時間にて硬化させ青色系発光ダイオードを形成させた。青色系発光ダイオードを端面が全て研磨されたアクリル性導光板の一端面に接続させた。アクリル板の片面及び側面は、白色反射部材としてチタン酸バリウムをアクリル系バインダー中に分散したものでスクリーン印刷及び硬化させた。

一方、フォトルミネセンス蛍光体は、緑色系及び赤色系をそれぞれ必要なY、Gd、Ce、Laの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムと混合して混合原料をそれぞれ得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中1400°Cの温度範囲で3時間焼成して焼成品を得た。焼成品をそれぞれ水中でボ

ールミルして、洗浄、分離、乾燥、最後に篩を通して形成した。

以上のようにして作製された、一般式$Y_3(Al_{0.6}Ga_{0.4})_5O_{12}$：Ｃｅで表される緑色系が発光可能な第１の蛍光体１２０重量部と、同様にして作製された、一般式$(Y_{0.4}Gd_{0.6})_3Al_5O_{12}$：Ｃｅで表される赤色系が発光可能な第２の蛍光体１００重量部とを、エポキシ樹脂１００重量部とよく混合してスラリーとし、このスラリーを厚さ０．５ｍｍのアクリル層上にマルチコーターを用いて均等に塗布、乾燥し、厚さ約３０μｍの色変換部材として蛍光体膜を形成した。蛍光体層を導光板の主発光面と同じ大きさに切断し導光板上に配置することにより面状の発光装置を作製した。以上のように作製した発光装置の色度点、演色性指数を測定した結果、色度点は、（ｘ＝０．２９，ｙ＝０．３４）であり、演色性指数（Ｒａ）は、９２．０と三波長型蛍光灯に近い性能を示した。また、発光効率は１２ｌｍ／ｗと白色電球並であった。さらに耐侯試験として室温６０ｍＡ通電、室温２０ｍＡ通電、６０℃９０％ＲＨ下で２０ｍＡ通電の各試験においても蛍光体に起因する変化は観測されなかった。

（比較例２）

実施例９の一般式$Y_3(Al_{0.6}Ga_{0.4})_5O_{12}$：Ｃｅで表される緑色系が発光可能な第１の蛍光体、及び一般式$(Y_{0.4}Gd_{0.6})_3Al_5O_{12}$：Ｃｅで表される赤色系が発光可能な第２の蛍光体からなるフォトルミネセンス蛍光体に代えて、それぞれペリレン系誘導体である緑色有機蛍光顔料（シンロイヒ（ＳＩＮＬＯＩＨＩ）化学製ＦＡ－００１）と赤色有機蛍光顔料（シンロイヒ化学製ＦＡ－００５）とを用いて同量で混合撹拌した以外は、実施例９と同様にして発光ダイオードを作製して実施例９と同様の耐侯試験を行った。作製した比較例１の発光ダイオードの色度点は、（ｘ＝０．３４，ｙ＝０．３５）であった。耐侯性試験として、カーボンアークで紫

外線量を２００ｈｒで太陽光の１年分とほぼ同等とさせ時間と共に輝度の保持率及び色調を測定した。また、信頼性試験として発光素子を発光させ７０℃一定における時間と共に発光輝度及び色調を測定した。この結果を実施例９と共に図１４及び図１５にそれぞれ示す。図１４，１５から明らかなように、いずれの試験においても、実施例９は、比較例２より劣化が少ない。

（実施例１０）

実施例１０の発光ダイオードは、リードタイプの発光ダイオードである。

実施例１０の発光ダイオードでは、実施例９と同様にして作製した４５０ｎｍの$In_{0.05}Ga_{0.95}N$の発光層を有する発光素子を用いた。そして、銀メッキした銅製のマウントリードの先端のカップに発光素子をエポキシ樹脂でダイボンディングし、発光素子の各電極とマウント・リード及びインナー・リードとをそれぞれ金線でワイヤーボンディングし電気的に導通させた。

一方、フォトルミネセンス蛍光体は、一般式$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表される緑色系が発光可能な第１の蛍光体と一般式$(Y_{0.2}Gd_{0.8})_3Al_5O_{12}$：Ｃｅで表される赤色系が発光可能な第２の蛍光体とをそれぞれ以下のようにして作製して混合して用いた。すなわち、必要なＹ、Ｇｄ、Ｃｅの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムと混合して混合原料をそれぞれ得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中１４００°Ｃの温度範囲で３時間焼成してそれぞれ焼成品を得た。焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通して所定の粒度の第１と第２の蛍光体を作製した。

以上のようにして作製された第１の蛍光体及び第２の蛍光体それぞれ４０重量部を、エポキシ樹脂１００重量部に混合してスラリーとし、このスラリーを発光素子が配置されたマウント・リード上のカップ内に注入した。注入後、注入されたフォトルミネセンス蛍光体を含有する樹脂を１３０℃１時間で硬化させた。こうして発光素子上に厚さ１２０μのフォトルミネセンス蛍光体が含有されたコーティング部材を形成した。なお、このコーティング部材は、発光素子に近いほどフォトルミネセンス蛍光体の量が徐々に多くなるように形成した。その後、さらに発光素子やフォトルミネセンス蛍光体を外部応力、水分及び塵芥などから保護する目的でモールド部材として透光性エポキシ樹脂を形成した。モールド部材は、砲弾型の型枠の中にフォトルミネセンス蛍光体のコーティング部が形成されたリードフレームを挿入し透光性エポシキ樹脂を混入後、１５０℃５時間にて硬化させて形成した。このようにして作製された実施例１０の発光ダイオードは、発光観測正面から視認するとフォトルミネセンス蛍光体のボディーカラーにより中央部が黄色っぽく着色されていた。

以上のように作製した実施例１０の発光ダイオードの色度点、色温度、演色性指数を測定した結果、色度点は、（ｘ＝０．３２，ｙ＝０．３４）であり、演色性指数（Ｒａ）＝８９．０、発光効率は１０１ｍ／ｗであった。さらに耐侯試験として室温６０ｍＡ通電、室温２０ｍＡ通電、６０℃９０％ＲＨ下で２０ｍＡ通電の各試験においてもフォトルミネセンス蛍光体に起因する変化は観測されず通常の青色系発光ダイオードと寿命特性に差がないことが確認できた。

（実施例１１）

ＬＥＤ素子として発光ピークが４７０ｎｍの$In_{0.4}Ga_{0.6}N$半導体を用いた。発光素子は、洗浄させたサファイヤ基板上にＴＭＧ（トリメチル

ガリウム）ガス、ＴＭＩ（トリメチルインジュウム）ガス、窒素ガス及びドーパントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化ガリウム系化合物半導体を成膜させることにより形成した。ドーパントガスとしてSiH_4とCp_2Mgと、を切り替えることによってN型導電性を有する窒化ガリウム半導体とＰ型導電性を有する窒化ガリウム半導体を形成しＰＮ接合を形成した。ＬＥＤ素子としては、N型導電性を有する窒化ガリウム半導体であるコンタクト層、Ｐ型導電性を有する窒化ガリウムアルミニウム半導体であるクラッド層、Ｐ型導電性を有する窒化ガリウム半導体であるコンタクト層を形成した。N型導電性を有するコンタクト層とＰ型導電性を有するクラッド層との間に厚さ約３ｎｍのノンドープＩｎＧａＮの活性層を形成することにより単一井戸構造とした。なお、サファイア基板上には、低温で窒化ガリウム半導体をバッファ層として形成した。

以上のように各層を形成した後、エッチングによりＰＮ各半導体表面を露出させ、スパッタリングによりｐ側及びｎ側の各電極を形成した。こうして出来上がった半導体ウエハーをスクライブラインを引いた後、外力により分割させ発光素子として発光素子を形成した。

この発光素子を銀メッキした銅製のマウントリードのカップにエポキシ樹脂を用いてダイボンディングした。発光素子の各電極とマウント・リード及びインナー・リードと、をそれぞれ直径３０μｍの金線でワイヤーボンディングし電気的導通を取った。

モールド部材は、砲弾型の型枠の中に発光素子が配置されたリードフレームを挿入し透光性エポシキ樹脂を混入後、１５０℃５時間にて硬化させ青色系発光ダイオードを形成した。青色系発光ダイオードを端面が全て研磨されたアクリル性導光板の一端面に接続した。アクリル板の片面及び側面は、白色反射部材としてチタン酸バリウムをアクリル系バインダー中に

分散したものをスクリーン印刷及び硬化して膜状に形成した。

一方、フォトルミネセンス蛍光体は、一般式（$Y_{0.8}Gd_{0.2}$）$_3Al_5O_{12}$：Ｃｅで表され比較的短波長側の黄色系が発光可能な蛍光体と、一般式（$Y_{0.4}Gd_{0.6}$）$_3Al_5O_{12}$：Ｃｅで表され比較的長波長側の黄色系が発光可能な蛍光体とを以下のようにして作製して混合して用いた。これらの蛍光体は、それぞれ必要なＹ、Ｇｄ、Ｃｅの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウムと混合して混合原料をそれぞれ得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中１４００℃の温度範囲で３時間焼成して焼成品を得た。焼成品をそれぞれ水中でボールミルして、洗浄、分離、乾燥、最後に篩を通して形成した。

以上のように作製した比較的短波長側の黄色系蛍光体１００重量部と比較的長波長側の黄色系蛍光体１００重量部とを、アクリル樹脂１０００重量部とよく混合して押し出し成形し、厚さ約１８０μｍの色変換部材として用いる蛍光体膜を形成した。蛍光体膜を導光板の主発光面と同じ大きさに切断し導光板上に配置することにより発光装置を作製した。このようにして作製した実施例１１の発光装置の色度点、演色性指数を測定した結果、色度点は、

（ｘ＝０．３３，ｙ＝０．３４）であり、演色性指数（Ｒａ）＝８８．０を示した。また、発光効率は１０ １ｍ／ｗであった。

図２２Ａ、図２２Ｂ及び図２２Ｃにはそれぞれ、実施例１１に使用した、式（$Y_{0.8}Gd_{0.2}$）$_3Al_5O_{12}$：Ｃｅで表される蛍光体、式（$Y_{0.4}Gd_{0.6}$）$_3Al_5O_{12}$：Ｃｅで表される蛍光体及び発光素子の各発光スペクトルを示す。また、図２３には、実施例１１の発光ダイオードの発光スペクトルを示す。　さらに耐候試験として室温６０ｍＡ通電、室温２０ｍＡ通電、

６０℃９０％ＲＨ下で２０ｍＡ通電の各試験においても蛍光体に起因する変化は観測されなかった。同様に、この蛍光体の含有量を種々変えることによって発光素子からの波長が変化しても所望の色度点を維持させることができる。（実施例１２）

実施例１２の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Y_3In_5O_{12}$：Ｃｅで表されるＡｌを含まない蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個作製した。実施例９の発光ダイオードは、輝度は低いが寿命試験において実施例１と同様に優れた耐候性を示していた。

産業上の利用可能性

以上説明したように、本発明に係る発光ダイオードは、所望の色を有する光を発光することができ、長時間高輝度の使用においても発光効率の劣化が少なくしかも耐候性に優れている。従って、一般的な電子機器に限られず、高い信頼性が要求される車載用、航空産業用、港内のブイ表示用及び高速道路の標識照明など屋外での表示や照明として新たな用途を開くことができる。

請 求 の 範 囲

1. 発光層が半導体である発光素子と、該発光素子によって発光された光の一部を吸収して、吸収した光の波長と異なる波長を有する光を発光するフォトルミネセンス蛍光体とを備えた発光装置において、

前記発光素子の発光層が窒化物系化合物半導体からなり、かつ前記フォトルミネセンス蛍光体が、Y、Lu、Sc、La、Gd及びSmからなる群から選ばれた少なくとも1つの元素と、Al、Ga及びInからなる群から選ばれる少なくとも1つの元素とを含んでなるセリウムで付活されたガーネット系蛍光体を含むことを特徴とする発光装置。

2. 前記フォトルミネセンス蛍光体が、YとAlを含むイットリウム・アルミニウム・ガーネット系蛍光体を含むことを特徴とする請求項1記載の発光装置。

3. 前記フォトルミネセンス蛍光体が、一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表される蛍光体を含む請求項1記載の発光装置。

ただし、$0 \leq r < 1$、$0 \leq s \leq 1$、Reは、Y、Gdから選択される少なくとも一種である。

4. 前記フォトルミネセンス蛍光体が、一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3(Al_{1-s}Ga_s)_5O_{12}$で表される請求項3記載の発光装置。

ただし、$0 \leq p \leq 0.8$、$0.003 \leq q \leq 0.2$、$0.0003 \leq r \leq 0.08$、$0 \leq s \leq 1$

5. 前記フォトルミネッセンス蛍光体は、それぞれYとAlとを含んでなる互いに組成の異なる2以上のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を含む請求項2記載の発光装置。

6. 前記フォトルミネッセンス蛍光体は、それぞれ一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}$：Ceで表され、互いに組成の異なる2以上の蛍光体を含む請求項3記載の発光装置。

ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Reは、Y、Gdから選択される少なくとも一種である。

7. 前記フォトルミネッセンス蛍光体は、一般式$Y_3(Al_{1-s}Ga_s)_5O_{12}$：Ceで表される第1の蛍光体と、一般式$Re_3Al_5O_{12}$：Ceで表される第2の蛍光体とを含む請求項1記載の発光装置。

ただし、$0 \leqq s \leqq 1$、Reは、Y、Ga、Laから選択される少なくとも一種である。

8. 前記フォトルミネッセンス蛍光体は、イットリウム・アルミニウムガーネット系蛍光体において、それぞれイットリウムの一部がガドリニウムに置換された第1の蛍光体と第2の蛍光体とを含んでなり、該第1と第2の蛍光体のイットリウム・アルミニウムガーネット系蛍光体におけるガドリニウムによる置換量が互いに異なる請求項2記載の発光装置。

9. 前記発光素子の発光スペクトルの主ピークが400nmから530nmの範囲内にあり、かつ前記フォトルミネッセンス蛍光体の主発光波長が前記発光素子の主ピークより長い請求項1記載の発光装置。

10. 前記発光素子において、該発光素子の発光層がInを含む窒化ガリウム系半導体を含んでなり、前記フォトルミネセンス蛍光体が、イットリウム・アルミニウム・ガーネット系蛍光体において、Alの一部がGaによってGa：Al＝1：1から4：6の範囲内の比率になるように置換されかつYの一部がGdによってY：Gd＝4：1から2：3の範囲内の比率になるように置換されていることを特徴とする請求項9記載の発光装置。

１１．　請求項１記載の発光装置においてさらに、その一側面に前記フォトルミネセンス蛍光体を介して前記発光素子が設けられ、かつその一主表面を除く表面が実質的に反射部材で覆われた略矩形の導光板を備え、前記発光素子が発光した光を前記フォトルミネセンス蛍光体と導光板とを介して面状にして、前記導光板の前記一主表面から出力することを特徴とする発光装置。

１２．　請求項１記載の発光装置においてさらに、その一側面に前記発光素子が設けられ、その一主表面に前記フォトルミネセンス蛍光体が設けられかつ該一主表面を除く表面が実質的に反射部材で覆われた略矩形の導光板を備え、前記発光素子が発光した光を導光板と前記フォトルミネセンス蛍光体とを介して面状にして、前記導光板の前記一主表面から出力することを特徴とする発光装置。

１３．　請求項１～１０の内の１つに記載の発光装置をマトリックス状に配置したＬＥＤ表示器と、該ＬＥＤ表示器を入力される表示データに従って駆動する駆動回路とを備えたＬＥＤ表示装置。

１４．　カップ部とリード部とを有するマウント・リードと、

前記マウント・リードのカップ内に載置されかつ一方の電極がマウント・リードに電気的に接続されたＬＥＤチップと、

該ＬＥＤチップの他方の電極と電気的に接続させたインナー・リードと、

前記ＬＥＤチップを覆うように前記カップ内に充填された透光性のコーティング部材と、

前記マウント・リードのカップ部と、前記インナーリードと該ＬＥＤチップの他方の電極との接続部分とを含み、前記コーティング部材で覆われたＬＥＤチップを被覆するモールド部材とを有する発光ダイオードであって、

前記ＬＥＤチップの発光層が窒化物系化合物半導体であり、かつ前記コ

ーティング部材がフォトルミネセンス蛍光体を含み、該フォトルミネセンス蛍光体がＹ、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍからなる群から選ばれた少なくとも１つの元素と、Ａｌ、Ｇａ及びＩｎからなる群から選ばれる少なくとも１つの元素とを含み、セリウムで付活されたガーネット系蛍光体からなるフォトルミネッセンス蛍光体を含むことを特徴とする発光ダイオード。

１５．　前記フォトルミネッセンス蛍光体が、ＹとＡｌを含むイットリウム・アルミニウム・ガーネット系蛍光体を含むことを特徴とする請求項１４記載の発光ダイオード。

１６．　前記フォトルミネッセンス蛍光体が、一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表される蛍光体を含む請求項１４記載の発光ダイオード。

ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇｄから選択される少なくとも一種である。

１７．　前記フォトルミネッセンス蛍光体が、一般式$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3(Al_{1-s}Ga_s)_5O_{12}$で表される請求項１４記載の発光ダイオード。

ただし、$0 \leqq p \leqq 0.8$、$0.003 \leqq q \leqq 0.2$、$0.0003 \leqq r \leqq 0.08$、$0 \leqq s \leqq 1$

１８．　前記フォトルミネッセンス蛍光体は、それぞれＹとＡｌとを含んでなる互いに組成の異なる２以上のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を含む請求項１５記載の発光ダイオード。

１９．　前記フォトルミネッセンス蛍光体は、それぞれ一般式$(Re_{1-r}Sm_r)_3(Al_{1-s}Ga_s)_5O_{12}:Ce$で表され、互いに組成の異なる２

以上の蛍光体を含む請求項１６記載の発光ダイオード。

ただし、$0 \leqq r < 1$、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇｄから選択される少なくとも一種である。

２０．　前記フォトルミネッセンス蛍光体は、一般式$Y_3(Al_{1-s}Ga_s)_5O_{12}$：Ｃｅで表される第１の蛍光体と、一般式$Re_3Al_5O_{12}$：Ｃｅで表される第２の蛍光体とを含む請求項１４記載の発光ダイオード。

ただし、$0 \leqq s \leqq 1$、Ｒｅは、Ｙ、Ｇａ、Ｌａから選択される少なくとも一種である。

２１．　前記フォトルミネッセンス蛍光体は、イットリウム・アルミニウムガーネット系蛍光体において、それぞれイットリウムの一部がガドリニウムに置換された第１の蛍光体と第２の蛍光体とを含んでなり、該第１と第２の蛍光体イットリウム・アルミニウムガーネット系蛍光体におけるガドリニウムによる置換量が互いに異なる請求項１８記載の発光ダイオード。

２２．　前記ＬＥＤチップの発光スペクトルの主ピークが４００ｎｍから５３０ｎｍの範囲内にあり、かつ前記フォトルミネッセンス蛍光体の主発光波長が前記ＬＥＤチップの主ピークより長い請求項１４記載の発光ダイオード。

２３．　前記発光素子の発光スペクトルの主ピークを４００ｎｍから５３０ｎｍの範囲内に設定し、かつ前記フォトルミネッセンス蛍光体の主発光波長を前記発光素子の主ピークより長く設定することにより白色系の発光を可能にした請求項１記載の発光装置。

図1

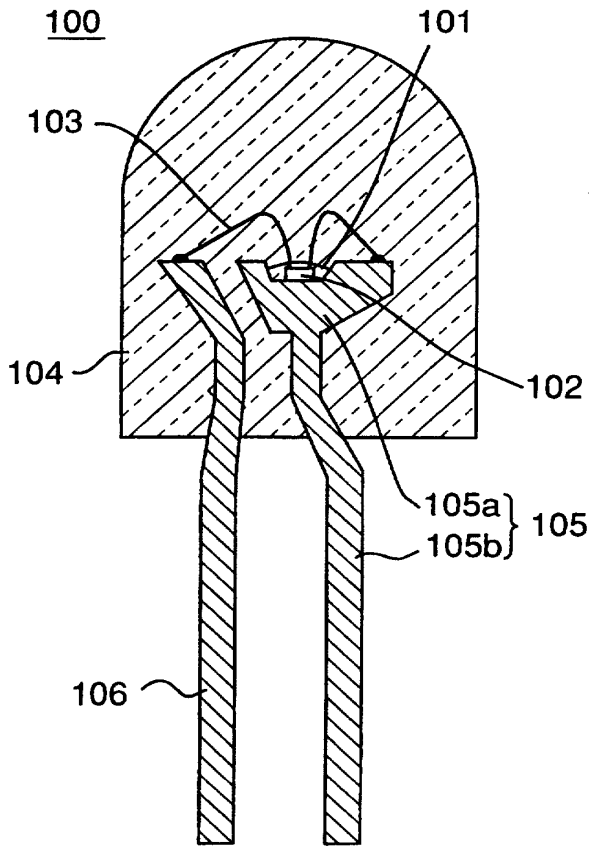


図2

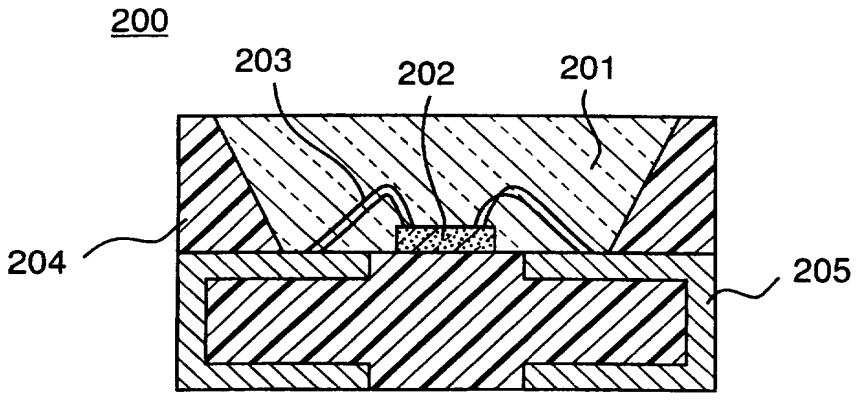


図3A

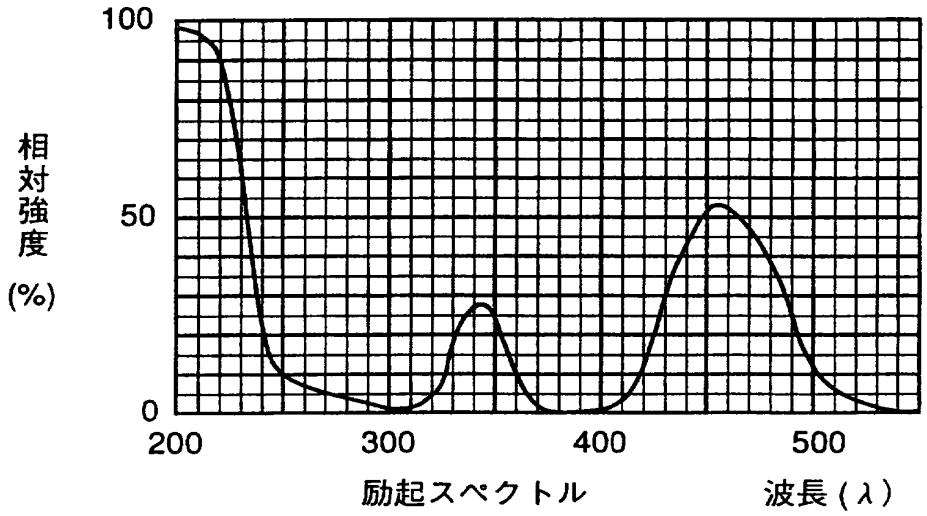

100
50
0
相対強度 (%)
200
300
400
500
励起スペクトル
波長 (λ)

図3B

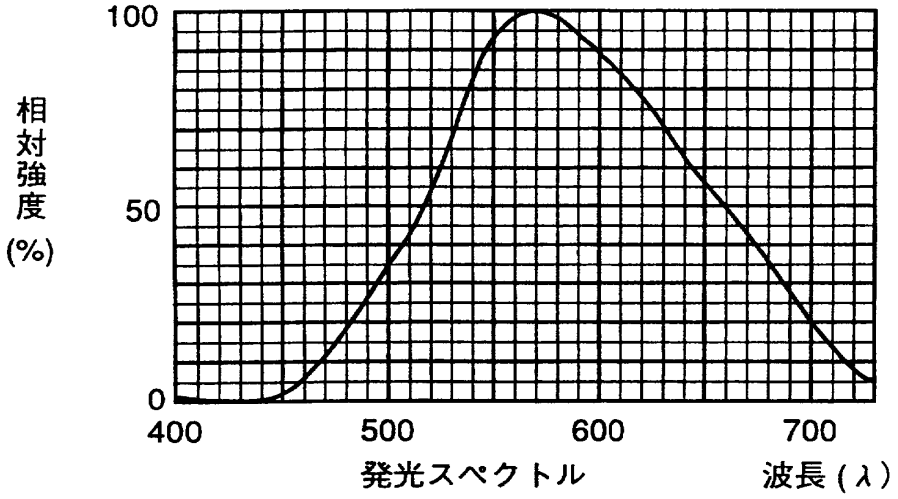

100
50
0
相対強度 (%)
400
500
600
700
発光スペクトル
波長 (λ)

図4

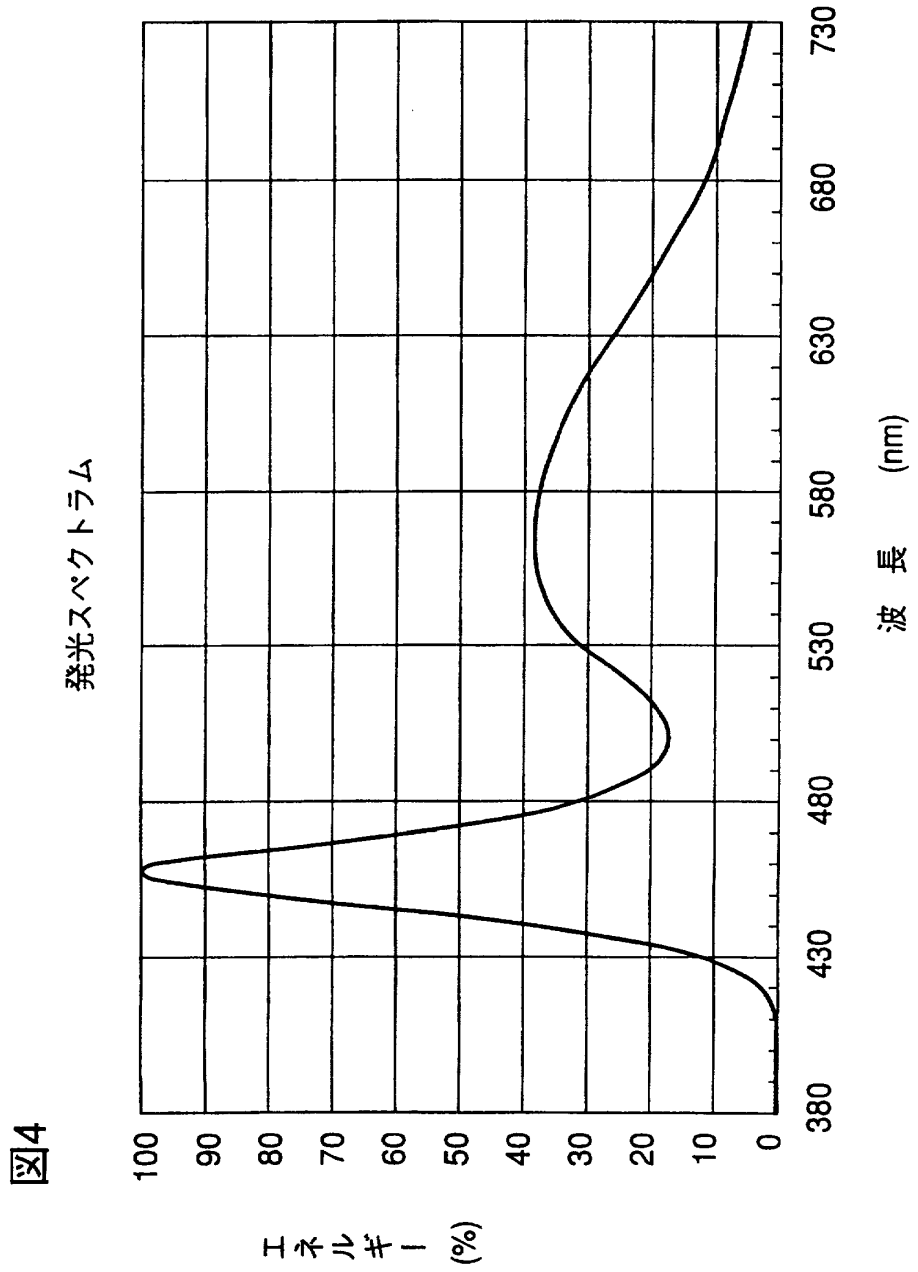

発光スペクトラム
エネルギー (%)
100
90
80
70
60
50
40
30
20
10
0
380
430
480
530
580
630
680
730
波長 (nm)

図5A

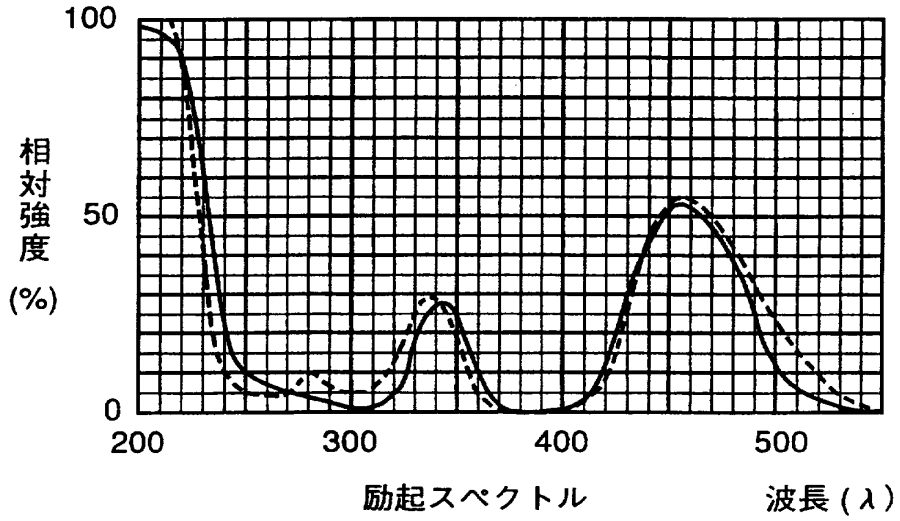

100
50
0
相対強度
(%)
200
300
400
500
励起スペクトル
波長(λ)

図5B

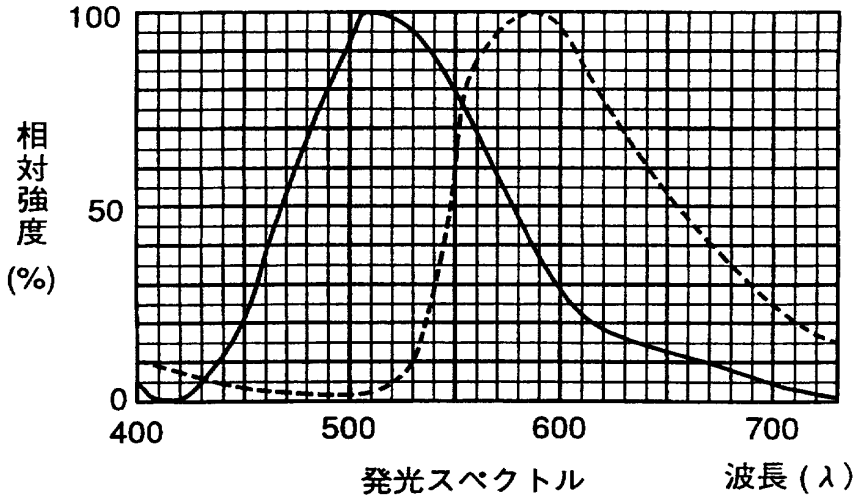

100
50
0
相対強度
(%)
400
500
600
700
発光スペクトル
波長(λ)

図6

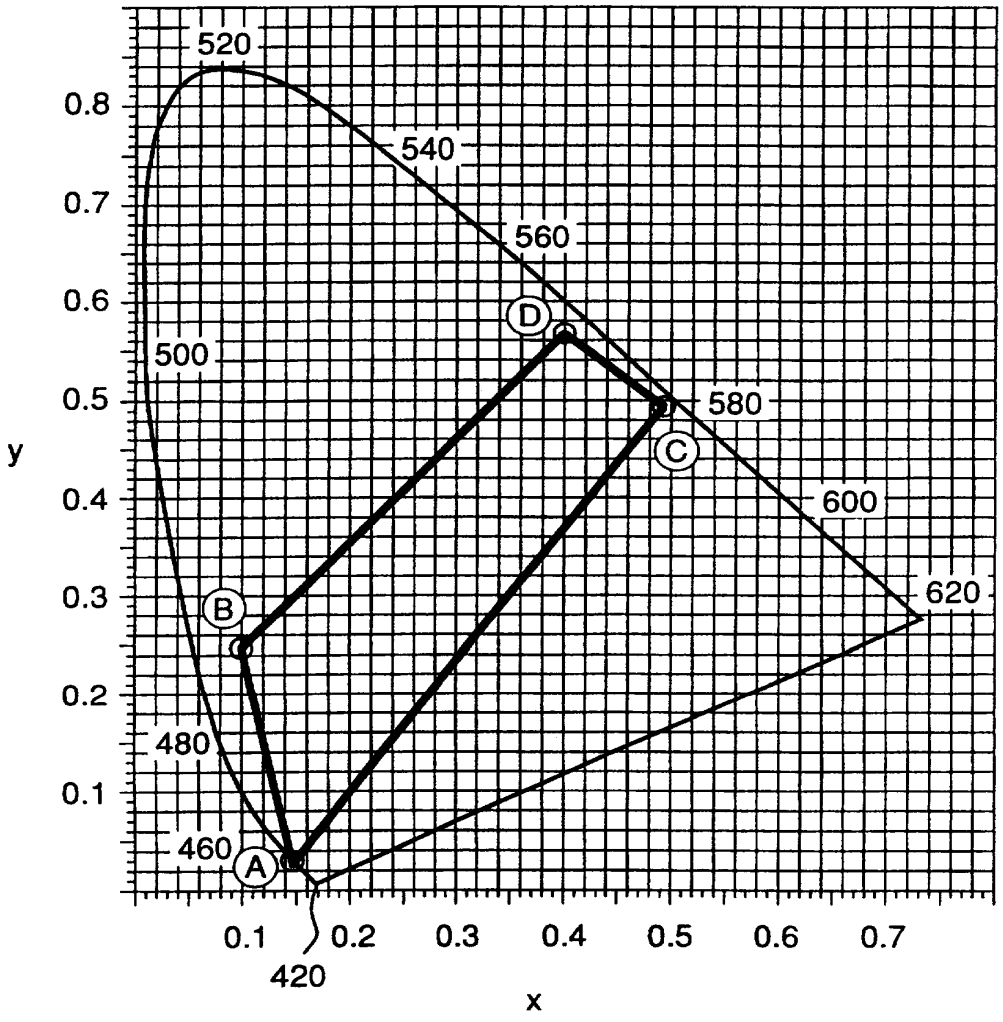

520
540
560
580
600
620
500
480
460
420
A
B
C
D
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
y
0.1
0.2
0.3
0.4
0.5
0.6
0.7
x

図7

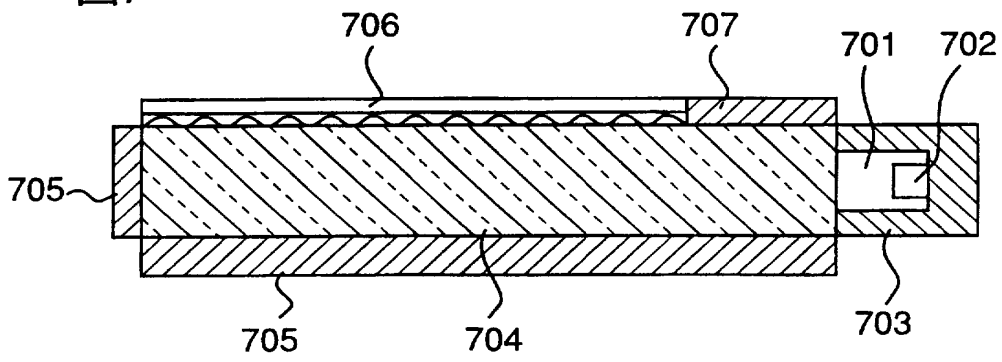

706
707
701
702
705
705
704
703

図8

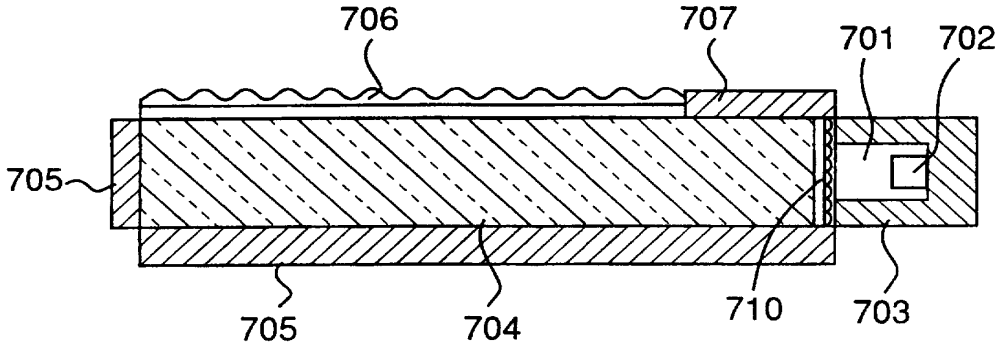

706
707
701
702
705
705
704
710
703

図9

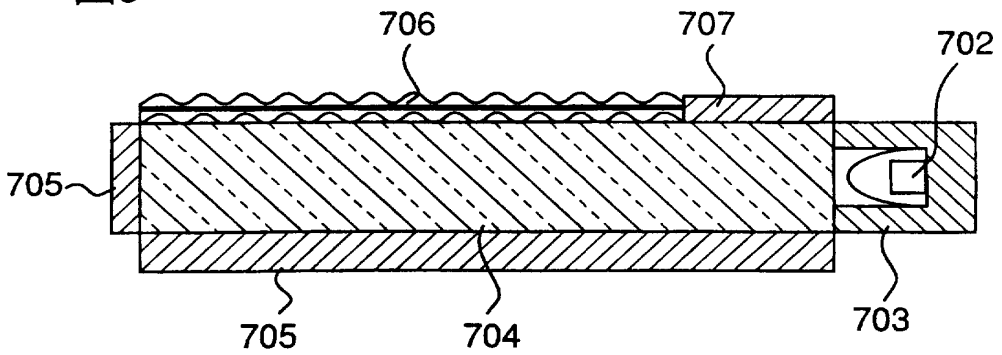

706
707
702
705
705
704
703

図10

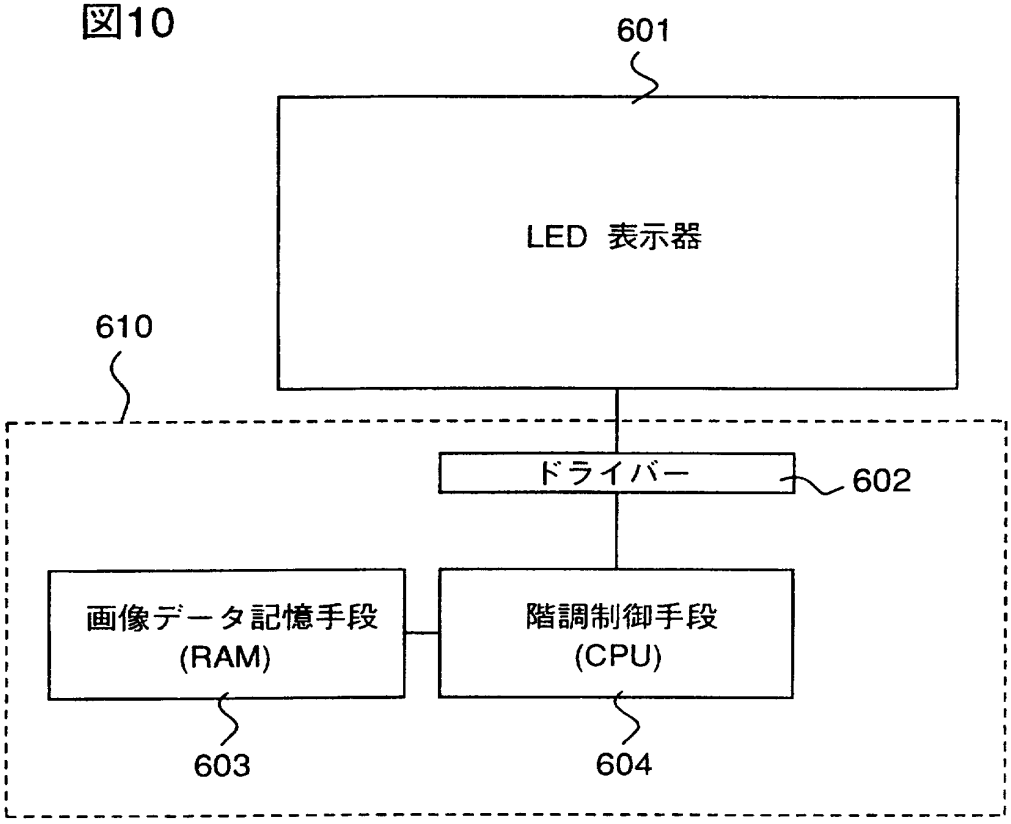


図11

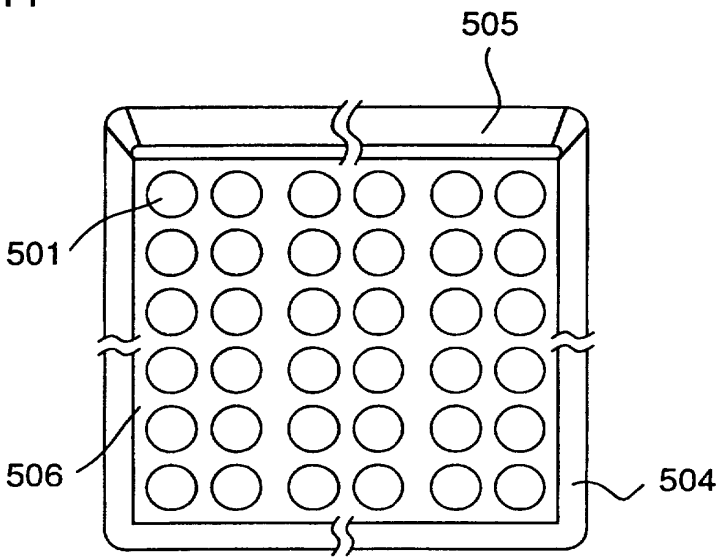


図12

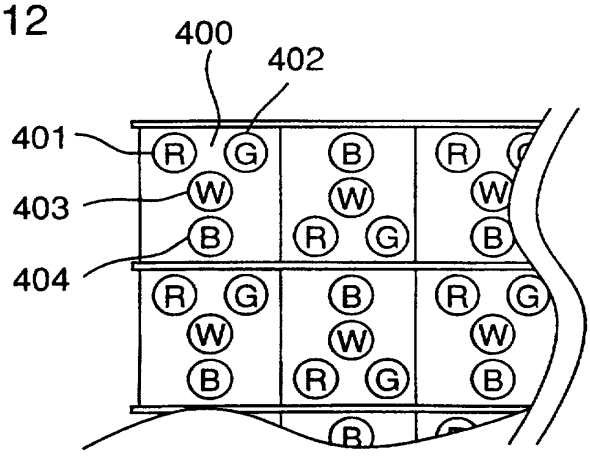


図13A

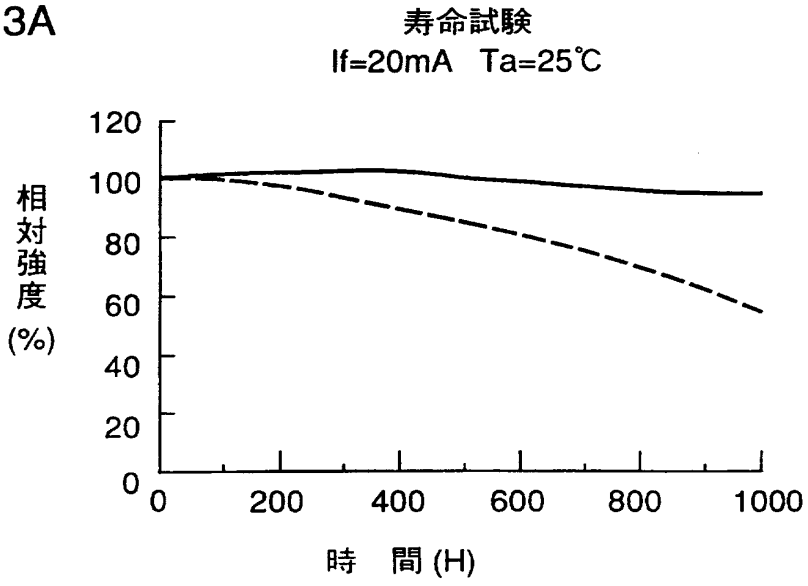

寿命試験
If=20mA Ta=25℃
相対強度 (%)
120
100
80
60
40
20
0
0
200
400
600
800
1000
時 間 (H)

図13B

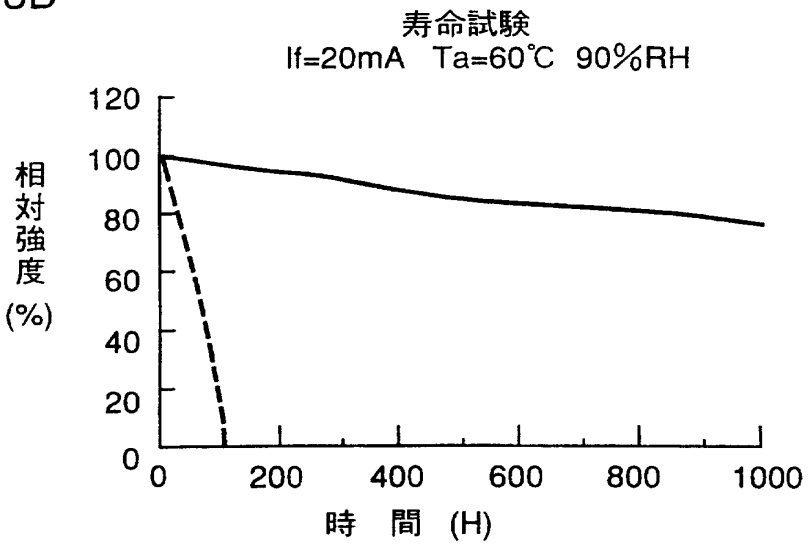

寿命試験
If=20mA Ta=60℃ 90%RH
相対強度 (%)
120
100
80
60
40
20
0
0
200
400
600
800
1000
時 間 (H)

図14A

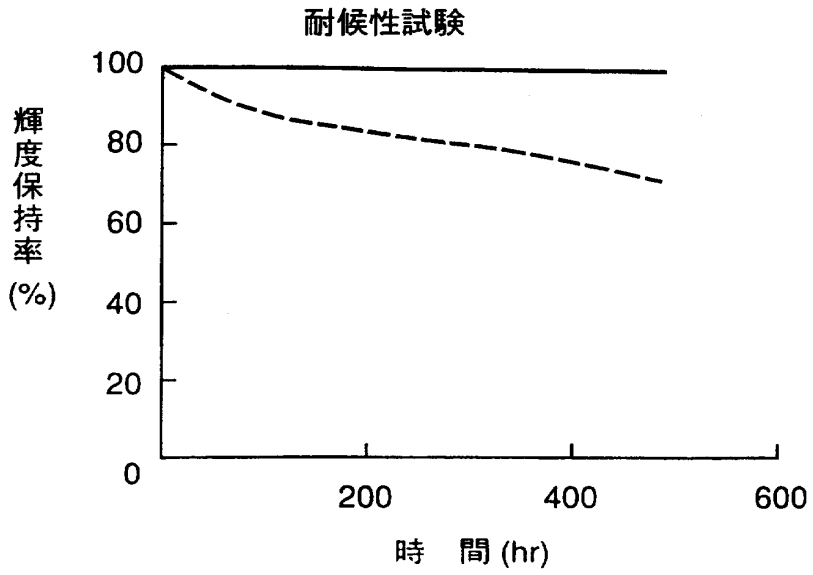

耐候性試験
100
80
60
40
20
0
輝度保持率(%)
200
400
600
時　間 (hr)

図14B

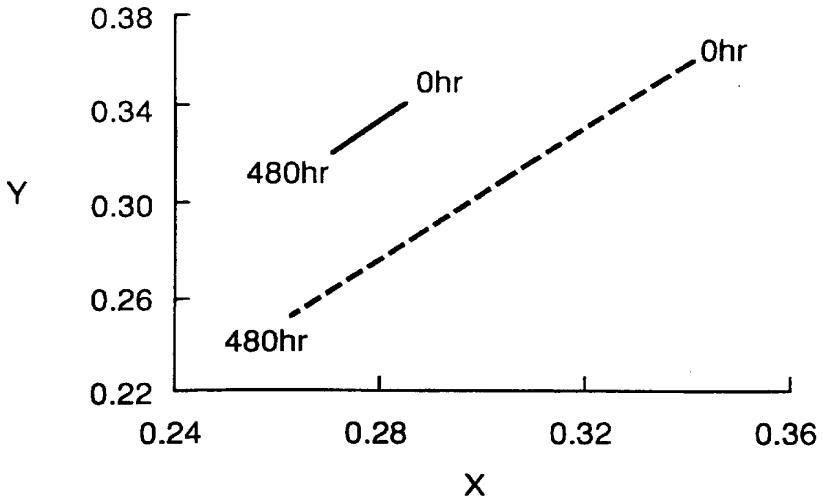

0.38
0.34
0.30
0.26
0.22
Y
0hr
480hr
0hr
480hr
0.24
0.28
0.32
0.36
X

図15A

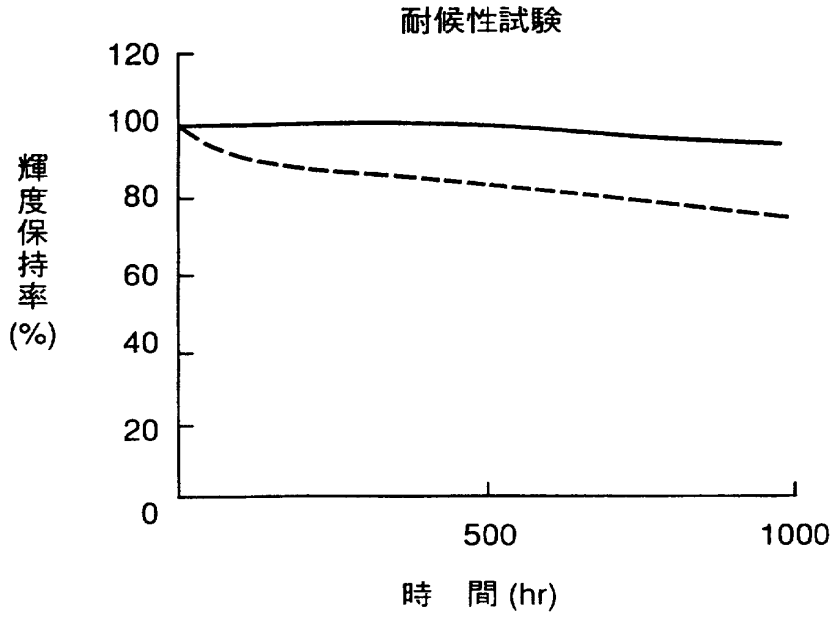

耐候性試験
120
100
80
60
40
20
0
輝度保持率(%)
500
1000
時 間 (hr)

図15B

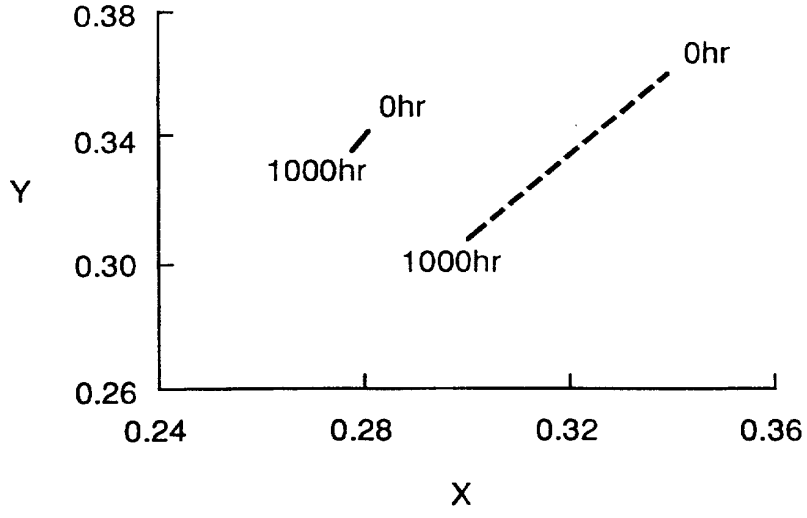

0.38
0.34
0.30
0.26
Y
0hr
1000hr
0hr
1000hr
0.24
0.28
0.32
0.36
X

図16

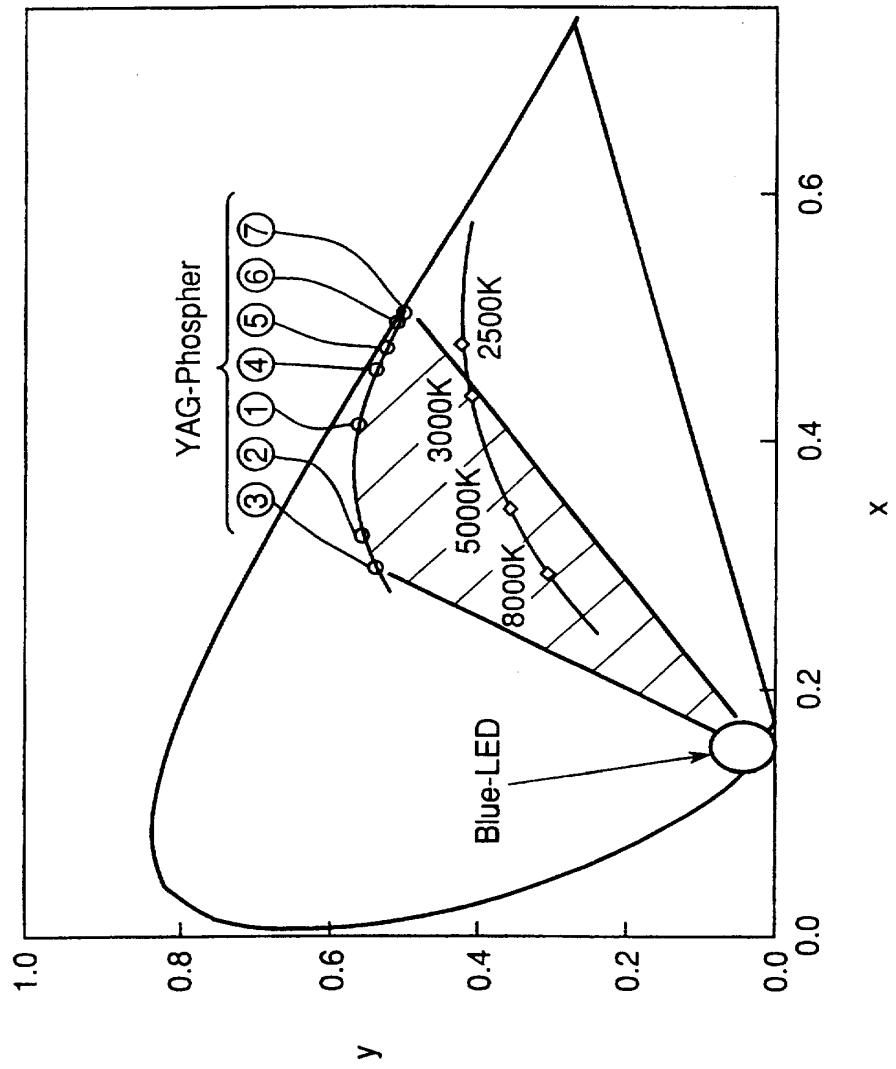

YAG-Phospher
①
②
③
④
⑤
⑥
⑦
2500K
3000K
5000K
8000K
Blue-LED
1.0
0.8
0.6
0.4
0.2
0.0
y
0.0
0.2
0.4
0.6
x

図17

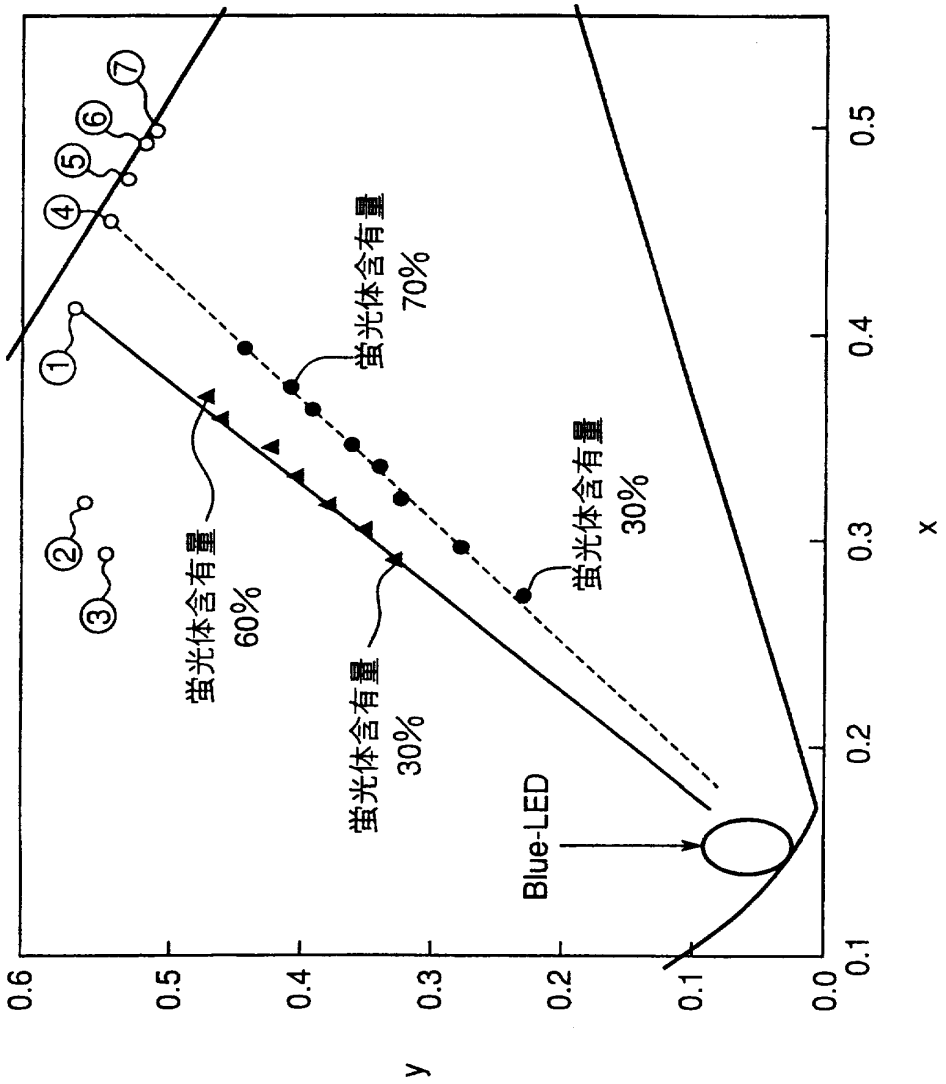

①
②
③
④
⑤
⑥
⑦
蛍光体含有量
60%
蛍光体含有量
30%
蛍光体含有量
70%
蛍光体含有量
30%
Blue-LED
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.1
0.2
0.3
0.4
0.5
y
x

図18A

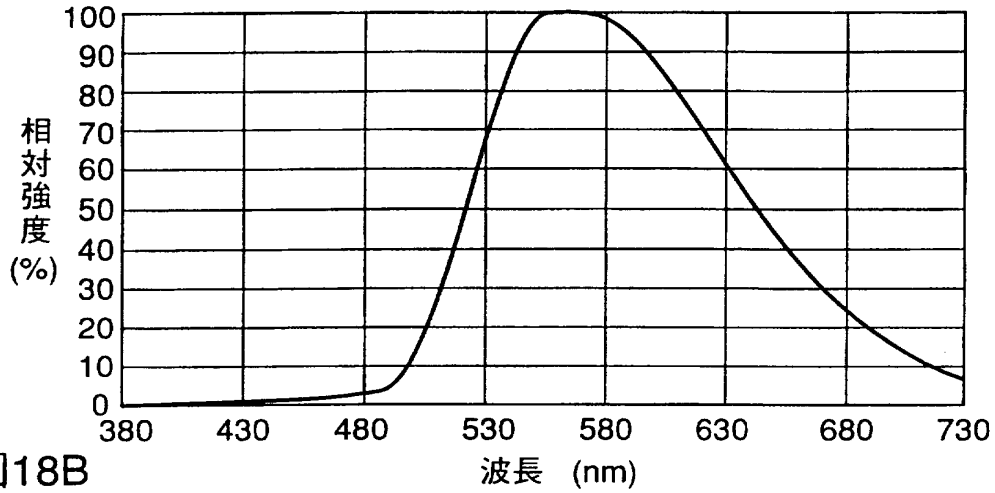


図18B

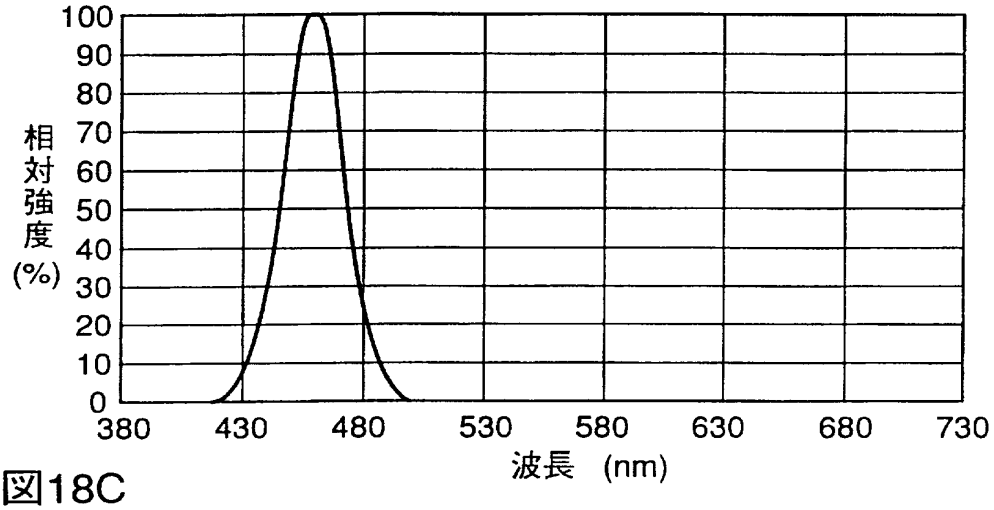


図18C

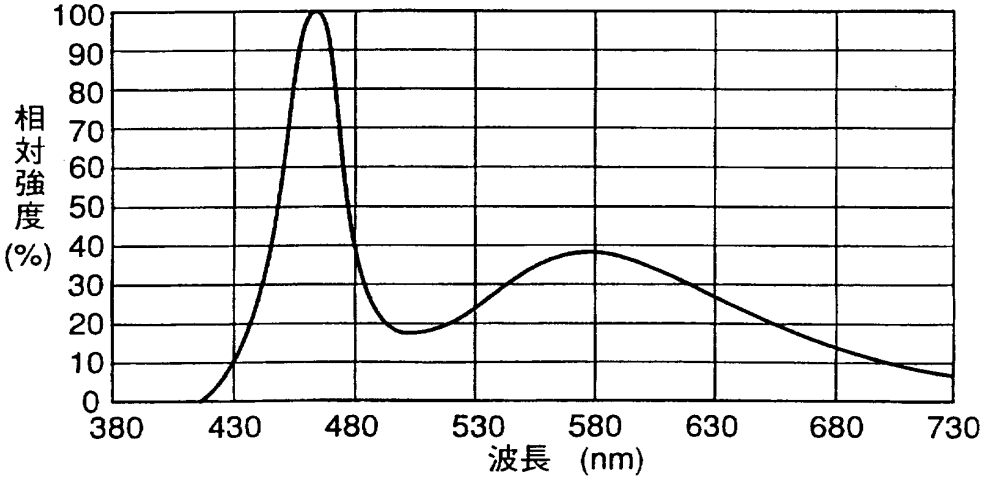


図19A

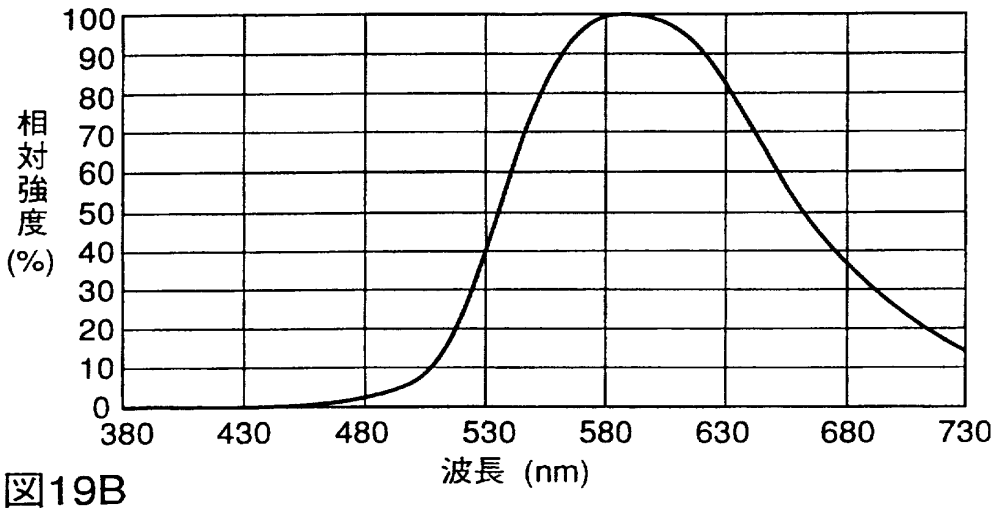


図19B

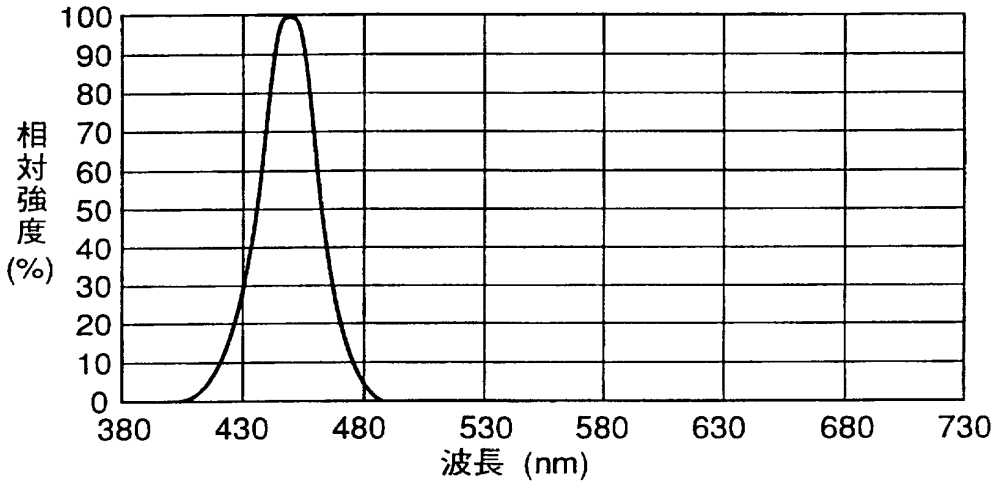


図19C

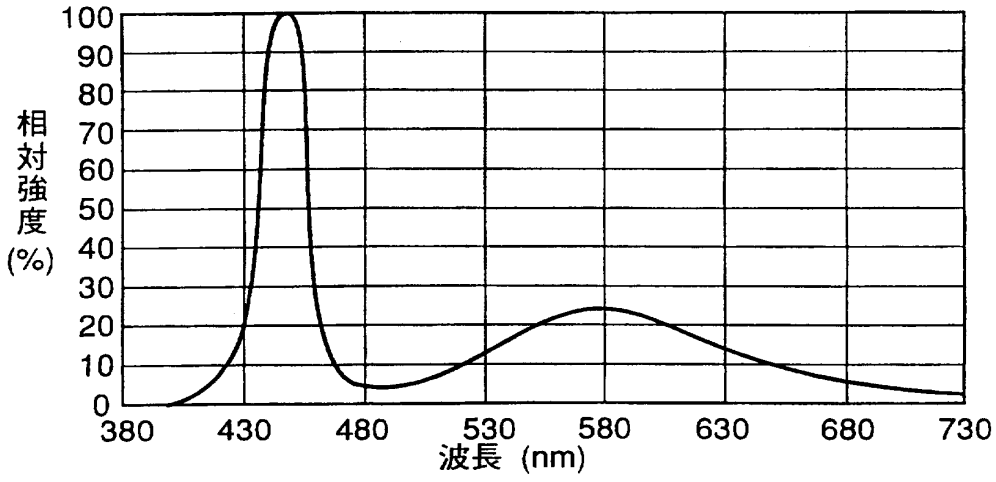


図20A

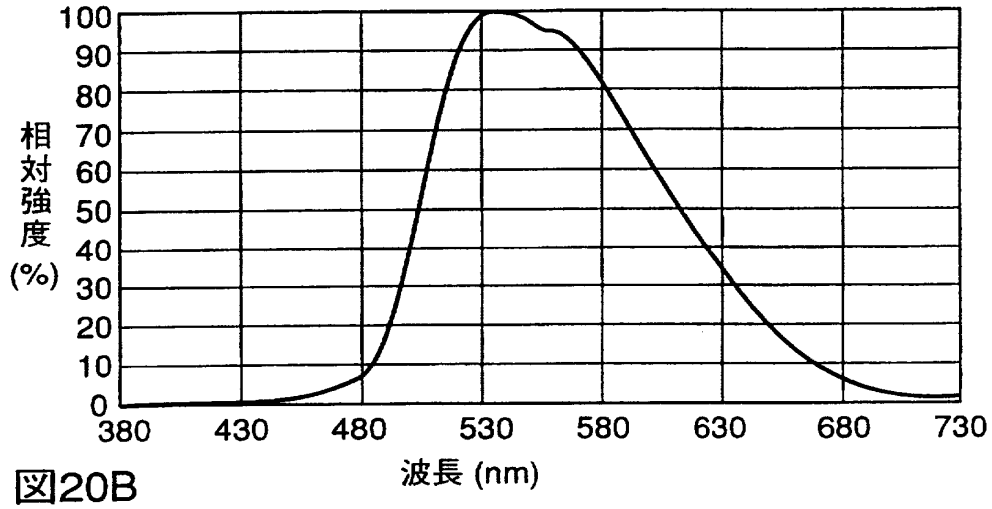


図20B

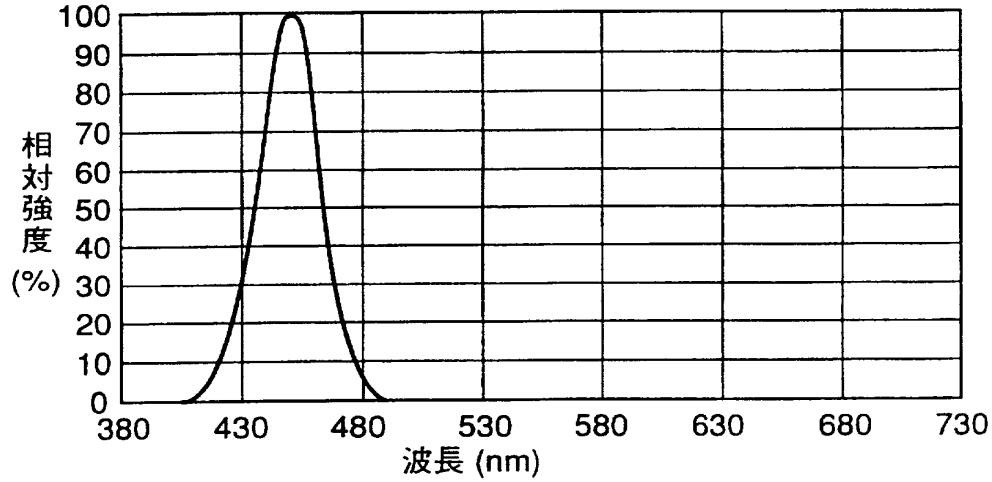


図20C

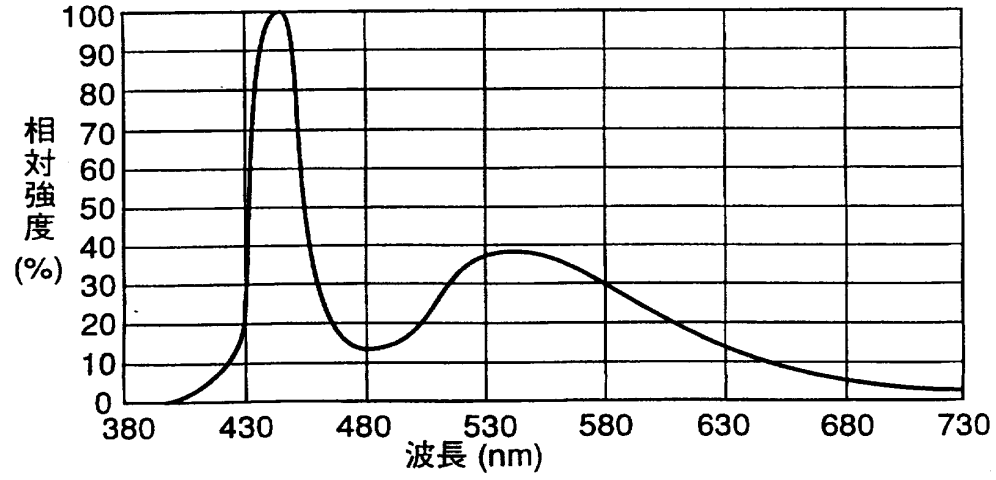


図21A

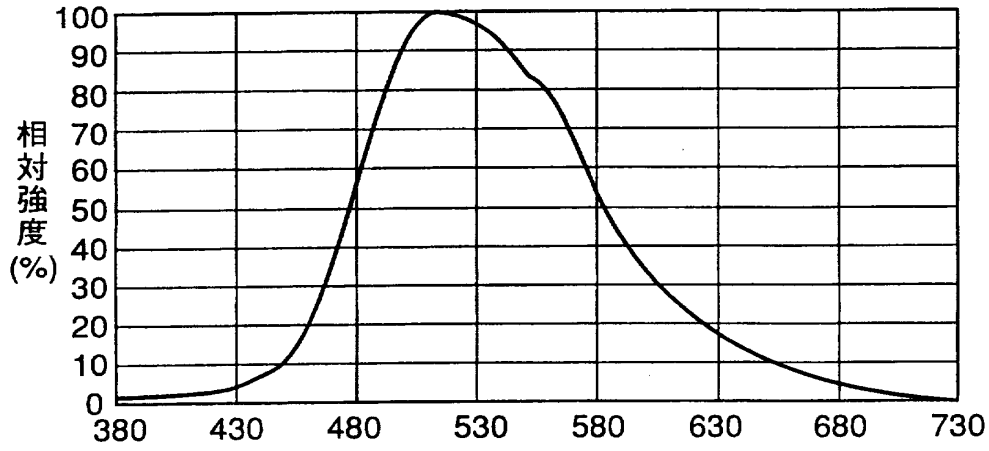


図21B

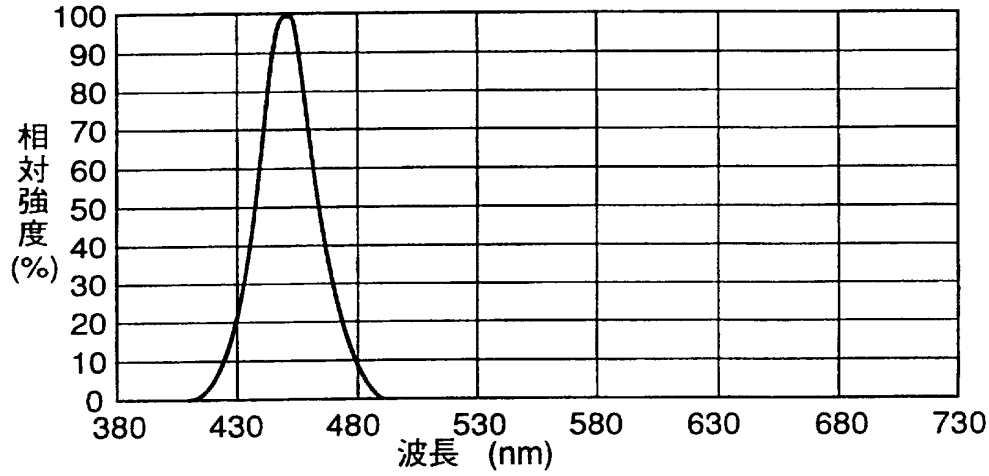


図21C

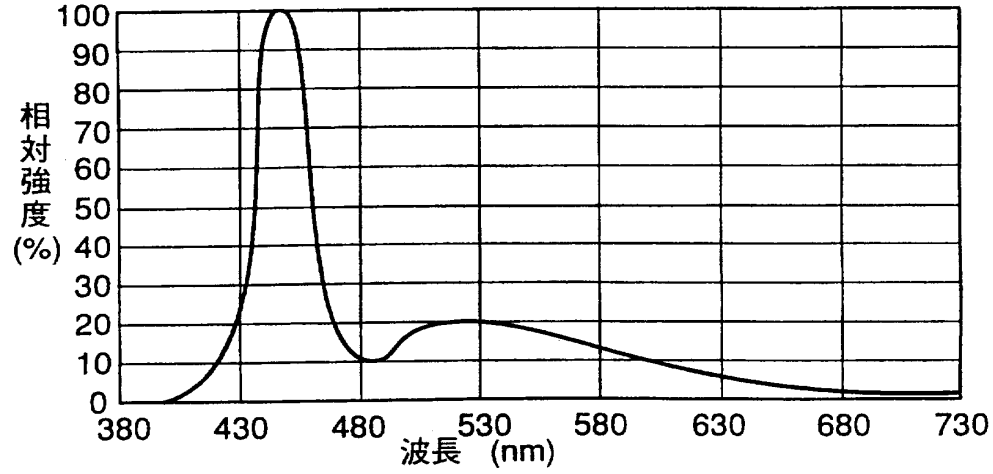


図22A

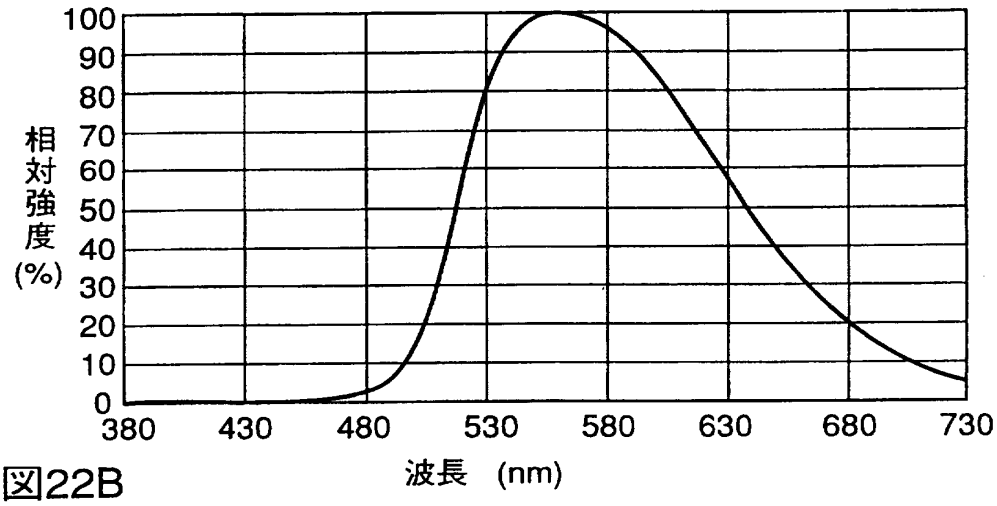


図22B

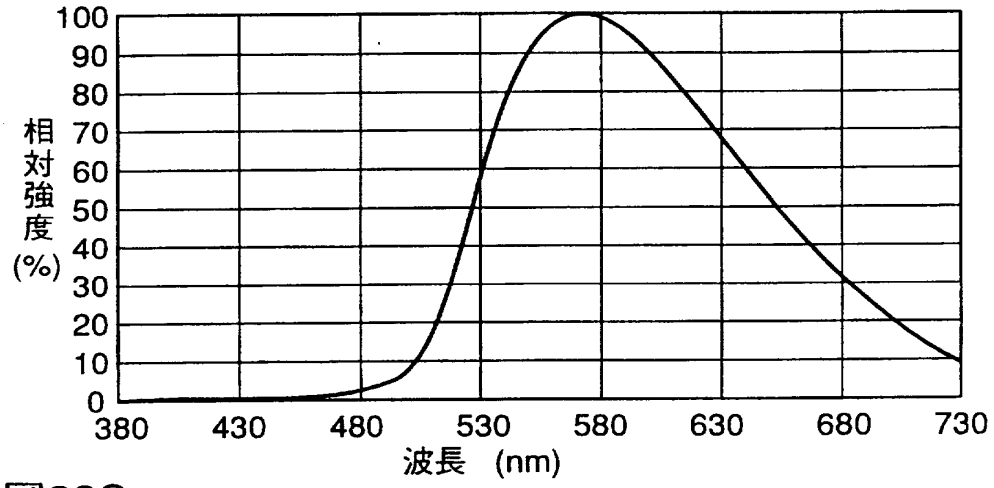


図22C

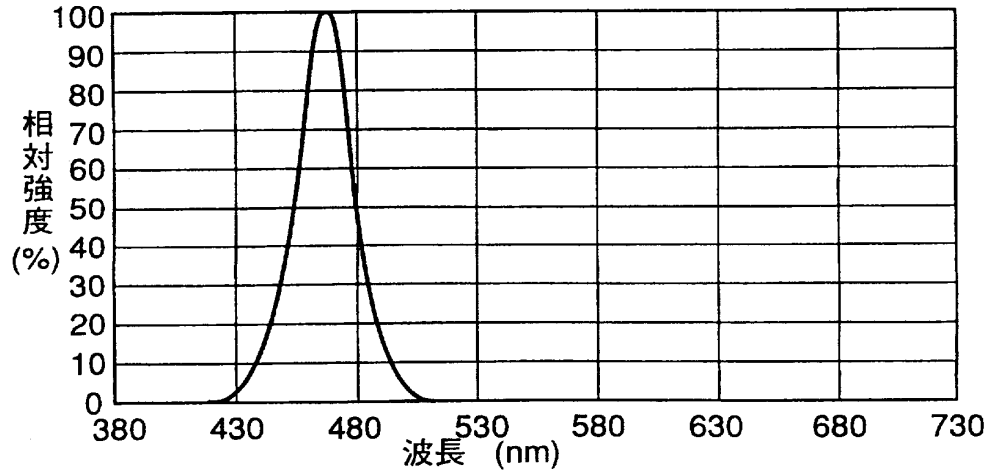
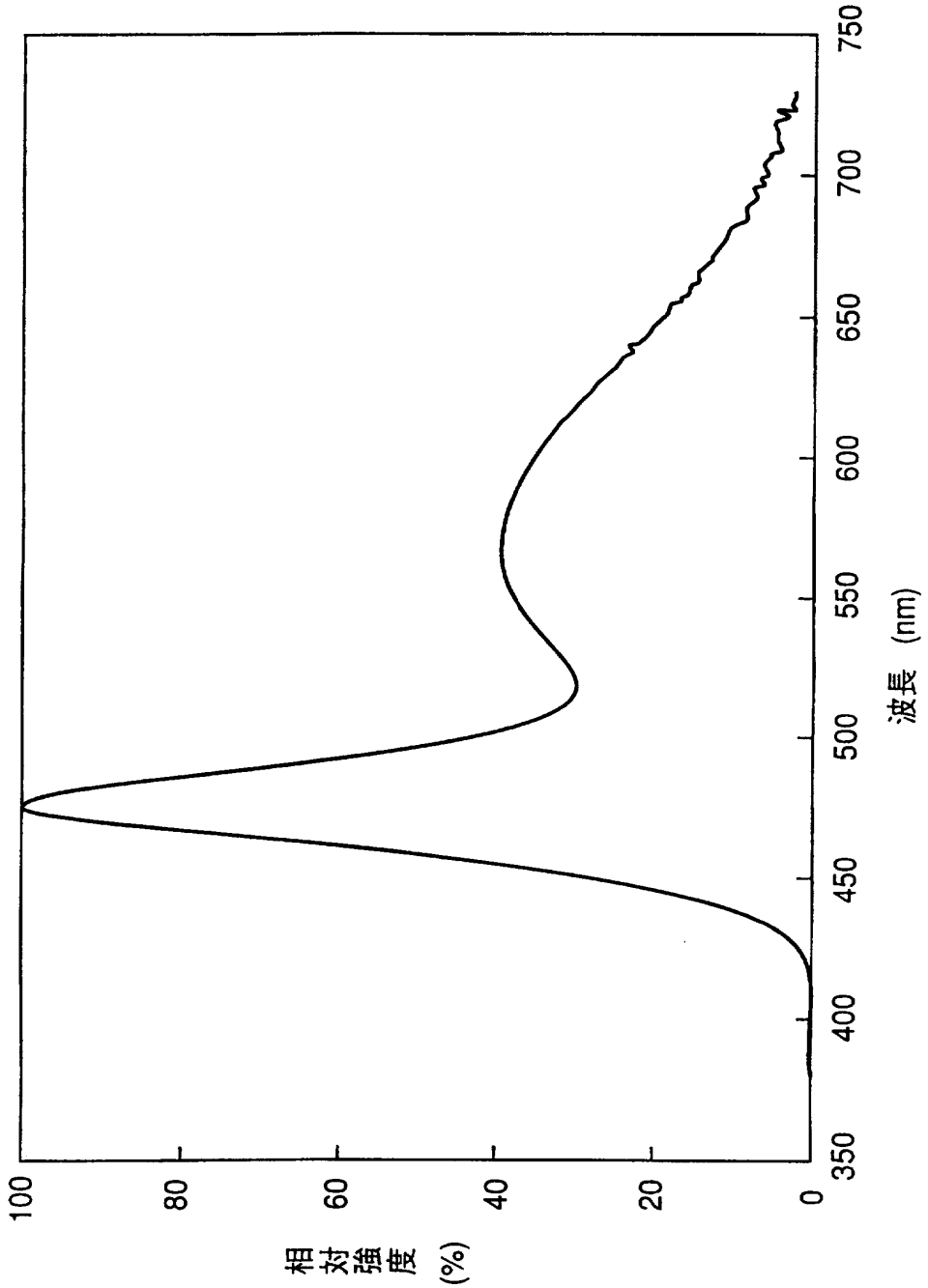


図23



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/02610

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 H01L33/00

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^6 H01L33/00

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

Jitsuyo Shinan Koho	1926 - 1996
Kokai Jitsuyo Shinan Koho	1971 - 1995
Toroku Jitsuyo Shinan Koho	1994 - 1996

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

JICST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 08-7614, A (Nichia Chemical K.K.), January 12, 1996 (12. 01. 96)(Family: none)	1 - 13
A	JP, 07-176794, A (Nichia Chemical K.K.), July 14, 1995 (14. 07. 95)(Family: none)	1 - 13
A	JP, 07-99345, A (Nichia Chemical K.K.), April 11, 1995 (11. 04. 95)(Family: none)	14 - 23
A	JP, 05-152609, A (Nichia Chemical K.K.), June 18, 1993 (18. 06. 93)(Family: none)	14 - 23
A	JP, 62-20237, A (Philips' Gloeilampenfabrieken), January 28, 1987 (28. 01. 87) & EP, 209942, A & US, 4727283, A	1 - 23
A	JP, 55-4898, A (Philips' Gloeilampenfabrieken), January 14, 1980 (14. 01. 80)(Family: none)	1 - 23
A	JP, 50-43913, A (Matsushita Electric Industrial Co., Ltd.),	1 - 23

[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
October 20, 1997 (20. 10. 97)	October 28, 1997 (28. 10. 97)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/02610

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	April 21, 1975 (21. 04. 75)(Family: none)	
P	JP, 09-27642, A (Clarion Co., Ltd.), January 28, 1997 (28. 01. 97)(Family: none)	1 - 23
P	Proceedings of SPIE - the International Society for Optical Engineering No. 3002 (1997), S. Nakamura "Present performance of InGaN based blue/green/yellow LEDs" p. 26-35	1 - 23

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

国際調査報告	国際出願番号　ＰＣＴ／ＪＰ９７／０２６１０

A.　発明の属する分野の分類（国際特許分類（ＩＰＣ））

Ｉｎｔ．Ｃｌ[6]　Ｈ０１Ｌ３３／００

B.　調査を行った分野

調査を行った最小限資料（国際特許分類（ＩＰＣ））

Ｉｎｔ．Ｃｌ[6]　Ｈ０１Ｌ３３／００

最小限資料以外の資料で調査を行った分野に含まれるもの

日本国実用新案公報　　１９２６－１９９６年
日本国公開実用新案公報　１９７１－１９９５年
日本国登録実用新案公報　１９９４－１９９６年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

ＪＩＣＳＴ

C.　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求の範囲の番号
Ａ	ＪＰ，０８－７６１４，Ａ（日亜化学工業株式会社） １２、１月、１９９６（１２．０１．９６）（ファミリーなし）	１－１３
Ａ	ＪＰ，０７－１７６７９４，Ａ（日亜化学工業株式会社） １４、７月、１９９５（１４．０７．９５）（ファミリーなし）	１－１３
Ａ	ＪＰ，０７－９９３４５，Ａ（日亜化学工業株式会社） １１、４月、１９９５（１１．０４．９５）（ファミリーなし）	１４－２３
Ａ	ＪＰ，０５－１５２６０９，Ａ（日亜化学工業株式会社） １８、６月、１９９３（１８．０６．９３）（ファミリーなし）	１４－２３

☒ Ｃ欄の続きにも文献が列挙されている。　　☐ パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー
「Ａ」特に関連のある文献ではなく、一般的技術水準を示すもの
「Ｅ」先行文献ではあるが、国際出願日以後に公表されたもの
「Ｌ」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「Ｏ」口頭による開示、使用、展示等に言及する文献
「Ｐ」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「Ｔ」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「Ｘ」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Ｙ」特に関連のある文献であって、当該文献と他の１以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「＆」同一パテントファミリー文献

国際調査を完了した日	国際調査報告の発送日
２０．１０．９７	28.10.97

国際調査機関の名称及びあて先	特許庁審査官（権限のある職員）	２Ｋ	９５１２
日本国特許庁（ＩＳＡ／ＪＰ） 郵便番号１００ 東京都千代田区霞が関三丁目４番３号	門田　かづよ		
	電話番号　０３－３５８１－１１０１　内線　３２５５		

様式ＰＣＴ／ＩＳＡ／２１０（第２ページ）（１９９２年７月）

C（続き）．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求の範囲の番号
A	JP，62－20237，A（ﾌｨﾘｯﾌﾟｽ　ﾌﾙｰｲﾗﾝﾍﾟﾝﾌｧﾌﾞﾘｹﾝ） 28、1月、1987（28．01．87） &EP，209942，A　&US，4727283，A	1－23
A	JP，55－4898，A（ﾌｨﾘｯﾌﾟｽ　ﾌﾙｰｲﾗﾝﾍﾟﾝﾌｧﾌﾞﾘｹﾝ） 14、1月、1980（14．01．80）（ファミリーなし）	1－23
A	JP，50－43913，A（松下電器産業株式会社） 21、4月、1975（21．04．75）（ファミリーなし）	1－23
P	JP，09－27642，A（クラリオン株式会社） 28、1月、1997（28．01．97）（ファミリーなし）	1－23
P	Proceedings of SPIE - the International Society for Optical Engineering 第3002号（1997）、S. Nakamura「Present performance of InGaN based blue/green/yellow LEDs」p. 26-35	1－23

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Korean FullDoc. English Fulltext

(19) KOREAN INTELLECTUAL PROPERTY OFFICE

KOREAN PATENT ABSTRACTS

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(43)Date of publication of application: 08.11.2001

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(22)Date of filing: 20.04.2000
(51)Int. Cl G02F 1/1335

(71)Applicant: LS TECH CO., LTD.
(72)Inventor: KIM, UK HYEON

(54) BACKLIGHT UNIT USING WHITE LED AND METHOD FOR EMITTING WHITE LIGHT OF HIGH PURITY

(57) Abstract:

PURPOSE: A backlight unit using a white LED(Light Emission Diode) and a method for emitting white light of high purity are provided to form a backlight unit by using a white LED or a tricolor LED. CONSTITUTION: A transparent resin is formed by doping a fluorescent material for white light on a blue LED. A white LED is formed by coating the transparent resin doped with the fluorescent material for white light. An LED kit(9) is formed by connecting the white LEDs in parallel. A plurality of refracted hemisphere is formed on a light guide panel(B). The refracted hemispheres have different sizes, respectively. A diffusion plate(10) includes an optical diffusion material. The refracted hemispheres have different density. The light guide panel(B) has a bottom plate inclined from the LED kit (9). A reflective plate(12) is used for reflect a refracted light or a diffused light.

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Legal Status
Date of request for an examination (20000420)
Notification date of refusal decision (00000000)
Final disposal of an application (rejection)
Date of final disposal of an application (20020527)
Patent registration number ( )
Date of registration (00000000)
Number of opposition against the grant of a patent ( )
Date of opposition against the grant of a patent (00000000)
Number of trial against decision to refuse ( )
Date of requesting trial against decision to refuse ( )

(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(51) 。Int. Cl. [7]
G02F 1/1335

(11) 공개번호 특2001-0097147
(43) 공개일자 2001년11월08일

(21) 출원번호 10-2000-0020967
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(71) 출원인 주식회사 엘에스텍
박득일
경기도 화성군 태안읍 반월리 636

(72) 발명자 김욱현
경기 성남시 분당구 이매동 111 이매촌아파트 810동 504호

(74) 대리인 박희섭

심사청구 : 있음

(54) 백색 발광 다이오드를 이용한 백라이트 유닛과 고순도백색광의 발광방법

요약

본 발명은 백색 발광 다이오드(white LED)를 이용한 백라이트(backlight) 유닛과 고순도 백색광 발광방법에 관한 것이다.

본 발명에서 사용되는 백색 발광 다이오드는 청색 발광 다이오드에 백색광용 형광체가 도핑된 투명수지로 코팅된 것을 특징으로 하며, 고순도 발광 다이오드는 청색 발광 다이오드에 녹색 발광용과 적색 발광용 형광체가 도핑된 투명수지로 코팅된 것을 특징으로 한다.

본 발명의 백라이트 유닛은 상기 다이오드와 확산판, 그리고 도광판으로 구성된다.

본 발명의 백라이트 유닛은 중소형 디스플레이 단말기에 적용될 경우, 장치의 소형화시킬 수 있으며, 높은 절전 효과를 얻을 수 있다.

대표도
도 6

명세서

도면의 간단한 설명

도 1은 본 발명에 사용되는 백색 발광 다이오드의 단면도이다.

도 2은 본 발명에 사용되는 고순도 발광 다이오드의 단면도이다.

도 3은 백색 발광 다이오드의 발광 스펙트럼이다.

도 4는 고순도 백색 발광 다이오드의 발광 스펙트럼이다.

도 5는 발광 다이오드와 확산판과 도광판으로 구성된 백라이트 유닛의 사시도이다.

도 6은 발광 다이오드와 확산판과 도광판으로 구성된 백라이트의 각 부분에 대한 분리 사시도이다.

도 7은 발광 다이오드를 복수개 병렬시킨 발광 다이오드 키트(kit)의 사시도이다.

도 8은 본 발명에서 사용되는 도광판의 사시도이다.

< 도면의 주요부분에 대한 부호의 설명>

A : 발광 다이오드 B : 도광판

1 : 반사컵 2 : 청색 발광 다이오드 3 : 연결선

4 : 백색광용 형광체 5 : 녹색광용 형광체 6 : 적색광용 형광체

7 : 에폭시 렌즈 8 : 납틀 9 : 발광 다이오드 키트 10 : 확산판 11 : 굴절용 반구 12 : 반사판

13 : 투명플라스틱 14 : 빛의 굴절 방향

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 백색 발광 다이오드를 이용한 백라이트 유닛(backlight unit) 및 고순도 백색광 발광방법에 관한 것으로, 보다 상세하게로는 백색 발광 다이오드(white LED) 또는 삼파장 발광 다이오드(tricolor LED)를 이용한 백라이트 유닛(backlight unit)과 삼파장 발광 다이오드(tricolor LED)를 이용한 고순도 백색광 발광방법에 관한 것이다.

백라이트는 주로 디스플레이의 광원으로 널리 사용된다. 노트북 컴퓨터의 경우는 냉각 음극 형광등(cold cathode fluorescent lamp)을 백라이트 광원으로 사용하고 있다. 노트북 콤퓨터에 사용되는 냉각 음극 형광등은 모든 색상이 가능하며 색 재현 범위가 우수하다.

그러나 냉각 음극 형광등의 구동에 있어서 인버터(inverter)를 사용해야 하므로 인버터가 차지하는 공간이 클 뿐만 아니라 인버터를 사용하게 되면 고전압이 걸리게 되므로 장기간 사용하면 열이 많이 발생하는 문제점이 있다. 따라서 구동에 필요한 소형의 고효율 배터리가 요구된다. 이에 따라 최근에는 소형 고효율의 배터리에 관한 연구가 집중되고 있다.

그러나 노트북 컴퓨터에 사용되는 냉각 음극 형광등은 에너지의 소모가 크므로 이것을 에너지의 소모가 거의 없는 백색 발광 다이오드를 이용한 백라이트로 대체하게 되면 기존의 배터리로도 충분히 장기간 사용할 수 있을 뿐만 아니라, 나아 가서는 현재 일반 가전용품에 사용되고 있는 소형 건전지로 대체하여 사용될 수도 있다.

또한 소형 디스플레이로 널리 사용되는 핸드폰은 표면 장착 발광 다이오드 [SMD(surface mounting device) LED]가 주로 사용되고 있다. SMD LED는 정보통신기기의 소형화 추세에 발맞추어 널리 사용되고 있다. SMD LED는 소형일 뿐만 아니라 전력 소모가 매우 적으므로, 핸드폰과 같은 소형 디스플레이의 백라이트에 최적의 조건을 가지고 있다.

그러나 현재 사용되는 SMD LED는 주로 녹색 LED을 사용하고 있다. 최근에는 적색 및 청색의 SMD LED도 사용되고 있다. 그러나 이러한 것들은 단색의 SMD LED를 사용하기 때문에 문자나 간단한 모노 칼라 영상을 디스플레이 하는데는 문제가 없지만 노트북처럼 다양한 색 재현이 필요한 곳에는 적용이 불가능하다.

만약 백색을 구현하기 위해서는 청색, 녹색, 적색의 LED를 동시에 사용해야 하므로 적용상의 문제점이 많이 발생한다. 특히, 청색, 녹색, 적색의 LED를 동시에 사용하는 경우에는 각각의 LED의 위치에 따라서 나오는 다른 색들을 모아서 백색을 만드는 기술적인 문제때문에 현실적으로 적용하기가 힘들다. 따라서 백색광을 구현하기 위하여는 한 개의 LED에서 삼파장이 모두 일정 세기 이상으로 발광되는 것이 요구된다.

이와 같이 색 재현 범위가 우수한 노트북의 냉각 음극 형광 등의 장점과 소형일 뿐만 아니라 전력 소모가 매우 작은 핸드폰의 SMD LED의 백라이트의 장점만을 살릴 수 있는 백라이트를 개발이 절실히 요구되고 있다.

발명이 이루고자 하는 기술적 과제

본 발명은 상기한 바와 같은 문제점을 해결하기 위한 것으로, 백색 발광 다이오드와 도광판 및 확산판으로 구성된 초절전형 및 초소형 백라이트 유닛(backlight unit)을 제공하는 것을 목적으로 한다. 본 발명의 다른 목적은 균일한 조도를 갖는 백라이트 유닛을 제공하는 것이다. 본 발명의 또 다른 목적은 고순도 백색광의 발생방법을 제공하는 것이다.

발명의 구성 및 작용

본 발명의 백라이트 유닛은 형광체가 도핑된 투명수지가 코팅된 발광 다이오드와 크기 또는 밀도가 상이한 굴절용 반구가 형성된 도광판, 그리고 광의 확산물질이 도핑된 확산판으로 구성된다.

본 발명의 고순도 백색광 발생방법은 청색 발광 다이오드에 청색, 녹색, 적색의 삼파장이 유사한 세기로 발광되도록 녹색광용 형광체와 적색광용 형광체가 도핑된 투명수지가 코팅하여 백색광을 발광시키는 것으로 구성된다.

이하, 본 발명을 첨부도면을 참조하면서 상세히 설명한다.

도1은 본 발명에서 사용되는 백색광용 발광 다이오드의 단면도로서, 반사컵(1) 상부에 청색 발광 다이오드(2)가 부착되며, 청색 발광 다이오드(2)의 상부는 백색광용 형광체(4)로 도핑된 투명수지로 코팅되었다. 연결선(3)은 청색 발광 다이오드(2)와 납틀(8)을 연결하여 주며, 이를 통하여 전기가 통전된다. 미설명부호 7은 발광된 빛이 통과하는 에폭시 렌즈이다.

도2는 도1과 같으나, 백색광용 형광체(4) 대신에 녹색광용 형광체(5)와 적색광용 형광체(6)가 함께 도핑된 투명수지가 코팅되었다.

도3은 도1의 발광 다이오드로부터 발광된 빛의 발광 스펙트럼이다.

도4는 도2의 발광 다이오드로부터 발광된 빛의 발광 스펙트럼이다.

도5는 본 발명의 백라이트 유닛의 외부 사시도로서, 도광판(B)과 발광 다이오드 키트(9), 반사판(12), 확산판(10) 및 납틀(8)로 구성되며, 도광판(B)과 발광 다이오드 키트(9)는 수직하게 형성된다.

도6은 도5의 분해 사시도로서, 내부의 도광판(B)에 크기가 상이한 다수개의 반구가 도광판의 저면과 일정한 각도를 이루며 형성되어 있다.

도7은 복수개의 발광 다이오드(A)가 병렬로 연결된 발광 다이오드 키트(9)이다.

도8은 본 발명에서 사용되는 도광판(B)에 의하여 빛이 굴절되는 것을 나타 내는 개략도로서, 형성된 반구(11)에 의하여 빛의 굴절방향(14)이 확산판으로 향하고 있음을 보여 준다. 미설명부호 13은 투명 플라스틱이다.

백색광용 형광체는 청색을 흡수해서 적녹색을 발광하는 YAG(yittrium alumium garnet) 계열의 형광체이며, 이에 해당되는 형광체로는 $Y_3Al_5O_{12}$:Ce 등이 있다. 녹색광용 형광체는 청색을 흡수해서 녹색을 발광하는 모든 형광체를 칭한다. 이 그룹에 해당되는 형광체의 바람직한 예는 $SrGa_2S_4$:Eu, ZnS:CuAl, ZnS:CuAuAl, $SrGa_2S_4$:Eu, $ZnGa_2S_4$:Eu, SrS:Ce 등이다. 적색광용 형광체는 청색을 흡수해서 적색을 발광하는 모든 형광체를 칭하며, 이 그룹에 해당되는 형광체의 바람직한 예는 (ZnCd)S:AgCl, (ZnCd)S:AgAuCl, (ZnCd)S:AgAuAl, $ZnGa_2S_4$:Mn, SrY_2S_4:Mn, SrS:Eu 등이다.

백색광을 발생시키는 방법은 도 1과 같이 청색 발광 다이오드(2)를 반사컵(1) 위에 부착한 다음, 백색광용 형광체(4)가 도핑된 투명수지를 청색 발광 다이오드(2) 상부에 코팅시키고 청색 발광 다이오드를 작동시키는 것이다.

이에 의하여 발광된 빛은 도3에 나타 난 바와 같이, 청색광(430 - 480 nm)과 아울러, 녹색광(510 - 550 nm)과 적색광(610 - 680 nm) 영역을 모두 포함하여 육안으로 볼 때 백색광으로 보여진다. 이렇게 발광된 빛은 현재 사용되고 있는 휴대폰과 같이 다양한 색의 재현이 불필요한 소형 디스플레이의 백라이트로는 효과적으로 적용될 수 있다.

그러나 도1의 다이오드에 의하여 발광된 빛은 도 3의 발광 스펙트럼에 의하여 확인되는 바와 같이, 청색광에 비하여 녹색광의 세기가 상대적으로 작으며, 특히 적색광은 그 세기가 매우 작으므로 칼라 동영상의 구현에 있어서 적색을 표현하기 어려운 문제점이 있다. 굳이 칼라 동영상의 구현에 적용시키려면 청색영역과 청색영역의 빛을 광필터로 일정부분 제거하여 그 세기가 적색영역의 것과 유사하게 조절하여야 한다. 그러나 이 경우에는 광의 손실이 많이 발생하게 된다.

도2의 발광 다이오드에 의하여 발생된 빛은 도4의 발광 스펙트럼에 의하여 확인되는 바와 같이, 청색영역과 녹색영역, 그리고 적색영역의 빛이 비슷한 세기를 가진다. 이에 의하여 다양한 색의 재현이 가능하며, 칼라 동영상의 구현이 용이하게 된다.

도1 또는 도2의 발광 다이오드에 의하여 발생된 빛은 도광판(B)에 형성된 굴절용 반구(11)와 반사판(12)에 의하여 확산됨과 동시에 진로가 확산판(10)으로 향하게 된다. 광 확산물질을 함유한 확산판(10)에 의하여 빛은 더욱 미세하게 확산된다. 광 확산물질의 예로는 TiO_2 분말을 들 수 있다.

발광 다이오드에 가까운 부분이 멀리 떨어져 있는 부분보다 조도가 높으므로 굴절용 반구(11)의 크기는 발광 다이오드에 가까운 부분은 작게하고, 먼 쪽은 점차적으로 크게 하거나, 굴절용 반구(11)의 크기를 동일하게 할 경우에는 반구(11)의 밀도(단위면적당 굴절용 반구의 수)를 가까운 부분은 작게, 먼 부분은 크게 한다.

또한, 굴절용 반구(11)가 형성된 바닥판은 발광 다이오드로부터 하향되게 경사진 것이 바람직하며, 디스플레이의 크기가 클 경우에는 발광 다이오드를 대응하는 양면에 형성시킬 수도 있고, 사면에 형성시킬 수도 있다. 이에 의하여 확산판(10)으로 향하게 되는 빛의 세기는 전체적으로 균일하게 조절된다. 적절한 굴절용 반구(11)의 직경은 1??m 내지 1 mm 정도이다.

고순도 백색광을 발광시키기 위한 형광체는 청색광을 흡수하여 녹색광과 적색광을 발광하게 되는 형광체가 30 : 70 내지 70 : 30 몰비로 적절히 혼합된 것이다. 청색광을 흡수하여 녹색광을 발광시키는 형광체의 바람직한 예는 $SrGa_2S_4$:Eu이며, 청색광을 흡수하여 적색광을 발광시키는 형광체의 바람직한 예는 (Zn Cd)S:AgCl이다.

두 형광체의 사용비율은 보다 바람직하게로는, 청색영역(430 - 480nm)의 광의 세기의 합(도4의 L)을 " 1" 로 한 경우에, 녹색영역(510 - 550nm)의 광의 세기의 합(도4의 M) 및 적색영역(610 - 680nm)의 광의 세기의 합(도4의 N)이 0.4 - 1.3, 더욱 바람직하게로는 0.85 내지 1.15의 범위에 있도록 조절하는 것이 좋다. 이에 의하여 고순도의 백색광을 얻을 수 있을 뿐만 아니라, 특히 칼라 동영상의 구현시 광의 손실을 최소화할 수 있다.

형광체가 도핑된 투명수지는 청색 발광 다이오드 위에 코팅되며, 그 적절한 두께는 5 - 100??m 이며, 이 위에는 투명 에폭시 수지가 다시 코팅된다. 투명 에폭시수지의 적절한 두께는 5mm 이내이다. 형광체를 도핑시키는 투명수지는 아크릴계 수지, 실리콘계 수지, 에폭시계 수지 등이 사용될 수 있으나, 아크릴계 수지의 사용이 가장 바람직하다.

본 발명에 따른 발광 다이오드 키트의 두께는 1mm 이내이다. 따라서 백색 발광 또는 삼파장 발광 백라이트 유닛의 두께는 2mm 이내로 제작이 가능하다. 이것은 기존에 널리 사용되고 있는 색 재현 범위가 우수한 노트북의 냉각 음극 형광등의 두께인 3mm에 비해서 작으므로 초소형의 디스플레이를 만드는데 적절하다. 또한 구동에 필요한 전압이 적으므로, 전원은 가전제품에 사용되는 초소형의 배터리가 사용가능하다.

종래의 디스플레이용 백라이트로 사용되는 냉각 음극 형광등은 인버터(inverter)를 사용해야만 한다. 이때의 인버터가 차지하는 공간이 클 뿐만 아니라 인버터를 사용하면서 고전압이 걸리게 되므로 장기간 사용하면 열이 많이 발생하는 문제점도 본 발명의 백라이트 유닛을 사용함으로 완전히 해소할 수 있다.

본 발명의 실시예는 아래와 같다.

< 실시예>

$SrGa_2S_4$:Eu과 (Zn Cd)S:AgCl을 몰비로 40 : 60의 비율로 혼합한 형광체를 용매(메톡시에탄올) 20부피%에 용해된 아크릴수지(존슨 폴리머사의 Joncryl 2630)에 도핑시켰다. 도핑된 형광체의 량은 아크릴수지 100중량비에 대하여 0.5중량비이었다. 형광체가 도핑된 아크릴수지를 청색 발광 다이오드 상부에 20????m의 두께로 코팅시켰으며, 이 위에 투명 에폭시수지를 다시 3mm 두께로 코팅하였다.

이와 같이 처리된 발광다이오드의 발광 스펙트럼은 도4와 같았다.

이에 의하여 청색, 녹색, 적색영역의 피크가 생기며, 이 영역의 광의 세기의 합(L, M, N)이 유사함을 알 수 있다.

발명의 효과

본 발명의 백라이트 유닛은 디스플레이를 종래의 냉각음극 형광 등에 비하여 그 두께를 1/2 내지 1/3정도로 초소형화 시킬 수 있으며, 전력소모를 10 내지 20%정도로 극소화시킬 수 있다. 이에 따라, 일반 가전제품용 건전지의 사용이 가능하게 되므로 고용량의 배터리의 개발이 불필요하게 된다. 또한, 백색 발광 다이오드의 수명은 기존의 냉각 음극 형광등의 수명보다 약 10배정도이므로 반영구적으로 사용될 수 있다.

본 발명의 고순도 백색광 발생방법은 청색과 녹색, 그리고 적색이 적절한 비율로 합성됨으로써 발생되는 백색광의 순도를 높히게 된다. 이에 의하여 발생된 고순도 백색광이 광원으로 사용된 백라이트 유닛은 선명도가 높은 칼라 동영상의 구현이 가능하게 한다.

(57) 청구의 범위

청구항 1.

청색 발광 다이오드에 백색광용 형광체가 도핑된 투명수지가 코팅되어 백색을 발광하는 백색 발광다이오드(A)가 병렬로 연결된 발광 다이오드 키트(9)와, 이와 수직하게 결합되며, 상부에 굴절용 반구(11)가 복수개 형성된 도광판(B)과, 광 확산물질을 함유한 확산판(10)과, 굴절 또는 확산된 광을 반사시키는 반사판(12)으로 구성된 것을 특징으로 하는 백라이트 유닛.

청구항 2.

제 1항에 있어서, 도광판(B)에 크기가 상이한 굴절용 반구(11)가 형성된 것을 특징으로 하는 백라이트 유닛.

청구항 3.

제 1항에 있어서, 도광판(B)에는 형성된 굴절용 반구(11)의 밀도가 상이한 것으로 특징으로 하는 백라이트 유닛.

청구항 4.

제 1항에 있어서, 도광판(B)은 발광 다이오드키트(9)로부터 하향되게 경사진 바닥판을 가지는 것을 특징으로 하는 백라이트 유닛.

청구항 5.

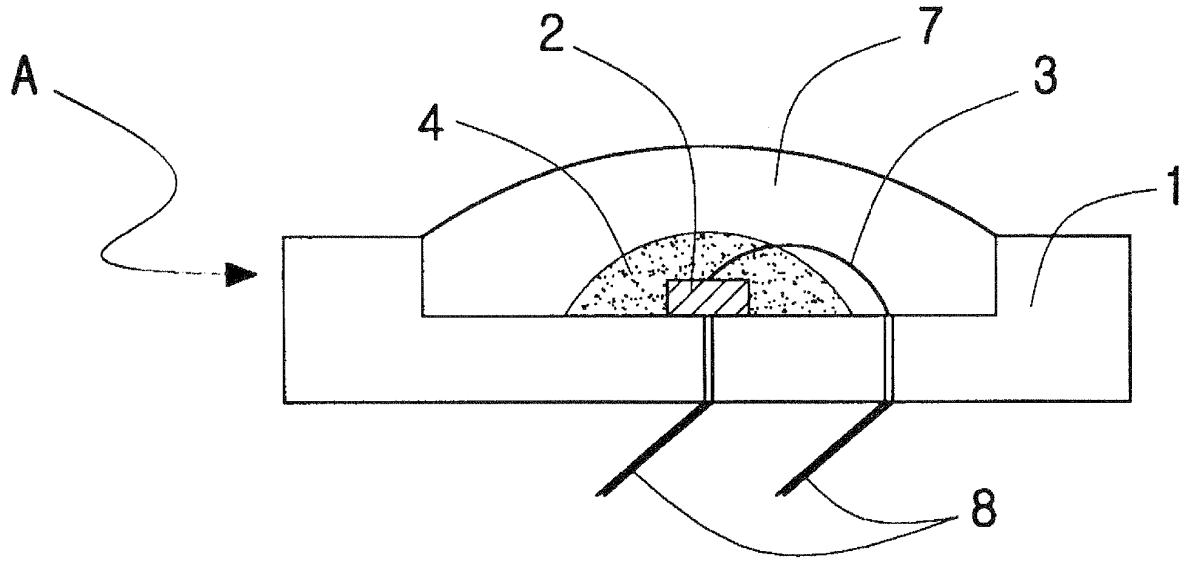
청색 발광다이오드에, 청색을 흡수하여 녹색을 발광시키는 형광체와, 청색을 흡수하여 적색을 발광시키는 형광체가 30 : 70 내지 70 : 30 의 몰비로 혼합된 형광체를 도핑한 투명수지를 코팅하여 청색(430 - 480nm): 녹색(510 - 550nm): 적색(610 - 680nm) 영역의 광의 세기의 합이 1 : (1.3 - 0.4) : (1.3 - 0.4)의 비율이 되도록 발광시키는 것을 특징으로 하는 고순도 백색광의 발광방법.

청구항 6.

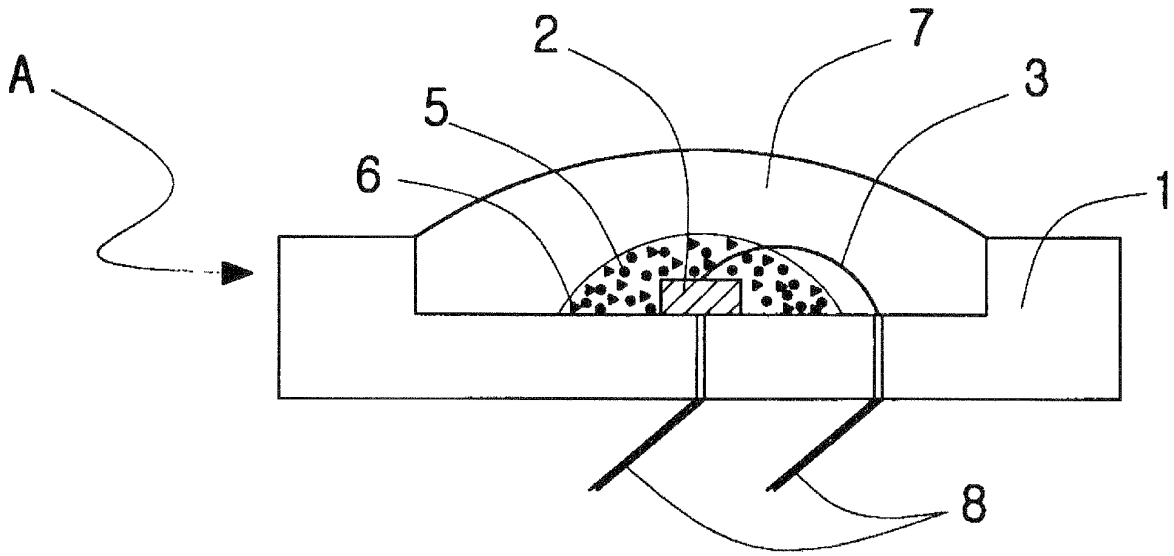
제 5항에 있어서, 청색(430 - 480nm) : 녹색(510 - 550nm): 적색(610 - 680nm) 영역의 광의 세기의 합이 1 : (1.15 - 0.85): (1.15 - 0.85)의 비율이 되도록 발광시키는 것을 특징으로 하는 고순도 백색광의 발광방법.

도면

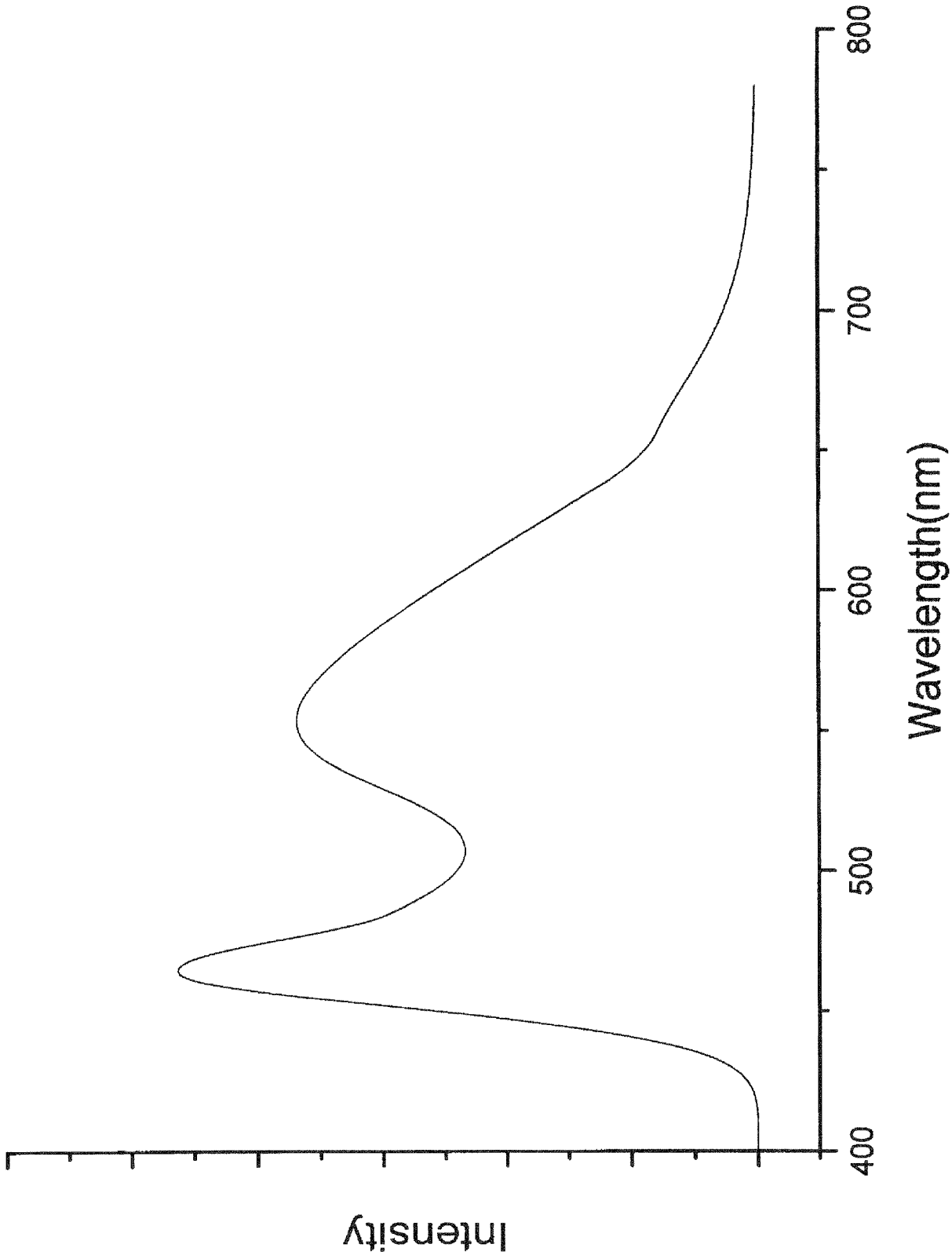
도면 1



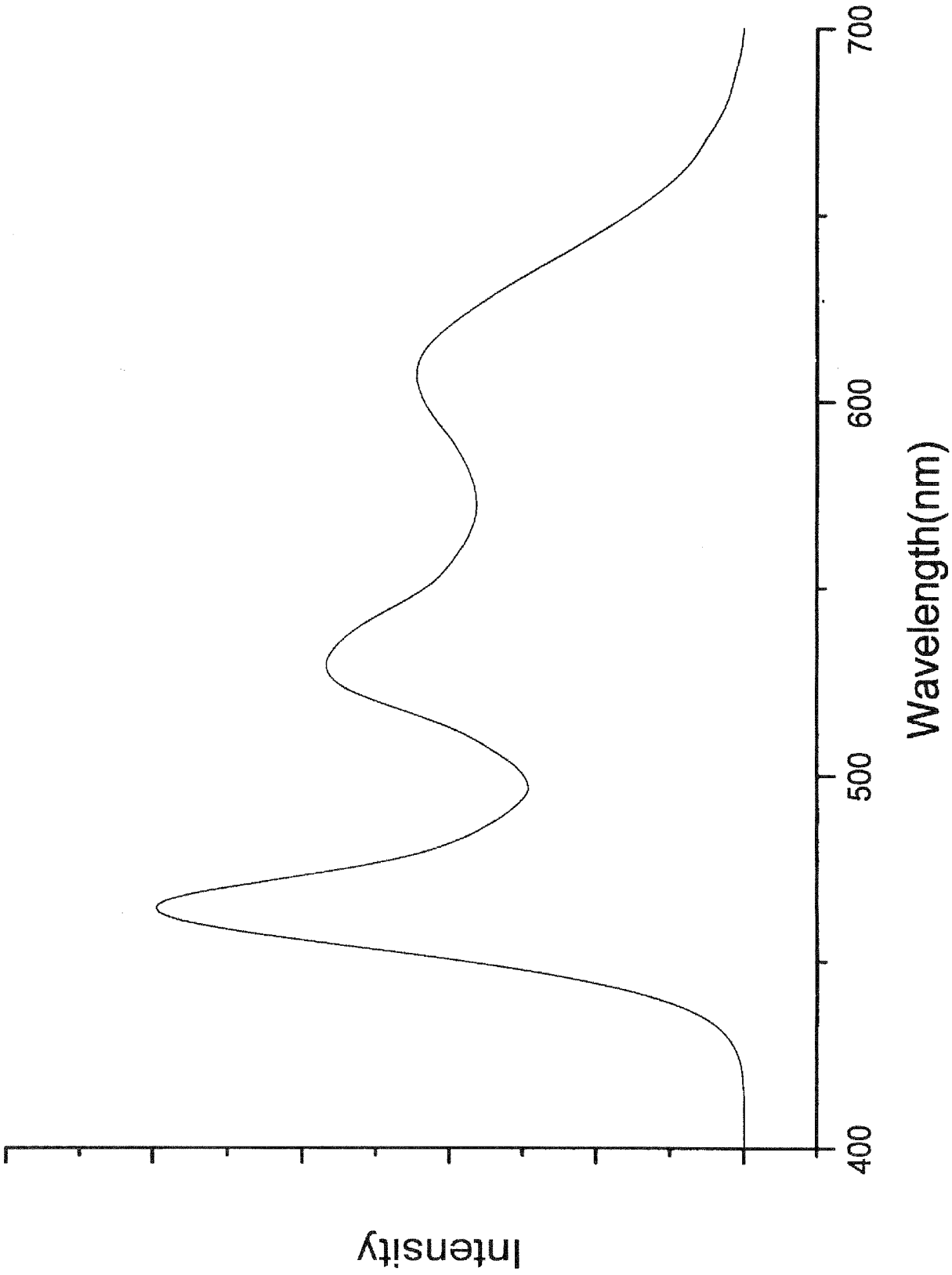
도면 2



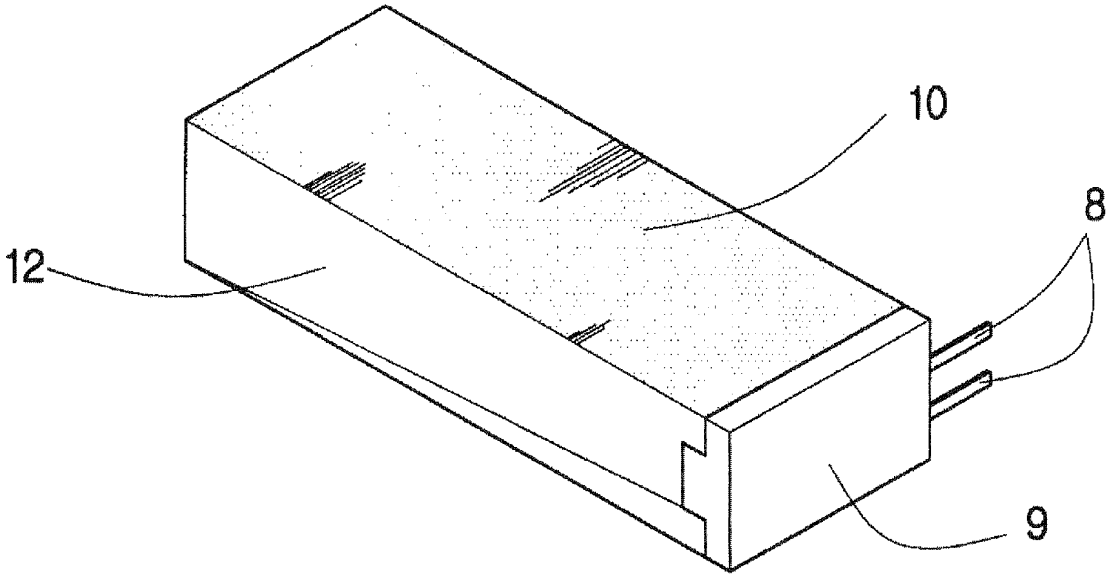
도면 3



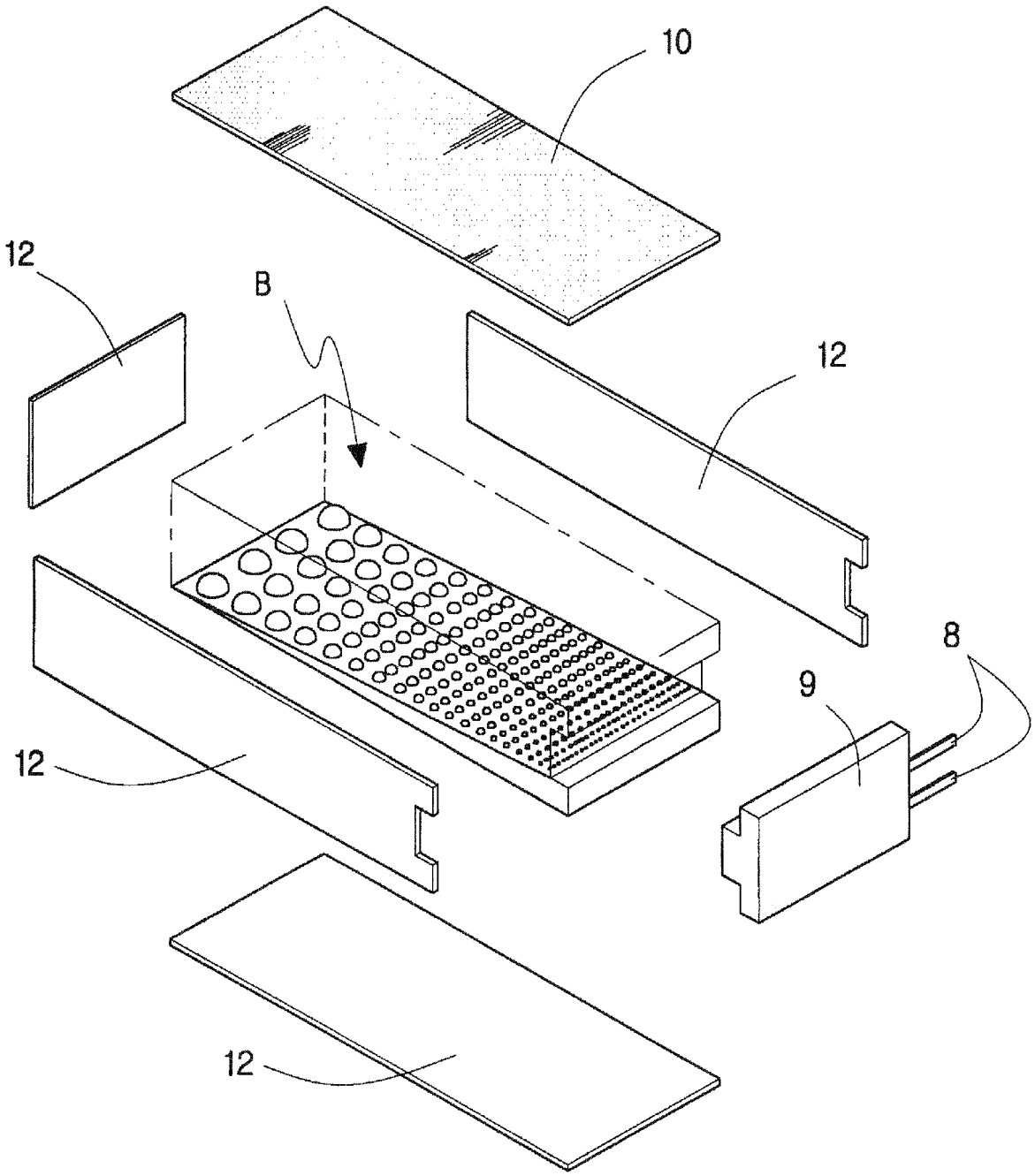
도면 4



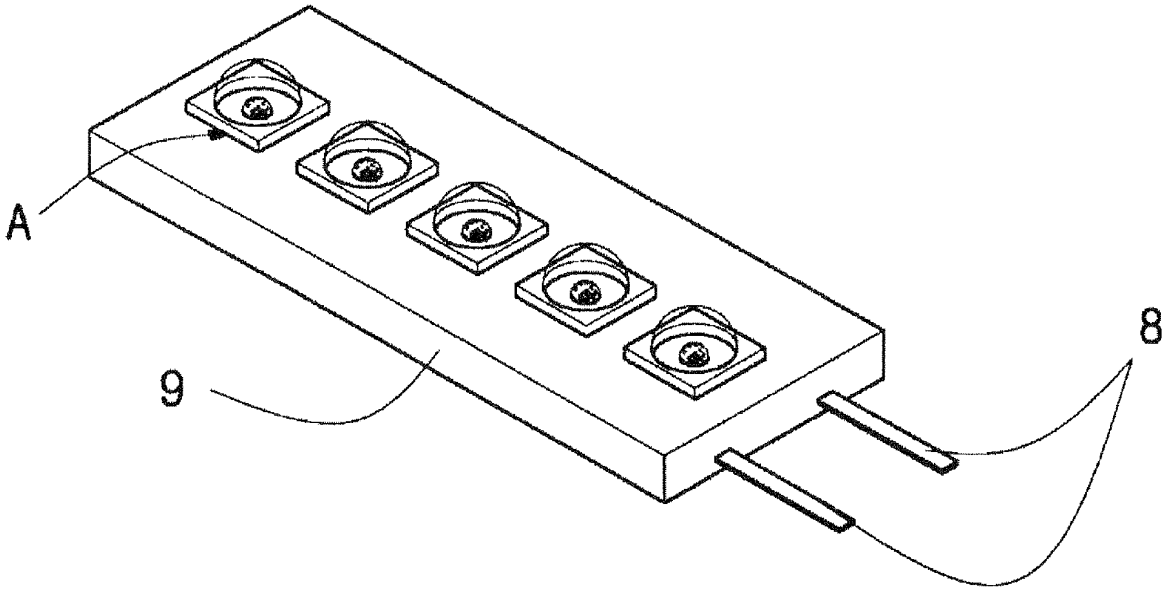
도면 5



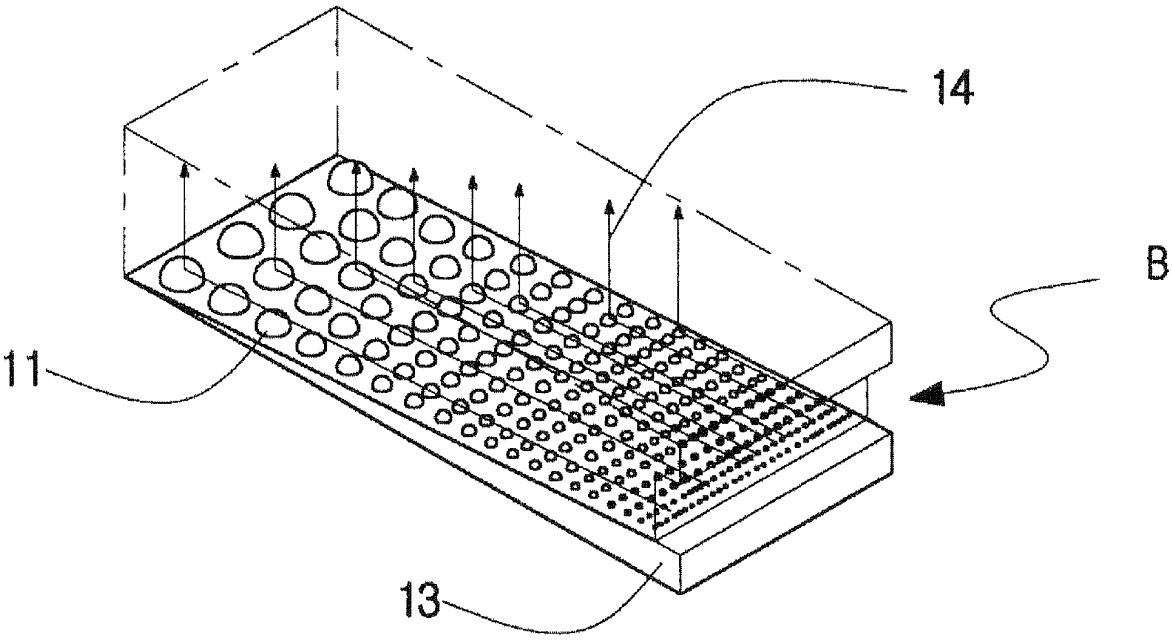
도면 6



도면 7



도면 8



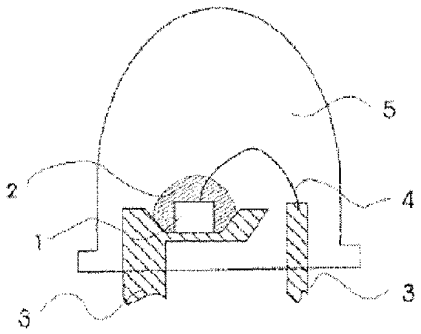
METHOD OF MANUFACTURING WHITE LIGHT-EMITTING DIODE

Publication number: JP2004296830
Publication date: 2004-10-21
Inventor: CHEN HSING
Applicant: SOLIDLITE CORP
Classification:
- international: ***C09K11/08; C09K11/61; C09K11/64; C09K11/66; C09K11/67; C09K11/74; C09K11/80; H01L33/00;*** **C09K11/08; C09K11/61; C09K11/64; C09K11/66; C09K11/67; C09K11/74; C09K11/77; H01L33/00;** (IPC1-7): H01L33/00; C09K11/08; C09K11/61; C09K11/64; C09K11/66; C09K11/67; C09K11/74; C09K11/80
- European:
Application number: JP20030087809 20030327
Priority number(s): JP20030087809 20030327

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Abstract of **JP2004296830**

PROBLEM TO BE SOLVED: To provide a white LED which is preferable in light-emitting efficiency and power, usable for a long term with preferable stability, and capable of changing white light to medium color light, and additionally, applicable to a wide range of use. SOLUTION: Blue LED crystal grains whose wavelengths are 425-475 nm are coated with green, red color mixed fluorescent powder. The component of green fluorescent powder is selected from among Li<SB>2</SB>TiO<SB>3</SB>:Mn, LiAlO<SB>2</SB>:Mn, 6MgO-As<SB>2</SB>O<SB>5</SB>-Mn<SP>4+</SP>or 3.5MgO-0.5MgF<SB>2</SB>-GeO<SB>2</SB>-Mn<SP>4+</SP>. The component of red fluorescent powder is selected from among Y<SB>3</SB>(Ga<SB>X</SB>Al<SB>1-X</SB>)<SB>5</SB>O<SB>12</SB>:Ce (0<x<1), La<SB>2</SB>O<SB>3</SB>-11Al<SB>2</SB>O<SB>3</SB>:Mn or Ca<SB>8</SB>Mg(SiO<SB>4</SB>)<SB>4</SB>Cl<SB>2</SB>:Eu, Mn. The white light is emitted by mixing the blue light with the light emitted from the mixed fluorescent powder when it is excited by the blue light from the blue LED crystal grains. COPYRIGHT: (C)2005,JPO&NCIPI



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(51)Int.Cl.[7]	F I		テーマコード（参考）
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C09K 11/64	C09K 11/64	CPY	
C09K 11/66	C09K 11/66	CPS	

審査請求 未請求　請求項の数 6　ＯＬ　（全 12 頁）　最終頁に続く

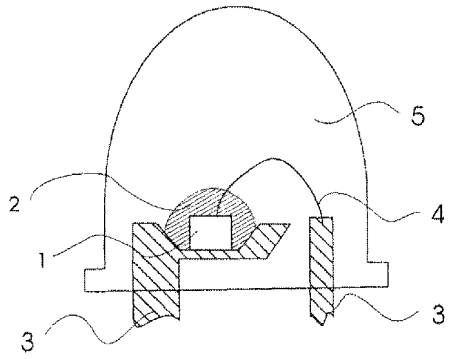
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(22)出願日　平成15年3月27日 (2003.3.27)

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5F041 AA03 AA11 CA33 CA40 CA43 DA16 DA19 DB02 DB09 EE25 FF01 FF11 FF16

(54)【発明の名称】白色ＬＥＤの製造方法

(57)【要約】
【課題】好ましい発光効率とパワーが得られ、使用寿命が長く、好ましい安定性を具え、さらに、白色光線を中間色系に変更することができ、幅広い用途に応用できる白色ＬＥＤを提供する。
【解決手段】波長が４２５～４７５ｎｍの青色ＬＥＤ結晶粒に緑、赤色混合蛍光粉を塗布する。緑色の蛍光粉の成分はLi_2TiO_3：Mnか、$LiAlO_2$：Mnか、$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$から選択する。赤色は$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）か、$La_2O_3 \cdot 11Al_2O_3$：Mnか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnから選択し、該青色ＬＥＤ結晶粒から発生する青色光線で混合蛍光粉を励起し、発生する光線と青色光線と混合して白色光線を発生させる。
【選択図】　図２



【特許請求の範囲】
【請求項1】
波長が４２５～４７５ｎｍの青色ＬＥＤ結晶粒と、
該青色ＬＥＤ結晶粒から発生する光線を吸収して励起する緑色の蛍光体であって、Li_2TiO_3：Mnか、$LiAlO_2$：Mnか、$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$から選択される緑色蛍光体と、及び該青色ＬＥＤ結晶粒から発生する光線を吸収して励起する赤色の蛍光体であって、$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（0＜x＜1）か、$La_2O_3 \cdot 11Al_2O_3$：Mnか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnから選択される赤色蛍光体とを混合してなる混合蛍光粉とを含んでなり、
該混合蛍光体が該青色ＬＥＤ結晶粒から発生する青色光線を吸収して励起し発生する光線を該青色光線と混合して３種類の波長を有する白色光線を発生させるように構成することを特徴とする白色ＬＥＤの製造方法。
【請求項2】
前記青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６５９ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光体は、成分がLi_2TiO_3：Mnのものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６７０ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光体は、成分が$LiAlO_2$：Mnのものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６５０ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光体は、成分が$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5Mg \cdot 0.5MgOF_2 \cdot GeO_2$：$Mn^{4+}$のものを選択することを特徴とする請求項１に記載の白色ＬＥＤの製造方法。
【請求項3】
前記青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５２０ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光体は、成分が$La_2O_3 \cdot 11Al_2O_3$：Mn　のものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５１６ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光体は、成分が$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（0＜x＜1）のものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５１５ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光体は、成分が$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnのものを選択することを特徴とする請求項１に記載の白色ＬＥＤの製造方法。
【請求項4】
前記青色ＬＥＤは、該赤、緑色の蛍光体を所定の比率で調合し、発生する白色光線を桃色、水色などの中間色系の光線にすることを特徴とする請求項１に記載の白色ＬＥＤの製造方法。
【請求項5】
前記青色ＬＥＤ結晶粒がＩｎＧａＮ型か、もしくはＳｉＣ型か、もしくはＺｎＳｅ型であることを特徴とする請求項１に記載の白色ＬＥＤの製造方法。
【請求項6】
前記青色ＬＥＤは実装することによってランプ型ＬＥＤか、もしくは表面実装型ＬＥＤにすることを特徴とする請求項１に記載の白色ＬＥＤの製造方法。

【発明の詳細な説明】
【０００１】
【発明の属する技術分野】

用ランプ、照明用、もしくは液晶表示装置のバックライトなどの幅広い用途に応用される白色ＬＥＤの製造方法に関する。

【０００２】

【従来の技術】

発光ダイオード（Ｌｉｇｈｔ　Ｅｍｉｔｔｉｎｇ　Ｄｉｏｄｅ、ＬＥＤ）は、使用寿命が長く、節電効果を具え、反応速度も速く、信頼性が高いのみならず、環境保全の観念に適合し、安全性が高いなどの特性を有する。しかも、技術の進歩に伴いＬＥＤの輝度は次第に上昇している。白色ＬＥＤの応用もすでに開発がなされていて、２１世紀の主要な照明用光源と称されている。このため、世界各国の研究機構でも積極的に白色ＬＥＤの研究に取り組んでいる。

【０００３】

従来の白色ＬＥＤは、２つ以上の異なる色彩の発光体の結晶粒を同一のフレーム、もしくは基板に実装する。かかる製造方法は、パッキングする場合、結晶粒を固定してリードを結線する作業が複雑であり、しかも赤、青、緑の３つの異なる色彩のＬＥＤ発光体は、結晶粒の材料がそれぞれ異なり、必要とする駆動電圧（Ｖｆ）も異なる。このため、電子回路のレイアウト時において、個々のＬＥＤ結晶粒上に異なる駆動電圧を印加して輝度と色彩を調整するように設計しなければならない。

【０００４】

また、最近の製造方式では単一のＬＥＤ結晶粒から白色光線を発生させることが可能になった。即ち、ＬＥＤの結晶粒表面に蛍光粉を塗布して層を形成することによって、発光体の結晶粒から照射される光線が蛍光体の層を励起し、本来発光体の結晶粒が発する光線と混合させて白色光線を発生させる。

【０００５】

目下採用されている白色ＬＥＤの主な製造方法には次の３種類がある。第１の製造方法は、青色ＬＥＤの結晶粒にＹＡＧ黄色蛍光粉を加える方式である。即ち、青色の光線でＹＡＧ黄色蛍光粉を励起して黄色の光線を発生させ、本来の青色ＬＥＤの結晶粒が発する青色の光線と混合し、黄色と青色とによって互いに補い、二種類の波長を具える白色光線を得る方式である。かかる白色ＬＥＤの製造技術は、日本国の日亜化学工業株式会社の開発した技術であって、台湾特許公告第３８３５０８号、及びアメリカ合衆国特許第５９９８９２５に開示される技術である。

【０００６】

第２の製造方法は、紫外線ＬＥＤ結晶粒（波長３５０～３９０ｎｍ）に赤、青、緑の３原色の蛍光粉を加える方式であって、紫外線で赤、青、緑色を混合した蛍光粉を励起して、３種類の波長の白色光線を発生させる。即ち、本発明者が開発した方法であって、台湾実用新案第１５７３３１号、及びアメリカ合衆国特許第５９５２６８１に開示される技術である。

【０００７】

第３の方式は紫色ＬＥＤ結晶粒（波長３９０～４１０ｎｍ）によって３原色の蛍光粉を励起するものであって、赤、青、緑色を混合した蛍光粉を励起して、３種類の波長の白色光線を得る。かかる方法も、本発明者が最先に開発した方法であって、台湾特許出願第０９０１３３５０８に開示される技術である。

【０００８】

上述の第１の製造方式は、青色ＬＥＤ結晶粒に黄色の蛍光粉を加える方式である。その最大の欠点は、発生した白色光線の波長が、青色と黄色の２種類のみであり、かかる方式で得られた白色光線は、例えばパイロットランプなどの指示用のランプに応用される程度であって、標準的な照明、もしくはＬＣＤカラーバックライトの光源用として使用するまでには至っていない。また、黄色の蛍光粉の使用量を正確に制御することは難しい。このため、光線の色度が青色、或いは黄色に偏る現象が発生する場合がある。この点も一つの欠点である。

【０００９】

第２の方式は、紫外線によって３原色の蛍光粉を励起して３種類の波長の白色光線を得る方式であって、最も理想的な方式である。但し、現実には使用寿命が長く、高効率の紫外線ＬＥＤ結晶粒は、未だに出現していない。現在の紫外線ＬＥＤ結晶粒は約２０ｍＷ（アメリカ合衆国Ｃｒｅｅ社製）が最高であるが、但し減衰時間が早く、使用寿命の長い紫外線ＬＥＤ結晶粒を作り出すこと難しい。その主な理由は、目下の材料特性と製造過程の影響によるものである。紫外線を使用するもう一つの欠点は、現在紫外線ＬＥＤの実装専用の透明樹脂がないことにある。即ち、ほとんどの有機樹脂は、ＵＶ周波数帯において紫外線を吸収するため、樹脂が紫外線の照射によって容易に劣化し、ＬＥＤの使用寿命と品質に影響を与える。

【００１０】

第３種の方式は、紫色光線（波長３９０～４１０ｎｍ）で３原色の蛍光粉を励起し、白色を発生するものである。本発明者は、数多くの実験を重ねた結果、紫色の光線を吸収して励起する蛍光粉を開発し、実用化することに成功し、特許を出願した。目下の紫色ＬＥＤ結晶粒は高効率の白色ＬＥＤを製造することができる。但し、使用寿命について、更なる改良が必要である。

【００１１】

この他、青色光線と硫化物（ＺｎＳなど）蛍光粉を利用して赤、緑色光線を励起する方法も試されたことがあった（例えばＨＰ社）。但し、かかる方式は、使用寿命と安定性が好ましくない。

【００１２】

目下、白色ＬＥＤの製造は、その多くが日亜化学工業株式会社の所有する技術を採用している。即ち、青色結晶粒でＹＡＧ黄色蛍光粉を励起するものである。該蛍光粉の化学成分は$(YGD)_3Al_5O_{12}:Ce$であって、波長約５５０～５６０ｎｍの黄色の光線が発生する。青色光線によってＹＡＧ黄色蛍光粉を励起して２種類の波長を具える白色光線を発生させる白色ＬＥＤの白色光線スペクトルを図１に開示する。

【００１３】

但し、三原色の一である緑色については、成分が$Y_3(Ga_xAl_{1-x})_5O_{12}:Ce$（$0<x<1$）の緑色の蛍光体によってなる蛍光粉によって、波長が５１５ｎｍ～５２０ｎｍの緑色の光線が得られる。その他赤色の蛍光粉では、$Li_2TiO_3:Mn$、或いは$LiAlO_2:Mn$、或いは$6MgO\cdot As_2O_5:Mn^{4+}$、或いは$3.5MgO\cdot 0.5MgF_2\cdot GeO_2:Mn^{4+}$など、また緑色の蛍光粉についても$La_2O_3\cdot 11Al_2O_3:Mn$、或いは$Ca_8Mg(SiO_4)_4Cl_2:Eu$、Ｍｎなどによって、赤色もしくは緑色の光線が得られる。但し、これらの蛍光体は、目下使用されていない。

【００１４】

即ち、上述の赤、緑の蛍光粉を適宜な比率で混合し、直接或いは間接的に青色ＬＥＤ結晶粒上に塗布して、混合蛍光粉を青色光線で励起することによっても３種類の波長の白色ＬＥＤを得ることができ、係る方式によって色度の純度が高く、好ましい輝度を具えた白色ＬＥＤを得ることが可能になる。

【００１５】

さらに、応用範囲を広くするために赤、緑の蛍光粉を適宜な比率で調合し、例えば桃色、水色などの中間色系のＬＥＤを得ることもできる。但し、従来の技術においては、これらの試みはなされていなくて、実用化されてもいない。

【００１６】

本発明者は多年にわたって白色ＬＥＤの研究に従事し、ＬＥＤに関連する数多くの特許を獲得しているが、上述の白色ＬＥＤについて、それぞれの製造方法の欠点を改善するとともに、新規な材料を応用した技術の開発が業界で望まれていて、本発明者もこれを開発の課題とする。

【００１７】

【発明が解決しようとする課題】

この発明は、波長が４２５～４７５ｎｍの間の青色ＬＥＤ結晶粒で
赤、緑色混合蛍光粉を励起して、三種類の波長を有する白色光線を発生させる白色ＬＥＤであって、従来の紫外線よりも高い効率とパワーが得られる白色ＬＥＤの製造方法を提供することを課題とする。

【００１８】

またこの発明は、使用寿命が長く、安定性を具えた白色ＬＥＤの製造方法を提供することを課題とする。

【００１９】

【課題を解決するための手段】

そこで、本発明者は従来の技術に見られる欠点に鑑み鋭意研究を重ねた結果、赤色の蛍光体によってなる蛍光粉と、緑色の蛍光体によってなる蛍光粉を混合した混合蛍光粉の層を波長が４２５～４７５ｎｍの青色ＬＥＤ結晶粒に塗布し、青色光線を利用して該赤、緑色の混合蛍光粉層を励起し、発生する光線と本来の青色光線とによって白色光線を得る白色ＬＥＤの構造と、その製造方法によって課題を解決できる点に着眼し、かかる知見に基づいて本発明を完成させた。

【００２０】

即ち、現時点において従来の技術に開示される紫外線ＬＥＤ結晶粒の技術に比して技術が成熟している青色ＬＥＤ結晶粒を応用することによって高い効率とパワーが得られ、さらに従来の硫化物（ＺｎＳなど）に比して使用寿命が長く、特性が安定した酸化物蛍光体である　Li_2TiO_3：Mnか、もしくは$LiAlO_2$：Mnか、もしくは$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$などを成分とする赤色蛍光粉と、$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）か、もしくは$La_2O_3 \cdot 11Al_2O_3$：Mnか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnなどを成分とする緑色蛍光粉を混合した混合蛍光粉を得て、該混合蛍光粉を青色ＬＥＤに塗布して青色光線で励起し、白色光線を得る白色ＬＥＤの構造と製造方法によって、本発明の課題を解決する白色ＬＥＤが得られる。

【００２１】

以下、この発明について具体的に説明する。

請求項１に記載する白色ＬＥＤの製造方法は、波長が４２５～４７５ｎｍの青色ＬＥＤ結晶粒と、

該青色ＬＥＤ結晶粒から発生する光線を吸収して励起する緑色の蛍光体であって、Li_2TiO_3：Mnか、$LiAlO_2$：Mnか、$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$から選択される緑色蛍光体と、及び該青色ＬＥＤ結晶粒から発生する光線を吸収して励起する赤色の蛍光体であって、$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）か、$La_2O_3 \cdot 11Al_2O_3$：Mnか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnから選択される赤色蛍光体とを混合してなる混合蛍光粉とを含んでなり、

該混合蛍光粉が該青色ＬＥＤ結晶粒から発生する青色光線を吸収して励起し発生する光線を該青色光線と混合して３種類の波長を有する白色光線を発生させるように構成する。

【００２２】

請求項２に記載する白色ＬＥＤの製造方法は、請求項１における青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６５９ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光粉は、成分がLi_2TiO_3：Mnのものを選択し、

該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６７０ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光粉は、成分が$LiAlO_2$：Mnのものを選択し、

該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約６５０ｎｍとする特性を有するものである場合、該青色光線によって励起される赤色蛍光粉は、成分が$6MgO \cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO \cdot 0.5MgF_2 \cdot Ge$

O_2：Mn^{4+}のものを選択する。
【００２３】
請求項３に記載する白色ＬＥＤの製造方法は、請求項１における青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５２０ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光粉は、成分が$La_2O_3 \cdot 11AI_2O_3$：Ｍｎ　のものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５１６ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光粉は、成分が$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ｃｅ（０＜ｘ＜１）のものを選択し、
該青色ＬＥＤの波長が４２５～４７５ｎｍであり、かつ発光波長のピーク値を約５１５ｎｍとする特性を有するものである場合、該青色光線によって励起される緑色蛍光粉は、成分が$Ca_8Mg(SiO_4)_4CI_2$：Ｅｕ、Ｍｎのものを選択する。
【００２４】
請求項４に記載する白色ＬＥＤの製造方法は、請求項１における青色ＬＥＤについて、該赤、緑色の蛍光体を所定の比率で調合し、発生する白色光線を桃色、水色などの中間色系の光線にすることを特徴とする請求項１に記載の白色ＬＥＤの製造方法。
【００２５】
請求項５に記載する白色ＬＥＤの製造方法は、請求項１における青色ＬＥＤ結晶粒がＩｎＧａＮ型か、もしくはＳｉＣ型か、もしくはＺｎＳｅ型である。
【００２６】
請求項６に記載する白色ＬＥＤの製造方法は、請求項１における青色ＬＥＤが実装することによってランプ型ＬＥＤか、もしくは表面実装型ＬＥＤにされる。
【００２７】
【発明の実施の形態】
この発明は、特に使用寿命が長く、高い安定性を有し、指示用ランプ、照明用、もしくは液晶表示装置のバックライトなどの幅広い用途に応用される白色ＬＥＤを提供するものであって、赤色の蛍光体によってなる蛍光粉と、緑色の蛍光体によってなる蛍光粉を混合した混合蛍光粉の層を波長が４２５～４７５ｎｍの青色ＬＥＤ結晶粒に塗布し、青色光線を利用して該赤、緑色の混合蛍光粉層を励起し、発生する光線と本来の青色光線とによって白色光線を得る。
かかる白色ＬＥＤの構造と、その製造方法の特徴を詳述するために、具体的な実施例を挙げ、図を参照して以下に説明する。
【００２８】
【実施例】
この発明による白色ＬＥＤは、図２、図３の断面図に開示するように、赤色蛍光体によってなる蛍光粉と、緑色蛍光体によってなる蛍光粉とを混合してゲル状の混合蛍光粉（２）を得る。次いで、波長が４２５ｎｍ～４７５ｎｍの青色ＬＥＤ結晶粒を選択して固定する。即ち、図２に開示するランプ型ＬＥＤの場合は青色ＬＥＤ結晶粒（１）をリードフレーム（３）に固定する。図３に開示するような表面実装型（ＳＭＤ）ＬＥＤの場合は実装基板（６）上に設ける。更にリード（４）の両端を青色ＬＥＤ結晶粒（１）とリードフレーム（３）、もしくは実装基板（６）とにそれぞれ電気的に接続し、該混合蛍光粉（２）を塗布、スポット接着、もしくはスクリーン印刷などの方法で、直接、もしくは間接的に青色ＬＥＤ結晶粒（１）上に塗布して混合蛍光体の層を形成し、樹脂を注入して実装を完成させる。
【００２９】
上述の構造の白色ＬＥＤは、青色ＬＥＤ結晶粒（１）から発生する青色光線によって赤、緑色を混合した混合蛍光粉（２）を励起し、赤色と緑色の光線を発生させ、本来の青色ＬＥＤ結晶粒（１）から発生する青色光線と混合させて赤、青、緑色が混合した３種類の波長を具える白色光線を得る。その発光スペクトルを図１５、１６に開示する。
【００３０】

青色ＬＥＤ結晶粒（１）は、波長が４２５ｎｍ～４７５ｎｍであって、ＩｎＧａＮ型か、もしくはＳｉＣ型か、もしくはＺｎＳｅ型から選択する。

【００３１】

蛍光粉は安定性と使用寿命に優れる酸化物蛍光粉を用いる。即ち、赤色蛍光粉の成分は、Li_2TiO_3：Mnであって、その励起されて発生する光線のスペクトルを図９に励起スペクトル、図１０に発光スペクトルを開示する。また、緑色蛍光粉の成分は$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnであって、その励起されて発生する光線のスペクトルを図７に励起スペクトル、図８に発光スペクトルを開示する。

【００３２】

但し、蛍光粉の成分は、前記の成分のみに限らず、赤色であればLi_2TiO_3：Mnか、$LiAlO_2$：Mn以外に、$6MgO\cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO\cdot 0.5MgF_2\cdot GeO_2$：$Mn^{4+}$から選択することができ、緑色であれば$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）か、もしくは$La_2O_3\cdot 11Al_2O_3$：Mnか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu、Mnから選択することができる。

【００３３】

$LiAlO_2$：Mnを成分とする赤色蛍光粉が励起されて発生する光線のスペクトルを図１１に励起スペクトル、１２に発光スペクトルを開示する。$6MgO\cdot As_2O_5$：Mn^{4+}を成分とする赤色蛍光粉が励起されて発生する光線のスペクトルを図１３に開示する。また、$3.5MgO\cdot 0.5MgF_2\cdot GeO_2$：$Mn^{4+}$を成分とする赤色蛍光粉が励起されて発生する光線のスペクトルを図１４に開示する。これらは、いずれも青色光線で励起して白色光線を得るのに適する。

【００３４】

$La_2O_3\cdot 11Al_2O_3$：Mnを成分とする緑色蛍光粉が励起されて発生する光線のスペクトルを図４に開示する。$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）を成分とする緑色蛍光粉が励起されて発生する光線のスペクトルを図５に励起スペクトル、６に発光スペクトルを開示する。これらは、いずれも青色光線で励起して白色光線を得るのに適する。

【００３５】

上述するそれぞれの蛍光粉は、励起されて発生する光線のスペクトルと、発生する光線の周波数帯がいずれも若干異なる。よって、異なる波長の青色ＬＥＤ結晶粒の波長特性に基づき、適宜な蛍光粉を選択することができる。例えば、４２５ｎｍの青色ＬＥＤ結晶粒を使用する場合は、赤色蛍光粉として、$6MgO\cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO\cdot 0.5MgF_2\cdot GeO_2$：$Mn^{4+}$を用いる。緑色の蛍光粉は$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ceか、もしくは$Ca_8Mg(SiO_4)_4Cl_2$：Eu，Mnを使用する。

【００３６】

即ち、赤色蛍光粉の成分については、青色ＬＥＤの波長が４２５～４７５ｎｍであって、かつ発光波長のピーク値を約６５９ｎｍとする特性を有する場合、成分がLi_2TiO_3：Mnのものを選択し、ピーク値を約６７０ｎｍとする特性を有する場合、成分が$LiAlO_2$：Mnのものを選択し、ピーク値を約６５０ｎｍとする特性を有する場合、$6MgO\cdot As_2O_5$：Mn^{4+}か、もしくは$3.5MgO\cdot 0.5MgF_2\cdot GeO_2$：$Mn^{4+}$のものを選択することによって、白色光線の好ましい発光効率とパワーが得られる。

【００３７】

緑色蛍光粉については、青色ＬＥＤの波長が４２５～４７５ｎｍであって、かつ発光波長のピーク値を約５２０ｎｍとする特性を有する場合、成分が$La_2O_3\cdot 11Al_2O_3$：Mn　のものを選択し、ピーク値を約５１６ｎｍとする特性を有するものである場合、成分が$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce（$0<x<1$）のものを選択し、ピーク値を約５１５ｎｍとする特性を有する場合、成分が$Ca_8Mg(SiO_4)_4Cl_2$：Eu，Mnのものを選択することによって、白色光線の好ましい発光効率とパワーが得られ

る。

【００３８】

この発明を、業界で著名な日亜化学工業株式会社の所有する白色ＬＥＤ関連特許に開示される技術と比較した場合、日亜化学工業の白色ＬＥＤが青色ＬＥＤ結晶粒に、成分が（$Y_xGd_{1-x})_3AI_5O_{12}$：ＣｅであるＹＡＧ黄色蛍光粉を加え、青色光線で該ＹＡＧ黄色蛍光粉を励起し、黄色と青色とが互いに色を補い合う２種類の波長の白色ＬＥＤを得る点において３種類の波長を備える本発明のＬＥＤと異なる。即ち本発明では、日亜化学工業株式会社の特許に開示される技術とは異なる蛍光粉を使用するとともに、得られる白色ＬＥＤが３種類の波長を具える点においても異なる。また、この発明においては、混合蛍光粉を励起して３種類の波長を具えた白色光線を得る以外に、赤、緑色の蛍光粉を所定の比例で調合し、例えば桃色、水色などの中間色系のＬＥＤを得ることもできる。

【００３９】

目下青色光線でＹＡＧ黄色蛍光粉を励起し、２種類の波長を有する白色光線を得るか、もしくは紫外線で赤、青、緑色の混合蛍光粉を励起して３種類の波長の白色光線を得る方法は、いずれも改善すべき欠点を有する。この発明は青色ＬＥＤ結晶粒で赤、緑色の混合蛍光粉を励起して３種類の波長を具える白色ＬＥＤの製造方式を提供するものである。現在の青色ＬＥＤ結晶粒は製造技術が熟成し、高い輝度が得られる。よって、係る青色ＬＥＤを利用して赤、緑色の混合蛍光粉を励起して得られる３種類の波長の白色ＬＥＤは、色度の純度が高く、好ましい輝度を有する。目下の単一白色ＬＥＤの中で最も輝度の高い３種類の波長を具える白色光線が得られる。

【００４０】

この発明においては、赤、緑色の混合蛍光粉であって、かつ青色光線（波長４２５～４７５ｎｍ）の励起に適したものを実験によって得た。係る蛍光粉はいずれも酸化物蛍光粉であって、好ましい安定性と、長い寿命を有する。また、この発明の方法によって得られる３種類の波長の白色ＬＥＤは応用範囲が広く、例えばパイロットランプなどの指示用ランプ、照明、もしくは単色、またはカラー液晶表示装置のバックライトなどの用途に応用することができる。

【００４１】

以上は、この発明の好ましい実施例であって、この発明の実施の範囲を限定するものではない。よって、当業者のなし得る修正、もしくは変更であって、この発明の精神の下においてなされ、この発明に対して均等の効果を有するものは、いずれもこの発明の特許請求の範囲に属するものとする。

【００４２】

【発明の効果】

この発明による白色ＬＥＤは、波長が４２５～４７５ｎｍの間の青色ＬＥＤ結晶粒で赤、緑色混合蛍光粉を励起して、三種類の波長を有する白色光線を発生させるため、従来の紫外線を利用して混合蛍光粉を励起する方法に比して、青色ＬＥＤの成熟した技術を応用することができるため、高い実用性を具えるのみならず、好ましい発光効率とパワーが得られる。

【００４３】

またこの発明による白色ＬＥＤは、使用寿命が長く、好ましい安定性を具える。

【００４４】

さらに、白色光線を中間色系に変更することができ、幅広い用途に応用できる効果を有する。

【図面の簡単な説明】

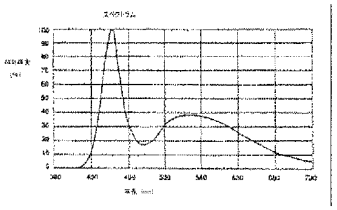
【図１】日亜化学工業株式会社所有の技術であって、青色光線でＹＡＧ黄色蛍光粉を励起する白色ＬＥＤの発光スペクトルを表わすグラフである。

【図２】この発明による白色ＬＥＤのランプ型ＬＥＤの実装構造を表わす断面図である。

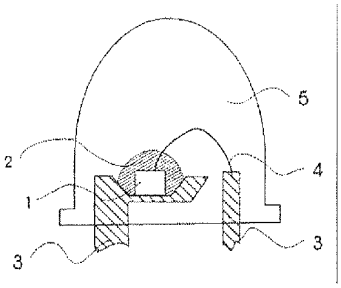
【図３】この発明による白色ＬＥＤの表面実装型ＬＥＤの実装構造を表わす断面図である

【図４】$La_2O_3 \cdot 11AI_2O_3$：Ｍｎを成分とする緑色蛍光粉を励起したときの励起スペクトルと発光スペクトルを表わすグラフである。
【図５】$Y_3(Ga_xAI_{1-x})_5O_{12}$：Ｃｅ（０＜ｘ＜１）を成分とする緑色蛍光粉を励起したときの励起スペクトルを表わすグラフである。
【図６】$Y_3(Ga_xAI_{1-x})_5O_{12}$：Ｃｅ（０＜ｘ＜１）を成分とする緑色蛍光粉を励起したときの発光スペクトルを表わすグラフである。
【図７】$Ca_8Mg(SiO_4)_4CI_2$：Ｅｕ、Ｍｎを成分とする緑色蛍光粉を励起したときの励起スペクトルを表わすグラフである。
【図８】$Ca_8Mg(SiO_4)_4CI_2$：Ｅｕ、Ｍｎを成分とする緑色蛍光粉を励起したときの発光スペクトルを表わすグラフである。
【図９】Li_2TiO_3：Ｍｎを成分とする赤色蛍光粉を励起したときの励起スペクトルを表わすグラフである。
【図１０】Li_2TiO_3：Ｍｎを成分とする赤色蛍光粉を励起したときの発光スペクトルを表わすグラフである。
【図１１】$LiAIO_2$：Ｍｎを成分とする赤色蛍光粉を励起したときの励起スペクトルを表わすグラフである。
【図１２】$LiAIO_2$：Ｍｎを成分とする赤色蛍光粉を励起したときの発光スペクトルを表わすグラフである。
【図１３】$6MgO \cdot As_2O_5$：Mn^{4+}を成分とする赤色蛍光粉を励起したときの励起スペクトルと発光スペクトルを表わすグラフである。
【図１４】$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$　を成分とする赤色蛍光粉を励起したときの励起スペクトルと発光スペクトルを表わすグラフである。
【図１５】この発明によるランプ型白色ＬＥＤの光線のスペクトルを表わすグラフである。
【図１６】この発明による表面実装型白色ＬＥＤの他の実施形態の光線スペクトルを表わすグラフである。
【符号の説明】
１　青色ＬＥＤ結晶粒
２　混合蛍光粉
３　リードフレーム
４　リード
５　樹脂
６　実装基板

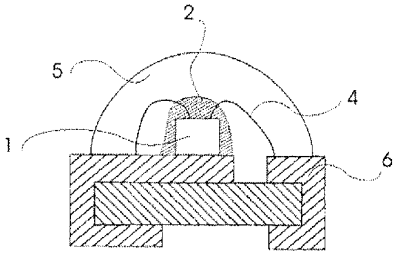
【図1】



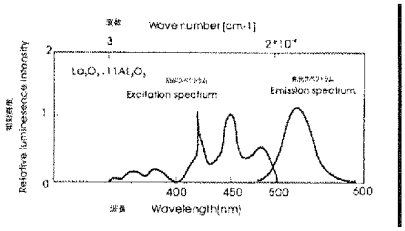
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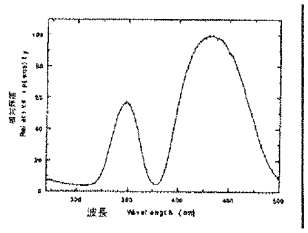
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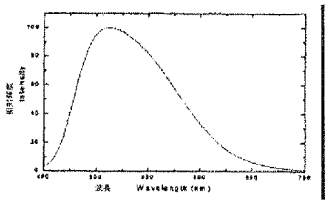
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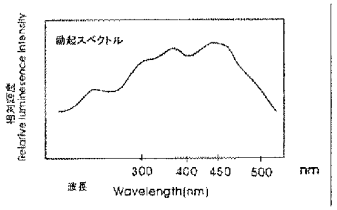
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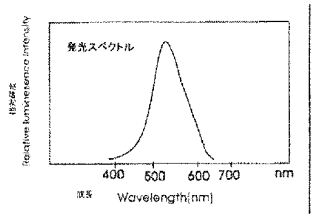
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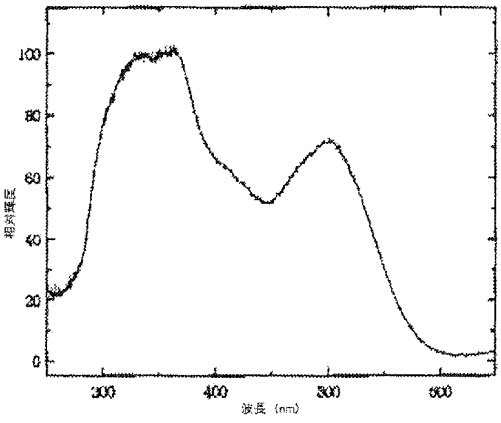
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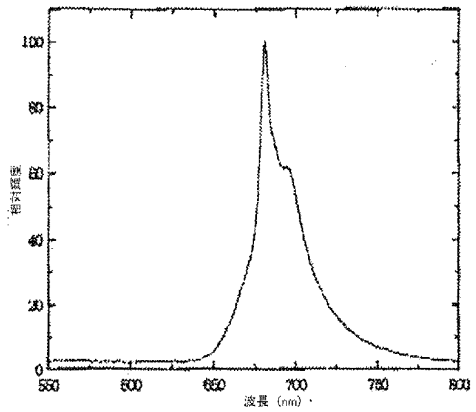
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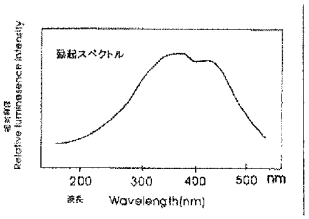
【図9】



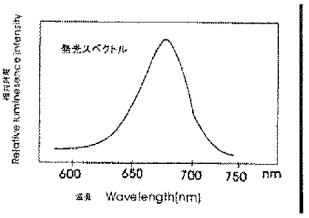
【図10】



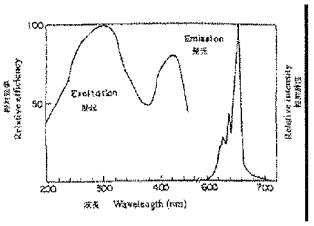
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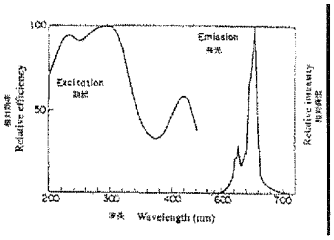
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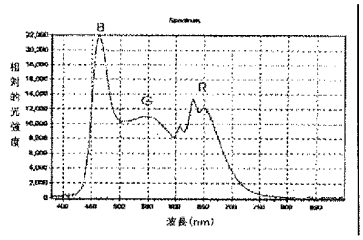
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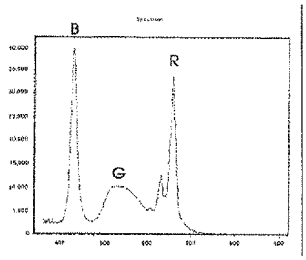
【図14】



【図15】



【図16】



(51)Int.Cl.⁷	FI		テーマコード（参考）
Ｃ０９Ｋ　11/67	Ｃ０９Ｋ　11/67	ＣＰＱ	
Ｃ０９Ｋ　11/74	Ｃ０９Ｋ　11/74	ＣＰＭ	
Ｃ０９Ｋ　11/80	Ｃ０９Ｋ　11/80	ＣＰＴ	

MANUFACTURING METHOD OF WHITE LIGHT EMITTING DEVICE

Publication number: JP2004119743
Publication date: 2004-04-15
Inventor: NOGUCHI KATSUHIKO; HORIUCHI MEGUMI
Applicant: CITIZEN ELECTRONICS
Classification:
- international: *H01L33/00;* H01L33/00; (IPC1-7): H01L33/00
- European: H01L33/00B3B
Application number: JP20020282023 20020926
Priority number(s): JP20020282023 20020926

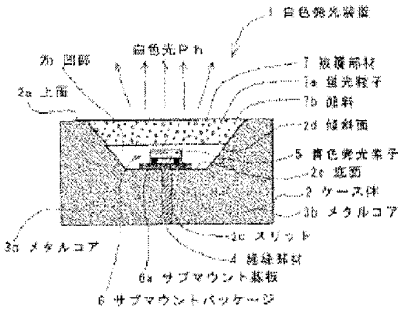
Also published as:
EP1403936 (A2)
US6858456 (B2)
US2004090161 (A1)
KR20040027378 (A)
EP1403936 (A3)

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Abstract of **JP2004119743**

PROBLEM TO BE SOLVED: To solve a problem of a blue light emitting element, the white light emitted from which is widely varied element by element in the color tone and the luminance, used for a white light emitting device because the wavelength and luminance of emitted light of each blue light emitting element is much dispersed.
SOLUTION: The blue light emitting elements 5 are graded for the emission wave length and the emission luminance, fluorescent particles 7a of a YAG group phosphor used to apply wavelength conversion of a blue light of the blue light emitting elements 5 and coating members 7 with which pigments 7b to adjust the emission luminance is mixed are graded corresponding to the grading of the blue light emitting elements 5, the blue light emitting element 5 and the coating member 7 corresponding to the grading are combined, mounted in a case body 2 and integrated so that the color tone and the luminance of the white light Ph are brought into a prescribed range.
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(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2004-119743
(P2004-119743A)
(43)公開日　平成16年4月15日(2004.4.15)

(51)Int.Cl.[7]	F I		テーマコード（参考）
H01L 33/00	H01L 33/00	M	5F041
	H01L 33/00	C	
	H01L 33/00	N	

審査請求 未請求　請求項の数 15　OL　（全 16 頁）

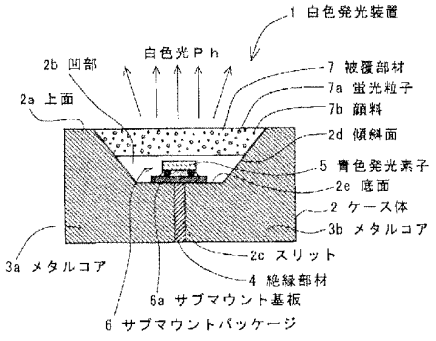
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(22)出願日　平成14年9月26日(2002.9.26)

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Fターム(参考)　5F041 AA05 CA40 CB15 DA11 DA13 DA14 DA35 DA36 DA45 DA46 EE25

(54)【発明の名称】白色発光装置の製造方法

(57)【要約】
【課題】白色発光装置に用いられる青色発光素子は発光波長と発光輝度にかなりのバラツキが生じるために、その白色光も色調と輝度のバラツキが大きい。
【解決手段】青色発光素子５を発光波長と発光輝度に従ってランク分けすると共に、前記青色発光素子５の青色光を波長変換するＹＡＧ系蛍光体の蛍光粒子７ａと、発光輝度を調整する顔料７ｂを混入する被覆部材７も、前記青色発光素子５のランク分けに対応してランク分けを行い、該ランク分けに対応して青色発光素子５と被覆部材７を組合せてケース体２に組み込み一体化し、白色光Ｐｈの色調と輝度が所定の範囲に入るようにする。
【選択図】　図２



【特許請求の範囲】
【請求項１】
青色発光素子の発光を蛍光体を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の青色発光素子をその発光波長及び発光輝度に従ってランク分けすると共に、前記青色発光素子の発光を波長変換して色調調整をするための蛍光体と、前記青色発光素子の発光の輝度調整をするための減光材との組合せ条件を、前記青色発光素子のランク分けに対応して異ならせた複数の被覆部材を設け、前記ランク分けに対応して青色発光素子と被覆部材とを組み合わせて一体化することを特徴とする白色発光装置の製造方法。
【請求項２】
前記被覆部材は一つの被覆部材に前記蛍光体と前記減光材との両方を混入したことを特徴とする請求項１記載の白色発光装置の製造方法。
【請求項３】
前記被覆部材は前記蛍光体を混入した第１の被覆部材と、前記減光材を混入した第２の被覆部材によってなることを特徴とする請求項１記載の白色発光装置の製造方法。
【請求項４】
前記被覆部材はシリコン系エラストマーに前記蛍光体と前記減光材とを混入した被覆部材であることを特徴とする請求項１乃至請求項３記載の白色発光装置の製造方法。
【請求項５】
前記減光材は青色発光素子の発光波長に関わらず輝度を低下させる顔料または染料であることを特徴とする請求項１乃至請求項４記載の白色発光装置の製造方法。
【請求項６】
前記青色発光素子はサブマウント基板に実装されたサブマウントパッケージとして一体化されていることを特徴とする請求項１記載の白色発光装置の製造方法。
【請求項７】
青色発光素子の発光を蛍光体を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の前記青色発光素子に通電して各青色発光素子の発光の色調及び輝度を測定してランク分けする工程と、前記青色発光素子のランクに対応して条件の異なる複数種類の前記被覆部材を作成する工程と、前記ランクに従って適合する青色発光素子と被覆部材とを組み合わせる工程と、前記適合した青色発光素子と被覆部材とを１つのケース体に組み込んで一体化する工程とを有することを特徴とする白色発光装置の製造方法。
【請求項８】
ケース体に組み込まれた青色発光素子の発光を、蛍光体と減光材を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の前記青色発光素子に通電して各青色発光素子の発光の色調及び輝度を測定してランク分けする工程と、前記ケース体を集合基板上に多数個形成する工程と、同一ランクの複数の青色発光素子を集合基板上に形成された各ケース体に実装する工程と、前記集合基板上に実装された複数の青色発光素子に同一条件の前記被覆部材を取り付けて発光装置を完成させる工程と、前記集合基板上の完成された発光装置を切り離す分離工程とを有することを特徴とする白色発光装置の製造方法。
【請求項９】
前記被覆部材は前記集合基板上に形成された多数個のケース体に対応した多数個の被覆部材を備えた被覆部材集合体によって成り、該被覆部材集合体のそれぞれの被覆部材は前記集合基板上に形成された多数個のケース体のそれぞれの位置に対応して配設されることを特徴とする請求項８記載の白色発光装置の製造方法。
【請求項１０】
前記被覆部材集合体は前記蛍光体と前記減光材の混入条件が略同一である多数個の被覆部材を備えたことを特徴とする請求項８又は請求項９記載の白色発装置の製造方法。
【請求項１１】

前記ケース体は反射面を形成した凹部を有し、該凹部の底面に前記青色発光素子を実装し、さらに、該凹部に前記被覆部材を組み込むことを特徴とする請求項７乃至請求項１０記載の白色発光装置の製造方法。

【請求項１２】

前記青色発光素子がＩｎＧａＮ系ＬＥＤであることを特徴とする請求項１乃至請求項１１の何れか１項記載の白色発光装置の製造方法。

【請求項１３】

前記蛍光体がＹＡＧ系蛍光体であることを特徴とする請求項１２記載の白色発光装置の製造方法。

【請求項１４】

前記滅光材が黒色系顔料であることを特徴とする請求項１２又は請求項１３記載の白色発光装置の製造方法。

【請求項１５】

前記ケース体は絶縁部材を挟んだ一対のメタルコア材であり、該メタルコアの表面には光沢メッキが施されていることを特徴とする請求項１乃至請求項１４のいずれかに記載の白色発光装置の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する分野】

本発明は青色発光素子の発光を蛍光体を混入した被覆部材を透過させて白色発光を行う白色発光装置の改良に関し、詳しくは発光色調と発光輝度とを所定範囲に管理することを可能とした白色発光装置の製造方法に関する。

【０００２】

【従来の技術】

従来、窒化ガリウム系化合物半導体である青色発光素子をイットリウム・アルミニューム・ガーネット系蛍光体（以下ＹＡＧ系蛍光体と略記）を混入した被覆部材を透過させて白色発光を行う蛍光体混色型の白色発光装置が開発されている（例えば、特許文献１及び該特許文献１に対応する米国の特許文献３、特許文献２及び該特許文献２に対応する米国の特許文献４参照）。以下図面により従来の白色発光装置について説明する。図１７は前記特許文献１～４に基づき、説明用に記載した従来技術における蛍光体混色型の白色発光装置の構成と作用とを示す断面図である。２０は白色発光装置であり、外部接続用の電極２１、２２を有する基板２３に青色発光素子２４がワイヤー２５によってボンディングされており、該青色発光素子２４をＹＡＧ系蛍光体の蛍光粒子２６を混入した透明な被覆部材２７でモールドしている。

【０００３】

上記白色発光装置２０の動作は、前記電極２１，２２に駆動電圧を印加すると青色発光素子２４が青色光Ｐｂを発光する。そしてこの青色光Ｐｂが被覆部材２７に混入された蛍光粒子２６に衝突すると該蛍光粒子２６が励起されて波長変換が行われ、蛍光粒子２６から図示のごとく黄色光Ｐｅが発光される。この結果、白色発光装置２０からは前記青色発光素子２４から発光されて蛍光粒子２６に衝突せずに出力される青色光Ｐｂと、蛍光粒子２６に衝突して波長変換された黄色光Ｐｅとが混合された白色光Ｐｎが発光される。

【０００４】

また、図１７に記載した蛍光体混色型の白色発光装置をさらに改良した公知技術がある（例えば、特許文献５及び該特許文献５に対応する米国の特許文献６）。この特許文献５には前記蛍光体を混入した被覆部材の中に着色材としての顔料を混入させることにより、前記青色発光素子２４の青色光Ｐｂを蛍光粒子で白色光にした後に着色用の顔料で所望の発光色に調整して出力する構成が開示されている。

【０００５】

さらに、前記特許文献５には蛍光体を混入した被覆部材を前記青色発光素子２４のモールドとせずに、キャップまたはシート状に形成して前記青色発光素子２４実装したケース体

に装着することで、前記青色発光素子２４と被覆部材とを組み合わせる構成が開示されている。
さらに、図１７に記載した蛍光体混色型の白色発光装置の色調を改良した公知技術として、前記ＹＡＧ系蛍光体を混入した被覆部材の中にストロンチュームを混入させることにより、赤色成分の補正を行った白色発光装置が開示されている（例えば、特許文献７及び該特許文献７に対応する米国の特許文献８）。
【０００６】
【特許文献１】
特許第２９９８６９６号明細書
【特許文献２】
特許第２９２７２７９号明細書
【特許文献３】
米国特許第５９９８９２５号明細書
【特許文献４】
米国特許第６０６９４４０号明細書
【特許文献５】
特開平１１－８７７８４号公報
【特許文献６】
米国特許第６３１９４２５号明細書
【特許文献７】
特開２０００－４４０２１号公報
【特許文献８】
米国特許第６３５１０６９号明細書
【０００７】
【発明が解決しようとする課題】
しかしながら、前記図１７に記載した青色発光素子と蛍光体を混入した被覆部材とによる蛍光体混色型の白色発光装置は、単純な構成で白色発光を得ることが出来るため、極めて優れた白色発光装置であるが、問題点としては前記青色発光素子は化合物半導体であるがゆえに、量産した場合に各青色発光素子の発光波長と発光輝度にかなりのバラツキが発生する。また、前記被覆部材に混入するＹＡＧ系蛍光体の蛍光粒子の量や分散のバラツキ等によっても混合される白色光Ｐｎに影響を及ぼし、この結果、完成した白色発光装置は図１８及び図１９で示すように色調と輝度に大きなバラツキが生じる。
【０００８】
図１８は、ある白色発光装置を１ロット量産したときの色調のバラツキを、一般によく知られているＸＹＺ表色系色度座標の一部を用いて示した分布図である。ここで、それぞれの黒点は白色発光装置の個々の色調データを示しており、その色調は図示するごとく右上がりの帯状に分散している。ここで、幅方向の分散（矢印線Ａ）は主に前記青色発光素子の発光波長のバラツキによって生じる色調のバラツキであり、長手方向の分散（矢印線Ｂ）は主に前記被覆部材に混入する蛍光粒子の量や分散バラツキによって生じる色調のバラツキである。尚、青色発光素子の発光波長はロット間バラツキが大きいので、実際の量産に於いては幅方向の分散（矢印線Ａ）はさらに広がっている。
【０００９】
このように、青色発光素子やＹＡＧ系蛍光体の蛍光粒子によって、白色発光装置の色調はかなりバラツキが生じるが、近年、白色発光装置を採用するメーカーの色調バラツキ要求範囲は非常に厳しく、色調バラツキの規格値はＸ、Ｙ共に０．３３±０．０１程度を要求されることが多い。例えば、図１８において、Ｘ、Ｙ共に０．３３±０．０１の範囲内（斜線エリア）を要求エリアとした場合は、大部分の白色発光装置が要求エリアから外れ採用されない。
【００１０】
また、図１９は、白色発光装置を前述と同様に量産したときの発光輝度のバラツキを示し

た分布図であり、Ｘ軸は発光輝度を表しＹ軸はその発光輝度を有する白色発光装置の個数を示している。図１９で明らかなように、発光輝度のバラツキは分布の中心に対して＋３０％～－４０％位ある。しかし、近年の白色発光装置を採用するメーカーの要求は厳しく、輝度バラツキの要求範囲は±２０％位であり、この範囲から外れる製品は採用されない。尚、実際の量産ではロット間バラツキもあるので、最小輝度と最大輝度の差はさらに大きく通常３倍以上にも及ぶことが多い。

【００１１】

また、前記特許文献５等に開示された改良に付いても、前記蛍光体を混入した被覆部材の中に着色材としての顔料を混入させることにより、白色光を所望の発光色に調整して出力する方式、すなわちカラー化のための顔料混入について開示されてはいるが、量産された青色発光素子の発光波長及び発光輝度のバラツキに対する白色発光装置としての色調と輝度の改良に付いてはなんら示唆されていない。

【００１２】

さらに、前記特許文献７等に開示された改良に付いても、青色発光素子とＹＡＧ系蛍光体との組合せによる白色発光装置の欠点である赤色成分の補正を行うことで、色調の改善を行うことは開示されてはいるが、量産された青色発光素子の発光波長のバラツキに対する色調補正についてはなんら示唆されておらず、また、青色発光素子の発光輝度のバラツキに対する補正についてはまったく開示されていない。

【００１３】

さらには、近年、車載用として白色発光装置の採用が求められているが、車載用電子部品の信頼性要求は非常に厳しく、特に動作温度範囲は一般的に－４０℃～＋８５℃とたいへん厳しい要求仕様がある。しかし、従来の図１７で示すチップタイプの白色発光装置では、青色発光素子の発熱を効率よく放熱できないために、特に高温側での動作保証が得られず、車載用として用いることは難しかった。

【００１４】

本発明は上記白色発光装置の量産において、青色発光素子の発光波長と発光輝度とのバラツキによって生じる、色調と輝度の分布を所定の範囲に調整することで、いわゆる規格外の製品を極力少なくする事が出来る白色発光装置の製造方法を提供することを目的としている。さらにまた、放熱性に優れ広範囲な動作温度範囲を保証する、信頼性に優れた白色発光装置の製造方法を提供することをも目的としている。

【００１５】

【課題を解決するための手段】

上記課題を解決するための本発明の手段は、青色発光素子の発光を蛍光体を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の青色発光素子をその発光波長及び発光輝度に従ってランク分けすると共に、前記青色発光素子の発光を波長変換して色調調整をするための蛍光体と、前記青色発光素子の発光の輝度調整をするための減光材との組合せ条件を、前記青色発光素子のランク分けに対応して異ならせた複数の被覆部材を設け、前記ランク分けに対応して青色発光素子と被覆部材とを組み合わせて一体化した白色発光装置の製造方法とした。

【００１６】

また、前記被覆部材は一つの被覆部材に前記蛍光体と前記減光材との両方を混入した白色発光装置の製造方法とした。

【００１７】

また、前記被覆部材は前記蛍光体を混入した第１の被覆部材と、前記減光材を混入した第２の被覆部材によってなる白色発光装置の製造方法とした。

【００１８】

さらに、前記被覆部材はシリコン系エラストマーに前記蛍光体と前記減光材とを混入した被覆部材である白色発光装置の製造方法とした。

【００１９】

また、前記減光材は青色発光素子の発光波長に関わらず輝度を低下させる顔料または染料

である白色発光装置の製造方法とした。

【００２０】

また、前記青色発光素子はサブマウント基板に実装されたサブマウントパッケージとして一体化する白色発光装置の製造方法とした。

【００２１】

上記課題を解決するための本発明の手段は、青色発光素子の発光を蛍光体を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の前記青色発光素子に通電して各青色発光素子の発光の色調及び輝度を測定してランク分けする工程と、前記青色発光素子のランクに対応して条件の異なる複数種類の前記被覆部材を作成する工程と、前記ランクに従って適合する青色発光素子と被覆部材とを組み合わせる工程と、前記適合した青色発光素子と被覆部材とを１つのケース体に組み込んで一体化する工程とを有する白色発光装置の製造方法とした。

【００２２】

上記課題を解決するための本発明の他の手段は、ケース体に組み込まれた青色発光素子の発光を蛍光体と滅光材を混入した被覆部材を透過させて白色発光させる白色発光装置の製造方法において、複数の前記青色発光素子に通電して各青色発光素子の発光の色調及び輝度を測定してランク分けする工程と、前記ケース体を集合基板上に多数個形成する工程と、同一ランクの複数の青色発光素子を集合基板上に形成された各ケース体に実装する工程と、前記集合基板上に実装された複数の青色発光素子に同一条件の前記被覆部材を取り付けて発光装置を完成させる工程と、前記集合基板上の完成された発光装置を切り離す分離工程とを有する白色発光装置の製造方法とした。

【００２３】

また、前記被覆部材は前記集合基板上に形成された多数個のケース体に対応した多数個の被覆部材を備えた被覆部材集合体によって成り、該被覆部材集合体のそれぞれの被覆部材は前記集合基板上に形成されたケース体のそれぞれの位置に対応して配設されている白色発装置の製造方法とした。

【００２４】

また、前記被覆部材集合体は前記蛍光体と前記滅光材の混入条件が略同一である多数個の被覆部材を備えた白色発装置の製造方法とした。

【００２５】

また、前記ケース体は反射面を形成した凹部を有し、該凹部の底面に前記青色発光素子を実装し、該凹部に前記被覆部材を組み込む白色発光装置の製造方法とした。

【００２６】

また、前記青色発光素子がＩｎＧａＮ系ＬＥＤである白色発光装置の製造方法とした。

【００２７】

また、前記蛍光体がＹＡＧ系蛍光体である白色発光装置の製造方法とした。

【００２８】

また、前記滅光材が黒色系顔料である白色発光装置の製造方法とした。

【００２９】

さらに、前記ケース体は絶縁部材を挟んだ一対のメタルコア材であり、該メタルコアの表面には光沢メッキが施されている白色発光装置の製造方法とした。

【００３０】

【発明の実施の形態】

以下、本発明の実施の形態を図面に基づいて詳細に説明する。図１は本発明の実施の形態である白色発光装置を構成するケース体の斜視図である。図１において、２は外形が略立方体形状のケース体であり、該ケース体２の上面２ａには、発光方向に向けた光を反射する傾斜面を有するカップ形状の凹部２ｂが形成されている。３ａ、３ｂは該ケース体２を構成する熱伝導性の高い射出成形が可能なＭｇ合金系のメタルコア材料から成る一対のメタルコアであり、スリット２ｃを隔てて対向している。

【００３１】

４はケース体２の一部を構成する絶縁部材であり、前記スリット２ｃの内部に充填され、前記メタルコア３ａ、３ｂを一対の電極として絶縁分離し、該メタルコア３ａ、３ｂを結合している。さらに、該メタルコア３ａ、３ｂの露出面には、光沢仕上げのＡｇメッキが施され、この結果、前記凹部２ｂの内面にある傾斜面２ｄはＡｇメッキで覆われた光反射面となっている。５は前記凹部２ｂの底面２ｅに実装された青色発光素子である。

【００３２】

図２は、図１のケース体２をＡ－Ａで断面し、さらに被覆部材を取り付けた本発明の白色発光装置の完成断面図である。図２において、１は白色発光装置であり、前記一対のメタルコア３ａ、３ｂと前記絶縁部材４によってなるケース体２で構成されている。６はサブマウントパッケージであり、前記青色発光素子５をセラミック等によってなるサブマウント基板６ａにフェースダウンボンディングでよって実装し一体化される。該サブマウントパッケージ６は前記凹部２ｂの底面２ｅに半田等の導電性結合部材によって実装される。

【００３３】

これにより、前記青色発光素子５はサブマウント基板６ａを介してメタルコア３ａ、３ｂと電気的に接続し、さらに該メタルコア３ａ、３ｂの下部は実装基板へ接続する端子電極を成している。７は外周に傾斜面を有する略円盤状に形成されたシリコン系エラストマーを成分とする被覆部材であり、ＹＡＧ系蛍光体の蛍光粒子７ａと滅光材としての顔料７ｂを混入し、前記凹部２ｂの傾斜面２ｄに外周の傾斜面を位置決めして装着し、必要に応じて接着やカシメ等によって固定することにより前記青色発光素子５の上面を覆っている。

【００３４】

次に白色発光装置１の動作を図２に基づいて説明する。尚、該白色発光装置１の基本動作は従来例の図１７で説明した動作と類似しているので詳細な説明は一部省略する。図２に於いて、白色発光装置１を構成する前記メタルコア３ａ、３ｂに駆動電圧を印加すると、サブマウント基板６ａを介して青色発光素子５に駆動電圧が印加され、該青色発光素子５から青色光Ｐｂ（図示せず）が発光する。そして該青色光Ｐｂが前記被覆部材７に混入された蛍光粒子７ａに衝突すると該蛍光粒子７ａが励起されて波長変換が行われ、蛍光粒子７ａから黄色光Ｐｅ（図示せず）が発光される。

【００３５】

この結果白色発光装置１からは、前記青色発光素子５から発光されて蛍光粒子７ａに衝突せずに出力される青色光Ｐｂと、前記蛍光粒子７ａに衝突して波長変換された黄色光Ｐｅとが混合された白色光Ｐｎが発光される。尚、青色発光素子５は前述した如く反射効率の優れたＡｇメッキが施された傾斜面２ｄによって周辺を囲まれているので、白色光Ｐｎは効率よく前方に発光することが出来る。

【００３６】

次に前記白色発光装置１を製造するための工程である、前記青色発光素子５の発光波長と発光輝度の測定工程について図面に基づいて説明する。まず、該青色発光素子５が実装されたサブマウントパッケージ６をＬＥＤ専用計測器であるＬＥＤテスタ（図示せず）に接続して駆動電圧を印加して発光させ、青色発光素子５の一つ一つについて発光波長と発光輝度を測定し記憶する。ここで、該青色発光素子５は前述したように化合物半導体であるがゆえに、量産時に於いてその発光波長は±１０ｎｍ程度バラツキが生じる。

【００３７】

図３はピーク波長が４７０ｎｍ仕様の青色発光素子５の量産時の発光波長の分布データを示しており、Ｘ軸は発光波長でありＹ軸は該青色発光素子５の発光波長に対する個数（ピーク値を１００とした）を表している。図３で明らかなように発光波長は４７０ｎｍ付近を中心として約４６０～４８０ｎｍの範囲で分布していることがわかる。また、図４はＬＥＤテスタで測定した青色発光素子５の量産時に於ける発光輝度の分布データであり、Ｘ軸は分布中心輝度を１とした相対値としての発光輝度であり、Ｙ軸は該発光輝度に対する青色発光素子５の個数（ピーク値を１００とした）を表している。図４で明らかなように、発光輝度は主に０．５～２．０位の範囲で分布しており、最小輝度と最大輝度の比率は約４倍程度ある。

【００３８】
次に、該青色発光素子５の発光波長の分布データと発光輝度の分布データに基づいて実施する、発光波長と発光輝度のランク分け工程について説明する。発光波長に関しては図３で示したように発光波長はほぼ４６０ｎｍ～４８０ｎｍの範囲で分布しているが、分布限界付近ではほとんど存在しないのでランク範囲を４６２ｎｍ～４７８ｎｍとして４ランクで分割する。図５は該青色発光素子５の発光波長のランク表であり、発光波長のランク番号と該ランク番号に対応する発光波長の範囲を示している。すなわち、発光波長のランクはａ１～ａ４までの４ランクとし、１ランクの波長範囲は４ｎｍである。
【００３９】
次に発光輝度に関しては図４で示したように相対輝度で約０．５～２．０の範囲で分布している。ここで、分布の最小輝度付近は輝度が暗すぎてしまうので、相対輝度０．６以下の青色発光素子５は除き、０．６～２．０の輝度範囲の青色発光素子を波長と同じく４ランクで分割する。図６は該青色発光素子５の発光輝度のランク表であり、発光輝度のランク番号と該ランク番号に対応する発光輝度の範囲を示している。すなわち、発光輝度のランクはｂ１～ｂ４までの４ランクとし、１ランクの輝度範囲は約１．３５倍である。
【００４０】
以上の工程を実施することにより、青色発光素子５は発光波長のランク数と発光輝度のランク数の積、４ランク×４ランク＝１６ランクに分類される。すなわち、発光波長で分類される４ランクのそれぞれひとつのランク毎に、発光輝度でランク分けされる４ランクが存在することになり、それぞれの青色発光素子５のランク番号をａ１ｂ１、ａ１ｂ２、ａ１ｂ３、ａ１ｂ４、ａ２ｂ１、ａ２ｂ２、ａ２ｂ３、ａ２ｂ４～ａ４ｂ４としてランク付けし製造工程の中で保存する。尚、青色発光素子５のランク数は１６ランクに限ることは無く、メーカーの要求仕様に応じて、また、青色発光素子５の特性や製造工程の都合等により、任意に変えることが出来る。
【００４１】
次にＹＡＧ系蛍光体の蛍光粒子７ａを混入した前記被覆部材７の製造工程について説明する。先に図２で説明した如く、ＹＡＧ系蛍光体の蛍光粒子７ａは前記青色発光素子の青色光Ｐｂが該蛍光粒子７ａに衝突すると黄色光Ｐｅを発光するが、この黄色光ＰｅはＹＡＧ系蛍光体の成分であるガリウムとガドリニウムの比率を変えることによって、その発光波長を変化させることができる。ここでは一例として、ピーク波長が５７０ｎｍであるＹＡＧ系蛍光体を、その成分調整によりピーク波長を約５６０ｎｍ～５８０ｎｍ程度の範囲で４ランクに分けて製造する。
【００４２】
次に、４ランクに分けて製造した前記ＹＡＧ系蛍光体の蛍光粒子７ａを前記被覆部材７の主成分であるシリコン系エラストマーに混入し、４ランクに分かれた被覆部材７を製造する。図７は該被覆部材７に混入したＹＡＧ系蛍光体の蛍光粒子７ａの発光波長によってランク分けしたランク表であり、ランク番号と該ランク番号に対応する発光波長の範囲を示している。すなわち、発光波長のランクはｃ１～ｃ４までの４ランクとし、１ランクの波長範囲は５ｎｍである。
【００４３】
次に前記ＹＡＧ系蛍光体の蛍光粒子７ａを混入すると共に、前記顔料７ｂを混入した被覆部材７の製造とランク分け工程について説明する。該被覆部材７への顔料７ｂの混入は、前記青色発光素子５の発光輝度ばらつきを補正して、個々の白色発光装置１ができる限り一定の発光輝度になるように、減光材としての役目を目的としている。ここで、顔料７ｂによる被覆部材７のランク分けは、該被覆部材７への顔料７ｂの混入率を変えることによって行う。図８は該被覆部材７に顔料７ｂを混入した顔料混入率ランク表でありランク番号と該ランク番号に対応する顔料混入率を示している。すなわち、顔料混入率のランクはｄ１～ｄ４までの４ランクとし、それぞれの混入率は前記青色発光素子５の発光輝度のランクを基にして実験的に定めたものであり、その混入率は０％～４５％位の範囲である。
【００４４】

尚、被覆部材７に混入する蛍光粒子７αと顔料７ｂの混入工程は、説明上別々に述べたが、実際には蛍光粒子７αと顔料７ｂの混入工程は同時に行うことが一般的である。以上の工程を実施することにより、被覆部材７はＹＡＧ系蛍光体のランクと顔料混入率のランクの積、４ランク×４ランク＝１６ランクで分割されることになる。すなわち、被覆部材７はＹＡＧ系蛍光体で分類されるランクｃ１～ｃ４のそれぞれに、顔料混入率で分類されるランクｄ１～ｄ４の顔料７ｂをさらに混入して完成するものであり、それぞれの被覆部材７のランク番号はｃ１ｄ１、ｃ１ｄ２、ｃ１ｄ３、ｃ１ｄ４、ｃ２ｄ１、ｃ２ｄ２、ｃ２ｄ３、ｃ２ｄ４～ｃ４ｄ４としてランク付けを行い製造工程の中で保存する。尚、該被覆部材７のランク数は１６ランクに限ることは無く、メーカーの要求仕様に応じて、また青色発光素子５のランク数に合わせて、さらにはＹＡＧ系蛍光体や顔料の種類によって任意に変えることが出来る。

【００４５】

次に、前記青色発光素子５のランク分け工程で分類した青色発光素子５を実装したサブマウントパッケージ６の各ランクと、前記被覆部材７のランク分け工程で分類した被覆部材７の各ランクを組み合わせる組み合わせ工程について説明する。図９は青色発光素子５を実装したサブマウントパッケージ６とＹＡＧ系蛍光体の蛍光粒子７α及び顔料７ｂを混入した被覆部材７との組み合わせ例を示した組み合わせ表である。図９において、グループＧ１は青色発光素子５の中心波長である４７０ｎｍに対して短波長側の４６２～４６６ｎｍにずれているランクα１と、被覆部材７に混入するＹＡＧ系蛍光体の発光波長が中心波長５７０ｎｍに対して同じく短波長側の５６０～５６５ｎｍにずれているランクｃ１との組み合わせである。

【００４６】

また同様に、グループＧ２～Ｇ４についても青色発光素子５の発光波長のランクα２～α４に対応して被覆部材７に混入するＹＡＧ系蛍光体の発光波長のランクｃ２～ｃ４を組み合わせている。以下同様に、グループＧ５～Ｇ８、グループＧ９～Ｇ１２、グループＧ１３～Ｇ１６においても、青色発光素子５のランクα１～α４に対応して被覆部材７もランクｃ１～ｃ４を組み合わせている。

【００４７】

また更にグループＧ１～Ｇ４は、青色発光素子５の発光輝度が最も小さいランクｂ１のグループであり、これに対応して被覆部材７は混入する顔料７ｂの混入率が最も少ないランクｄ１を組み合わせている。以下同様に、グループＧ５～Ｇ８では青色発光素子５のランクｂ２と被覆部材７のランクｄ２を組み合わせ、グループＧ９～Ｇ１２では青色発光素子５のランクｂ３と被覆部材７のランクｄ３を組み合わせ、グループＧ１３～Ｇ１６では青色発光素子５のランクｂ４と被覆部材７のランクｄ４を組み合わせる。

【００４８】

次に図１０に於いて、図９で示した組み合わせグループＧ１～Ｇ１６を実際に組み合わせて発光させた場合、青色発光素子５が発光する青色光Ｐｂと被覆部材７に混入するＹＡＧ系蛍光体が発光する黄色光Ｐｅを混合した白色光Ｐｎの色調がどのように補正されるかを説明する。図１０はＸＹ Ｚ表色系色度座標の一部を用いた色調補正の概念図であり、直線Ｇ１～Ｇ４は前記グループＧ１～Ｇ４がそれぞれ発光する白色光Ｐｎの色調の変化を示している。ここで、直線Ｇ１～Ｇ４の左下付近（楕円Ｐ１）は、前記被覆部材７に混入しているＹＡＧ系蛍光体の蛍光粒子７αの混入量が少ない場合の色調であり、前記青色発光素子５の青色光Ｐｂが大きく影響しやや青味を帯びた白色光Ｐｎとなる。

【００４９】

また、直線Ｇ１～Ｇ４の右上付近（楕円Ｐ２）は前記被覆部材７に混入しているＹＡＧ系蛍光体の蛍光粒子７αの混入量が多い場合の色調であり、該ＹＡＧ系蛍光体の黄色光Ｐｅが大きく影響しやや黄色味を帯びた白色光Ｐｎとなる。ここで、グループＧ１は青色発光素子５の波長が最も短いランクα１であるので、直線Ｇ１の左下付近（楕円Ｐ１）では色度座標Ｘの値は最も大きく色度座標Ｙの値は最も小さく、楕円Ｐ１付近の色調としては他のグループより青に近い。また、該グループＧ１はＹＡＧ系蛍光体の発光波長も最も短い

ランクｃ１であるので、直線Ｇ１の右上付近（楕円Ｐ２）では色度座標Ｘの値が最も小さく色度座標Ｙの値は最も大きく、楕円Ｐ２付近の色調としては他のグループより緑に近づいている。この結果、直線Ｇ１は他の直線Ｇ２～Ｇ４より最も傾きが大きい。

【００５０】

また、グループＧ４は青色発光素子５の波長が最も長いランクａ４であるので、直線Ｇ４の左下付近（楕円Ｐ１）では色度座標Ｘの値は最も小さく色度座標Ｙの値は最も大きく、楕円Ｐ１付近の色調としては他のグループよりやや緑に近づいている。また、該グループＧ４はＹＡＧ系蛍光体の発光波長も最も長いランクｃ４であるので、直線Ｇ４の右上付近（楕円Ｐ２）では色度座標Ｘの値が最も大きく色度座標Ｙの値は最も小さく、楕円Ｐ２付近の色調としては他のグループよりやや赤に近づいている。この結果、直線Ｇ４は他の直線Ｇ１～Ｇ３より最も傾きが小さい。このように、各青色発光素子５とそれに対応するＹＡＧ系蛍光体を混入する被覆部材７を組み合わせたそれぞれのグループＧ１～Ｇ４は、その発光波長の僅かな違いによってそれぞれの色調の傾きが変化することがわかる。

【００５１】

ここで、前述した如く、メーカーが要求する前記白色発光装置１の白色光Ｐｎの色調バラツキ要求範囲は一般的に色度座標Ｘで０．３３±０．０１、色度座標Ｙで同じく０．３３±０．０１であり、図１０で斜線を引いたエリアが要求エリアとなる。よって、該要求エリアの外に白色光Ｐｎの色調があると、その白色発光装置は規格外品として採用されない。しかし、図１０で示すようにグループＧ１～Ｇ４の色調変化を示す直線Ｇ１～Ｇ４は、すべて要求エリアを通過するので、該要求エリア上でグループＧ１～Ｇ４を発光させることができれば、どのグループであってもその白色発光装置１は採用される。

【００５２】

ここで、該グループＧ１～Ｇ４の色調を楕円Ｐ１領域から楕円Ｐ２領域に移動させるためには、被覆部材７に混入するＹＡＧ系蛍光体の蛍光粒子７ａの混入量を変えることによって可能であるので、該被覆部材７に混入するＹＡＧ系蛍光体の蛍光粒子７ａの混入量を適切に管理すれば、グループＧ１～Ｇ４のどの組み合わせであってもほとんど全ての白色発光装置１の色調を要求エリア（すなわち図１０の斜線エリア）に入れることが可能である。尚、他のグループであるグループＧ５～Ｇ１６についても、その組み合わせは図９で説明したように同じであるので、色調補正は同様に可能となる。

【００５３】

次に前記青色発光素子５を実装したサブマウントパッケージ６の発光輝度ランクと前記被覆部材７の顔料混入率のランクの組み合わせによって、混合された白色光Ｐｎがどのように輝度補正され一定の輝度範囲内に調整されるかを説明する。図１１は青色発光素子５を実装したサブマウントパッケージ６と被覆部材７の組合せによって輝度補正される有様を示した輝度補正概念図である。図１１に於いて、横軸は相対値としての輝度を示している。ここで青色発光素子５はｂ１～ｂ４の４つのランクに分類されているので、被覆部材７と組合せる前の青色発光素子５の発光輝度は、実線の丸印で図示するようにそれぞれｂ１～ｂ４のランクに分かれて分散している。

【００５４】

ここで、先に示した図９の組合せに従ってランクｂ１の青色発光素子５にはランクｄ１の被覆部材７を組合せ、ランクｂ２の青色発光素子５にはランクｄ２の被覆部材７を組合せ、ランクｂ３の青色発光素子５にはランクｄ３の被覆部材７を組合せ、ランクｂ４の青色発光素子５にはランクｄ４の被覆部材７を組合せると、その組合せ後の白色光Ｐｎの発光輝度は図１１の実線の矢印線と丸印で示すように、すべてのランクがランクｂ１の輝度レベルに補正される。

【００５５】

すなわち、青色発光素子５の発光輝度が最も暗いランクｂ１は、顔料混入率が０％のランクｄ１である被覆部材７と組み合わされるので、白色光Ｐｎは顔料に妨げられることなく被覆部材７を通過する。また、青色発光素子５の発光輝度が最も明るいランクｂ４は顔料混入率が最も高い４５％のランクｄ４の被覆部材７と組み合わされるので、合成される白

色光Ｐｎは顔料７ｂに最も妨げられて被覆部材７を通過し、よってランクｂ４の輝度はランクｂ１と同じレベルまで低下し、結果としてすべての白色光Ｐｎがランクｂ１の範囲に収まることになる。

【００５６】

また、白色発光装置を採用するメーカーの発光輝度のバラツキ要求範囲が、それほど厳しくなく、図１１において要求範囲が０．６～１．１程度（すなわち２ランク分の範囲）である場合について説明する。この場合は、青色発光素子５のランクｂ１とｂ２は顔料混入率が０％のランクｄ１の被覆部材７と組み合わせる。また、青色発光素子５のランクｂ３はランクｄ２の被覆部材７と組合せ、さらに青色発光素子５のランクｂ４はランクｄ３の被覆部材７と組み合わせる。図１１において破線の矢印線と破線の丸印がこの組合せを示しており、この組合せに於いては、被覆部材７のランクが３種類だけで青色発光素子５の全ランクをカバーすることが出来ので、製造工程が簡素化しコストダウンが可能となる。

【００５７】

次に、前記青色発光素子５を実装したサブマウントパッケージ６と前記被覆部材７の組み合わせ工程で得られた組合せグループＧ１～Ｇ１６を１つの前記ケース体２に組み込んで一体化し、白色発光装置１として完成する工程ついて説明する。図１２は前記ケース体２にサブマウントパッケージ６と被覆部材７をグループごとに組み込む工程を示している。図１２において、例えば、グループＧ１の白色発光装置１を完成させる場合は、まず、図示する如くランクａ１ｂ１のサブマウントパッケージ６をケース体２に実装する。次に、前記サブマウントパッケージ６のランクａ１ｂ１に対応する被覆部材７のランクｃ１ｄ１を選び、前記ケース体２に組み込む。これにより、一体化したグループＧ１の白色発光装置１が完成する。

【００５８】

以下同様に、グループＧ２を完成する場合は、まず、ランクａ２ｂ１のサブマウントパッケージ６をケース体２に実装し、次にランクｃ２ｄ１の被覆部材７をケース体に組み込み、グループＧ２の白色発光装置１を完成する。また、グループＧ１６を完成させる場合は、ランクａ４ｂ４のサブマウントパッケージ６をケース体２に実装し、次にランクｃ４ｄ４の被覆部材７をケース体２に組み込み、グループＧ１６の白色発光装置１を完成する。すなわち、この組み込み工程により、前記青色発光素子５を実装したサブマウントパッケージ６と前記ＹＡＧ系蛍光体の蛍光粒子７ａと顔料７ｂを混入した被覆部材７との最適な組合せが可能となり、色調と輝度のバラツキが極めて少ない白色発光装置１を得ることが出来る。

【００５９】

次に白色発光装置１の製造効率を上げるために、前記ケース体２を集合基板によって多数個同時に形成する製造工程を説明する。図１３は集合基板の製造工程を示す斜視図であり、１０は集合基板でありＭｇ合金等のメタルコア材料から射出成形又はプレス成形によって形成され、カップ状の前記凹部２ｂが縦横に合計９個整列している。次に該凹部２ｂの中心を左右に分離するようにスリット２ｃを加工し、更に、該スリット２ｃへ前記絶縁部材４である樹脂を充填して硬化させる。次に、凹部２ｂの内側の傾斜面２ｄに光沢Ａｇメッキを施し、該凹部２ｂの傾斜面２ｄが光の反射面として機能するようにする。

【００６０】

次に集合基板１０に前記青色発光素子５実装したサブマウントパッケージ６を実装する工程を説明する。図１４は前記集合基板１０に複数のサブマウントパッケージ６を実装する工程を示している。ここで、青色発光素子５を実装したサブマウントパッケージ６は、前述した如く発光波長のランクと発光輝度のランクにより各グループに分類されているが、集合基板１０に複数のサブマウントパッケージ６を実装する場合、同一グループのサブマウントパッケージ６を実装する。すなわち、図１４で示すように、１つの集合基板１０に９個の凹部２ｂが形成され９個の白色発光装置１が製造される場合は、発光波長のランクと発光輝度のランクが共に等しい同一グループのサブマウントパッケージ６を９個用意し、該９個のサブマウントパッケージ６を１つの集合基板１０の凹部２ｂの底面２ｅにそれ

それ同時に実装する。

【００６１】

次にサブマウントパッケージ６を実装した集合基板１０に前記被覆部材７を取り付ける工程を説明する。図１５は集合基板１０に多数個の被覆部材７を同時に取り付ける工程を示している。１１は多数個の前記被覆部材７が一体化された被覆部材集合体であり、それぞれの被覆部材７は前記集合基板１０に形成されるケース体２を構成する凹部２ｂの位置に対応して配設される。１１αは連結部材であり、それぞれの前記被覆部材７の周辺部を３箇所乃至４箇所連結して一体化し、前記被覆部材集合体１１を構成する。

【００６２】

ここで、被覆部材７は前述した如く、混入するＹＡＧ系蛍光体の発光波長のランクと混入する顔料７ｂの混入率のランクにより各グループに分類されているが、前記被覆部材集合体１１を構成する各被覆部材７は、混入するＹＡＧ系蛍光体の発光波長ランクも混入する顔料７ｂの混入率ランクも同一ランクによって構成される。すなわち、前記集合基板１０に前記被覆部材集合体１１を取り付ける場合、既に実装されている青色発光素子５を実装した前記サブマウントパッケージ６と同一グループの被覆部材７によって構成される被覆部材集合体１１を取り付ける。

【００６３】

例えば、既に実装されている青色発光素子５が図９で示したグループＧ４（すなわちランクα４ｂ１）であったとするならば、取り付ける被覆部材集合体１１も同一グループであるグループＧ４（すなわちランクｃ４ｄ１）を用意し、前記集合基板１０を構成するそれぞれの凹部２ｂにはめ込む形で装着し、必要に応じて接着やカシメ等によって固定する。また、前記連結部材１１αは各被覆部材７が集合基板１０に取り付けられた後、治具等によって該被覆部材７から切断され除去される。

【００６４】

次に完成した集合基板１０から白色発光装置１を切り離す分離工程について説明する。図１６は白色発光装置１の分離工程を示しており、９０度の角度で交差する複数のダイシングラインＤＬに沿って集合基板１０を切断分離し、個々の白色発光装置１を完成させる。このように、集合基板１０と被覆部材集合体１１による製造方法によれば、白色発光装置１の大量生産が可能となり、製造効率を大幅に向上させることが出来る。

【００６５】

また、１つの集合基板１０ごとに、同一グループの青色発光素子５を実装したサブマウントパッケージ６と、該サブマウントパッケージ６に対応する同一グループの被覆部材集合体１１を取り付ける工程を実施するならば、１つの集合基板１０に、別々のグループのサブマウントパッケージ６と該サブマウントパッケージ６に対応する別々のグループの被覆部材７を取り付ける工程と比べて、作業効率が格段に優れ、また、サブマウントパッケージ６と被覆部材７の組合せミスも防ぐことが出来る。

【００６６】

なお、集合基板１０は白色発光装置１の取り個数を９個として示したが、取り個数はこれに限定されず、適宜選択できることは勿論である。また、絶縁部材４の形状は、一対のメタルコア３α、３ｂを絶縁分離する機能と結束する機能とを有する限り、必ずしも以上の実施の形態の形状に限定されるものではない。また、被覆部材７はランク分けしたＹＡＧ系蛍光体の蛍光粒子７αとランク分けした顔料７ｂの両方を混入して一つの被覆部材として白色発光装置を製造したが、これに限定されず、例えば二つの被覆部材として構成し、第１の被覆部材にランク分けしたＹＡＧ系蛍光体の蛍光粒子７αを混入し、第２の被覆部材にランク分けした顔料７ｂを混入し、第１の被覆部材と第２の被覆部材を組み合わせて色調及び輝度を調整する白色発光装置の製造方法も可能である。さらに前記第１の被覆部材と第２の被覆部材とを、それぞれ被覆部材集合体として大量生産を行うことで、製造効率の大幅向上が可能となる。

【００６７】

【発明の効果】

以上の説明によって明らかなように本発明の白色発光装置の製造方法によれば、青色発光素子の発光波長や発光輝度がばらついたとしても、被覆部材に混入するＹＡＧ系発光体と顔料をそれぞれランク分けして組み合わせることにより、白色光の色調と輝度の分布を所定の範囲に調整できるので、白色発光装置を量産する上において規格外の製品を極力減らすことができ、製造工程の効率化、品質向上、コストダウン等にその効果は極めて大きい。

【００６８】

また、青色発光素子は放熱効果の優れたメタルコア上に実装されているので、周囲温度が高い環境での動作も可能となり、車載用を初めとして多くの用途で使用することが可能である。さらには、発光の反射面となる凹部内側の傾斜面は、光の反射効率の良い光沢メッキが施されているので、被覆部材に混入する顔料によって発光輝度がある程度低下したとしても、その低下分を十分に補う反射面を有しているので、発光効率の優れた白色発光装置を提供することが出来る。

【図面の簡単な説明】

【図１】本発明の実施の形態である白色発光装置を構成するケース体の斜視図である。

【図２】本発明の実施の形態である白色発光装置の完成断面図である。

【図３】本発明の実施の形態である青色発光素子の発光波長分布図である。

【図４】本発明の実施の形態である青色発光素子の発光輝度分布図である。

【図５】本発明の実施の形態である青色発光素子の発光波長ランク表である。

【図６】本発明の実施の形態である青色発光素子の発光輝度ランク表である。

【図７】本発明の実施の形態である被覆部材の発光波長ランク表である。

【図８】本発明の実施の形態である被覆部材の顔料混入率ランク表である。

【図９】本発明の実施の形態である青色発光素子を実装したサブマウントパッケージと被覆部材の組み合わせ表である。

【図１０】本発明の実施の形態であるＸＹＺ表色系色度座標の一部を用いた色調補正の概念図である。

【図１１】本発明の実施の形態である青色発光素子を実装したサブマウントパッケージと被覆部材との組合せによる輝度補正概念図である。

【図１２】本発明の実施の形態である青色発光素子を実装したサブマウントパッケージと被覆部材の組み込み工程を示す説明図である。

【図１３】本発明の実施の形態である集合基板の製造工程を示す斜視図である。

【図１４】本発明の実施の形態である集合基板にサブマウントパッケージを実装する工程を示す斜視図である。

【図１５】本発明の実施の形態である集合基板に被覆部材集合体を取り付ける工程を示す斜視図である。

【図１６】本発明の実施の形態である集合基板から白色発光装置を切り離す分離工程を示す斜視図である。

【図１７】従来の白色発光装置の構成と作用を示す断面図である。

【図１８】従来の白色発光装置の色調バラツキを示す分布図である。

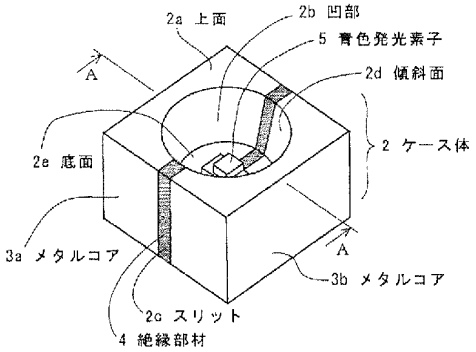
【図１９】従来の白色発光装置の発光輝度のバラツキを示す分布図である。

【符号の説明】

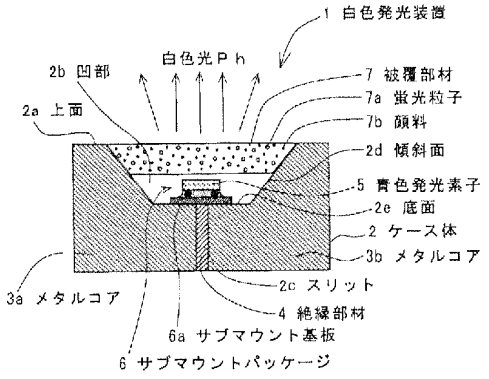
１、２０　白色発光装置
２　ケース体
２ａ　上面
２ｂ　凹部
２ｃ　スリット
２ｄ　傾斜面
２ｅ　底面
３ａ、３ｂ　メタルコア
４　絶縁部材

５、２４　青色発光素子
６　サブマウントパッケージ
６ａ　サブマウント基板
７、２７　被覆部材
７ａ、２６　蛍光粒子
７ｂ　顔料
１０　集合基板
１１　被覆部材集合体
１１ａ　連結部材
Ｐｂ　青色光
Ｐｅ　黄色光
Ｐｈ　白色光

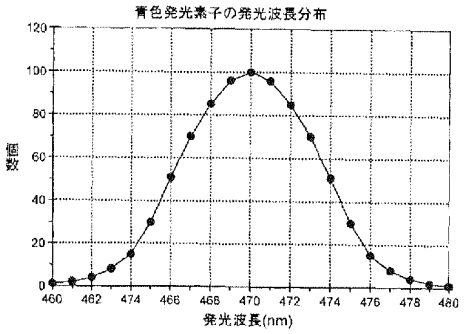
【図１】



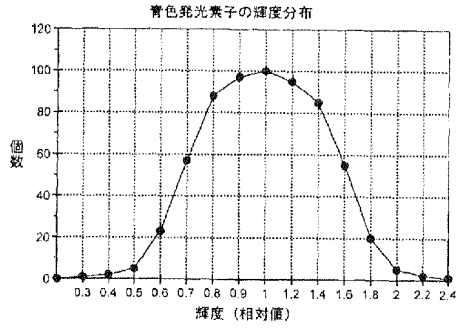
【図２】



【図３】



【図４】



【図５】

発光波長ランク表

波長のランク番号	発光波長範囲
ａ１	４６２～４６６ｎｍ
ａ２	４６６～４７０ｎｍ
ａ３	４７０～４７４ｎｍ
ａ４	４７４～４７８ｎｍ

【図６】

発光輝度ランク表

輝度のランク番号	輝度範囲（相対値）
ｂ１	０．６～０．８
ｂ２	０．８～１．１
ｂ３	１．１～１．５
ｂ４	１．５～２．０

【図７】

被覆部材の発光波長ランク表

波長のランク番号	発光波長範囲
ｃ１	５６０～５６５ｎｍ
ｃ２	５６５～５７０ｎｍ
ｃ３	５７０～５７５ｎｍ
ｃ４	５７５～５８０ｎｍ

【図８】

被覆部材の顔料混入率ランク表

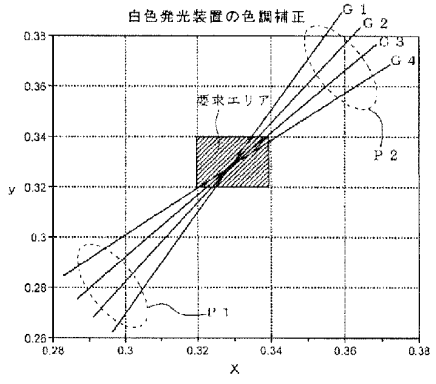
顔料ランク番号	顔料混入率
ｄ１	０％
ｄ２	１５％
ｄ３	３０％
ｄ４	４５％

【図９】

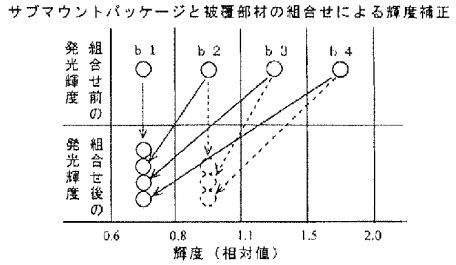
サブマウントパッケージと被覆部材の組み合わせ表

グループ	青色発光素子のランク	被覆部材のランク
Ｇ１	ａ１ｂ１	ｃ１ｄ１
Ｇ２	ａ２ｂ１	ｃ２ｄ１
Ｇ３	ａ３ｂ１	ｃ３ｄ１
Ｇ４	ａ４ｂ１	ｃ４ｄ１
～	～	～
Ｇ９	ａ１ｂ３	ｃ１ｄ３
Ｇ１０	ａ２ｂ３	ｃ２ｄ３
Ｇ１１	ａ３ｂ３	ｃ３ｄ３
Ｇ１２	ａ４ｂ３	ｃ４ｄ３
Ｇ１３	ａ１ｂ４	ｃ１ｄ４
Ｇ１４	ａ２ｂ４	ｃ２ｄ４
Ｇ１５	ａ３ｂ４	ｃ３ｄ４
Ｇ１６	ａ４ｂ４	ｃ４ｄ４

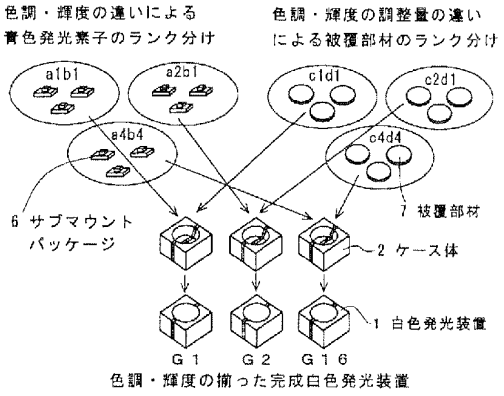
【図１０】



【図１１】

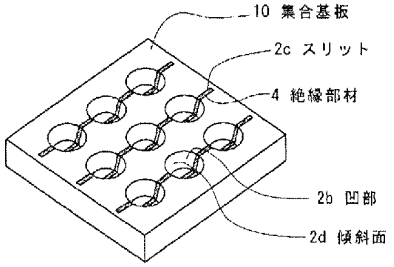


【図１２】

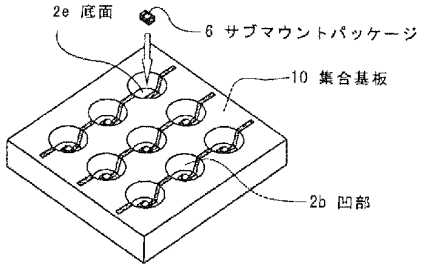


色調・輝度の揃った完成白色発光装置

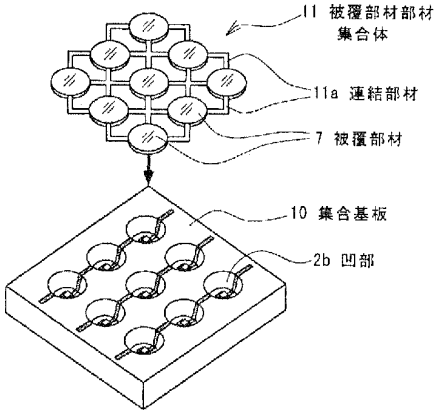
【図１３】



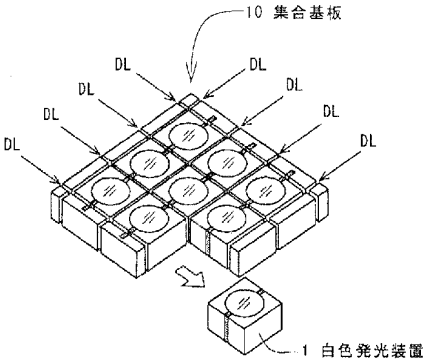
【図１４】



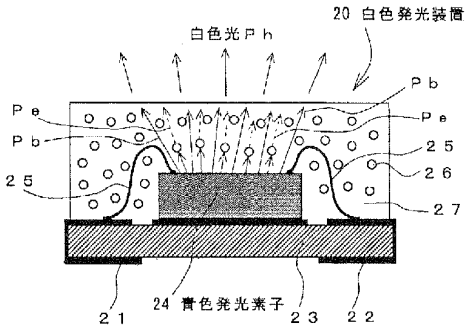
【図１５】



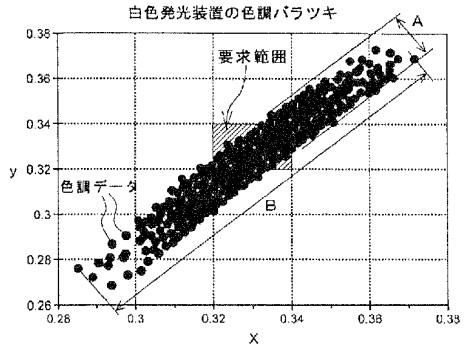
【図１６】



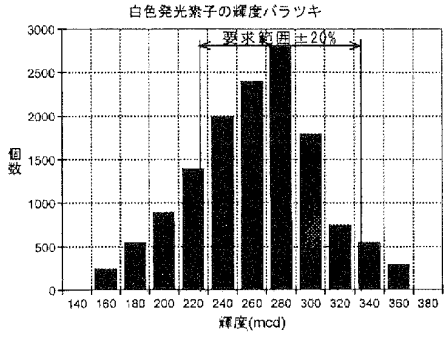
【図１７】



【図１８】



【図１９】



Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol RYU
Filer:	Timothy E. Murphy/Jennifer Abernathy
Attorney Docket Number:	1226-021
Filed as Large Entity	

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	300	300
Natl Stage Search Fee - Report provided	1642	1	400	400
National Stage Exam - all other cases	1633	1	200	200
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**900**

Electronic Acknowledgement Receipt	
EFS ID:	2240415
Application Number:	11909700
International Application Number:	PCT/KR06/00885
Confirmation Number:	7772
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol RYU
Customer Number:	20575
Filer:	Timothy E. Murphy/Jennifer Abernathy
Filer Authorized By:	Timothy E. Murphy
Attorney Docket Number:	1226-021
Receipt Date:	25-SEP-2007
Filing Date:	
Time Stamp:	18:16:08
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$900
RAM confirmation Number	2755
Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1	Miscellaneous Incoming Letter	1226-021_Misc_Fee.pdf	54021 0e9f3a6e617560c63067c7a5432f78062f7de3ba	no	1
Warnings:					
Information:					
2	Documents submitted with 371 Applications	1226-021_DO_EO_US_transmittal.pdf	492202 e8dc9a0d39cc96dd7dc8846da9a965b0e5f7a3f4	no	3
Warnings:					
Information:					
3	Application Data Sheet	1226-021_Application_Data_Sheet.pdf	1010460 32afffee077f4e13666ee59b194a70b84f37cf45	no	5
Warnings:					
Information:					
4		1226-021_Application.pdf	1512493 f819909b70aae050d1edbe4033e2dae77d16bbc9	yes	20

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	15
Claims	16	19
Abstract	20	20

Warnings:					
Information:					
5	Drawings	1226-021_Drawings.pdf	100732 44dd9cbde00051de5e45cc4471af03f3750b48f5	no	2
Warnings:					
Information:					
6	Oath or Declaration filed	1226-021_Declaration.pdf	286522 7b8647cb956d153097b7d30dc21cc5cbb6f13356	no	3
Warnings:					
Information:					
7	Preliminary Amendment	1226-021_Preliminary_Amendment.pdf	471084 61c5b8afd40b8d363451a7741634e3cb1aba2601	no	6
Warnings:					
Information:					

8	Documents submitted with 371 Applications	WO2006104319.pdf	817157 9d8bff244291d0856856872c63e034f36d503371	no	17
Warnings:					
Information:					
9	Documents submitted with 371 Applications	1226-021_PCT_IB_304.pdf	79795 8ab0b8e94f5740088e8a2d847bc201e88aa34650	no	1
Warnings:					
Information:					
10	Documents submitted with 371 Applications	1226-021_PCT_IB_308.pdf	79476 e9e6eae95d10888a6788f04b8ed2d9e9e0568574	no	1
Warnings:					
Information:					
11	Documents submitted with 371 Applications	1226-021_Search_Report.pdf	316805 ace40fa499a077f2a4062dc2b0936c981de9b5fa	no	3
Warnings:					
Information:					
12	Information Disclosure Statement (IDS) Filed	1226-021_IDS.pdf	688026 39d8958bb9b62c50a5f873bc34acb90f1a62994d	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.					
13	Foreign Reference	WO9805078.pdf	3298595 209be965153a8fa228c2e37e27332de5a93f8382	no	85
Warnings:					
Information:					
14	Foreign Reference	KR1020010097147.pdf	981886 b9df51ad3af149e024a4e8040f804868cf718892	no	13
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15	Foreign Reference	JP2004296830.PDF	1237399 0da73a37d92f1e26f280e4adb89035e9a284e290	no	13
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16	Foreign Reference	JP2004119743.pdf	2061557 8146684eb170d9213c3a7b507d0e3d480db4720d	no	17
Warnings:					
Information:					
17	Fee Worksheet (PTO-06)	fee-info.pdf	8465 d954ac9f9268192c352a579e644d2060954ec8c3	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	13496675	

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.

Docket No.: 1226-021

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

MISCELLANEOUS TRANSMITTAL LETTER FOR

EFS FILING OF PATENT APPLICATION REGARDING PAYMENT OF FEES

	Number of Claims Filed with New Application
Total Claims	16
Independent Claims	2

☒ Payment of fees is made via electronic filing system authorizing credit card payment for the following: (1) Basic National Fee - $300.00; (2) Examination Fee - $200.00; and (3) Search Fee -- $400.00. **(Total = $900.00).**

☒ In the event of computer malfunction, Applicant requests that any fees be charged to deposit account number 13-1703.

☒ Please charge any deficiency or overpayment to deposit account number 13-1703.

Customer No. 20575

Respectfully submitted,



Hosoon Lee
Registration No. 56,737

MARGER JOHNSON & McCOLLOM, P.C.
210 SW Morrison Street, Suite 400
Portland, OR 97204
(503) 222-3613

PTO-1390 (Rev. 09-2006)
Approved for use through 3/31/2007. OMB 0651-0021
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.

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

		ATTORNEY'S DOCKET NUMBER: 1226-021
		U.S. APPLICATION NO. (If known, see 37 CFR 1.5):
INTERNATIONAL APPLICATION NO.: PCT/KR2006/000885	INTERNATIONAL FILING DATE: March 13, 2006 (13.03.2006)	PRIORITY DATE CLAIMED: March 31, 2005 (31.03.2005)

TITLE OF INVENTION: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHO

APPLICANT(S) FOR DO/EO/US: Seung Ryeol Ryu and Seok Jin Kang

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☑ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☑ A preliminary amendment. PLEASE ENTER PRELIMINARY AMENDMENT PRIOR TO CALCULATION OF CLAIM FEES
14. ☑ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☐ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. 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 15 minutes to complete, including gathering information, preparing, and submitting the completed 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: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
	PCT/KR2006/000885	1226-021

20. Other items or information:

PCT/IB/304
PCT/IB/308
Search Report

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) **$300**	$ 300.00	
22. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4)..... **$0** All other situations..... **$200**	$ 200.00	
23. ☑ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4)..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority..... **$100** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB..... **$400** All other situations..... **$500**	$ 400.00	
TOTAL OF 21, 22 and 23 =	$900.00	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
The fee is **$250** for each additional 50 sheets of paper or fraction thereof.

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE	
22 - 100 =	0 /50 =	0	x $250	$ 0.00

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	10 - 20 =		x $ **50**	$ 0.00	
Independent claims	2 - 3 =		x **$200**	$ 0.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$360**	$ 0.00	
			TOTAL OF ABOVE CALCULATIONS =	$ 900.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.					
			SUBTOTAL =	$ 900.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$ 0.00	
			TOTAL NATIONAL FEE =	$ 900.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00	
			TOTAL FEES ENCLOSED =	$ 900.00	
			Amount to be refunded:	$	
			Amount to be charged	$	

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 131703. A duplicate copy of this sheet is enclosed.

d. ☑ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR.** To protect your information, it is recommended paying fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

Marger Johnson & McCollom, P.C.
210 SW Morrison Street, Suite 400
Portland, Oregon 97204
US



SIGNATURE

Hosoon Lee

NAME

56,737

REGISTRATION NUMBER

PTO/SB/14 (02-07)
Approved for use through 02/28/2007. 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 contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	1226-021
	Application Number	
Title of Invention	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	1226-021
	Application Number	
Title of Invention	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR	

Customer Number	20575		
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Application Information:

Title of the Invention	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR		
Attorney Docket Number	1226-021	**Small Entity Status Claimed** ☐	
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	2	**Suggested Figure for Publication (if any)**	
Publication Information:			
☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)			
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not been and will not be the subject of an application filed in another country, or under a multilateral agreement, that requires publication at eighteen months after filing.			

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Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)

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This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
PCT/KR2006/000885	WO	2006-03-13	(•) Yes ( ) No

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
10-2005-0027133	KR	2005-03-31	(•) Yes ( ) No

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Assignee Information:

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Assignee 1 Remove

If the Assignee is an Organization check here. ☒

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Signature:

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Signature	/Hosoon Lee/			Date (YYYY-MM-DD)	2007-09-25
First Name	Hosoon	Last Name	Lee	Registration Number	56737

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This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

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BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Technical Field

The present invention relates to a backlight panel for backlighting a display panel, and more particularly, to a backlight panel employing a white light emitting diode with red and green phosphors as a light source to enhance color reproducibility and luminance.

Background Art

A passive display device such as a liquid crystal display (LCD) reflects or absorbs ambient sunlight or indoor light to display images on an LCD panel. Thus, the ambient sunlight or indoor light is required for a user to view the displayed image. However, in a case where intensity of the ambient sunlight or indoor light is not sufficient to illuminate a display panel, there is a problem in that the user cannot view the displayed image. As an alternative to such a problem, a backlight panel for backlighting a display panel is generally employed.

A backlight panel includes a light source such as an incandescent lamp, fluorescent lamp or light emitting diode (LED). Light emitted from the light source illuminates the LCD panel, and thus, images are implemented. Meanwhile, since the LED has superior reproducibility, it has been frequently used as a backlight source. In addition, since the LED is environmentally friendly, it is expected that its use will be further increased in the future.

Fig. 1 is a partial sectional view illustrating a conventional backlight panel for backlighting an LCD panel 17 using light emitting diodes (LEDs).

Referring to Fig. 1, an LED array is arranged on a printed circuit board 1. The LED array is an array in which red, green and blue LEDs 3r, 3g and 3b are arranged at a

predetermined interval. The LEDs are arranged on the printed circuit board 1 in a regular order and constructed into an LED module, and a plurality of LED modules are used to backlight the LCD panel 17.

Each of the LEDs employs a lens designed for side-luminescence such that major light can be radiated almost in a side direction.

A reflection sheet 5 is positioned below light exit surfaces of the LEDs. The reflection sheet may be formed with a reflection layer 5a on the top thereof. The reflection sheet reflects light emitted from the LEDs in an upward direction.

Furthermore, a light transmission layer 7 is positioned above the LEDs. The light transmission layer is a layer through which light emitted from the LED can be transmitted. The light transmission layer is generally made of a transparent resin such as PMMA (poly methyl methacrylate). The light transmission layer 7 is provided with light shielding patterns 9 at positions corresponding to the LEDs. The light shielding patterns function to prevent light emitted upward from the LEDs from penetrating the light transmission layer and then traveling toward the LCD panel 17. The light shielding patterns may be formed through an ESR (eletroslag remelting) process.

The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a first gap 6a which is an air layer. The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are mixed with one another.

A diffusion plate 11 is positioned above and spaced apart from the light transmission layer 7. The diffusion plate 11 diffuses light incident thereon to make the light uniform. The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a second gap 10a which is an air layer. Thus, the light

transmitted through the light transmission layer 7 is again mixed within the second gap 10a and the mixed light is then incident onto the diffusion plate 11.

A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film-embossed (DBEF-E) is positioned on a top surface of the BEF 13. The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

Since the red, green and blue LEDs are used as light sources according to a prior art, the color reproducibility can be enhanced. However, it is necessary to mix light emitted from the LEDs in order to obtain the uniform light. Accordingly, it is necessary to prevent light emitted from the LEDs from transmitting directly through the light transmission layer 7 and traveling toward the diffusion plate 11 by using the light shielding pattern 9. Further, air layers such as the first and second gaps 6a and 10a are required. These result in an increase in thickness of a backlight panel.

Further, while light emitted from the LEDs is mixed, light loss is generated. Thus, such light loss should be compensated by increasing an amount of current supplied to the LEDs, by using a larger number of LEDs or by using the BEF 13, the DBEF 15 and the like. However, in a case where the amount of current is increased or a large number of LEDs are used, power consumption is increased. In particular, the increase in the amount of current leads to an increase of heat generated from the LEDs, and the light shielding layer may be deteriorated. In addition, the use of the BEFs causes the total thickness of the backlight

panel to be further increased and the manufacturing costs of the backlight panel to be increased.

Technical Problem

An object of the present invention is to provide a backlight panel which has smaller thickness and reduced manufacturing costs as compared with a conventional backlight panel.

Another object of the present invention is to provide a backlight panel capable of enhancing its luminance as compared with a conventional backlight panel.

Technical Solution

In order to achieve the above objects of the present invention, there is provided a backlight panel employing a white light emitting diode with red and green phosphors. A backlight panel according to an aspect of the present invention comprises a light guide plate for emitting light incident from a side direction. The light guide plate emits light through a top surface thereof. The white light emitting diodes are arranged at a side of the light guide plate to emit white light into the light guide plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a diffusion plate is positioned over the top surface of the light guide plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and the thickness of the backlight panel can also be reduced, by employing the white light emitting diode with three red, green and blue wavelengths.

Further, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate. The brightness enhancement films can enhance the luminance of the backlight panel.

A backlight panel according to another aspect of the present invention comprises a diffusion plate having a top surface and a bottom surface. White light emitting diodes are arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a reflection sheet is positioned below light exit surfaces of the white light emitting diodes and also allows light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and spaces or gaps where light is mixed can also be reduced, so that the thickness of the backlight panel can be reduced. Further, since the luminance can be enhanced with the use of a light source for upward emitting light, brightness enhancement films can be omitted.

In addition, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate to further increase the luminance of the backlight panel.

Preferably, the red phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate red light. The red phosphor may be an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of about 2 to about 5; and a/x is set within a range of about 0.0005 to about 0.02.

Preferably, the green phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate green light. The green phosphor may be a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element selected from

the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of about 0.01 to about 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of about 0.2 to about 0.8.

Advantageous Effects

According to the embodiments of the present invention, there is provided a backlight panel which has smaller thickness and reduced manufacturing costs as compared with the coventional backlight panel. Further, there is provided a backlight panel having enhanced luminance as compared with the conventional backlight panel.

Meanwhile, in a case where the red, green and blue LEDs are used as described in the prior art, the life spans and degrees of deterioration of the LEDs are different from one another. Thus, a color sensor should be installed on the LCD panel to detect the deterioration of the LEDs and to perform a compensation work. However, since the white LEDs of the same kinds are used in the embodiments of the present invention, the life spans and deterioration of the LEDs are generally similar to one another. Therefore, it is less necessary to use the color sensor and perform the compensation work. Accordingly, an operation circuit of the LCD panel can be further simplified.

Description of Drawings

Fig. 1 is a sectional view illustrating a conventional backlight panel.

Fig. 2 is a sectional view illustrating a backlight panel according to an aspect of the present invention.

Fig. 3 is a sectional view illustrating another embodiment of the backlight panel according to the aspect of the present invention.

Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

Fig. 5 is a sectional view illustrating a white light emitting diode of the present invention.

Mode for Invention

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided only for illustrative purposes so that those skilled in the art can fully understand the spirit of the present invention. Therefore, the present invention is not limited to the following embodiments but may be implemented in other forms. In the drawings, the widths, lengths, thicknesses and the like of components may be exaggerated for convenience of illustration. Like reference numerals indicate like elements throughout the specification and drawings.

Fig. 2 is a sectional view illustrating a backlight panel for backlighting a liquid crystal display panel 37 (hereinafter, referred to as "LCD panel") according to an aspect of the present invention.

Referring to Fig. 2, a light guide plate 27 is positioned below the LCD panel 37. The light guide plate converts light emitted from a light source 23w into surface light and then emits the surface light upward toward the LCD panel. The light guide plate 27 may be made of glass, a transparent resin such as a transparent acryl resin or a polycarbonate or epoxy resin, or the like. Both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns,

if necessary. Further, a reflection sheet 25 may be positioned on a bottom surface of the light guide plate.

White light emitting diodes (hereinafter, referred to as "LEDs") are positioned adjacent to a side of the light guide plate. Each of the white LEDs emits white light toward the side of the light guide plate 27. The white LED may be mounted on a printed circuit board 21, and a plurality LEDs may be mounted on the printed circuit board 21 as an LED module. The LEDs 23w mounted on the printed circuit board 21 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 27. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

The white LED 23w includes a blue LED chip, and green and red phosphors which are positioned over the blue LED chip to convert a portion of blue light into green and red light, respectively. The white LED 23w will be described in detail later with reference to Fig. 5.

Meanwhile, light shielding walls 29 are positioned above and below the white LED 23w, respectively. The light shielding walls prevent light emitted from the white LED 23w from traveling toward regions other than the side of the light guide plate 27. A reflection layer is coated on an inner wall of the light shielding wall 29 to enable light incident onto the light shielding wall to be reflected. Such a reflection layer may be also formed on a top surface of the printed circuit board 21.

A diffusion plate 31 is positioned over top surface of the light guide plate 27. The diffusion plate 31 may be a thin sheet. The diffusion plate 31 diffuses light incident from the light guide plate 27 into uniform light. Moreover, a brightness enhancement film (BEF) 33 and/or a dual brightness enhancement film (DBEF) 35 may be interposed between the

diffusion plate 31 and the LCD panel 37. The BEFs 33 and 35 collect light emitted from the light guide plate 27 within a certain showing angle to increase the luminance of light.

Since the backlight panel according to the aspect of the present invention is mounted with the white LED to enable uniform white light to be emitted from the LED, an air layer used for mixing the red, green and blue light with one another is not necessary, as compared with the prior art. Thus, the thickness of the backlight panel can be decreased. Further, since light emitted from the white LED is incident directly onto the light guide plate 27, the light emitting luminance can be enhanced. Thus, the BEFs 33 and 35 may be omitted. Furthermore, in a case where the BEFs are used, the luminance can be further enhanced. Thus, the number of LEDs used can also be reduced.

Fig. 3 is a sectional view illustrating another embodiment of the backlight panel according to the aspect of the present invention.

Referring to Fig. 3, the diffusion plate 31, the BEFs 33 and 35, and the LCD panel 37 are provided in the same manner as described with reference to Fig. 2. Hereinafter, only differences between the backlight panels of Figs. 2 and 3 will be described in detail.

A light guide plate 47 is positioned below the diffusion plate 31. The light guide plate 47 is formed with a receiving groove 47a at a side thereof to accommodate LEDs in the receiving groove. As described with reference to Fig. 2, the light guide plate 47 may be made of glass, a transparent resin such as a transparent acryl resin or a polycarbonate or epoxy resin, or the like. Further, both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Furthermore, the reflection sheet 25 can be positioned on a bottom surface of the light guide plate. The reflection sheet 25 may be attached to the bottom surface of the light guide plate 47 to extend to the side thereof and have a through-hole

through which the LEDs can be received in the receiving groove 47a of the light guide plate 47.

A white LED 43w is accommodated in the receiving groove 47a. The white LED is a side-view LED which emits light almost in parallel with top and bottom surfaces of the light guide plate 47, i.e. perpendicular to the side surfaces thereof. The side-view LED can adjust a showing angle of emitted light to be smaller than that of an LED emitting light upward, so that the thickness of the light guide plate 47 can be reduced.

The white LED may be mounted on a printed circuit board 41, and a plurality LEDs may also be mounted on the printed circuit board 41 as an LED module. The LEDs 43w mounted on the printed circuit board 41 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 47. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

According to this embodiment, the side-view LED capable of adjusting a showing angle to be smaller is mounted such that the thickness of the light guide plate can be reduced.

Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

Referring to Fig. 4, a diffusion plate 61 is positioned below an LCD panel 67. The diffusion plate has a top surface and a bottom surface. BEF 63 and/or DBEF 65 may be interposed between the diffusion plate and the LCD panel 67.

Meanwhile, white LEDs 53w are arranged below the bottom surface of the diffusion plate 61 at a certain interval from the diffusion plate 61. Each of the white LEDs 53w includes a blue LED chip, and green and red phosphors positioned over the blue LED chip. The white LEDs 53w will be described in detail later with reference to Fig. 5.

Each of the white LEDs 53w emits white light toward the diffusion plate 61. The white LED may be mounted on a printed circuit board 51, and a plurality LEDs may be mounted on the printed circuit board 51 as an LED module. The LEDs 53w mounted on the printed circuit board 51 may be simultaneously driven through a circuit printed on the printed circuit board. A plurality of LED modules may be arranged below the diffusion plate 61 to uniformly backlight the LCD panel 67.

Furthermore, a reflection sheet 55 is positioned below light exit surfaces of the white LEDs 53w. The reflection sheet 55 may be formed with a reflection layer 55a thereon. The reflection sheet may be made of an aluminum sheet and coated with the reflection layer 55a thereon. Further, the reflection sheet 55 may be attached onto the printed circuit board 51 as shown in this figure.

The reflection sheet 55 and the diffusion plate 61 are spaced apart from each other by a predetermined interval to define a gap 60a corresponding to an air layer. White light emitted from the white LEDs 53w are mixed with one another in the gap 60a and then incident onto the diffusion plate 61.

The backlight panel according to this aspect does not use an additional light guide plate. Thus, the diffusion plate 61 may be thicker than the diffusion plate 31 of Fig. 2 or 3 such that light emitted from the white LEDs 53w can be uniform.

In the meantime, since the backlight panel according to this aspect employs top-view white LEDs contrary to the prior art, the light transmission layer 7 (Fig. 1) formed with the light shielding pattern 9 (Fig. 1) may be omitted. Further, since light emitted from the white LEDs 53w is incident directly onto the diffusion plate 61, the light loss can be reduced so that the luminance of the LCD panel 67 can be enhanced. Accordingly, since the BEF 63 and the DBEF 65 can be omitted, the thickness of the backlight panel can also be reduced.

Fig. 5 is a sectional view illustrating the white LED 23w, 43w or 53w used in the embodiments of the present invention.

Referring to Fig. 5, the white LED includes a package body 71. The package body may be formed using an injection molding, pressing or machining technique, and particularly injection-molded using a plastic resin. The package body is formed with a cavity which exposes lead terminals 73. Further, a sidewall of the cavity may be an inclined surface inclined at a certain angle.

The lead terminals 73 extend outward to protrude out of the package body 71. The lead terminals 73 protruding to the outside are connected to a printed circuit board and electrically connected to an external power source. The lead terminals 73 may be bent from the outside such that they can be surface mounted.

Meanwhile, a heat sink 75 may be attached to the bottom of the package body 71. The heat sink is provided to easily dissipate heat generated from an LED chip 77 to the outside. The heat sink 75 may be formed with a base and a projection protruding upward from a center portion of the base. The projection is inserted into the package body and then exposed to the cavity. After the package body 71 has been formed with a through-hole, the heat sink can be inserted into the through-hole of the package body and mounted to the package body. Alternatively, the heat sink 75 can be attached to the package body 71 by positioning the lead terminals 73 and the heat sink 75 and then forming the package body using an insert-molding technique. The heat sink 75 may be electrically isolated from the lead terminals 75, or electrically connected to any one of the lead terminals.

A blue LED chip 77 for emitting blue light is mounted on the heat sink 75. The LED chip 77 is a GaN, InGaN or AlGaInN-based light emitting diode and radiates blue light with a wavelength of about 420 to about 480 nm. The LED chip 77 has two electrodes for the connection with an external source. The electrodes may be positioned on the same side

or opposite sides of the LED 77. The electrodes may be electrically connected to the lead terminals through an adhesive or bonding wires as shown in this figure. In a case where the electrodes are formed on the same side of the LED chip, the LED chip 77 and the lead terminals are connected through the two bonding wires, respectively, so that they can be electrically connected as shown in this figure. On the other hand, in a case where the electrodes are positioned on the opposite sides, one of the electrodes is connected to the heat sink 75 using a conductive adhesive and one of the lead terminals is connected to the heat sink 75 through the bonding wire, so that the lead terminals and the LED chip 77 can be electrically connected with each other.

Over the blue LED chip 77 is positioned red and green phosphors 81r and 81g which are excited by blue light to radiate red and green light, respectively, such that the radiated light is mixed with a portion of blue light emitted from the LED chip 77 to become white light. The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.

For example, the red phosphor 81r may be an alkali earth metal sulfide-based red phosphor, while the green phosphor 81g may be a thiogallate-based green phosphor. More specifically, the alkali earth metal sulfide-based red phosphor is expressed as general formula $A_{x-a}Eu_aGeS_z$, where A is Ca and/or Sr, $z=x+2$, x is set within a range of 2 to 5, and a/x is set within a range of about 0.0005 to about 0.02.

Further, the thiogallate-based green phosphor is expressed as general formula $(A_{1-x-y}Eu_x(M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$, where A is at least one element selected from the group consisting of Ba, Sr and Ca, B is at least one element selected from the group consisting of Al, Ga and In, and $0<x, y, x+y<1$. Preferably, x is set within a range of about 0.01 to about 0.1.

Meanwhile, M^{I} is at least one element selected from the group consisting of Li, Na and K, and M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La. Preferably, y is set within a range of about 0.2 to about 0.8.

Such red and green phosphors 81r and 81g are obtained in the following manners. That is, phosphor raw materials and an activator raw material are weighted to have a predetermined mixing ratio in accordance with a desired composition and sufficiently mixed into a uniform mixture by using a ball milling or a mixer such as agate mortar within an alcohol solvent for effective mixing. Then, the mixture is dried in an oven at a temperature of about 100 to about 150°C for about 1 to 2 hours. The dried mixture is heat-treated in a high-purity alumina boat at a temperature of about 800 to about 1300°C under the atmosphere of H_2S using an electric furnace to synthesize phosphor powder and then sufficiently pulverize the synthesized phosphor powder.

According to the results of measuring photoluminescence (PL) of the powder, the thiogallate-based green phosphor of a typical composition expressed as $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$ exhibits strong photoluminescence spectrum throughout a region of 470 to 630 nm while the alkali earth metal sulfide-based red phosphor expressed as $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ exhibits strong photoluminescence spectrum throughout a region of 520 to 780 nm. Accordingly, white light with distinct red, green and blue wavelengths can be radiated using the blue LED chip 77 and the phosphors, and thus, the color reproducibility of the LCD panel can be enhanced.

Meanwhile, the LED chip 77 and the phosphors 81r and 81g are covered with a lens 83. The lens may be formed into a variety of shapes. For example, to implement a top-view LED according to the aspects of the present invention, the lens may take the shape of a convex lens as shown in this figure. At this time, the curvature of the lens is determined depending on a desired showing angle. Meanwhile, to implement a side-view

LED shown in Fig. 2, the lens is designed to emit light from the LED chip 77 in a side direction. An example of such a side-view LED is shown in Fig. 1, and the other side-view LEDs can be implemented into a variety of lens shapes.

CLAIMS

1. A backlight panel, comprising:

a light guide plate for emitting light incident from a side direction, the light guide emitting light through a top surface thereof;

white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and

a diffusion plate positioned over the top surface of the light guide plate,

wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

2. The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

3. The backlight panel as claimed in claim 1, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of about 2 to about 5; and a/x is set within a range of about 0.0005 to about 0.02.

4. The backlight panel as claimed in claim 1, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of about 0.01 to about 0.1; M^I is at least one element selected from the group

consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of about 0.2 to about 0.8.

5. The backlight panel as claimed in claim 1, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of about 2 to about 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$, where $0<x,\ y,\ x+y<1$; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of about 0.01 to about 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of about 0.2 to about 0.8.

6. A backlight panel, comprising:

a diffusion plate having a top surface and a bottom surface;

white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and

a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,

wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

7. The backlight panel as claimed in claim 6, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

8. The backlight panel as claimed in claim 6, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of about 2 to about 5; and a/x is set within a range of about 0.0005 to about 0.02.

9. The backlight panel as claimed in claim 6, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^I_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of about 0.01 to about 0.1; M^I is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of about 0.2 to about 0.8.

10. The backlight panel as claimed in claim 6, wherein

the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of about 2 to about 5; and a/x is set within a range of about 0.0005 to about 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^I_{0.5}M^{III}_{0.5})_y)B_2S_4$, where $0<x, y, x+y<1$; A is at least one element

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selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of about 0.01 to about 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of about 0.2 to about 0.8.

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

ABSTRACT

Disclosed is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Accordingly, since the backlighting can be performed using white light with distinct red, green and blue wavelengths, the color reproducibility can be enhanced. Further, since the white light can be implemented with a single light emitting diode, the manufacturing costs and thickness of the backlight panel can also be reduced.

Figure 1

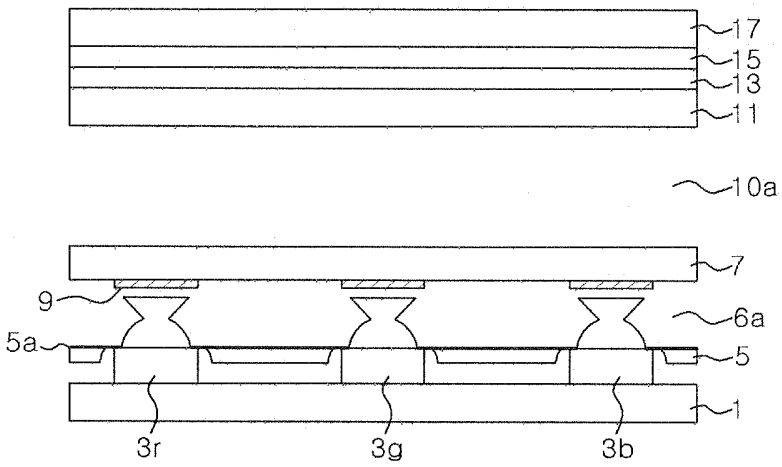


Figure 2

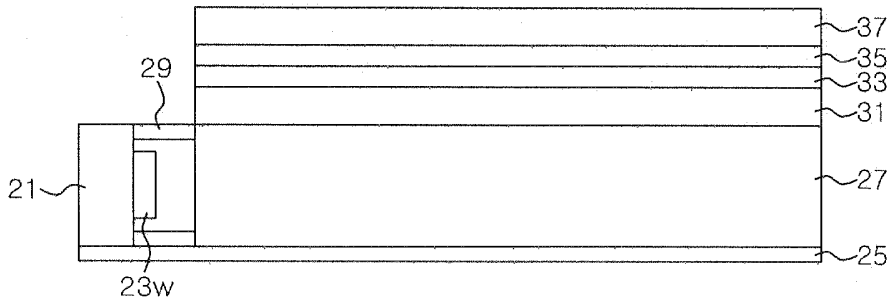


Figure 3

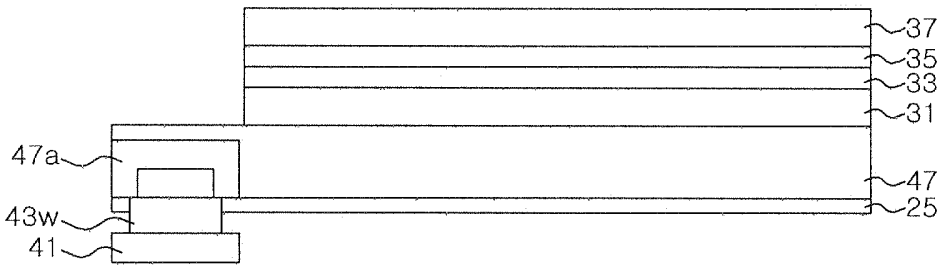


Figure 4

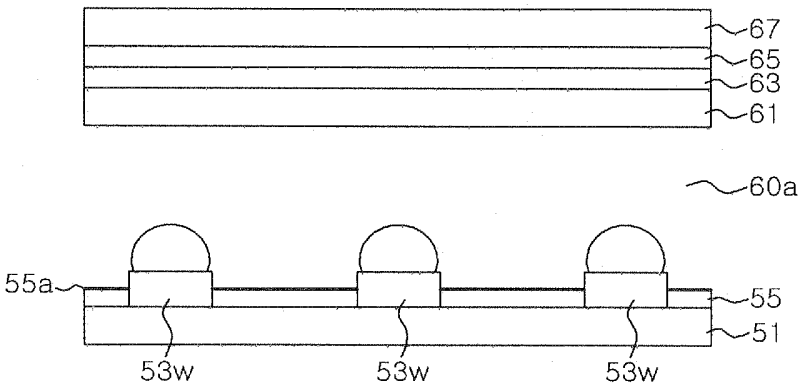
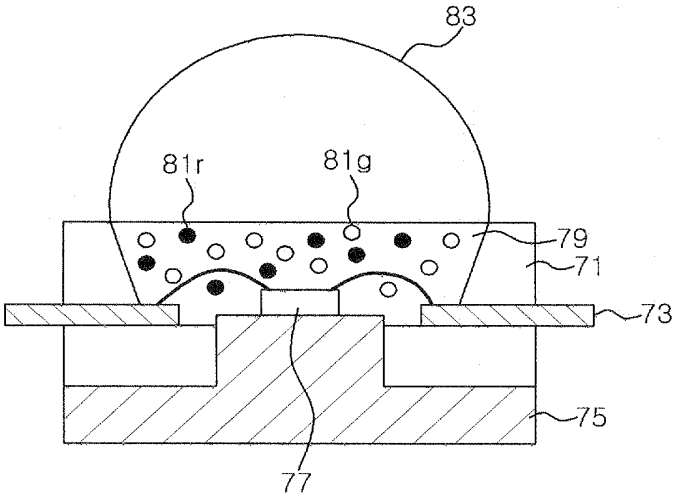


Figure 5



Attorney's Do. No. 1226-021
Client Ref: P06-5004/US

COMBINED DECLARATION AND POWER OF ATTORNEY
FILED WITH U.S. DESIGNATED OFFICE UNDER 35 U.S.C. 371(c)(4)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR**, described and claimed in international application number PCT/KR2006/000885, filed 13 March 2006, which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Sec. 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Sec. 119(a)-(d) or Sec. 365(b) of any foreign application(s) for patent or inventor's certificate or Sec. 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
10-2005-0027133	Korea	31 March 2005	☒	☐
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Sec. 119(e) of any United States provisional application listed below: **NONE.**

I hereby claim the benefit under Title 35, United States Code, Sec. 120 or §365 (c) of any PCT international application designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Sec. 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Sec. 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

PCT/KR2006/000885	13 March 2006	pending
(Applic. Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby appoint the attorneys or agents associated with **Customer No. 20575** to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with the above application.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse



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This is to certify that the following application annexed hereto is a true copy from the records of the Korean Intellectual Property Office

출 원 번 호 : Application Number		특허출원 2005년 제 0027133 호 10-2005-0027133
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출 원 인 : Applicant(s)		서울반도체 주식회사 SEOUL SEMICONDUCTOR CO.,LTD

2006 년 03 월 28 일

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【참조번호】 0134

【제출일자】 2005.03.31

【발명의 국문명칭】 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널

【발명의 영문명칭】 BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

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【취지】 특허법 제42조의 규정에 의하여 위와 같이 출원합니다.

대리인 이수완 (인)

대리인 조진태 (인)

대리인 윤종섭 (인)

대리인 이성규 (인)

【수수료】

【기본출원료】	0	면	38,000 원
【가산출원료】	22	면	0 원
【우선권주장료】	0	건	0 원
【심사청구료】	0	항	0 원

【합계】	38,000 원
【감면사유】	중소기업
【감면후 수수료】	19,000 원
【첨부서류】	1.중소기업기본법시행령 제2조에의한 중소기업에 해당함을 증명하는 서류_1통

【요약서】

【요약】

백색 발광다이오드를 채택한 백라이트 패널이 개시된다. 이 백색 발광다이오드는 청색 발광다이오드 칩 및 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 이에 따라, 적색, 녹색 및 청색의 선명한 파장을 갖는 백색광으로 백라이팅함으로써 색재현성이 양호하며, 단일의 발광다이오드로 백색을 구현할 수 있어 백라이트 패널의 제조비용 및 두께를 감소시킬 수 있다.

【대표도】

도 4

【색인어】

백라이트 패널, 발광다이오드, 형광체

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【명세서】

【발명의 명칭】

적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널{BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR}

【도면의 간단한 설명】

<1> 도 1은 종래의 백라이트 패널을 설명하기 위한 단면도이다.

<2> 도 2는 본 발명의 일 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<3> 도 3은 본 발명의 일 태양에 따른 백라이트 패널의 다른 실시예를 설명하기 위한 단면도이다.

<4> 도 4는 본 발명의 다른 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<5> 도 5는 본 발명의 백색 발광다이오드를 설명하기 위한 단면도이다.

【발명의 상세한 설명】

【발명의 목적】

【발명이 속하는 기술분야 및 그 분야의 종래기술】

<6> 본 발명은 디스플레이 패널을 백라이팅하기 위한 백라이트 패널에 관한 것으로서, 보다 상세하게는 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를

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광원으로 채택하여 디스플레이 패널의 색재현성 및 휘도를 향상시킨 백라이트 패널에 관한 것이다.

<7> 액정 디스플레이(liquid crystal display)와 같은 수동 디스플레이 장치는 주위의 태양광 또는 실내 광을 반사하거나 흡수하여 이미지를 구현할 수 있다. 따라서, 디스플레이되는 이미지를 보기 위해, 주위의 태양광 또는 실내 광이 요구된다. 그러나, 주위의 태양광 또는 실내 광의 강도가 디스플레이 패널을 조명하기에 충분하지 않을 경우 디스플레이되는 이미지를 볼 수 없는 문제점이 있다. 이러한 문제점에 대한 대안으로 디스플레이 패널을 백라이팅하기 위한 백라이트 패널이 일반적으로 채택된다.

<8> 백라이트 패널은 백열 램프, 형광 램프 또는 발광 다이오드(LED)와 같은 광원을 포함한다. 광원에서 방출된 광이 상기 LCD 패널을 조명함으로써 이미지가 구현된다. 한편, LED는 색재현성이 우수하여 백라이트 광원으로 종종 사용되며, 환경친화적이어서 앞으로 그 사용이 더욱 증가할 것으로 기대된다.

<9> 도 1은 발광 다이오드를 채택하여 LCD 패널(17)을 백라이팅하는 종래의 백라이트 패널을 설명하기 위한 부분 단면도이다.

<10> 도 1을 참조하면, 인쇄회로기판(1) 상에 LED 어레이가 위치한다. 상기 LED 어레이는 적색(3r), 녹색(3g) 및 청색(3b) LED들이 소정간격으로 배열된 어레이이다. 이들 LED 들은 인쇄회로기판(1) 상에 규칙적으로 배열되어 LED 모듈을 구성하며, 복수개의 LED 모듈이 상기 LCD 패널(17)을 백라이팅하기 위해 사용된다.

<11> 상기 LED들은 측면 발광이 되도록 설계된 렌즈를 채택하여 주광을 거의 측면

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방향으로 방출한다.

<12> 상기 LED들의 광 출사면 하부에 반사시트(5)가 위치한다. 상기 반사시트는 그 상부에 반사층(5a)을 가질 수 있다. 상기 반사시트는 LED들에서 방출된 광을 상부 측으로 반사시킨다.

<13> 한편, 상기 LED들 상부에 투광층(7)이 위치한다. 상기 투광층은 LED들에서 출사된 광이 투과할 수 있는 층으로, PMMA(poly methyl methacrylate)와 같은 투명 수지로 제조된다. 상기 투광층(7)은 LED들에 대응하는 위치에 차광패턴들(9)을 갖는다. 상기 차광패턴들은 LED들에서 상부방향으로 출사된 광이 투광층을 투과하여 LCD(17)로 향하는 것을 방지하기 위한 것으로, ESR(eletroslag remelting)로 형성된다.

<14> 상기 투광층(7)과 반사시트(5)는 소정 간격 이격되어 공기층으로 된 제1 간격(6a)을 형성한다. 상기 제1 간격은 LED들(3r, 3g, 3b)에서 방출된 적색, 녹색 및 청색의 빛이 서로 혼합되는 영역이다.

<15> 투광층(7) 상부에 상기 투광층(7)과 이격되어 확산판(11)이 위치한다. 상기 확산판(11)은 입사된 광들을 확산시키어 광을 균일하게 만든다. 상기 확산판과 투광층(7)은 소정 간격 이격되어 공기층으로 된 제2 간격(10a)을 형성한다. 따라서, 투광층(7)을 투과한 광들이 상기 제2 간격(10a) 내에서 다시 혼합되어 상기 확산판(11)으로 입사된다.

<16> 상기 확산판(11) 상부에 프리즘 시트와 같은 밝기강화필름(brightness enhancement film; BEF, 13)이 위치한다. 상기 BEF는 두개의 시트로 구성될 수 있

으며, 두개의 시트는 각각 종방향 및 횡방향으로 형성된 상향 프리즘을 갖는다. 이에 더하여, 상기 BEF(13) 상부에 엠보싱 처리된 이중 밝기 강화 필름(dual brightness enhancement-embossed; DBEF-E)과 같은 이중 밝기 강화 필름(DBEF, 15)이 위치할 수 있다. 이들 BEF 필름들(13, 15)은 확산판(11)에서 큰 지향각으로 출사된 광을 좁은 지향각으로 굴절시키어 LCD 패널(17)로 입사시킨다. 이에 따라, LCD 패널의 휘도를 증가시킨다.

<17> 종래기술에 따르면, 적색, 녹색 및 청색 LED들을 광원으로 사용하므로 색재현성을 향상시킬 수 있다. 그러나, 적색, 녹색 및 청색 LED들을 사용함에 따라, 균일한 광을 얻기 위해 LED들에서 방출된 광을 혼합할 필요가 있다. 이에 따라, 차광패턴(7)을 사용하여 LED들에서 출사된 광이 직접 투광층(7)을 투과하여 확산판(11)으로 향하는 것을 방지할 필요가 있으며, 제1 간격(6a) 및 제2 간격(10a)과 같은 공기층이 요구된다. 이는 백라이트 패널의 두께증가로 이어진다.

<18> 또한, LED들에서 방출된 광을 혼합하는 동안, 광손실이 발생한다. 따라서, LED들에 공급되는 전류량을 증가시키거나, 보다 많은 수의 LED들을 사용하거나, BEF(13) 및 DBEF(15)등을 사용하여 이러한 광손실을 보상한다. 그러나, 전류량의 증가 또는 다수의 LED들을 사용할 경우, 전력소모가 증가된다. 특히, 전류량의 증가는 LED들에 발생되는 열의 증가로 이어지며, 차광층을 열화시킬 수 있다. 또한, BEF 필름들의 사용은 백라이트 패널 전체의 두께를 더욱 증가시키며, 백라이트 패널의 제조비용을 상승시킨다.

【발명이 이루고자 하는 기술적 과제】

<19> 본 발명이 이루고자 하는 기술적 과제는, 종래기술에 비해 제조비용을 절감할 수 있으며, 더 얇은 두께를 갖는 백라이트 패널을 제공하는 데 있다.

<20> 본 발명이 이루고자 하는 다른 기술적 과제는, 종래기술에 비해 휘도를 향상시킬 수 있는 백라이트 패널을 제공하는 데 있다.

【발명의 구성】

<21> 상기 기술적 과제들을 달성하기 위하여, 본 발명은 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널을 제공한다. 본 발명의 일 태양에 따른 상기 백라이트 패널은 측면 방향에서 입사된 광을 상부로 출사시키는 도광판을 포함한다. 백색 발광다이오드들이 상기 도광판의 측면 측에 위치하여 상기 도광판 내부로 백색광을 출사한다. 상기 백색 발광다이오드들 각각은 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 한편, 상기 도광판 상부에 확산판이 위치한다. 본 발명의 일 태양에 따르면, 적색, 녹색 및 청색의 3파장을 갖는 백색 발광다이오드를 채택하여 액정표시화면의 색재현성을 보장하면서, 백라이트 패널의 두께를 감소시킬 수 있다.

<22> 한편, 상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름이 위치할 수 있다. 이들 밝기 강화 필름은 백라이트 패널의 휘도를 향상시킨다.

<23> 본 발명의 다른 태양에 따른 백라이트 패널은 하부면 및 상부면을 갖는 확산판을 포함한다. 백색 발광다이오드들이 상기 확산판과 이격되어 상기 하부면 아래

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에 배열된다. 상기 백색 발광다이오드들 각각은 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 한편, 반사시트가 상기 백색 발광다이오드들의 출사면 아래에 위치한다. 상기 반사시트는 상기 확산판에 대향하는 방향으로 진행하는 광을 확산판으로 반사시킨다. 이에 따라, 액정표시화면의 색재현성을 보장하면서, 광을 혼합하기 위한 간격들을 줄일 수 있어 백라이트 패널의 두께를 감소시킬 수 있다. 또한, 상향으로 출사하는 광원을 사용하여 휘도를 향상시킬 수 있어, 밝기 강화 필름들을 생략할 수 있다.

<24> 한편, 상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 배치하여 휘도를 더욱 증가시킬 수 있다.

<25> 본 발명의 태양들에 따른 적색 형광체는 청색 발광다이오드 칩에서 방출된 청색광에 의해 여기되어 적색을 방출하는 형광체이다. 상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체일 수 있다.

<26> 본 발명의 태양들에 따른 녹색 형광체는 청색 발광다이오드 칩에서 방출된 청색광에 의해 여기되어 녹색을 방출하는 형광체이다. 상기 녹색 형광체는 일반식 $(A_{1-x-y}Eu_x\ (M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$; $0 < x, y, x+y < 1$이고, 여기에서 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, x는 0.01에서 0.1 범위 내

로 설정되고, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, y는 0.2에서 0.8 범위내로 설정되는 티오갈레이트계 녹색 형광체일 수 있다.

<27> 이하, 첨부한 도면들을 참조하여 본 발명의 실시예들을 상세히 설명한다. 다음에 소개되는 실시예들은 당업자에게 본 발명의 사상이 충분히 전달될 수 있도록 하기 위해 예로서 제공되어지는 것이다. 따라서, 본 발명은 이하 설명되어지는 실시예들에 한정되지 않고 다른 형태로 구체화될 수도 있다. 그리고, 도면들에 있어서, 구성요소의 폭, 길이, 두께 등은 편의를 위하여 과장되어 표현될 수도 있다. 명세서 전체에 걸쳐서 동일한 참조번호들은 동일한 구성요소들을 나타낸다.

<28> 도 2는 본 발명의 일 태양에 따른 액정표시 패널(37, 이하 LCD 패널)을 백라이팅하기 위한 백라이트 패널을 설명하기 위한 단면도이다.

<29> 도 2를 참조하면, 상기 LCD 패널(37)의 하부에 도광판(27)이 위치한다. 상기 도광판은 광원(23w)에서 방출된 광을 면광으로 변환하여 상부 방향으로 방출한다. 상기 도광판(27)은 투명 아크릴 수지, 폴리카보네이트 또는 에폭시 수지 등의 투명 수지나 유리 등으로 제조할 수 있다. 상기 도광판의 양면은 필요에 따라 V형 그루브(groove)들, 렌즈 형상, 프리즘 형상 또는 홀로그램 패턴 등 다양한 패턴들로 가공될 수 있다. 또한, 상기 도광판의 하부에 반사시트(25)가 배치될 수도 있다.

<30> 상기 도광판의 측면에 인접하여 백색 발광다이오드(이하, LED)들이

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설치된다. 상기 백색 LED는 상기 도광판(27)의 측면을 향해 백색광을 출사시킨다. 상기 백색 LED는 인쇄회로기판(21) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(21) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(21) 상에 탑재된 LED들(23w)은 인쇄회로기판에 인쇄된 회로를 통해 동시에 구동될 수 있다. 한편, 상기 LED들은 도광판(27)의 양쪽 측면에 배치될 수 있다. 이에 따라, LCD 패널(37)의 휘도를 더욱 향상시킬 수 있다.

<31> 상기 백색 LED(23w)는 청색 LED칩을 가지며, 상기 청색 LED칩 상부에 위치하여 청색광의 일부를 녹색광으로 파장변환시키는 녹색 형광체 및 적색광으로 파장변환시키는 적색 형광체를 갖는다. 상기 백색 LED(23w)에 대해서는 도 5를 참조하여 뒤에서 상세히 설명한다.

<32> 한편, 상기 백색 LED(23w)의 상부 및 하부에 차광벽(29)이 위치한다. 상기 차광벽은 백색 LED(23w)에서 방출된 광이 도광판(27)의 측면 이외의 영역으로 출사되는 것을 방지한다. 상기 차광벽(27)의 내벽에는 반사층이 코팅되어, 차광벽으로 입사된 광을 반사시킬 수 있다. 이러한, 반사층은 상기 인쇄회로기판(21) 상부면에도 형성될 수 있다.

<33> 상기 도광판(27) 상부에 확산판(31)이 위치한다. 상기 확산판(31)은 얇은 시트일 수 있다. 확산판(31)은 도광판(27)에서 입사된 광을 확산시키어 균일한 광으로 만든다. 이에 더하여, 상기 확산판(31)과 LCD 패널(37) 사이에 밝기 강화 필름(33) 및/또는 이중 밝기 강화 필름(35)이 더 개재될 수 있다. 상기 BEF들(33, 35)은 도광판(27)에서 출사된 광을 일정한 지향각 내로 집광시키어 휘도를

증가시킨다.

<34> 본 발명의 일 태양에 따른 상기 백라이트 패널은 백색 LED를 탑재하여 LED에서 균일한 백색광을 방출하므로, 종래기술과 대비하여, 적색, 녹색 및 청색광을 혼합하기 위한 공기층이 별도로 필요하지 않아 백라이트 패널의 두께를 감소시킬 수 있다. 또한, 백색 LED에서 방출된 광을 직접 도광판(27)에 입사시키므로, 발광 휘도를 향상시킬 수 있어, BEF들(33, 35)을 생략할 수 있다. 또한, BEF들을 사용할 경우, 휘도를 더욱 향상시킬 수 있어, 사용 LED 수를 감소시킬 수 있다.

<35> 도 3은 본 발명의 일 태양에 따른 백라이트 패널의 다른 실시예를 설명하기 위한 단면도이다.

<36> 도 3을 참조하면, 도 2를 참조하여 설명한 바와 같이, 확산판(31), BEF들(33, 35) 및 LCD 패널(37)이 위치한다. 이하, 도 2의 백라이트 패널과 다른 점에 대해 상세히 설명한다.

<37> 도광판(47)이 상기 확산판(31) 하부에 위치한다. 상기 도광판(47)은 그 측면측에 LED들을 수용하기 위한 수용홈(47a)을 갖는다. 상기 도광판(47)은, 도 2를 참조하여 설명한 바와 같이, 투명 아크릴 수지, 폴리카보네이트 또는 에폭시 수지 등의 투명 수지나 유리 등으로 제조할 수 있으며, 도광판의 양면은 필요에 따라 V형 그루브(groove)들, 렌즈 형상, 프리즘 형상 또는 홀로그램 패턴 등 다양한 패턴들로 가공될 수 있다. 또한, 상기 도광판의 하부에 반사시트(25)가 배치될 수도 있다. 상기 반사시트(25)는 도광판(47)의 하부면에 부착되어, 도광판의 측면까지 연장될 수 있으며, LED들을 상기 도광판(47)에 수용할 수 있도록 관통홀을 가질 수

있다.

<38> 상기 수용홈(47a) 내에 백색 LED(43w)가 수용된다. 상기 백색 LED는 도광판(47)의 면을 따라 거의 평행한 광, 즉 측면에 수직인 광을 방출하는 측면발광 LED이다. 측면발광 LED는 상부로 발광하는 LED에 비해 출사되는 광의 지향각을 더 좁게 조절할 수 있어, 도광판(47)의 두께를 감소시킬 수 있다.

<39> 상기 백색 LED는 인쇄회로기판(41) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(41) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(41) 상에 탑재된 LED들(43w)은 인쇄회로기판에 인쇄된 회로를 통해 동시에 구동될 수 있다. 한편, 상기 LED들은 도광판(47)의 양쪽 측면 측에 배치될 수 있다. 이에 따라, LCD 패널(37)의 휘도를 더욱 향상시킬 수 있다.

<40> 본 실시예에 따르면, 지향각을 좁게 조절할 수 있는 측면발광 LED를 탑재하여 도광판의 두께를 감소시킬 수 있다.

<41> 도 4는 본 발명의 다른 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<42> 도 4를 참조하면, LCD 패널(67) 하부에 확산판(61)이 위치한다. 상기 확산판은 상부면 및 하부면을 갖는다. 상기 확산판과 LCD 패널(67) 사이에 BEF(63) 및/또는 DBEF(65)가 개재될 수 있다.

<43> 한편, 백색 LED들(53w)이 상기 확산판(61)과 이격되어 상기 확산판의 하부면 아래에 배열된다. 상기 백색 LED들(53w) 각각은 청색 LED칩 및 상기 청색 LED칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 상기 백색 LED들(53w)에 대해

서는 도 5를 참조하여 뒤에서 상세히 설명한다.

<44> 상기 백색 LED들(53w)은 확산판(61)을 향해 백색광을 출사시킨다. 상기 백색 LED는 인쇄회로기판(51) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(51) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(51) 상에 탑재된 LED들(53w)은 인쇄회로기판(51)에 인쇄된 회로를 통해 동시에 구동될 수 있다. 상기 확산판(61) 하부에는 균일한 백라이팅을 위해 복수개의 LED 모듈이 배치될 수 있다.

<45> 한편, 상기 백색 LED들(53w)의 출사면 아래에 반사시트(55)가 위치한다. 상기 반사시트(55)는 상부에 반사층(55a)을 가질 수 있다. 상기 반사시트는 알루미늄 시트로 형성될 수 있으며, 그 위에 반사층(55a)이 코팅될 수 있다. 또한, 상기 반사시트(55)는, 도시한 바와 같이, 인쇄회로기판(51) 상에 부착될 수 있다.

<46> 상기 반사시트(55)와 확산판(61)은 소정 간격 이격되어 공기층으로 구성된 간격(60a)을 형성한다. 상기 백색 LED(53w)에서 출사된 백색광은 상기 간격(60a) 내에서 서로 혼합되어 확산판(61)으로 입사된다.

<47> 본 태양에 따른 백라이트 패널은 별도의 도광판을 사용하지 않는다. 따라서, 백색 LED(53w)에서 방출된 광을 균일하게 하기 위해 확산판(61)이 도 2 또는 도 3의 확산판(31)에 비해 더 두꺼울 수 있다.

<48> 한편 본 태양에 따른 백라이트 패널은, 종래기술과 달리, 상부발광 백색 LED들을 채택하므로, 차광패턴(도 1의 9)을 갖는 투광층(도 1의 7)을 생략할 수 있다. 또한, 백색 LED들(53w)에서 방출된 광을 직접 확산판(61)으로 입사시키므로, 광손

실을 감소시킬 수 있어, LCD 패널(67)의 휘도를 증가시킬 수 있다. 따라서, BEF(63) 및 DBEF(65)를 생략할 수 있어, 백라이트 패널의 두께를 감소시킬 수 있다.

<49> 도 5는 본 발명의 실시예들에서 사용되는 백색 LED(23w, 43w 또는 53w)를 설명하기 위한 단면도이다.

<50> 도 5를 참조하면, 상기 백색 LED는 패키지 본체(71)를 갖는다. 상기 패키지 본체는 사출, 프레싱 또는 가공기술을 사용하여 형성될 수 있으며, 특히 플라스틱 수지를 사용하여 사출 성형될 수 있다. 상기 패키지 본체는 요홈부를 갖도록 형성되며, 상기 요홈부에 리드 단자들(73)이 노출된다. 또한, 상기 요홈부의 측벽은 일정한 각도로 경사진 경사면으로 이루어진다.

<51> 상기 리드 단자들(73)은 외부로 연장되어 패키지 본체(71) 밖으로 돌출된다. 외부로 돌출된 리드단자들(73)이 인쇄회로기판에 접속되어 외부전원에 전기적으로 연결된다. 상기 리드 단자들(73)은 표면실장이 가능하도록 외부에서 절곡될 수 있다.

<52> 한편, 상기 패키지 본체(71)의 하부에 히트싱크(75)가 장착될 수 있다. 상기 히트싱크는 LED칩(77)에서 발생된 열을 외부로 쉽게 방출하기 위해 장착된다. 상기 히트싱크(75)는 기저부 및 기저부의 중앙부분에서 상향 돌출된 돌출부를 가질 수 있다. 상기 돌출부는 패키지 본체에 삽입되어 요홈부에 노출된다. 상기 히트싱크는 관통홀을 갖는 패키지 본체(71)를 형성한 후, 패키지 본체의 관통홀에 삽입되어 장착될 수 있다. 이와 달리, 리드단자들(73)과 히트싱크(75)를 위치시킨 후 인서트 몰딩 기술을 사용하여 패키지 본체를 형성함으로써 상기 히트싱크(75)를 패키지 본

체(71)에 장착할 수 있다. 상기 히트싱크(75)는 상기 리드단자들(73)과 전기적으로 절연될 수 있으나, 상기 리드단자들 중 하나와 전기적으로 연결될 수도 있다.

<53> 상기 히트싱크(75) 상에 청색광을 방출하는 청색 LED칩(77)이 탑재된다. 상기 LED칩(77)은 GaN, InGaN, AlGaN 또는 AlGaInN 계열의 발광 다이오드로서, 420 내지 480 nm 범위의 청색 광을 방출한다. 상기 LED칩(77)은 외부전원에 연결되기 위해 두 개의 전극들을 구비한다. 상기 전극들은 LED칩(77)의 동일 측면(side) 또는 서로 반대 측면 상에 위치할 수 있다. 상기 전극들은 접착제를 통해 리드단자에 전기적으로 연결되거나, 도시한 바와 같이, 본딩와이어를 통해 리드단자에 연결될 수 있다. 동일측면에 전극들이 형성된 LED칩의 경우, 도시한 바와 같이, 두개의 본딩와이어로 LED칩(77)과 리드단자들을 각각 연결하여 전기적으로 연결할 수 있다. 이와 달리, 서로 반대측면 상에 전극들이 위치하는 경우, 하나의 전극은 상기 히트싱크(75)에 전도성 접착제를 이용하여 연결하고, 본딩와이어로 하나의 리드단자와 히트싱크(75)를 연결하여, 리드단자들과 LED칩(77)을 전기적으로 연결할 수 있다.

<54> 상기 청색 LED칩(77)의 상부에는 상기 LED칩(77)에서 방출된 광의 일부와 혼색되어 백색광을 방출시키도록 청색광에 의해 여기되어 적색광을 방출하는 적색형광체(81r)와 청색광에 의해 여기되어 녹색광을 방출하는 녹색 형광체(81g)가 위치한다. 상기 적색 및 녹색 형광체들은 상기 LED칩(77) 상에 코팅되거나, 도시한 바와 같이, 몰딩부재(79) 내에 함유되어 위치할 수 있다. 상기 몰딩부재(79)는 에폭시 수지 또는 실리콘 수지로 형성될 수 있으며, 단일층 또는 다중층으로 형성될 수 있다.

<55> 상기 적색 형광체(81r)는 예컨대, 알칼리 토금속 황화물계 적색 형광체일 수 있으며, 녹색 형광체(81g)는 티오갈레이트 녹색 형광체일 수 있다. 보다 구체적으로 상기 알칼리 토금속 황화물계 적색 형광체는 일반식 $A_{x-a}Eu_aGeS_z$ 로 표현된다. 여기서, A는 Ca 및/또는 Sr이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정된다.

<56> 또한, 상기 티오갈레이트 녹색 형광체는 일반식 $(A_{1-x-y}Eu_x(M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$ 로 표현된다. 여기서, A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, $0< x, y, x+y < 1$ 이다. 바람직하게는, x는 0.01에서 0.1 범위 내로 설정된다. 한편, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이다. y는 0.2에서 0.8 범위내로 설정되는 것이 바람직하다.

<57> 이러한 적색 및 녹색 형광체(81r, 81g)는 형광체 원료물질과 활성제를 원하는 조성에 따른 각각의 소정비가 되도록 평량하고 보다 효과적인 혼합을 위해 알코올 용매하에서, 볼밀링(ball milling) 또는 마노유발 같은 혼합기를 이용하여 균일한 조성이 되도록 충분히 혼합한다.

<58> 그 후, 이 혼합물을 오븐에 넣고, 100 내지 150℃ 에서 1 ~ 2시간 동안 건조한다. 건조한 혼합물을 고순도 알루미나 보트에 넣고 전기로를 사용하여 800 ~ 1300℃ 사

이의 온도에서 H_2S 대기중에 열처리하여 형광체 분말을 합성한 후 충분히 분쇄한다.

<59> 이들 분말에 대하여 빛 발광강도(Photoluminescence, PL)를 측정한 결과 $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$로 표현되는 대표적인 조성의 티오갈레이트계 녹색 형광체는 470 ~ 630nm의 영역에 걸쳐서 강한 발광 스펙트럼을 나타내고, $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ 알칼리 토금속 황화물계 적색 형광체는 520 ~ 780nm의 영역에 걸쳐서 강한 발광 스펙트럼을 나타내었다. 따라서, 청색 LED칩(77)과 상기 형광체들을 사용하여 적색, 녹색 및 청색의 뚜렷한 파장을 갖는 백색광을 방출할 수 있으며, 이에 따라 LCD 패널의 색재현성을 향상시킬 수 있다.

<60> 한편, 렌즈(83)가 상기 LED칩(77) 및 형광체들(81r, 81g)을 덮는다. 상기 렌즈는 다양한 형상을 가질 수 있다. 예컨대, 본 발명의 태양들에 따른 상부발광 LED를 구현하기 위해, 상기 렌즈는 도시한 바와 같이, 볼록렌즈의 형상을 가질 수 있다. 이때, 렌즈의 곡률은 요구되는 지향각에 따라 결정된다. 한편, 도 2와 같은 측면발광 LED를 구현하기 위해 상기 렌즈는 LED칩(77)에서 방출된 광을 측면으로 출사시키도록 설계된다. 이러한, 측면발광 LED의 예가 도 1에 도시된 LED들이며, 이외에 다양한 렌즈형상들로 측면발광 LED를 구현할 수 있다.

【발명의 효과】

<61> 본 발명의 실시예들에 따르면, 종래기술에 비해 제조비용을 절감할 수 있으며, 더 얇은 두께를 갖는 백라이트 패널을 제공할 수 있다. 또한, 종래기술에 비해 휘도가 향상된 백라이트 패널을 제공할 수 있다.

EX1015, Page 221

<62> 한편, 종래기술과 같이, 적색, 녹색 및 청색 LED들을 사용할 경우, 상기 LED들의 수명 및 열화정도가 서로 다르다. 따라서, LCD 패널 상부에 컬러센서를 부착하여 이들의 열화를 감지한 후, 보상작업을 할 필요가 있다. 그러나, 본 발명의 실시예들에 따르면, 동일한 종류의 백색 LED들을 사용하므로, 수명 및 열화가 대체로 비슷하여 컬러센서 및 보상작업의 필요성이 적다. 따라서, LCD 패널의 동작회로를 보다 단순화할 수 있다.

【특허청구범위】

【청구항 1】

측면 방향에서 입사된 광을 상부로 출사시키는 도광판;

상기 도광판의 측면 측에 위치하여 상기 도광판 내부로 백색광을 출사하되, 각각 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는 백색 발광다이오드들; 및

상기 도광판 상부에 위치하는 확산판을 포함하는 백라이트 패널.

【청구항 2】

청구항 1에 있어서,

상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 더 포함하는 백라이트 패널.

【청구항 3】

하부면 및 상부면을 갖는 확산판;

상기 확산판과 이격되어 상기 하부면 아래에 배열되고, 각각 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는 백색 발광다이오드들; 및

상기 백색 발광다이오드들의 출사면 아래에 위치하여 상기 확산판에 대향하는 방향으로 진행하는 광을 확산판으로 반사시키는 반사시트를 포함하는 백라이트 패널.

【청구항 4】

청구항 3에 있어서,

상기 확산판 상부면 상에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 더 포함하는 백라이트 패널.

【청구항 5】

청구항 1 내지 4의 어느 한 항에 있어서,

상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체인 것을 특징으로 하는 백라이트 패널.

【청구항 6】

청구항 1 내지 4의 어느 한 항에 있어서,

상기 녹색 형광체는 일반식이 $(A_{1-x-y}Eu_x\ (M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$; $0 < x, y, x+y < 1$이고, 여기에서 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, x는 0.01에서 0.1 범위 내로 설정되고, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, y는 0.2에서 0.8 범위내로 설정되는

티오갈레이트계 녹색 형광체인 것을 특징으로 하는 백라이트 패널.

【청구항 7】

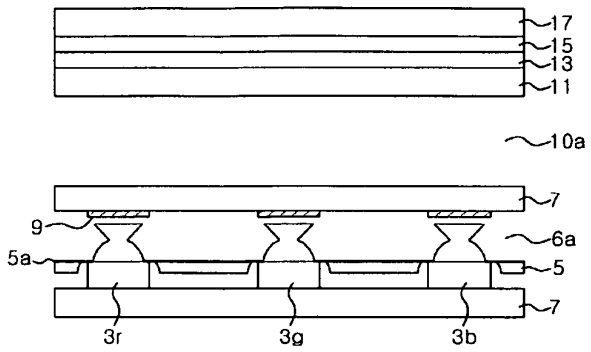
청구항 1 내지 4의 어느 한 항에 있어서,

상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체이고,

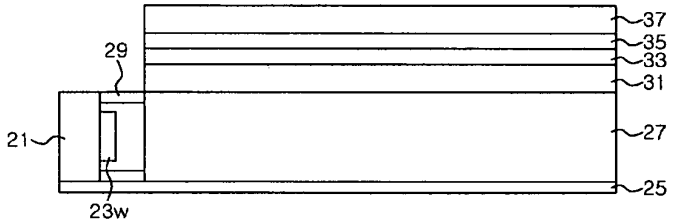
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【도면】

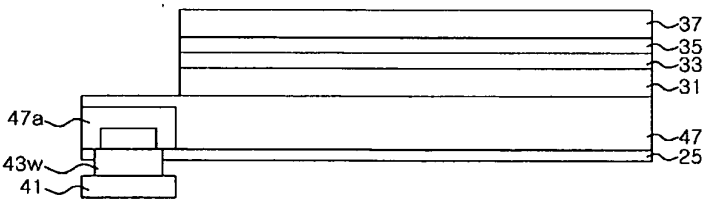
【도 1】


17
15
13
11
10a
7
9
6a
5a
5
7
3r
3g
3b

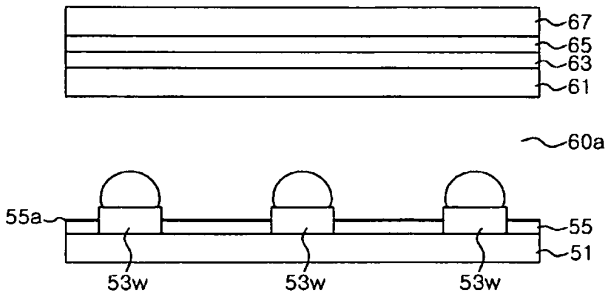
【도 2】


37
35
33
31
29
21
27
25
23w

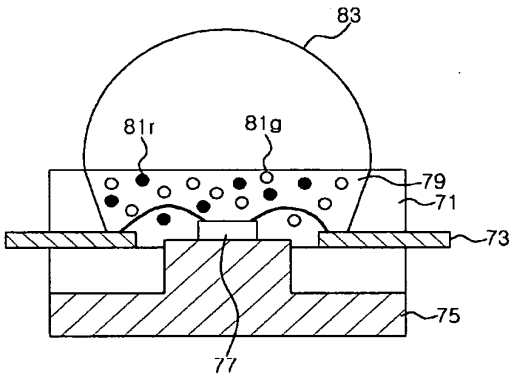
【도 3】


37
35
33
31
47a
47
25
43w
41

【도 4】



【도 5】



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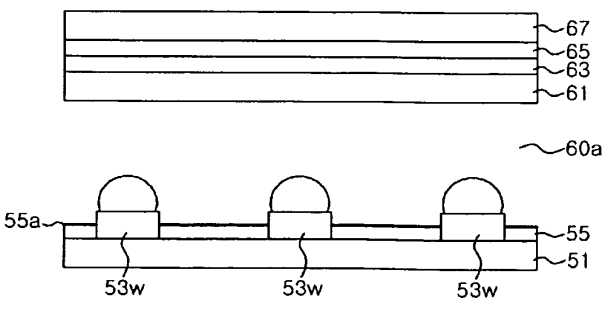
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(54) Title: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR



(57) Abstract: Disclosed is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Accordingly, since the backlighting can be performed using white light with distinct red, green and blue wavelengths, the color reproducibility can be enhanced. Further, since the white light can be implemented with a single light emitting diode, the manufacturing costs and thickness of the backlight panel can also be reduced.

Description

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Technical Field

[1] The present invention relates to a backlight panel for backlighting a display panel, and more particularly, to a backlight panel employing a white light emitting diode with red and green phosphors as a light source to enhance color reproducibility and luminance.

Background Art

[2] A passive display device such as a liquid crystal display (LCD) reflects or absorbs ambient sunlight or indoor light to display images on an LCD panel. Thus, the ambient sunlight or indoor light is required for a user to view the displayed image. However, in a case where intensity of the ambient sunlight or indoor light is not sufficient to illuminate a display panel, there is a problem in that the user cannot view the displayed image. As an alternative to such a problem, a backlight panel for backlighting a display panel is generally employed.

[3] A backlight panel includes a light source such as an incandescent lamp, fluorescent lamp or light emitting diode (LED). Light emitted from the light source illuminates the LCD panel, and thus, images are implemented. Meanwhile, since the LED has superior reproducibility, it has been frequently used as a backlight source. In addition, since the LED is environmentally friendly, it is expected that its use will be further increased in the future.

[4] Fig. 1 is a partial sectional view illustrating a conventional backlight panel for backlighting an LCD panel 17 using light emitting diodes (LEDs).

[5] Referring to Fig. 1, an LED array is arranged on a printed circuit board 1. The LED array is an array in which red, green and blue LEDs 3r, 3g and 3b are arranged at a predetermined interval. The LEDs are arranged on the printed circuit board 1 in a regular order and constructed into an LED module, and a plurality of LED modules are used to backlight the LCD panel 17.

[6] Each of the LEDs employs a lens designed for side-luminescence such that major light can be radiated almost in a side direction.

[7] A reflection sheet 5 is positioned below light exit surfaces of the LEDs. The reflection sheet may be formed with a reflection layer 5a on the top thereof. The reflection sheet reflects light emitted from the LEDs in an upward direction.

[8] Furthermore, a light transmission layer 7 is positioned above the LEDs. The light transmission layer is a layer through which light emitted from the LED can be

transmitted. The light transmission layer is generally made of a transparent resin such as PMMA (poly methyl methacrylate). The light transmission layer 7 is provided with light shielding patterns 9 at positions corresponding to the LEDs. The light shielding patterns function to prevent light emitted upward from the LEDs from penetrating the light transmission layer and then traveling toward the LCD panel 17. The light shielding patterns may be formed through an ESR (eletroslag remelting) process.

[9] The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a first gap 6a which is an air layer. The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are mixed with one another.

[10] A diffusion plate 11 is positioned above and spaced apart from the light transmission layer 7. The diffusion plate 11 diffuses light incident thereon to make the light uniform. The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a second gap 10a which is an air layer. Thus, the light transmitted through the light transmission layer 7 is again mixed within the second gap 10a and the mixed light is then incident onto the diffusion plate 11.

[11] A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film-embossed (DBEF-E) is positioned on a top surface of the BEF 13. The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

[12] Since the red, green and blue LEDs are used as light sources according to a prior art, the color reproducibility can be enhanced. However, it is necessary to mix light emitted from the LEDs in order to obtain the uniform light. Accordingly, it is necessary to prevent light emitted from the LEDs from transmitting directly through the light transmission layer 7 and traveling toward the diffusion plate 11 by using the light shielding pattern 9. Further, air layers such as the first and second gaps 6a and 10a are required. These result in an increase in thickness of a backlight panel.

[13] Further, while light emitted from the LEDs is mixed, light loss is generated. Thus, such light loss should be compensated by increasing an amount of current supplied to the LEDs, by using a larger number of LEDs or by using the BEF 13, the DBEF 15 and the like. However, in a case where the amount of current is increased or a large number of LEDs are used, power consumption is increased. In particular, the increase in the amount of current leads to an increase of heat generated from the LEDs, and the light

shielding layer may be deteriorated. In addition, the use of the BEFs causes the total thickness of the backlight panel to be further increased and the manufacturing costs of the backlight panel to be increased.

Disclosure of Invention

Technical Problem

[14] An object of the present invention is to provide a backlight panel which has smaller thickness and reduced manufacturing costs as compared with a conventional backlight panel.

[15] Another object of the present invention is to provide a backlight panel capable of enhancing its luminance as compared with a conventional backlight panel.

Technical Solution

[16] In order to achieve the above objects of the present invention, there is provided a backlight panel employing a white light emitting diode with red and green phosphors. A backlight panel according to an aspect of the present invention comprises a light guide plate for emitting light incident from a side direction. The light guide plate emits light through a top surface thereof. The white light emitting diodes are arranged at a side of the light guide plate to emit white light into the light guide plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a diffusion plate is positioned over the top surface of the light guide plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and the thickness of the backlight panel can also be reduced, by employing the white light emitting diode with three red, green and blue wavelengths

[17] Further, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate. The brightness enhancement films can enhance the luminance of the backlight panel.

[18] A backlight panel according to another aspect of the present invention comprises a diffusion plate having a top surface and a bottom surface. White light emitting diodes are arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a reflection sheet is positioned below light exit surfaces of the white light emitting diodes and also allows light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and spaces or gaps where light is mixed can also be reduced, so that the thickness of the backlight panel can be reduced. Further, since the luminance can be enhanced with the use of a light

source for upward emitting light, brightness enhancement films can be omitted.

[19] In addition, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate to further increase the luminance of the backlight panel.

[20] Preferably, the red phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate red light. The red phosphor may be an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

[21] Preferably, the green phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate green light. The green phosphor may be a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y <1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

Advantageous Effects

[22] According to the embodiments of the present invention, there is provided a backlight panel which has smaller thickness and reduced manufacturing costs as compared with the coventional backlight panel. Further, there is provided a backlight panel having enhanced luminance as compared with the conventional backlight panel.

[23] Meanwhile, in a case where the red, green and blue LEDs are used as described in the prior art, the life spans and degrees of deterioration of the LEDs are different from one another. Thus, a color sensor should be installed on the LCD panel to detect the deterioration of the LEDs and to perform a compensation work. However, since the white LEDs of the same kinds are used in the embodiments of the present invention, the life spans and deterioration of the LEDs are generally similar to one another. Therefore, it is less necessary to use the color sensor and perform the compensation work. Accordingly, an operation circuit of the LCD panel can be further simplified.

Brief Description of the Drawings

[24] Fig. 1 is a sectional view illustrating a conventional backlight panel.

[25] Fig. 2 is a sectional view illustrating a backlight panel according to an aspect of the present invention.

[26] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel

according to the aspect of the present invention.

[27] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[28] Fig. 5 is a sectional view illustrating a white light emitting diode of the present invention.

Mode for the Invention

[29] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided only for illustrative purposes so that those skilled in the art can fully understand the spirit of the present invention. Therefore, the present invention is not limited to the following embodiments but may be implemented in other forms. In the drawings, the widths, lengths, thicknesses and the like of components may be exaggerated for convenience of illustration. Like reference numerals indicate like elements throughout the specification and drawings.

[30] Fig. 2 is a sectional view illustrating a backlight panel for backlighting a liquid crystal display panel 37 (hereinafter, referred to as "LCD panel") according to an aspect of the present invention.

[31] Referring to Fig. 2, a light guide plate 27 is positioned below the LCD panel 37. The light guide plate converts light emitted from a light source 23w into surface light and then emits the surface light upward toward the LCD panel. The light guide plate 27 may be made of glass, a transparent resin such as a transparent acryl resin or a polycarbonate or epoxy resin, or the like. Both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Further, a reflection sheet 25 may be positioned on a bottom surface of the light guide plate.

[32] White light emitting diodes (hereinafter, referred to as "LEDs") are positioned adjacent to a side of the light guide plate. Each of the white LEDs emits white light toward the side of the light guide plate 27. The white LED may be mounted on a printed circuit board 21, and a plurality LEDs may be mounted on the printed circuit board 21 as an LED module. The LEDs 23w mounted on the printed circuit board 21 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 27. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[33] The white LED 23w includes a blue LED chip, and green and red phosphors which are positioned over the blue LED chip to convert a portion of blue light into green and red light, respectively. The white LED 23w will be described in detail later with reference to Fig. 5.

[34] Meanwhile, light shielding walls 29 are positioned above and below the white LED 23w, respectively. The light shielding walls prevent light emitted from the white LED 23w from traveling toward regions other than the side of the light guide plate 27. A reflection layer is coated on an inner wall of the light shielding wall 29 to enable light incident onto the light shielding wall to be reflected. Such a reflection layer may be also formed on a top surface of the printed circuit board 21.

[35] A diffusion plate 31 is positioned over top surface of the light guide plate 27. The diffusion plate 31 may be a thin sheet. The diffusion plate 31 diffuses light incident from the light guide plate 27 into uniform light. Moreover, a brightness enhancement film (BEF) 33 and/or a dual brightness enhancement film (DBEF) 35 may be interposed between the diffusion plate 31 and the LCD panel 37. The BEFs 33 and 35 collect light emitted from the light guide plate 27 within a certain showing angle to increase the luminance of light.

[36] Since the backlight panel according to the aspect of the present invention is mounted with the white LED to enable uniform white light to be emitted from the LED, an air layer used for mixing the red, green and blue light with one another is not necessary, as compared with the prior art. Thus, the thickness of the backlight panel can be decreased. Further, since light emitted from the white LED is incident directly onto the light guide plate 27, the light emitting luminance can be enhanced. Thus, the BEFs 33 and 35 may be omitted. Furthermore, in a case where the BEFs are used, the luminance can be further enhanced. Thus, the number of LEDs used can also be reduced.

[37] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel according to the aspect of the present invention.

[38] Referring to Fig. 3, the diffusion plate 31, the BEFs 33 and 35, and the LCD panel 37 are provided in the same manner as described with reference to Fig. 2. Hereinafter, only differences between the backlight panels of Figs. 2 and 3 will be described in detail.

[39] A light guide plate 47 is positioned below the diffusion plate 31. The light guide plate 47 is formed with a receiving groove 47a at a side thereof to accommodate LEDs in the receiving groove. As described with reference to Fig. 2, the light guide plate 47 may be made of glass, a transparent resin such as a transparent acryl resin or a poly-carbonate or epoxy resin, or the like. Further, both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Furthermore, the reflection sheet 25 can be positioned on a bottom surface of the light guide plate. The reflection sheet 25 may be attached to the bottom surface of the light guide plate 47 to extend to the side thereof and have a through-hole through which the LEDs can be received in the receiving

groove 47a of the light guide plate 47.

[40] A white LED 43w is accommodated in the receiving groove 47a. The white LED is a side-view LED which emits light almost in parallel with top and bottom surfaces of the light guide plate 47, i.e. perpendicular to the side surfaces thereof. The side-view LED can adjust a showing angle of emitted light to be smaller than that of an LED emitting light upward, so that the thickness of the light guide plate 47 can be reduced.

[41] The white LED may be mounted on a printed circuit board 41, and a plurality LEDs may also be mounted on the printed circuit board 41 as an LED module. The LEDs 43w mounted on the printed circuit board 41 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 47. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[42] According to this embodiment, the side-view LED capable of adjusting a showing angle to be smaller is mounted such that the thickness of the light guide plate can be reduced.

[43] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[44] Referring to Fig. 4, a diffusion plate 61 is positioned below an LCD panel 67. The diffusion plate has a top surface and a bottom surface. BEF 63 and/or DBEF 65 may be interposed between the diffusion plate and the LCD panel 67.

[45] Meanwhile, white LEDs 53w are arranged below the bottom surface of the diffusion plate 61 at a certain interval from the diffusion plate 61. Each of the white LEDs 53w includes a blue LED chip, and green and red phosphors positioned over the blue LED chip. The white LEDs 53w will be described in detail later with reference to Fig. 5.

[46] Each of the white LEDs 53w emits white light toward the diffusion plate 61. The white LED may be mounted on a printed circuit board 51, and a plurality LEDs may be mounted on the printed circuit board 51 as an LED module. The LEDs 53w mounted on the printed circuit board 51 may be simultaneously driven through a circuit printed on the printed circuit board. A plurality of LED modules may be arranged below the diffusion plate 61 to uniformly backlight the LCD panel 67.

[47] Furthermore, a reflection sheet 55 is positioned below light exit surfaces of the white LEDs 53w. The reflection sheet 55 may be formed with a reflection layer 55a thereon. The reflection sheet may be made of an aluminum sheet and coated with the reflection layer 55a thereon. Further, the reflection sheet 55 may be attached onto the printed circuit board 51 as shown in this figure.

[48] The reflection sheet 55 and the diffusion plate 61 are spaced apart from each other by a predetermined interval to define a gap 60a corresponding to an air layer. White

light emitted from the white LEDs 53w are mixed with one another in the gap 60a and then incident onto the diffusion plate 61.

[49] The backlight panel according to this aspect does not use an additional light guide plate. Thus, the diffusion plate 61 may be thicker than the diffusion plate 31 of Fig. 2 or 3 such that light emitted from the white LEDs 53w can be uniform.

[50] In the meantime, since the backlight panel according to this aspect employs top-view white LEDs contrary to the prior art, the light transmission layer 7 (Fig. 1) formed with the light shielding pattern 9 (Fig. 1) may be omitted. Further, since light emitted from the white LEDs 53w is incident directly onto the diffusion plate 61, the light loss can be reduced so that the luminance of the LCD panel 67 can be enhanced. Accordingly, since the BEF 63 and the DBEF 65 can be omitted, the thickness of the backlight panel can also be reduced.

[51] Fig. 5 is a sectional view illustrating the white LED 23w, 43w or 53w used in the embodiments of the present invention.

[52] Referring to Fig. 5, the white LED includes a package body 71. The package body may be formed using an injection molding, pressing or machining technique, and particularly injection-molded using a plastic resin. The package body is formed with a cavity which exposes lead terminals 73. Further, a sidewall of the cavity may be an inclined surface inclined at a certain angle.

[53] The lead terminals 73 extend outward to protrude out of the package body 71. The lead terminals 73 protruding to the outside are connected to a printed circuit board and electrically connected to an external power source. The lead terminals 73 may be bent from the outside such that they can be surface mounted.

[54] Meanwhile, a heat sink 75 may be attached to the bottom of the package body 71. The heat sink is provided to easily dissipate heat generated from an LED chip 77 to the outside. The heat sink 75 may be formed with a base and a projection protruding upward from a center portion of the base. The projection is inserted into the package body and then exposed to the cavity. After the package body 71 has been formed with a through-hole, the heat sink can be inserted into the through-hole of the package body and mounted to the package body. Alternatively, the heat sink 75 can be attached to the package body 71 by positioning the lead terminals 73 and the heat sink 75 and then forming the package body using an insert-molding technique. The heat sink 75 may be electrically isolated from the lead terminals 75, or electrically connected to any one of the lead terminals.

[55] A blue LED chip 77 for emitting blue light is mounted on the heat sink 75. The LED chip 77 is a GaN, InGaN or AlGaInN-based light emitting diode and radiates blue light with a wavelength of 420 to 480 nm. The LED chip 77 has two electrodes for the connection with an external source. The electrodes may be positioned on the same side

or opposite sides of the LED 77. The electrodes may be electrically connected to the lead terminals through an adhesive or bonding wires as shown in this figure. In a case where the electrodes are formed on the same side of the LED chip, the LED chip 77 and the lead terminals are connected through the two bonding wires, respectively, so that they can be electrically connected as shown in this figure. On the other hand, in a case where the electrodes are positioned on the opposite sides, one of the electrodes is connected to the heat sink 75 using a conductive adhesive and one of the lead terminals is connected to the heat sink 75 through the bonding wire, so that the lead terminals and the LED chip 77 can be electrically connected with each other.

[56] Over the blue LED chip 77 is positioned red and green phosphors 81r and 81g which are excited by blue light to radiate red and green light, respectively, such that the radiated light is mixed with a portion of blue light emitted from the LED chip 77 to become white light. The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.

[57] For example, the red phosphor 81r may be an alkali earth metal sulfide-based red phosphor, while the green phosphor 81g may be a thiogallate-based green phosphor. More specifically, the alkali earth metal sulfide-based red phosphor is expressed as general formula $A_{x-a}Eu_aGeS_z$, where A is Ca and/or Sr, z=x+2, x is set within a range of 2 to 5, and a/x is set within a range of 0.0005 to 0.02.

[58] Further, the thiogallate-based green phosphor is expressed as general formula $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where A is at least one element selected from the group consisting of Ba, Sr and Ca, B is at least one element selected from the group consisting of Al, Ga and In, and $0<x, y, x+y<1$. Preferably, x is set within a range of 0.01 to 0.1. Meanwhile, M^{I} is at least one element selected from the group consisting of Li, Na and K, and M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La. Preferably, y is set within a range of 0.2 to 0.8.

[59] Such red and green phosphors 81r and 81g are obtained in the following manners. That is, phosphor raw materials and an activator raw material are weighted to have a predetermined mixing ratio in accordance with a desired composition and sufficiently mixed into a uniform mixture by using a ball milling or a mixer such as agate mortar within an alcohol solvent for effective mixing. Then, the mixture is dried in an oven at a temperature of 100 to 150°C for 1 to 2 hours. The dried mixture is heat-treated in a high-purity alumina boat at a temperature of 800 to 1300°C under the atmosphere of H_2S using an electric furnace to synthesize phosphor powder and then sufficiently pulverize the synthesized phosphor powder.

[60] According to the results of measuring photoluminescence (PL) of the powder, the

thiogallate-based green phosphor of a typical composition expressed as $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$ exhibits strong photoluminescence spectrum throughout a region of 470 to 630 nm while the alkali earth metal sulfide-based red phosphor expressed as $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ exhibits strong photoluminescence spectrum throughout a region of 520 to 780 nm. Accordingly, white light with distinct red, green and blue wavelengths can be radiated using the blue LED chip 77 and the phosphors, and thus, the color reproducibility of the LCD panel can be enhanced.

[61] Meanwhile, the LED chip 77 and the phosphors 81r and 81g are covered with a lens 83. The lens may be formed into a variety of shapes. For example, to implement a top-view LED according to the aspects of the present invention, the lens may take the shape of a convex lens as shown in this figure. At this time, the curvature of the lens is determined depending on a desired showing angle. Meanwhile, to implement a side-view LED shown in Fig. 2, the lens is designed to emit light from the LED chip 77 in a side direction. An example of such a side-view LED is shown in Fig. 1, and the other side-view LEDs can be implemented into a variety of lens shapes.

Claims

[1] A backlight panel, comprising:
a light guide plate for emitting light incident from a side direction, the light guide emitting light through a top surface thereof;
white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and
a diffusion plate positioned over the top surface of the light guide plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[2] The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[3] A backlight panel, comprising:
a diffusion plate having a top surface and a bottom surface;
white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and
a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[4] The backlight panel as claimed in claim 3, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[5] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

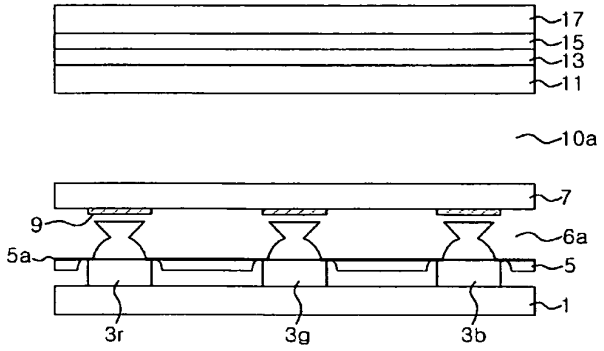
[6] The backlight panel as claimed in any one of claims 1 to 4, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li,

Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

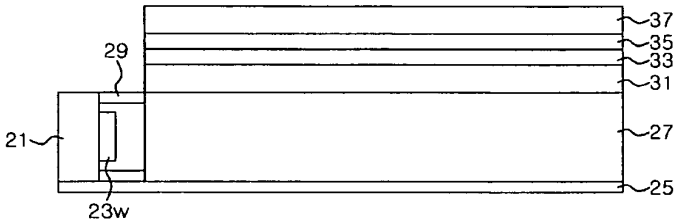
[7] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

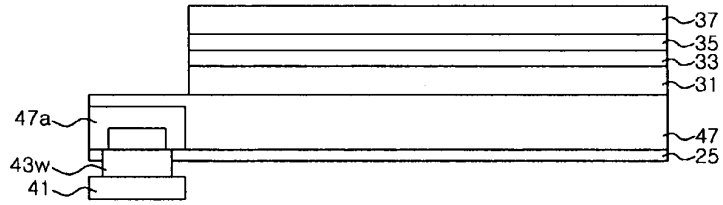
[Fig. 1]



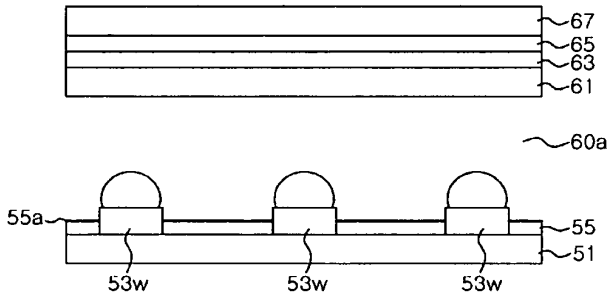
[Fig. 2]



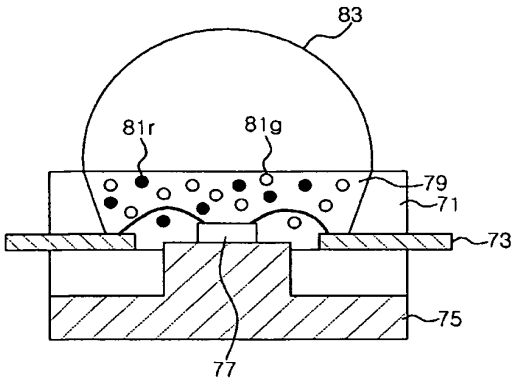
[Fig. 3]



[Fig. 4]



[Fig. 5]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/000885

A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/13357(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)
IPC8 G02F 1/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
Korean Utility Models and applications for Utility Models since 1975
Japanese Utility Models and applications for Utility Models since 1975

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2001-97147 A (LS TECH CO., LTD.) 08.11.2001 see the Page 2-3, Fig2,6	1
A	WO 98/05078 A (NICHIA KAGAKU KOGYO KABUSHIKI KAISHA) 05.02.1998 see the whole document	1-7
A	JP 2004-296830 A (SOLIDLITE CORP) 21.10.2004 see the whole document	1-7
A	JP 2004-119743 A (CITIZEN ELECTRONICS CO LTD.) 15.04.2004 see the whole document	1-7

☐ 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
20 JUNE 2006 (20.06.2006)	**21 JUNE 2006 (21.06.2006)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	CHANG, Kyung Tae Telephone No. 82-42-481-5769

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2006/000885

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 2001-97147A	08.11.2001	NONE	
WO9805078A1	05.02.1998	US6608332BB	19.08.2003
		EP00936682B1	23.08.2000
		JP2003179259A2	27.06.2003
		KR1020030097609A	31.12.2003
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JP 2004-119743A	15.04.2004	CN1501519A	02.06.2004
		EP1403936A2	31.03.2004
		JP2004119743A2	15.04.2004
		KR1020040027378A	01.04.2004
		US6858456BB	22.02.2005

Form PCT/ISA/210 (patent family annex) (April 2005)

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 P06-5004	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/KR2006/000885	International filing date *(day/month/year)* 13 March 2006 (13.03.2006)	Priority date *(day/month/year)* 31 March 2005 (31.03.2005)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant SEOUL SEMICONDUCTOR CO., LTD.		

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 4 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 03 October 2007 (03.10.2007)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Philippe Becamel e-mail: pt12.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
LEE, Soo Wan

1901-ho, Keungil Tower 19F, 677-25 Yeoksam-dong
Gangnam-gu Seoul 135-914 Republic of Korea

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**21 JUNE 2006 (21.06.2006)**
Applicant's or agent's file reference P06-5004	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/KR2006/000885	**13 MARCH 2006 (13.03.2006)**	31 MARCH 2005 (31.03.2005)

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

G02F 1/13357(2006.01)i

Applicant

SEOUL SEMICONDUCTOR CO., LTD. et al

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 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.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	20 JUNE 2006 (20.06.2006)	CHANG, Kyung Tae Telephone No.82-42-481-576[illegible]

Form PCT/ISA/237 (cover sheet) (April 2005)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/KR2006/000885

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. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material
      ☐ a sequence listing
      ☐ table(s) related to the sequence listing

   b. format of material
      ☐ on paper
      ☐ in electronic form

   c. time of filing/furnishing
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      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto 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.

4. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/KR2006/000885

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	2-7	YES
	Claims	1	NO
Inventive step (IS)	Claims	2-7	YES
	Claims	1	NO
Industrial applicability (IA)	Claims	1-7	YES
	Claims		NO

2. Citations and explanations :

D1 : KR 2001-97147 A (2001.11.08)

D1 includes a blue LED(2), a green and red phosphors(5,6), a light guide plate(B), a reflection plate(10), a diffusion plate(9) and a solder frame(7). After blue light from the blue LED passes through the red/green phosphors over the blue LED, white light is emitted.

The present invention is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red/green phosphors positioned over the blue light emitting diode chip.

1. Industrial applicability:

Claims 1-7 fulfill the requirements of Article 33(4) PCT.

2. Novelty:

Claim 1 lacks novelty under PCT Article 33(2) as being anticipated by D1. D1 discloses backlight panel that comprises a light guide plate(B), a reflection plate(10), a diffusion plate(9), a blue LED(2) and a green and red phosphors(5,6). The red and green phosphors are positioned over the blue LED.

3. Inventive Step:

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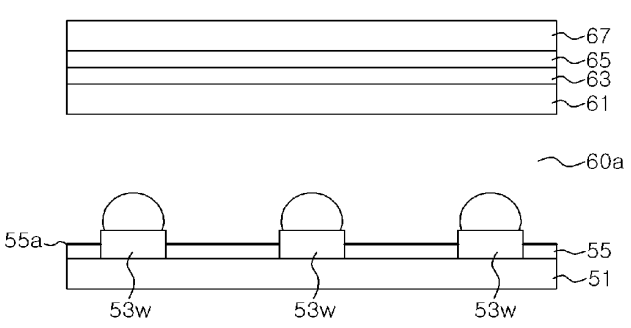
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2006/104319 A1

(54) Title: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR



(57) Abstract: Disclosed is a backlight panel employing a white light emitting diode. The white light emitting diode includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Accordingly, since the backlighting can be performed using white light with distinct red, green and blue wavelengths, the color reproducibility can be enhanced. Further, since the white light can be implemented with a single light emitting diode, the manufacturing costs and thickness of the backlight panel can also be reduced.

Description

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Technical Field

[1] The present invention relates to a backlight panel for backlighting a display panel, and more particularly, to a backlight panel employing a white light emitting diode with red and green phosphors as a light source to enhance color reproducibility and luminance.

Background Art

[2] A passive display device such as a liquid crystal display (LCD) reflects or absorbs ambient sunlight or indoor light to display images on an LCD panel. Thus, the ambient sunlight or indoor light is required for a user to view the displayed image. However, in a case where intensity of the ambient sunlight or indoor light is not sufficient to illuminate a display panel, there is a problem in that the user cannot view the displayed image. As an alternative to such a problem, a backlight panel for backlighting a display panel is generally employed.

[3] A backlight panel includes a light source such as an incandescent lamp, fluorescent lamp or light emitting diode (LED). Light emitted from the light source illuminates the LCD panel, and thus, images are implemented. Meanwhile, since the LED has superior reproducibility, it has been frequently used as a backlight source. In addition, since the LED is environmentally friendly, it is expected that its use will be further increased in the future.

[4] Fig. 1 is a partial sectional view illustrating a conventional backlight panel for backlighting an LCD panel 17 using light emitting diodes (LEDs).

[5] Referring to Fig. 1, an LED array is arranged on a printed circuit board 1. The LED array is an array in which red, green and blue LEDs 3r, 3g and 3b are arranged at a pre-determined interval. The LEDs are arranged on the printed circuit board 1 in a regular order and constructed into an LED module, and a plurality of LED modules are used to backlight the LCD panel 17.

[6] Each of the LEDs employs a lens designed for side-luminescence such that major light can be radiated almost in a side direction.

[7] A reflection sheet 5 is positioned below light exit surfaces of the LEDs. The reflection sheet may be formed with a reflection layer 5a on the top thereof. The reflection sheet reflects light emitted from the LEDs in an upward direction.

[8] Furthermore, a light transmission layer 7 is positioned above the LEDs. The light transmission layer is a layer through which light emitted from the LED can be

transmitted. The light transmission layer is generally made of a transparent resin such as PMMA (poly methyl methacrylate). The light transmission layer 7 is provided with light shielding patterns 9 at positions corresponding to the LEDs. The light shielding patterns function to prevent light emitted upward from the LEDs from penetrating the light transmission layer and then traveling toward the LCD panel 17. The light shielding patterns may be formed through an ESR (eletroslag remelting) process.

[9] The light transmission layer 7 and the reflection sheet 5 are spaced apart at a predetermined interval to define a first gap 6a which is an air layer. The first gap is a region where red, green and blue light emitted respectively from the LEDs 3r, 3g and 3b are mixed with one another.

[10] A diffusion plate 11 is positioned above and spaced apart from the light transmission layer 7. The diffusion plate 11 diffuses light incident thereon to make the light uniform. The diffusion plate and the light transmission layer 7 are spaced apart from each other by a predetermined interval to define a second gap 10a which is an air layer. Thus, the light transmitted through the light transmission layer 7 is again mixed within the second gap 10a and the mixed light is then incident onto the diffusion plate 11.

[11] A brightness enhancement film (BEF) 13 such as a prism sheet is positioned on a top surface of the diffusion plate 11. The BEF may be composed of two sheets which have upward prisms formed in longitudinal and transverse directions, respectively. In addition, a dual brightness enhancement film (DBEF) 15 such as a dual brightness enhancement film-embossed (DBEF-E) is positioned on a top surface of the BEF 13. The BEFs 13 and 15 refract light emitted at a large showing angle from the diffusion plate 11 into light with a small showing angle such that the light can be incident onto the LCD panel 17. Accordingly, the luminance of the LCD panel is increased.

[12] Since the red, green and blue LEDs are used as light sources according to a prior art, the color reproducibility can be enhanced. However, it is necessary to mix light emitted from the LEDs in order to obtain the uniform light. Accordingly, it is necessary to prevent light emitted from the LEDs from transmitting directly through the light transmission layer 7 and traveling toward the diffusion plate 11 by using the light shielding pattern 9. Further, air layers such as the first and second gaps 6a and 10a are required. These result in an increase in thickness of a backlight panel.

[13] Further, while light emitted from the LEDs is mixed, light loss is generated. Thus, such light loss should be compensated by increasing an amount of current supplied to the LEDs, by using a larger number of LEDs or by using the BEF 13, the DBEF 15 and the like. However, in a case where the amount of current is increased or a large number of LEDs are used, power consumption is increased. In particular, the increase in the amount of current leads to an increase of heat generated from the LEDs, and the light

shielding layer may be deteriorated. In addition, the use of the BEFs causes the total thickness of the backlight panel to be further increased and the manufacturing costs of the backlight panel to be increased.

Disclosure of Invention

Technical Problem

[14] An object of the present invention is to provide a backlight panel which has smaller thickness and reduced manufacturing costs as compared with a conventional backlight panel.

[15] Another object of the present invention is to provide a backlight panel capable of enhancing its luminance as compared with a conventional backlight panel.

Technical Solution

[16] In order to achieve the above objects of the present invention, there is provided a backlight panel employing a white light emitting diode with red and green phosphors. A backlight panel according to an aspect of the present invention comprises a light guide plate for emitting light incident from a side direction. The light guide plate emits light through a top surface thereof. The white light emitting diodes are arranged at a side of the light guide plate to emit white light into the light guide plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a diffusion plate is positioned over the top surface of the light guide plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and the thickness of the backlight panel can also be reduced, by employing the white light emitting diode with three red, green and blue wavelengths

[17] Further, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate. The brightness enhancement films can enhance the luminance of the backlight panel.

[18] A backlight panel according to another aspect of the present invention comprises a diffusion plate having a top surface and a bottom surface. White light emitting diodes are arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate. Each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip. Furthermore, a reflection sheet is positioned below light exit surfaces of the white light emitting diodes and also allows light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate. Therefore, the color reproducibility of a liquid crystal display can be ensured and spaces or gaps where light is mixed can also be reduced, so that the thickness of the backlight panel can be reduced. Further, since the luminance can be enhanced with the use of a light

source for upward emitting light, brightness enhancement films can be omitted.

[19] In addition, a brightness enhancement film and/or a dual brightness enhancement film may be positioned over the diffusion plate to further increase the luminance of the backlight panel.

[20] Preferably, the red phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate red light. The red phosphor may be an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

[21] Preferably, the green phosphor of the present invention is a phosphor that is excited by blue light emitted from the blue light emitting diode chip to radiate green light. The green phosphor may be a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y <1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

Advantageous Effects

[22] According to the embodiments of the present invention, there is provided a backlight panel which has smaller thickness and reduced manufacturing costs as compared with the coventional backlight panel. Further, there is provided a backlight panel having enhanced luminance as compared with the conventional backlight panel.

[23] Meanwhile, in a case where the red, green and blue LEDs are used as described in the prior art, the life spans and degrees of deterioration of the LEDs are different from one another. Thus, a color sensor should be installed on the LCD panel to detect the deterioration of the LEDs and to perform a compensation work. However, since the white LEDs of the same kinds are used in the embodiments of the present invention, the life spans and deterioration of the LEDs are generally similar to one another. Therefore, it is less necessary to use the color sensor and perform the compensation work. Accordingly, an operation circuit of the LCD panel can be further simplified.

Brief Description of the Drawings

[24] Fig. 1 is a sectional view illustrating a conventional backlight panel.

[25] Fig. 2 is a sectional view illustrating a backlight panel according to an aspect of the present invention.

[26] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel

according to the aspect of the present invention.

[27] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[28] Fig. 5 is a sectional view illustrating a white light emitting diode of the present invention.

Mode for the Invention

[29] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided only for illustrative purposes so that those skilled in the art can fully understand the spirit of the present invention. Therefore, the present invention is not limited to the following embodiments but may be implemented in other forms. In the drawings, the widths, lengths, thicknesses and the like of components may be exaggerated for convenience of illustration. Like reference numerals indicate like elements throughout the specification and drawings.

[30] Fig. 2 is a sectional view illustrating a backlight panel for backlighting a liquid crystal display panel 37 (hereinafter, referred to as "LCD panel") according to an aspect of the present invention.

[31] Referring to Fig. 2, a light guide plate 27 is positioned below the LCD panel 37. The light guide plate converts light emitted from a light source 23w into surface light and then emits the surface light upward toward the LCD panel. The light guide plate 27 may be made of glass, a transparent resin such as a transparent acryl resin or a polycarbonate or epoxy resin, or the like. Both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Further, a reflection sheet 25 may be positioned on a bottom surface of the light guide plate.

[32] White light emitting diodes (hereinafter, referred to as "LEDs") are positioned adjacent to a side of the light guide plate. Each of the white LEDs emits white light toward the side of the light guide plate 27. The white LED may be mounted on a printed circuit board 21, and a plurality LEDs may be mounted on the printed circuit board 21 as an LED module. The LEDs 23w mounted on the printed circuit board 21 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 27. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[33] The white LED 23w includes a blue LED chip, and green and red phosphors which are positioned over the blue LED chip to convert a portion of blue light into green and red light, respectively. The white LED 23w will be described in detail later with reference to Fig. 5.

[34] Meanwhile, light shielding walls 29 are positioned above and below the white LED 23w, respectively. The light shielding walls prevent light emitted from the white LED 23w from traveling toward regions other than the side of the light guide plate 27. A reflection layer is coated on an inner wall of the light shielding wall 29 to enable light incident onto the light shielding wall to be reflected. Such a reflection layer may be also formed on a top surface of the printed circuit board 21.

[35] A diffusion plate 31 is positioned over top surface of the light guide plate 27. The diffusion plate 31 may be a thin sheet. The diffusion plate 31 diffuses light incident from the light guide plate 27 into uniform light. Moreover, a brightness enhancement film (BEF) 33 and/or a dual brightness enhancement film (DBEF) 35 may be interposed between the diffusion plate 31 and the LCD panel 37. The BEFs 33 and 35 collect light emitted from the light guide plate 27 within a certain showing angle to increase the luminance of light.

[36] Since the backlight panel according to the aspect of the present invention is mounted with the white LED to enable uniform white light to be emitted from the LED, an air layer used for mixing the red, green and blue light with one another is not necessary, as compared with the prior art. Thus, the thickness of the backlight panel can be decreased. Further, since light emitted from the white LED is incident directly onto the light guide plate 27, the light emitting luminance can be enhanced. Thus, the BEFs 33 and 35 may be omitted. Furthermore, in a case where the BEFs are used, the luminance can be further enhanced. Thus, the number of LEDs used can also be reduced.

[37] Fig. 3 is a sectional view illustrating another embodiment of the backlight panel according to the aspect of the present invention.

[38] Referring to Fig. 3, the diffusion plate 31, the BEFs 33 and 35, and the LCD panel 37 are provided in the same manner as described with reference to Fig. 2. Hereinafter, only differences between the backlight panels of Figs. 2 and 3 will be described in detail.

[39] A light guide plate 47 is positioned below the diffusion plate 31. The light guide plate 47 is formed with a receiving groove 47a at a side thereof to accommodate LEDs in the receiving groove. As described with reference to Fig. 2, the light guide plate 47 may be made of glass, a transparent resin such as a transparent acryl resin or a poly-carbonate or epoxy resin, or the like. Further, both surfaces of the light guide plate may be machined with a variety of patterns such as V-shaped grooves, lens shapes, prism shapes or hologram patterns, if necessary. Furthermore, the reflection sheet 25 can be positioned on a bottom surface of the light guide plate. The reflection sheet 25 may be attached to the bottom surface of the light guide plate 47 to extend to the side thereof and have a through-hole through which the LEDs can be received in the receiving

groove 47a of the light guide plate 47.

[40] A white LED 43w is accommodated in the receiving groove 47a. The white LED is a side-view LED which emits light almost in parallel with top and bottom surfaces of the light guide plate 47, i.e. perpendicular to the side surfaces thereof. The side-view LED can adjust a showing angle of emitted light to be smaller than that of an LED emitting light upward, so that the thickness of the light guide plate 47 can be reduced.

[41] The white LED may be mounted on a printed circuit board 41, and a plurality LEDs may also be mounted on the printed circuit board 41 as an LED module. The LEDs 43w mounted on the printed circuit board 41 may be simultaneously driven through a circuit printed on the printed circuit board. Meanwhile, the LEDs may be positioned at both sides of the light guide plate 47. Accordingly, the luminance of the LCD panel 37 can be further enhanced.

[42] According to this embodiment, the side-view LED capable of adjusting a showing angle to be smaller is mounted such that the thickness of the light guide plate can be reduced.

[43] Fig. 4 is a sectional view illustrating a backlight panel according to another aspect of the present invention.

[44] Referring to Fig. 4, a diffusion plate 61 is positioned below an LCD panel 67. The diffusion plate has a top surface and a bottom surface. BEF 63 and/or DBEF 65 may be interposed between the diffusion plate and the LCD panel 67.

[45] Meanwhile, white LEDs 53w are arranged below the bottom surface of the diffusion plate 61 at a certain interval from the diffusion plate 61. Each of the white LEDs 53w includes a blue LED chip, and green and red phosphors positioned over the blue LED chip. The white LEDs 53w will be described in detail later with reference to Fig. 5.

[46] Each of the white LEDs 53w emits white light toward the diffusion plate 61. The white LED may be mounted on a printed circuit board 51, and a plurality LEDs may be mounted on the printed circuit board 51 as an LED module. The LEDs 53w mounted on the printed circuit board 51 may be simultaneously driven through a circuit printed on the printed circuit board. A plurality of LED modules may be arranged below the diffusion plate 61 to uniformly backlight the LCD panel 67.

[47] Furthermore, a reflection sheet 55 is positioned below light exit surfaces of the white LEDs 53w. The reflection sheet 55 may be formed with a reflection layer 55a thereon. The reflection sheet may be made of an aluminum sheet and coated with the reflection layer 55a thereon. Further, the reflection sheet 55 may be attached onto the printed circuit board 51 as shown in this figure.

[48] The reflection sheet 55 and the diffusion plate 61 are spaced apart from each other by a predetermined interval to define a gap 60a corresponding to an air layer. White

light emitted from the white LEDs 53w are mixed with one another in the gap 60a and then incident onto the diffusion plate 61.

[49] The backlight panel according to this aspect does not use an additional light guide plate. Thus, the diffusion plate 61 may be thicker than the diffusion plate 31 of Fig. 2 or 3 such that light emitted from the white LEDs 53w can be uniform.

[50] In the meantime, since the backlight panel according to this aspect employs top-view white LEDs contrary to the prior art, the light transmission layer 7 (Fig. 1) formed with the light shielding pattern 9 (Fig. 1) may be omitted. Further, since light emitted from the white LEDs 53w is incident directly onto the diffusion plate 61, the light loss can be reduced so that the luminance of the LCD panel 67 can be enhanced. Accordingly, since the BEF 63 and the DBEF 65 can be omitted, the thickness of the backlight panel can also be reduced.

[51] Fig. 5 is a sectional view illustrating the white LED 23w, 43w or 53w used in the embodiments of the present invention.

[52] Referring to Fig. 5, the white LED includes a package body 71. The package body may be formed using an injection molding, pressing or machining technique, and particularly injection-molded using a plastic resin. The package body is formed with a cavity which exposes lead terminals 73. Further, a sidewall of the cavity may be an inclined surface inclined at a certain angle.

[53] The lead terminals 73 extend outward to protrude out of the package body 71. The lead terminals 73 protruding to the outside are connected to a printed circuit board and electrically connected to an external power source. The lead terminals 73 may be bent from the outside such that they can be surface mounted.

[54] Meanwhile, a heat sink 75 may be attached to the bottom of the package body 71. The heat sink is provided to easily dissipate heat generated from an LED chip 77 to the outside. The heat sink 75 may be formed with a base and a projection protruding upward from a center portion of the base. The projection is inserted into the package body and then exposed to the cavity. After the package body 71 has been formed with a through-hole, the heat sink can be inserted into the through-hole of the package body and mounted to the package body. Alternatively, the heat sink 75 can be attached to the package body 71 by positioning the lead terminals 73 and the heat sink 75 and then forming the package body using an insert-molding technique. The heat sink 75 may be electrically isolated from the lead terminals 75, or electrically connected to any one of the lead terminals.

[55] A blue LED chip 77 for emitting blue light is mounted on the heat sink 75. The LED chip 77 is a GaN, InGaN or AlGaInN-based light emitting diode and radiates blue light with a wavelength of 420 to 480 nm. The LED chip 77 has two electrodes for the connection with an external source. The electrodes may be positioned on the same side

or opposite sides of the LED 77. The electrodes may be electrically connected to the lead terminals through an adhesive or bonding wires as shown in this figure. In a case where the electrodes are formed on the same side of the LED chip, the LED chip 77 and the lead terminals are connected through the two bonding wires, respectively, so that they can be electrically connected as shown in this figure. On the other hand, in a case where the electrodes are positioned on the opposite sides, one of the electrodes is connected to the heat sink 75 using a conductive adhesive and one of the lead terminals is connected to the heat sink 75 through the bonding wire, so that the lead terminals and the LED chip 77 can be electrically connected with each other.

[56] Over the blue LED chip 77 is positioned red and green phosphors 81r and 81g which are excited by blue light to radiate red and green light, respectively, such that the radiated light is mixed with a portion of blue light emitted from the LED chip 77 to become white light. The red and green phosphors may be either coated on the LED chip 77 or positioned in a molding member 79 in a state where they are contained therein as shown in this figure. The molding member 79 may be made of an epoxy or silicone resin and formed into a single layer or multiple layers.

[57] For example, the red phosphor 81r may be an alkali earth metal sulfide-based red phosphor, while the green phosphor 81g may be a thiogallate-based green phosphor. More specifically, the alkali earth metal sulfide-based red phosphor is expressed as general formula $A_{x-a}Eu_aGeS_z$, where A is Ca and/or Sr, z=x+2, x is set within a range of 2 to 5, and a/x is set within a range of 0.0005 to 0.02.

[58] Further, the thiogallate-based green phosphor is expressed as general formula $(A_{1-x-y}Eu_x(M^I_{0.5}M^{III}_{0.5})_y)B_2S_4$, where A is at least one element selected from the group consisting of Ba, Sr and Ca, B is at least one element selected from the group consisting of Al, Ga and In, and $0<x, y, x+y<1$. Preferably, x is set within a range of 0.01 to 0.1. Meanwhile, M^I is at least one element selected from the group consisting of Li, Na and K, and M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La. Preferably, y is set within a range of 0.2 to 0.8.

[59] Such red and green phosphors 81r and 81g are obtained in the following manners. That is, phosphor raw materials and an activator raw material are weighted to have a predetermined mixing ratio in accordance with a desired composition and sufficiently mixed into a uniform mixture by using a ball milling or a mixer such as agate mortar within an alcohol solvent for effective mixing. Then, the mixture is dried in an oven at a temperature of 100 to 150°C for 1 to 2 hours. The dried mixture is heat-treated in a high-purity alumina boat at a temperature of 800 to 1300°C under the atmosphere of H_2S using an electric furnace to synthesize phosphor powder and then sufficiently pulverize the synthesized phosphor powder.

[60] According to the results of measuring photoluminescence (PL) of the powder, the

thiogallate-based green phosphor of a typical composition expressed as $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$ exhibits strong photoluminescence spectrum throughout a region of 470 to 630 nm while the alkali earth metal sulfide-based red phosphor expressed as $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ exhibits strong photoluminescence spectrum throughout a region of 520 to 780 nm. Accordingly, white light with distinct red, green and blue wavelengths can be radiated using the blue LED chip 77 and the phosphors, and thus, the color reproducibility of the LCD panel can be enhanced.

[61] Meanwhile, the LED chip 77 and the phosphors 81r and 81g are covered with a lens 83. The lens may be formed into a variety of shapes. For example, to implement a top-view LED according to the aspects of the present invention, the lens may take the shape of a convex lens as shown in this figure. At this time, the curvature of the lens is determined depending on a desired showing angle. Meanwhile, to implement a side-view LED shown in Fig. 2, the lens is designed to emit light from the LED chip 77 in a side direction. An example of such a side-view LED is shown in Fig. 1, and the other side-view LEDs can be implemented into a variety of lens shapes.

Claims

[1] A backlight panel, comprising:
a light guide plate for emitting light incident from a side direction, the light guide emitting light through a top surface thereof;
white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and
a diffusion plate positioned over the top surface of the light guide plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[2] The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[3] A backlight panel, comprising:
a diffusion plate having a top surface and a bottom surface;
white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and
a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,
wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip.

[4] The backlight panel as claimed in claim 3, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

[5] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

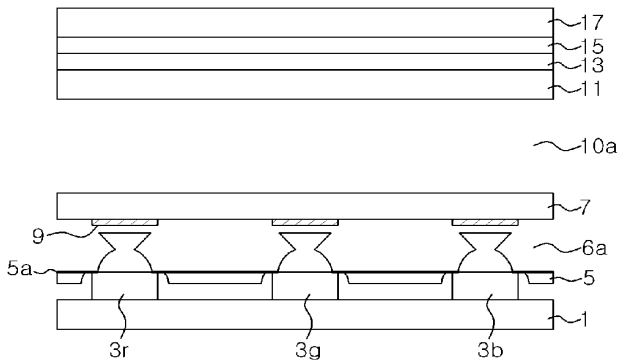
[6] The backlight panel as claimed in any one of claims 1 to 4, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li,

Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

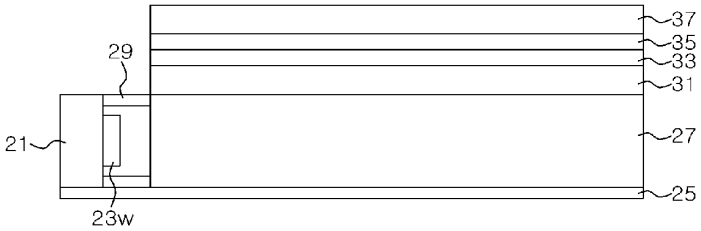
[7] The backlight panel as claimed in any one of claims 1 to 4, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

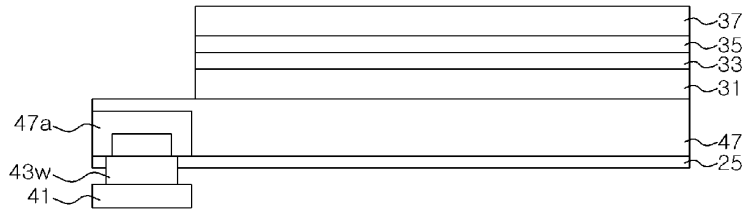
[Fig. 1]



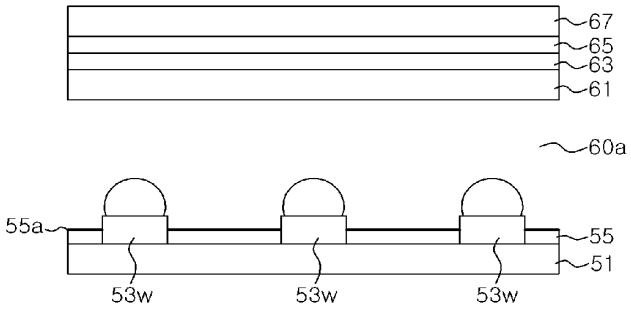
[Fig. 2]



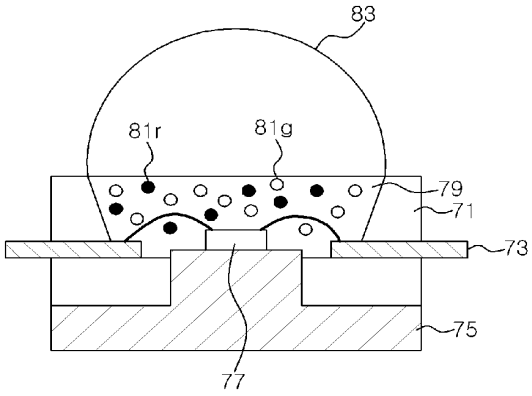
[Fig. 3]



[Fig. 4]



[Fig. 5]



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【서지사항】

【서류명】 특허출원서

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【수신처】 특허청장

【참조번호】 0134

【제출일자】 2005.03.31

【발명의 국문명칭】 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널

【발명의 영문명칭】 BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

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【취지】 특허법 제42조의 규정에 의하여 위와 같이 출원합니다.

대리인 이수완 (인)

대리인 조진태 (인)

대리인 윤종섭 (인)

대리인 이성규 (인)

【수수료】

【기본출원료】	0	면	38,000 원
【가산출원료】	22	면	0 원
【우선권주장료】	0	건	0 원
【심사청구료】	0	항	0 원

【합계】 38,000 원

【감면사유】 중소기업

【감면후 수수료】 19,000 원

【첨부서류】 1.중소기업기본법시행령 제2조에의한 중소기업에 해당함을 증명하는 서류_1통

【요약서】

【요약】

백색 발광다이오드를 채택한 백라이트 패널이 개시된다. 이 백색 발광다이오드는 청색 발광다이오드 칩 및 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 이에 따라, 적색, 녹색 및 청색의 선명한 파장을 갖는 백색광으로 백라이팅함으로써 색재현성이 양호하며, 단일의 발광다이오드로 백색을 구현할 수 있어 백라이트 패널의 제조비용 및 두께를 감소시킬 수 있다.

【대표도】

도 4

【색인어】

백라이트 패널, 발광다이오드, 형광체

【명세서】

【발명의 명칭】

적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널{BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR}

【도면의 간단한 설명】

<1> 도 1은 종래의 백라이트 패널을 설명하기 위한 단면도이다.

<2> 도 2는 본 발명의 일 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<3> 도 3은 본 발명의 일 태양에 따른 백라이트 패널의 다른 실시예를 설명하기 위한 단면도이다.

<4> 도 4는 본 발명의 다른 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<5> 도 5는 본 발명의 백색 발광다이오드를 설명하기 위한 단면도이다.

【발명의 상세한 설명】

【발명의 목적】

【발명이 속하는 기술분야 및 그 분야의 종래기술】

<6> 본 발명은 디스플레이 패널을 백라이팅하기 위한 백라이트 패널에 관한 것으로서, 보다 상세하게는 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를

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광원으로 채택하여 디스플레이 패널의 색재현성 및 휘도를 향상시킨 백라이트 패널에 관한 것이다.

<7> 액정 디스플레이(liquid crystal display)와 같은 수동 디스플레이 장치는 주위의 태양광 또는 실내 광을 반사하거나 흡수하여 이미지를 구현할 수 있다. 따라서, 디스플레이되는 이미지를 보기 위해, 주위의 태양광 또는 실내 광이 요구된다. 그러나, 주위의 태양광 또는 실내 광의 강도가 디스플레이 패널을 조명하기에 충분하지 않을 경우 디스플레이되는 이미지를 볼 수 없는 문제점이 있다. 이러한 문제점에 대한 대안으로 디스플레이 패널을 백라이팅하기 위한 백라이트 패널이 일반적으로 채택된다.

<8> 백라이트 패널은 백열 램프, 형광 램프 또는 발광 다이오드(LED)와 같은 광원을 포함한다. 광원에서 방출된 광이 상기 LCD 패널을 조명함으로써 이미지가 구현된다. 한편, LED는 색재현성이 우수하여 백라이트 광원으로 종종 사용되며, 환경친화적이어서 앞으로 그 사용이 더욱 증가할 것으로 기대된다.

<9> 도 1은 발광 다이오드를 채택하여 LCD 패널(17)을 백라이팅하는 종래의 백라이트 패널을 설명하기 위한 부분 단면도이다.

<10> 도 1을 참조하면, 인쇄회로기판(1) 상에 LED 어레이가 위치한다. 상기 LED 어레이는 적색(3r), 녹색(3g) 및 청색(3b) LED들이 소정간격으로 배열된 어레이이다. 이들 LED 들은 인쇄회로기판(1) 상에 규칙적으로 배열되어 LED 모듈을 구성하며, 복수개의 LED 모듈이 상기 LCD 패널(17)을 백라이팅하기 위해 사용된다.

<11> 상기 LED들은 측면 발광이 되도록 설계된 렌즈를 채택하여 주광을 거의 측면

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방향으로 방출한다.

<12> 상기 LED들의 광 출사면 하부에 반사시트(5)가 위치한다. 상기 반사시트는 그 상부에 반사층(5a)을 가질 수 있다. 상기 반사시트는 LED들에서 방출된 광을 상부 측으로 반사시킨다.

<13> 한편, 상기 LED들 상부에 투광층(7)이 위치한다. 상기 투광층은 LED들에서 출사된 광이 투과할 수 있는 층으로, PMMA(poly methyl methacrylate)와 같은 투명 수지로 제조된다. 상기 투광층(7)은 LED들에 대응하는 위치에 차광패턴들(9)을 갖는다. 상기 차광패턴들은 LED들에서 상부방향으로 출사된 광이 투광층을 투과하여 LCD(17)로 향하는 것을 방지하기 위한 것으로, ESR(eletroslag remelting)로 형성된다.

<14> 상기 투광층(7)과 반사시트(5)는 소정 간격 이격되어 공기층으로 된 제1 간격(6a)을 형성한다. 상기 제1 간격은 LED들(3r, 3g, 3b)에서 방출된 적색, 녹색 및 청색의 빛이 서로 혼합되는 영역이다.

<15> 투광층(7) 상부에 상기 투광층(7)과 이격되어 확산판(11)이 위치한다. 상기 확산판(11)은 입사된 광들을 확산시키어 광을 균일하게 만든다. 상기 확산판과 투광층(7)은 소정 간격 이격되어 공기층으로 된 제2 간격(10a)을 형성한다. 따라서, 투광층(7)을 투과한 광들이 상기 제2 간격(10a) 내에서 다시 혼합되어 상기 확산판(11)으로 입사된다.

<16> 상기 확산판(11) 상부에 프리즘 시트와 같은 밝기강화필름(brightness enhancement film; BEF, 13)이 위치한다. 상기 BEF는 두개의 시트로 구성될 수 있

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으며, 두개의 시트는 각각 종방향 및 횡방향으로 형성된 상향 프리즘을 갖는다. 이에 더하여, 상기 BEF(13) 상부에 엠보싱 처리된 이중 밝기 강화 필름(dual brightness enhancement-embossed; DBEF-E)과 같은 이중 밝기 강화 필름(DBEF, 15)이 위치할 수 있다. 이들 BEF 필름들(13, 15)은 확산판(11)에서 큰 지향각으로 출사된 광을 좁은 지향각으로 굴절시키어 LCD 패널(17)로 입사시킨다. 이에 따라, LCD 패널의 휘도를 증가시킨다.

<17> 종래기술에 따르면, 적색, 녹색 및 청색 LED들을 광원으로 사용하므로 색재현성을 향상시킬 수 있다. 그러나, 적색, 녹색 및 청색 LED들을 사용함에 따라, 균일한 광을 얻기 위해 LED들에서 방출된 광을 혼합할 필요가 있다. 이에 따라, 차광패턴(7)을 사용하여 LED들에서 출사된 광이 직접 투광층(7)을 투과하여 확산판(11)으로 향하는 것을 방지할 필요가 있으며, 제1 간격(6a) 및 제2 간격(10a)과 같은 공기층이 요구된다. 이는 백라이트 패널의 두께증가로 이어진다.

<18> 또한, LED들에서 방출된 광을 혼합하는 동안, 광손실이 발생한다. 따라서, LED들에 공급되는 전류량을 증가시키거나, 보다 많은 수의 LED들을 사용하거나, BEF(13) 및 DBEF(15)등을 사용하여 이러한 광손실을 보상한다. 그러나, 전류량의 증가 또는 다수의 LED들을 사용할 경우, 전력소모가 증가된다. 특히, 전류량의 증가는 LED들에 발생되는 열의 증가로 이어지며, 차광층을 열화시킬 수 있다. 또한, BEF 필름들의 사용은 백라이트 패널 전체의 두께를 더욱 증가시키며, 백라이트 패널의 제조비용을 상승시킨다.

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【발명이 이루고자 하는 기술적 과제】

<19> 본 발명이 이루고자 하는 기술적 과제는, 종래기술에 비해 제조비용을 절감할 수 있으며, 더 얇은 두께를 갖는 백라이트 패널을 제공하는 데 있다.

<20> 본 발명이 이루고자 하는 다른 기술적 과제는, 종래기술에 비해 휘도를 향상시킬 수 있는 백라이트 패널을 제공하는 데 있다.

【발명의 구성】

<21> 상기 기술적 과제들을 달성하기 위하여, 본 발명은 적색 형광체 및 녹색 형광체를 갖는 백색 발광다이오드를 채택한 백라이트 패널을 제공한다. 본 발명의 일 태양에 따른 상기 백라이트 패널은 측면 방향에서 입사된 광을 상부로 출사시키는 도광판을 포함한다. 백색 발광다이오드들이 상기 도광판의 측면 측에 위치하여 상기 도광판 내부로 백색광을 출사한다. 상기 백색 발광다이오드들 각각은 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 한편, 상기 도광판 상부에 확산판이 위치한다. 본 발명의 일 태양에 따르면, 적색, 녹색 및 청색의 3파장을 갖는 백색 발광다이오드를 채택하여 액정표시화면의 색재현성을 보장하면서, 백라이트 패널의 두께를 감소시킬 수 있다.

<22> 한편, 상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름이 위치할 수 있다. 이들 밝기 강화 필름은 백라이트 패널의 휘도를 향상시킨다.

<23> 본 발명의 다른 태양에 따른 백라이트 패널은 하부면 및 상부면을 갖는 확산판을 포함한다. 백색 발광다이오드들이 상기 확산판과 이격되어 상기 하부면 아래

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에 배열된다. 상기 백색 발광다이오드들 각각은 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 한편, 반사시트가 상기 백색 발광다이오드들의 출사면 아래에 위치한다. 상기 반사시트는 상기 확산판에 대향하는 방향으로 진행하는 광을 확산판으로 반사시킨다. 이에 따라, 액정표시화면의 색재현성을 보장하면서, 광을 혼합하기 위한 간격들을 줄일 수 있어 백라이트 패널의 두께를 감소시킬 수 있다. 또한, 상향으로 출사하는 광원을 사용하여 휘도를 향상시킬 수 있어, 밝기 강화 필름들을 생략할 수 있다.

<24> 한편, 상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 배치하여 휘도를 더욱 증가시킬 수 있다.

<25> 본 발명의 태양들에 따른 적색 형광체는 청색 발광다이오드 칩에서 방출된 청색광에 의해 여기되어 적색을 방출하는 형광체이다. 상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체일 수 있다.

<26> 본 발명의 태양들에 따른 녹색 형광체는 청색 발광다이오드 칩에서 방출된 청색광에 의해 여기되어 녹색을 방출하는 형광체이다. 상기 녹색 형광체는 일반식 $(A_{1-x-y}Eu_x\ (M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$; $0 < x, y, x+y < 1$이고, 여기에서 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, x는 0.01에서 0.1 범위 내

로 설정되고, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, y는 0.2에서 0.8 범위내로 설정되는 티오갈레이트계 녹색 형광체일 수 있다.

<27> 이하, 첨부한 도면들을 참조하여 본 발명의 실시예들을 상세히 설명한다. 다음에 소개되는 실시예들은 당업자에게 본 발명의 사상이 충분히 전달될 수 있도록 하기 위해 예로서 제공되어지는 것이다. 따라서, 본 발명은 이하 설명되어지는 실시예들에 한정되지 않고 다른 형태로 구체화될 수도 있다. 그리고, 도면들에 있어서, 구성요소의 폭, 길이, 두께 등은 편의를 위하여 과장되어 표현될 수도 있다. 명세서 전체에 걸쳐서 동일한 참조번호들은 동일한 구성요소들을 나타낸다.

<28> 도 2는 본 발명의 일 태양에 따른 액정표시 패널(37, 이하 LCD 패널)을 백라이팅하기 위한 백라이트 패널을 설명하기 위한 단면도이다.

<29> 도 2를 참조하면, 상기 LCD 패널(37)의 하부에 도광판(27)이 위치한다. 상기 도광판은 광원(23w)에서 방출된 광을 면광으로 변환하여 상부 방향으로 방출한다. 상기 도광판(27)은 투명 아크릴 수지, 폴리카보네이트 또는 에폭시 수지 등의 투명 수지나 유리 등으로 제조할 수 있다. 상기 도광판의 양면은 필요에 따라 V형 그루브(groove)들, 렌즈 형상, 프리즘 형상 또는 홀로그램 패턴 등 다양한 패턴들로 가공될 수 있다. 또한, 상기 도광판의 하부에 반사시트(25)가 배치될 수도 있다.

<30> 상기 도광판의 측면에 인접하여 백색 발광다이오드(이하, LED)들이

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설치된다. 상기 백색 LED는 상기 도광판(27)의 측면을 향해 백색광을 출사시킨다. 상기 백색 LED는 인쇄회로기판(21) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(21) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(21) 상에 탑재된 LED들(23w)은 인쇄회로기판에 인쇄된 회로를 통해 동시에 구동될 수 있다. 한편, 상기 LED들은 도광판(27)의 양쪽 측면에 배치될 수 있다. 이에 따라, LCD 패널(37)의 휘도를 더욱 향상시킬 수 있다.

<31> 상기 백색 LED(23w)는 청색 LED칩을 가지며, 상기 청색 LED칩 상부에 위치하여 청색광의 일부를 녹색광으로 파장변환시키는 녹색 형광체 및 적색광으로 파장변환시키는 적색 형광체를 갖는다. 상기 백색 LED(23w)에 대해서는 도 5를 참조하여 뒤에서 상세히 설명한다.

<32> 한편, 상기 백색 LED(23w)의 상부 및 하부에 차광벽(29)이 위치한다. 상기 차광벽은 백색 LED(23w)에서 방출된 광이 도광판(27)의 측면 이외의 영역으로 출사되는 것을 방지한다. 상기 차광벽(27)의 내벽에는 반사층이 코팅되어, 차광벽으로 입사된 광을 반사시킬 수 있다. 이러한, 반사층은 상기 인쇄회로기판(21) 상부면에도 형성될 수 있다.

<33> 상기 도광판(27) 상부에 확산판(31)이 위치한다. 상기 확산판(31)은 얇은 시트일 수 있다. 확산판(31)은 도광판(27)에서 입사된 광을 확산시키어 균일한 광으로 만든다. 이에 더하여, 상기 확산판(31)과 LCD 패널(37) 사이에 밝기 강화 필름(33) 및/또는 이중 밝기 강화 필름(35)이 더 개재될 수 있다. 상기 BEF들(33, 35)은 도광판(27)에서 출사된 광을 일정한 지향각 내로 집광시키어 휘도를

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증가시킨다.

<34> 본 발명의 일 태양에 따른 상기 백라이트 패널은 백색 LED를 탑재하여 LED에서 균일한 백색광을 방출하므로, 종래기술과 대비하여, 적색, 녹색 및 청색광을 혼합하기 위한 공기층이 별도로 필요하지 않아 백라이트 패널의 두께를 감소시킬 수 있다. 또한, 백색 LED에서 방출된 광을 직접 도광판(27)에 입사시키므로, 발광 휘도를 향상시킬 수 있어, BEF들(33, 35)을 생략할 수 있다. 또한, BEF들을 사용할 경우, 휘도를 더욱 향상시킬 수 있어, 사용 LED 수를 감소시킬 수 있다.

<35> 도 3은 본 발명의 일 태양에 따른 백라이트 패널의 다른 실시예를 설명하기 위한 단면도이다.

<36> 도 3을 참조하면, 도 2를 참조하여 설명한 바와 같이, 확산판(31), BEF들(33, 35) 및 LCD 패널(37)이 위치한다. 이하, 도 2의 백라이트 패널과 다른 점에 대해 상세히 설명한다.

<37> 도광판(47)이 상기 확산판(31) 하부에 위치한다. 상기 도광판(47)은 그 측면 측에 LED들을 수용하기 위한 수용홈(47a)을 갖는다. 상기 도광판(47)은, 도 2를 참조하여 설명한 바와 같이, 투명 아크릴 수지, 폴리카보네이트 또는 에폭시 수지 등의 투명 수지나 유리 등으로 제조할 수 있으며, 도광판의 양면은 필요에 따라 V형 그루브(groove)들, 렌즈 형상, 프리즘 형상 또는 홀로그램 패턴 등 다양한 패턴들로 가공될 수 있다. 또한, 상기 도광판의 하부에 반사시트(25)가 배치될 수도 있다. 상기 반사시트(25)는 도광판(47)의 하부면에 부착되어, 도광판의 측면까지 연장될 수 있으며, LED들을 상기 도광판(47)에 수용할 수 있도록 관통홀을 가질 수

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있다.

<38> 상기 수용홈(47a) 내에 백색 LED(43w)가 수용된다. 상기 백색 LED는 도광판(47)의 면을 따라 거의 평행한 광, 즉 측면에 수직인 광을 방출하는 측면발광 LED이다. 측면발광 LED는 상부로 발광하는 LED에 비해 출사되는 광의 지향각을 더 좁게 조절할 수 있어, 도광판(47)의 두께를 감소시킬 수 있다.

<39> 상기 백색 LED는 인쇄회로기판(41) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(41) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(41) 상에 탑재된 LED들(43w)은 인쇄회로기판에 인쇄된 회로를 통해 동시에 구동될 수 있다. 한편, 상기 LED들은 도광판(47)의 양쪽 측면 측에 배치될 수 있다. 이에 따라, LCD 패널(37)의 휘도를 더욱 향상시킬 수 있다.

<40> 본 실시예에 따르면, 지향각을 좁게 조절할 수 있는 측면발광 LED를 탑재하여 도광판의 두께를 감소시킬 수 있다.

<41> 도 4는 본 발명의 다른 태양에 따른 백라이트 패널을 설명하기 위한 단면도이다.

<42> 도 4를 참조하면, LCD 패널(67) 하부에 확산판(61)이 위치한다. 상기 확산판은 상부면 및 하부면을 갖는다. 상기 확산판과 LCD 패널(67) 사이에 BEF(63) 및/또는 DBEF(65)가 개재될 수 있다.

<43> 한편, 백색 LED들(53w)이 상기 확산판(61)과 이격되어 상기 확산판의 하부면 아래에 배열된다. 상기 백색 LED들(53w) 각각은 청색 LED칩 및 상기 청색 LED칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는다. 상기 백색 LED들(53w)에 대해

서는 도 5를 참조하여 뒤에서 상세히 설명한다.

<44> 상기 백색 LED들(53w)은 확산판(61)을 향해 백색광을 출사시킨다. 상기 백색 LED는 인쇄회로기판(51) 상에 탑재될 수 있으며, 복수개의 LED들이 하나의 인쇄회로기판(51) 상에 탑재되어 LED 모듈을 구성할 수 있다. 인쇄회로기판(51) 상에 탑재된 LED들(53w)은 인쇄회로기판(51)에 인쇄된 회로를 통해 동시에 구동될 수 있다. 상기 확산판(61) 하부에는 균일한 백라이팅을 위해 복수개의 LED 모듈이 배치될 수 있다.

<45> 한편, 상기 백색 LED들(53w)의 출사면 아래에 반사시트(55)가 위치한다. 상기 반사시트(55)는 상부에 반사층(55a)을 가질 수 있다. 상기 반사시트는 알루미늄 시트로 형성될 수 있으며, 그 위에 반사층(55a)이 코팅될 수 있다. 또한, 상기 반사시트(55)는, 도시한 바와 같이, 인쇄회로기판(51) 상에 부착될 수 있다.

<46> 상기 반사시트(55)와 확산판(61)은 소정 간격 이격되어 공기층으로 구성된 간격(60a)을 형성한다. 상기 백색 LED(53w)에서 출사된 백색광은 상기 간격(60a) 내에서 서로 혼합되어 확산판(61)으로 입사된다.

<47> 본 태양에 따른 백라이트 패널은 별도의 도광판을 사용하지 않는다. 따라서, 백색 LED(53w)에서 방출된 광을 균일하게 하기 위해 확산판(61)이 도 2 또는 도 3의 확산판(31)에 비해 더 두꺼울 수 있다.

<48> 한편 본 태양에 따른 백라이트 패널은, 종래기술과 달리, 상부발광 백색 LED들을 채택하므로, 차광패턴(도 1의 9)을 갖는 투광층(도 1의 7)을 생략할 수 있다. 또한, 백색 LED들(53w)에서 방출된 광을 직접 확산판(61)으로 입사시키므로, 광손

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실을 감소시킬 수 있어, LCD 패널(67)의 휘도를 증가시킬 수 있다. 따라서, BEF(63) 및 DBEF(65)를 생략할 수 있어, 백라이트 패널의 두께를 감소시킬 수 있다.

<49> 도 5는 본 발명의 실시예들에서 사용되는 백색 LED(23w, 43w 또는 53w)를 설명하기 위한 단면도이다.

<50> 도 5를 참조하면, 상기 백색 LED는 패키지 본체(71)를 갖는다. 상기 패키지 본체는 사출, 프레싱 또는 가공기술을 사용하여 형성될 수 있으며, 특히 플라스틱 수지를 사용하여 사출 성형될 수 있다. 상기 패키지 본체는 요홈부를 갖도록 형성되며, 상기 요홈부에 리드 단자들(73)이 노출된다. 또한, 상기 요홈부의 측벽은 일정한 각도로 경사진 경사면으로 이루어진다.

<51> 상기 리드 단자들(73)은 외부로 연장되어 패키지 본체(71) 밖으로 돌출된다. 외부로 돌출된 리드단자들(73)이 인쇄회로기판에 접속되어 외부전원에 전기적으로 연결된다. 상기 리드 단자들(73)은 표면실장이 가능하도록 외부에서 절곡될 수 있다.

<52> 한편, 상기 패키지 본체(71)의 하부에 히트싱크(75)가 장착될 수 있다. 상기 히트싱크는 LED칩(77)에서 발생된 열을 외부로 쉽게 방출하기 위해 장착된다. 상기 히트싱크(75)는 기저부 및 기저부의 중앙부분에서 상향 돌출된 돌출부를 가질 수 있다. 상기 돌출부는 패키지 본체에 삽입되어 요홈부에 노출된다. 상기 히트싱크는 관통홀을 갖는 패키지 본체(71)를 형성한 후, 패키지 본체의 관통홀에 삽입되어 장착될 수 있다. 이와 달리, 리드단자들(73)과 히트싱크(75)를 위치시킨 후 인서트 몰딩 기술을 사용하여 패키지 본체를 형성함으로써 상기 히트싱크(75)를 패키지 본

체(71)에 장착할 수 있다. 상기 히트싱크(75)는 상기 리드단자들(73)과 전기적으로 절연될 수 있으나, 상기 리드단자들 중 하나와 전기적으로 연결될 수도 있다.

<53> 상기 히트싱크(75) 상에 청색광을 방출하는 청색 LED칩(77)이 탑재된다. 상기 LED칩(77)은 GaN, InGaN, AlGaN 또는 AlGaInN 계열의 발광 다이오드로서, 420 내지 480 nm 범위의 청색 광을 방출한다. 상기 LED칩(77)은 외부전원에 연결되기 위해 두 개의 전극들을 구비한다. 상기 전극들은 LED칩(77)의 동일 측면(side) 또는 서로 반대 측면 상에 위치할 수 있다. 상기 전극들은 접착제를 통해 리드단자에 전기적으로 연결되거나, 도시한 바와 같이, 본딩와이어를 통해 리드단자에 연결될 수 있다. 동일측면에 전극들이 형성된 LED칩의 경우, 도시한 바와 같이, 두개의 본딩와이어로 LED칩(77)과 리드단자들을 각각 연결하여 전기적으로 연결할 수 있다. 이와 달리, 서로 반대측면 상에 전극들이 위치하는 경우, 하나의 전극은 상기 히트싱크(75)에 전도성 접착제를 이용하여 연결하고, 본딩와이어로 하나의 리드단자와 히트싱크(75)를 연결하여, 리드단자들과 LED칩(77)을 전기적으로 연결할 수 있다.

<54> 상기 청색 LED칩(77)의 상부에는 상기 LED칩(77)에서 방출된 광의 일부와 혼색되어 백색광을 방출시키도록 청색광에 의해 여기되어 적색광을 방출하는 적색형광체(81r)와 청색광에 의해 여기되어 녹색광을 방출하는 녹색 형광체(81g)가 위치한다. 상기 적색 및 녹색 형광체들은 상기 LED칩(77) 상에 코팅되거나, 도시한 바와 같이, 몰딩부재(79) 내에 함유되어 위치할 수 있다. 상기 몰딩부재(79)는 에폭시 수지 또는 실리콘 수지로 형성될 수 있으며, 단일층 또는 다중층으로 형성될 수 있다.

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<55> 상기 적색 형광체(81r)는 예컨대, 알칼리 토금속 황화물계 적색 형광체일 수 있으며, 녹색 형광체(81g)는 티오갈레이트 녹색 형광체일 수 있다. 보다 구체적으로 상기 알칼리 토금속 황화물계 적색 형광체는 일반식 $A_{x-a}Eu_aGeS_z$ 로 표현된다. 여기서, A는 Ca 및/또는 Sr이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정된다.

<56> 또한, 상기 티오갈레이트 녹색 형광체는 일반식 $(A_{1-x-y}Eu_x(M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$ 로 표현된다. 여기서, A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, $0< x, y, x+y < 1$ 이다. 바람직하게는, x는 0.01에서 0.1 범위 내로 설정된다. 한편, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이다. y는 0.2에서 0.8 범위내로 설정되는 것이 바람직하다.

<57> 이러한 적색 및 녹색 형광체(81r, 81g)는 형광체 원료물질과 활성제를 원하는 조성에 따른 각각의 소정비가 되도록 평량하고 보다 효과적인 혼합을 위해 알코올 용매하에서, 볼밀링(ball milling) 또는 마노유발 같은 혼합기를 이용하여 균일한 조성이 되도록 충분히 혼합한다.

<58> 그 후, 이 혼합물을 오븐에 넣고, 100 내지 150℃ 에서 1 ~ 2시간 동안 건조한다. 건조한 혼합물을 고순도 알루미나 보트에 넣고 전기로를 사용하여 800 ~ 1300℃ 사

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이의 온도에서 H_2S 대기중에 열처리하여 형광체 분말을 합성한 후 충분히 분쇄한다.

<59> 이들 분말에 대하여 빛 발광강도(Photoluminescence, PL)를 측정한 결과 $Sr_{0.36}Eu_{0.04}Y_{0.3}Li_{0.3}Ga_2S_4$로 표현되는 대표적인 조성의 티오갈레이트계 녹색 형광체는 470 ~ 630nm의 영역에 걸쳐서 강한 발광 스펙트럼을 나타내고, $Sr_{2.185}Eu_{0.015}Ca_{0.8}GeS_5$ 알칼리 토금속 황화물계 적색 형광체는 520 ~ 780nm의 영역에 걸쳐서 강한 발광 스펙트럼을 나타내었다. 따라서, 청색 LED칩(77)과 상기 형광체들을 사용하여 적색, 녹색 및 청색의 뚜렷한 파장을 갖는 백색광을 방출할 수 있으며, 이에 따라 LCD 패널의 색재현성을 향상시킬 수 있다.

<60> 한편, 렌즈(83)가 상기 LED칩(77) 및 형광체들(81r, 81g)을 덮는다. 상기 렌즈는 다양한 형상을 가질 수 있다. 예컨대, 본 발명의 태양들에 따른 상부발광 LED를 구현하기 위해, 상기 렌즈는 도시한 바와 같이, 볼록렌즈의 형상을 가질 수 있다. 이때, 렌즈의 곡률은 요구되는 지향각에 따라 결정된다. 한편, 도 2와 같은 측면발광 LED를 구현하기 위해 상기 렌즈는 LED칩(77)에서 방출된 광을 측면으로 출사시키도록 설계된다. 이러한, 측면발광 LED의 예가 도 1에 도시된 LED들이며, 이외에 다양한 렌즈형상들로 측면발광 LED를 구현할 수 있다.

【발명의 효과】

<61> 본 발명의 실시예들에 따르면, 종래기술에 비해 제조비용을 절감할 수 있으며, 더 얇은 두께를 갖는 백라이트 패널을 제공할 수 있다. 또한, 종래기술에 비해 휘도가 향상된 백라이트 패널을 제공할 수 있다.

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<62> 한편, 종래기술과 같이, 적색, 녹색 및 청색 LED들을 사용할 경우, 상기 LED들의 수명 및 열화정도가 서로 다르다. 따라서, LCD 패널 상부에 컬러센서를 부착하여 이들의 열화를 감지한 후, 보상작업을 할 필요가 있다. 그러나, 본 발명의 실시예들에 따르면, 동일한 종류의 백색 LED들을 사용하므로, 수명 및 열화가 대체로 비슷하여 컬러센서 및 보상작업의 필요성이 적다. 따라서, LCD 패널의 동작회로를 보다 단순화할 수 있다.

【특허청구범위】

【청구항 1】

측면 방향에서 입사된 광을 상부로 출사시키는 도광판;

상기 도광판의 측면 측에 위치하여 상기 도광판 내부로 백색광을 출사하되, 각각 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는 백색 발광다이오드들; 및

상기 도광판 상부에 위치하는 확산판을 포함하는 백라이트 패널.

【청구항 2】

청구항 1에 있어서,

상기 확산판 상부에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 더 포함하는 백라이트 패널.

【청구항 3】

하부면 및 상부면을 갖는 확산판;

상기 확산판과 이격되어 상기 하부면 아래에 배열되고, 각각 청색 발광다이오드 칩 및 상기 청색 발광다이오드 칩 상부에 위치하는 적색 형광체와 녹색 형광체를 갖는 백색 발광다이오드들; 및

상기 백색 발광다이오드들의 출사면 아래에 위치하여 상기 확산판에 대향하는 방향으로 진행하는 광을 확산판으로 반사시키는 반사시트를 포함하는 백라이트 패널.

【청구항 4】

청구항 3에 있어서,

상기 확산판 상부면 상에 밝기 강화 필름 및/또는 이중 밝기 강화 필름을 더 포함하는 백라이트 패널.

【청구항 5】

청구항 1 내지 4의 어느 한 항에 있어서,

상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체인 것을 특징으로 하는 백라이트 패널.

【청구항 6】

청구항 1 내지 4의 어느 한 항에 있어서,

상기 녹색 형광체는 일반식이 $(A_{1-x-y}Eu_x\ (M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$; $0 < x, y, x+y < 1$이고, 여기에서 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, x는 0.01에서 0.1 범위 내로 설정되고, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, y는 0.2에서 0.8 범위내로 설정되는

티오갈레이트계 녹색 형광체인 것을 특징으로 하는 백라이트 패널.

【청구항 7】

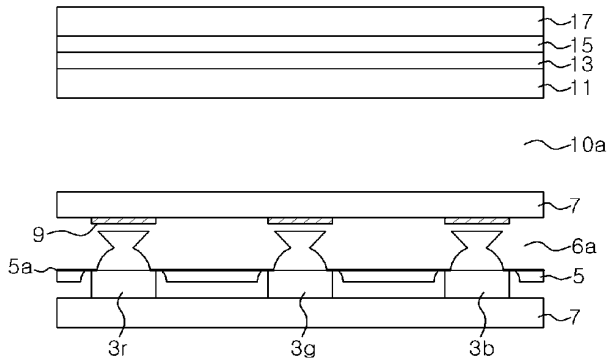
청구항 1 내지 4의 어느 한 항에 있어서,

상기 적색 형광체는 일반식이 $A_{x-a}Eu_aGeS_z$ 이고, 여기에서, A는 Ca, Sr 그룹으로부터 선택된 적어도 하나의 원소이고, z=x+2이고, x는 2에서 5 범위 내로 설정되고, a/x는 0.0005에서 0.02 범위 내로 설정되는 알칼리 토금속 황화물계 적색 형광체이고,

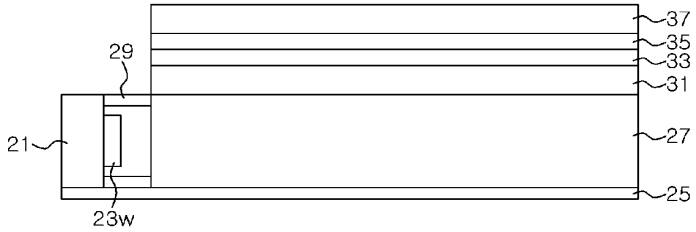
상기 녹색 형광체는 일반식이 $(A_{1-x-y}Eu_x\ (M^{I}_{0.5}\ M^{III}_{0.5})_y)B_2S_4$; $0 < x, y, x+y < 1$이고, 여기에서 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, B는 Al, Ga, In 으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, x는 0.01에서 0.1 범위 내로 설정되고, M^{I}은 Li, Na, K으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이며, M^{III}는 Sc, Y, Lu, Gd, La으로 이루어진 그룹으로부터 선택된 적어도 하나의 원소이고, y는 0.2에서 0.8 범위내로 설정되는 티오갈레이트계 녹색 형광체인 것을 특징으로 하는 백라이트 패널.

【도면】

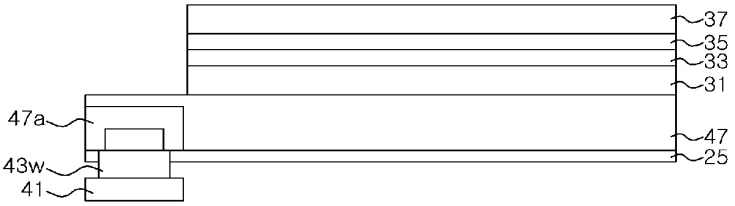
【도 1】


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3g
3b

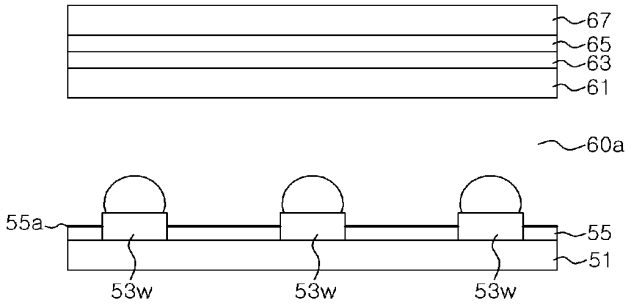
【도 2】


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23w

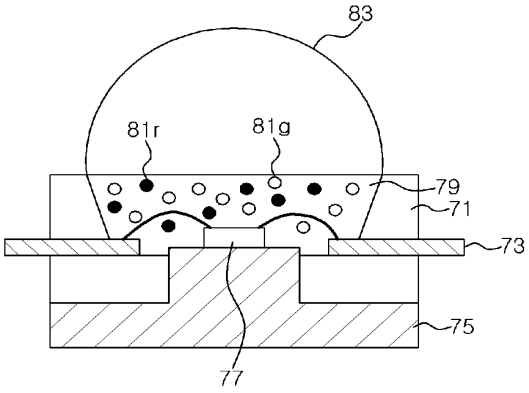
【도 3】


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31
47a
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43w
25
41

【도 4】



【도 5】



PTO/SB/06 (07-06)
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/909,700	09/25/2007	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			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 $250 ($125 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			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
	09/25/2007	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	X $ =		OR	X $50=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $200=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	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.

Legal Instrument Examiner:
/YOLANDA CHADWICK/

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.**

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(**Not for submission under 37 CFR 1.99)**

Application Number	11909700
Filing Date	2007-09-25
First Named Inventor	
Art Unit	2875
Examiner Name	Seung RYU
Attorney Docket Number	P2630US00

U.S.PATENTS

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					

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U.S.PATENT APPLICATION PUBLICATIONS

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					

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FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] ¡	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	1584703	CN		2005-02-23	LG Philips LCD Co., Ltd.		☐
	2	10-2004-0000004	KR		2004-01-03	LG Electronics Inc.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	
	Art Unit	2875
	Examiner Name	Seung RYU
	Attorney Docket Number	P2630US00

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]
	1	Chinese Office Action dated August 29, 2008	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	
	Art Unit	2875
	Examiner Name	Seung RYU
	Attorney Docket Number	P2630US00

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ 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).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/hae-chan park/	Date (YYYY-MM-DD)	2008-12-09
Name/Print	Hae-Chan Park	Registration Number	50114

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 1 hour 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.**

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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 the Freedom of Information Act requires disclosure of these record s.

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 inspections 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.

Liquid crystal display device using dual light units

Publication number: CN1584703
Publication date: 2005-02-23
Inventor: JIN KIM KYEONG (KR); HOON KANG (KR); KYOUNG JANG MI (KR)
Applicant: LG PHILIPS LCD CO LTD (KR)
Classification:
- international: ***F21V8/00; G02F1/133; G02F1/1335; G02F1/13357; G09F9/00; G09F9/35; G09F9/40;*** *F21Y101/02;* **F21V8/00; G02F1/13; G09F9/00; G09F9/35; G09F9/40;** (IPC1-7): G02F1/1335
- European: G02F1/13357E
Application number: CN20041059446 20040628
Priority number(s): KR20030058194 20030822

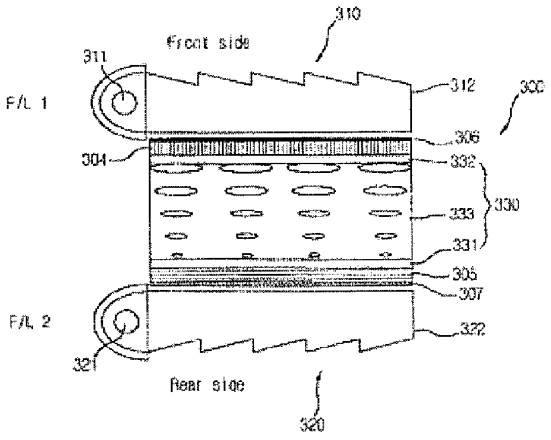
Also published as:
US7027113 (B2)
US2005041176 (A1)
KR20050020332 (A)
JP2005122103 (A)
GB2405252 (A)
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Abstract not available for CN1584703
Abstract of corresponding document: **GB2405252**

A liquid crystal display (LCD) that can be viewed from both front and rear directions is provided with two front light units 310, 320 on opposite sides of the LCD. A dual brightness enhancement (DBEF) is also provided for receiving external or ambient light an directing it towards the rear side of the display. The light sources 311, 321 comprise LEDs.

Fig.3



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[19] 中华人民共和国国家知识产权局

[51] Int. Cl[7]
G02F 1/1335

[12] 发明专利申请公开说明书

[21] 申请号 200410059446.8

[43] 公开日 2005 年 2 月 23 日

[11] 公开号 CN 1584703A

[22] 申请日 2004.6.28
[21] 申请号 200410059446.8
[30] 优先权
[32] 2003.8.22 [33] KR [31] 10-2003-0058194
[71] 申请人 LG. 菲利浦 LCD 株式会社
地址 韩国汉城
[72] 发明人 金庆镇 姜 勋 张美庆

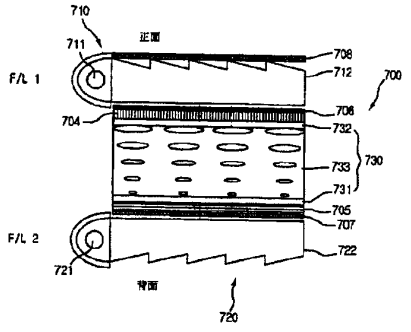
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代理人 徐金国 祁建国

权利要求书 3 页 说明书 9 页 附图 9 页

[54] 发明名称 采用双面光单元的液晶显示装置

[57] 摘要

一种液晶显示装置包括一液晶面板；附接在液晶面板相对表面上的第一和第二偏振板；在液晶面板正面上方的第一正面光单元；在液晶面板背面上方的第二正面光单元；设置在第一偏振板和第一正面光单元之间的第一薄膜，其用于接收环境光并将环境光引向液晶面板的背面；以及设置在第二偏振板和第二正面光单元之间的漫射片。



ISSN1008-4274

1.一种液晶显示装置包括：

一液晶面板；

附接在液晶面板相对表面上的第一和第二偏振板；

在液晶面板正面上方的第一正面光单元；

在液晶面板背面上方的第二正面光单元；

设置在第一偏振板和第一正面光单元之间的第一薄膜，其用于接收环境光并将环境光引向液晶面板的背面；以及

设置在第二偏振板和第二正面光单元之间的漫射片。

2.按照权利要求1的液晶显示装置，其特征在于，第一薄膜是一反射偏振板。

3.按照权利要求1的液晶显示装置，其特征在于，第一薄膜是一双亮度增强薄膜DBEF。

4.按照权利要求3的液晶显示装置，其特征在于，DBEF根据光的偏振特性接收由液晶面板反射的光，DBEF再次向液晶面板反射所接收到的光。

5.按照权利要求1的液晶显示装置，其特征在于，第一薄膜是一超亮薄膜UBF。

6.按照权利要求5的液晶显示装置，其特征在于，UBF薄膜接收外部环境光并把接收到的环境光引向液晶面板。

7.按照权利要求1的液晶显示装置，其特征在于，第一正面光单元和第二正面光单元处于关断状态时，第一薄膜相对于液晶面板的正面用作一反射镜。

8.按照权利要求1的液晶显示装置，其特征在于，还包括位于第一正面光单元和第一薄膜之间的一散射薄膜。

9.按照权利要求1的液晶显示装置，其特征在于，操作第一正面光单元使图像显示在液晶面板的背面，而操作第二正面光单元使图像显示在液晶面板的正面。

10.按照权利要求1的液晶显示装置，其特征在于，液晶面板用选自TN模式、ECB模式和OCB模式中的一种模式形成。

11.按照权利要求1的液晶显示装置，其特征在于，第一和第二偏振板位

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于液晶面板的两个表面上方，使得第一和第二偏振板的光轴彼此垂直。

12. 按照权利要求 1 的液晶显示装置，其特征在于，第一正面光单元和第二正面光单元中的每一个都包括至少一个 LED 芯片，第一正面光单元的 LED 芯片的数目与第二正面光单元的 LED 芯片的数目相同。

13. 按照权利要求 1 的液晶显示装置，其特征在于，第一正面光单元和第二正面光单元中的每一个都包括至少一个 LED 芯片，第一正面光单元的 LED 芯片的数目不同于第二正面光单元的 LED 芯片的数目。

14. 一种液晶显示装置包括：

一液晶面板；

附接在液晶面板相对表面上的第一和第二偏振板；

在液晶面板正面上方的第一正面光单元；

在第一正面光单元正面上方的一局部反射器；

在液晶面板背面上方的第二正面光单元；

设置在第一偏振板和第一正面光单元之间的第一薄膜，其用于接收环境光并将环境光引向液晶面板的背面；以及

设置在第二偏振板和第二正面光单元之间的漫射片。

15. 按照权利要求 14 的液晶显示装置，其特征在于，第一薄膜是一反射偏振板。

16. 按照权利要求 14 的液晶显示装置，其特征在于，第一薄膜是一双亮度增强薄膜 DBEF。

17. 按照权利要求 16 的液晶显示装置，其特征在于，DBEF 根据光的偏振特性接收由液晶面板反射的光，DBEF 再次向液晶面板反射所接收到的光。

18. 按照权利要求 14 的液晶显示装置，其特征在于，第一薄膜是一超亮薄膜 UBF。

19. 按照权利要求 18 的液晶显示装置，其特征在于，UBF 薄膜接收外部环境光并把接收到的环境光引向液晶面板。

20. 按照权利要求 14 的液晶显示装置，其特征在于，还包括设置在第一正面光单元和第一薄膜之间的一散射薄膜。

21. 按照权利要求 14 的液晶显示装置，其特征在于，在第一正面光单元和第二正面光单元处于关断状态时，局部反射器相对于液晶面板的正面用作一反

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射镜。

22. 按照权利要求 14 的液晶显示装置，其特征在于，局部反射器具有 50-90%的反射率。

23. 按照权利要求 14 的液晶显示装置，其特征在于，局部反射器用双亮度增强薄膜 DBEF 形成。

24. 按照权利要求 14 的液晶显示装置，其特征在于，局部反射器是通过涂覆金属材料形成的。

25. 按照权利要求 14 的液晶显示装置，其特征在于，形成的局部反射器的反射率随提供的电压改变。

26. 按照权利要求 25 的液晶显示装置，其特征在于，局部反射器包括胆甾型液晶层和 λ / 4 板。

27. 按照权利要求 14 的液晶显示装置，其特征在于，第一正面光单元和第二正面光单元中的每一个都包括至少一个 LED 芯片，第一正面光单元的 LED 芯片的数目与第二正面光单元的 LED 芯片的数目相同。

28. 按照权利要求 14 的液晶显示装置，其特征在于，第一正面光单元和第二正面光单元中的每一个都包括至少一个 LED 芯片，第一正面光单元的 LED 芯片的数目不同于第二正面光单元的 LED 芯片的数目。

29. 按照权利要求 14 的液晶显示装置，其特征在于，操作第一正面光单元使图像显示在液晶面板的背面，而操作第二正面光单元使图像显示在液晶面板的正面。

30. 按照权利要求 14 的液晶显示装置，其特征在于，液晶面板用选自 TN 模式、ECB 模式和 OCB 模式中的一种模式形成。

31. 按照权利要求 14 的液晶显示装置，其特征在于，第一和第二偏振板位于液晶面板的两个表面上方，使得第一和第二偏振板的光轴彼此垂直。

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采用双面光单元的液晶显示装置

技术领域

本发明涉及具有双面光单元(dual light units)的液晶显示装置(LCD)。

背景技术

通常，LCD是具有相对小的尺寸、纤细的轮廓和低功耗的平板显示装置。LCD因此被广泛地用于笔记本计算机等移动式计算机、办公自动化设备和音频/视频机器。

LCD是通过控制液晶材料感应的电场来操纵透过液晶材料的光，从而显示图像。LCD本身不需要发光，而是利用一个外部光源。而诸如电致发光(EL)、阴极射线管(CRT)和发光二极管(LED)等其他显示装置是靠自身发光。

LCD可以大致划分成两种不同类型：透射型LCD和反射型LCD。透射型LCD包括具有介于两个基板之间的液晶层的液晶面板。透射型LCD还包括一个向液晶面板供应光的背光单元。然而，由于背光单元的体积和重量，难以制造具有纤细轮廓且重量轻的透射型LCD。背光单元还需要大量的电功率。这种大的电功率需求缩短了LCD计算机笔记本用电池电源工作的时间。

反射型LCD不是单独提供光源，而是根据自然(环境)光条件来显示图像。因此，反射型LCD不需要任何额外的光源，而且反射型LCD消耗的电功率很小，并能在电子笔记本和个人数字助理(PDA)等移动显示装置中广泛使用。然而，当环境光不足时，例如是在黑夜，那么反射型LCD的亮度水平就会降低，造成无法读取显示的信息。克服在黑暗条件下显示图像这一问题的常规方法包括在反射LCD中安装一个正面光（front light）单元。

图1示出了按照现有技术采用正面光单元的一种反射型LCD的透视示意图，而图2示出了图1所示的反射型LCD的剖面图。在图1和图2中，一反射LCD 100包括一反射液晶面板120和位于反射液晶面板120上的用来提供光的一正面光单元110。反射液晶面板120具有第一基板121和第二基板122，其中在第二基板122上形成一漫反射（diffusing reflective）电极123。漫反射

电极 123 反射从反射液晶面板 120 的上表面提供的环境光，或是反射从正面光单元 110 发射的入射光。

正面光单元 110 包括光源 111、光导板 112 和反射镜 113。光源 111 产生光。光导板 112 将光投射到反射液晶面板 120 的显示面上。反射镜 113 向光导板 112 反射由光源 111 产生的光。

图 2 示出了形成具有棱镜结构的光导板 112 的上表面，使得从光源 111 发出的光在光导板 112 的上表面和下表面反射。然后，提供给光导板 112 的光沿着与位于光导板 112 下方的反射液晶面板 120 垂直的方向传播。接着，用反射液晶面板 120 的反射电极 123 反射垂直供给反射液晶面板 120 的光，并且光向上传播到光导板 110 上方，从而显示出一个图像。结果，现有技术产生了一种仅在显示器一侧显示图像的显示器。

发明内容

本发明旨在提供一种采用双面光单元的 LCD，其能够基本上消除因现有技术的局限和缺点造成的一个或多个问题。

本发明的目的是提供了一种采用单一液晶面板在正、反两面显示图像的 LCD。

以下要说明本发明的附加特征和优点，一部分可以从说明书中看出，或是通过对本发明的实践来学习。采用说明书及其权利要求书和附图中具体描述的结构就能实现并达到本发明的目的和其他优点。

本发明的一方面涉及一种 LCD，其包括一液晶面板；附接在液晶面板相对表面上的第一和第二偏振板；附接在液晶面板正面上方的第一正面光单元；附接在液晶面板背面的第二正面光单元；设置在第一偏振板和第一正面光单元之间的第一薄膜，其用于接收环境光并把环境光引向液晶面板的背面；以及设置在第二偏振板和第二正面光单元之间的漫射片（diffusing sheet）。

本发明的另一方面涉及一种 LCD，其包括一液晶面板；附接在液晶面板相对表面上的第一和第二偏振板；附接在液晶面板正面上方的第一正面光单元；附接在第一正面光单元正面上方的一局部反射器；附接在液晶面板背面上方的第二正面光单元；设置在第一偏振板和第一正面光单元之间的第一薄膜，其用于接收环境光并将环境光引向液晶面板的背面；以及设置在第二偏振板和第二

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正面光单元之间的漫射片。

应该意识到以上的概述和下文的详细说明都是示例性和解释性的描述，都是为了进一步解释所要求保护的本发明。

附图说明

所包括的用来便于理解本发明并且作为本申请一个组成部分的附图表示了本发明的实施例，连同说明书一起可用来解释本发明的原理。在附图中：

图 1 示出了现有技术采用正面光单元的一种反射 LCD 的透视示意图；

图 2 示出了图 1 所示的现有技术采用正面光单元的反射 LCD 的剖面图；

图 3 示出了按照本发明的第一实施例采用双面光单元的示例性 LCD 的示意性剖面图；

图 4 和图 5 示出了按照本发明采用双面光单元的另一示例性 LCD 的示意性剖面图；

图 6 示出了按照本发明的第二实施例采用双面光单元的示例性 LCD 的示意性剖面图；

图 7 示出了按照本发明的第三实施例采用双面光单元的示例性 LCD 的示意性剖面图；

图 8 示出了按照本发明的第四实施例采用双面光单元的示例性 LCD 的示意性剖面图；以及

图 9 示出了按照本发明采用双面光单元的 LCD 中具有变化反射率的局部反射器的示意图。

具体实施方式

以下要具体描述在附图中表示的本发明的最佳实施例。

图 3 示出了按照本发明的第一实施例采用双面光单元的示例性 LCD 的示意性剖面图。

图 3 示出了一 LCD 300，它包括通过在第一基板 331 和第二基板 332 之间夹有一液晶层 333 而形成的液晶面板 330。第一偏振板 304 和第二偏振板 305 附接在液晶面板 330 的相对表面上，而第一正面光单元 310 附接在液晶面板 330 的正面。第二正面光单元 320 附接在液晶面板 330 的背面。

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LCD 300 还包括设置在第一偏振板 304 和第一正面光单元 310 之间的第一薄膜 306，以及设置在第二偏振板 305 和第二正面光单元 320 之间的第二薄膜 307。以下将详细描述第一薄膜 306 和第二薄膜 307 的特性。

所述的液晶面板 330 是一种透射型液晶面板。第一基板 331 设置有薄膜晶体管（TFT），而第二基板设置有滤色片层。第一基板 331 面对第二基板 332，第二基板 332 与第一基板 331 彼此分开一预定距离。

第一基板 331 在其内表面上设置有按矩阵构造形成的栅极总线和数据总线。用作开关元件的 TFT 形成在邻近栅极总线和数据总线的各个交叉点处。在栅极总线和数据总线所包围的象素区上形成方形的象素电极。

根据作为有源层的半导体层的相，可以将液晶面板 330 的第一基板 331 上形成的 TFT 分为不同的两类：i）采用不具有晶格周期的含氢非晶硅的非晶 TFT；和 ii）采用多晶硅的多晶硅 TFT。

而且，第二基板 332 面对第一基板 331，并且第二基板 332 包括在其内表面上方形成的黑色矩阵（BM）层、滤色片层和公共电极。

在上述液晶面板中，向所选择的栅极总线和所选择的数据总线施加电压使连接到所选择的栅极总线的 TFT 导通，而且电荷累积到连接到 TFT 漏极的象素电极上，由此改变象素电极和公共电极之间液晶分子的角度。

液晶面板通过控制施加给具有介电各向异性的液晶分子的电场来显示画面或图像。液晶可以具有正型或负型介电各向异性。通常采用的是具有正型介电各向异性的向列型液晶。尽管图 3 示出扭曲向列(TN)模式的例子，但是，还可以采用其他的模式，例如电控制的双折射(ECB)模式、光学补偿双折射(OCB)模式或类似的模式。

第一偏振板 304、第二偏振板 305 和补偿板（图中未示）设置在液晶显示面板 330 的外表面上方。第一偏振板 304 和第二偏振板 305 附接在液晶面板 330 外表面的上方，使得第一偏振板 304 的光轴垂直于第二偏振板 305 的光轴。第一偏振板 304 和第二偏振板 305 只穿过沿一个方向振动（即，取向）的光，以便使自然光偏振。

补偿板（图中未示）用来补偿光在相对方向上的相位变化，以便解决视角问题。用单轴补偿板或者双轴补偿板形成该补偿板。

同时，设置在液晶面板 330 正面的第一正面光单元 310 将线性光转换为

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表面光，而从光源 311 发出的光穿过光导板 312。光导板 312 用形成在其上表面上的具有棱镜图案的透明材料形成，并改变光的传播路径，所述的光沿与垂直于显示表面的方向成一倾斜角度入射。第二正面光单元 320 也分别具有第二光源 321、和第二正面光单元 320 的第二光导板 322。

当通过从第一正面光单元 310 发出的光在液晶面板 330 的背面上显示图像时，第一薄膜 306 通过向着液晶面板 330 沿第一光轴方向偏振的光，而且第一薄膜 306 反射沿垂直于第一光轴方向的第二光轴方向偏振的光。沿第二光轴方向偏振的光再次被第一正面光单元 310 的光导板 312 反射，然后部分穿过液晶面板 330，从而提高了液晶面板 330 背面上显示的图像的亮度。反射偏振板或双亮度增强薄膜（DBEF）可以用作第一薄膜 306。

当第一正面光单元 310 和第二正面光单元 320 处于关断状态时，第一薄膜 306 还起到一反射镜（mirror）的作用。

漫射片可以用作第二薄膜 307。第二薄膜 307 使穿过光源 311 的光导板 312 供给的光的亮度均匀。

图 4 示出了当第一正面光单元 310 处于导通状态时本发明 LCD 的图像显示。

图 4 示出，当第一正面光单元 310 处于导通状态且没有向液晶面板 330 施加电压时，已穿过第一偏振板 304 的光沿液晶分子的扭曲路径传播，而且光穿过具有一光轴的第二偏振板 305，该光轴垂直于第一偏振板 304 的光轴。因此，在液晶面板 330 上显示的图像处于白色模式。

这样，当没有施加电压时，从第一正面光单元 310 发出的光穿过液晶面板 330，并且液晶面板 330 的背面处于正常白色模式。

然而，当如图 4 所示，向液晶面板 330 施加电压时，液晶分子沿电场方向取向，使穿过第一偏振板 304 的光不再穿过第二偏振板 305，而是被第二偏振板 305 阻挡。换句话说，当施加电压时，第二偏振板 305 阻挡光，因此液晶面板 330 的背面相应地在黑色模式下工作。

因此，通过有选择地向液晶面板 330 施加电压，便能够控制穿过液晶面板 330 的光，以在液晶面板 330 的背面上显示所期望的图像。

当在液晶面板 330 的背面上显示图像时，第一薄膜 306 允许沿第一光轴方向偏振的光穿过液晶面板 330。同时，第一薄膜 306 反射沿垂直于第一光轴

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方向的第二光轴方向偏振的光。然后，反射的光再次被第一正面光单元 310 的光导板 312 反射，并部分穿过液晶面板 330。显示在液晶面板 330 背面上的图像亮度因此能够得到增强。

图 5 示出了当第二正面光单元 320 处于导通状态时在按照本发明 LCD 中的图像显示。

图 5 示出，当第二正面光单元 320 处于导通状态且没有向液晶面板 330 施加电压时，已穿过第二偏振板 305 的光沿液晶分子的扭曲路径传播，而且光穿过具有一光轴的第一偏振板 304，该光轴垂直于第二偏振板 305 的光轴。因此，液晶面板 330 在正常白色模式下工作。

当没有施加电压时，从第二正面光单元 320 发出的光穿过液晶面板 330，并且在液晶面板 330 的正面上显示的图像处于白色模式。

然而，当向液晶面板 330 施加电压时，液晶分子沿电场方向取向，使穿过第二偏振板 305 的光不穿过第一偏振板 304，而是被第一偏振板 304 阻挡。换句话说，当施加电压时，第一偏振板 304 阻挡光，并且液晶面板 330 的正面在黑色模式下工作。

因此，通过有选择地向液晶面板 330 施加电压，便能够控制穿过液晶面板 330 的光，以在液晶面板 330 的正面上显示所期望的图像。

换句话说，如图 4 和 5 所示，有可能在液晶面板 330 的正面或者背面上显示图像，这取决于第一正面光单元 310 或者第二正面光单元 320 导通或者关断。

图 6 示出了按照本发明第二实施例采用双面光单元的示例性 LCD 的示意性剖面图。

图 6 示出一 LCD 600，其包括通过在第一基板 631 和第二基板 632 之间夹有一液晶层 633 而形成的液晶面板 630，和附接在液晶面板 630 的相对的表面上的第一偏振板 604 和第二偏振板 605。第一正面光单元 610 附接在液晶面板 630 的正面，而第二正面光单元 620 附接在液晶面板 630 的背面。

LCD 600 还包括设置在第一偏振板 604 和第一正面光单元 610 之间的第一薄膜 606，设置在第二偏振板 605 和第二正面光单元 620 之间的第二薄膜 607，以及设置在第一正面光单元 610 和第一薄膜 606 之间的散射薄膜(scattering film) 608。

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当在液晶面板 630 的背面上显示图像时，散射薄膜 608 防止由第一正面光单元 610 的光导板 612 的图案引起的莫尔条纹现象。

莫尔条纹现象由两个或多个周期性图案彼此重叠时形成的干涉条纹表示。例如，当光照射到具有类似间隔的两个或多个晶格上时，便形成不同于两个晶格的线条纹。这个线条纹是莫尔条纹现象。

图 6 的 LCD 描述了功能类似于图 3 至图 5 中所示 LCD 的那些元件的其他元件，这里省略了对它们的详细描述。在图 6 中，光源 611 设置在第一正面光单元 610 中，而光源 621 和光导板 622 设置在第二正面光单元 620 中。

图 7 示出了按照本发明第三实施例采用双面光单元的示例性 LCD 的示意性剖面图。

图 7 示出一 LCD 700，其包括通过在第一基板 731 和第二基板 732 之间夹有一液晶层 733 而形成的液晶面板 730。第一偏振板 704 和第二偏振板 705 附接在液晶面板 730 的相对的表面上。第一正面光单元 710 附接在液晶面板 730 的正面，而第二正面光单元 720 附接在液晶面板 730 的背面。

LCD 700 还包括设置在第一偏振板 704 和第一正面光单元 710 之间的第一薄膜 706，设置在第二偏振板 705 和第二正面光单元 720 之间的第二薄膜 707，以及附接在第一正面光单元 710 正面上方的局部反射器 708。

局部反射器 708 是通过涂敷金属薄膜制成的，该金属薄膜具有相对于外部入射光大约 50%到 90%的反射率（从而形成半反射镜），或者是用双亮度增强薄膜(DBEF，dual brightness enhancement film)制成。金属薄膜可以用例如银、铝或者其他任何合适的金属形成。

反射偏振板可以用作第一薄膜 706。而且，DBEF 或者超亮度（ultra brightness）薄膜（UBF）也可以用作第一薄膜 706。

当用反射偏振板构成第一薄膜 706 时，并且通过从第一正面光单元 710 发出的光作为内部光源在液晶面板 730 的背面显示图像时，第一薄膜 706 允许沿第一光轴方向偏振的光穿过液晶面板 730。然而，第一薄膜 706 反射沿垂直于第一光轴方向的第二光轴方向偏振的光。然后，第一正面光单元 710 的光导板 712 再次反射在第二光轴方向上偏振的光。再次被反射的光部分穿过液晶面板 730，由此显示在液晶面板 730 背面上的图像的亮度得到增强。

当用 UBF 作为第一薄膜 706 时，第一薄膜 706 以相对于外部光源成一角

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度 θ 反射入射光，由此提高了穿过液晶面板 730 的光效率，增加了显示在液晶面板 730 背面上的图像的亮度。

当第一正面光单元 710 和第二正面光单元 720 处于关断状态时，局部反射器 708 可以用作一反射镜。

第二薄膜 707 可以用一漫射片形成。第二薄膜 707 起到使穿过光源 711 的光导板 712 供给的光的亮度均匀的作用。

第一正面光单元 710 和第二正面光单元 720 中的每一个都使用 LED 芯片。在第一正面光单元 710 中使用的 LED 芯片的数目可以与在第二正面光单元 720 中使用的 LED 芯片的数目不同，从而最大限度地减小了功耗。

例如，在第一正面光单元 710 中使用三个 LED 芯片用于向液晶面板 730 的背面提供光，而在第二正面光单元 720 中使用两个 LED 芯片用于向液晶面板 730 的正面提供光，作为一个子窗口。这便导致 3 比 2（3：2 或者 1.5）的比例。然而，本发明不限于这个 LED 芯片的数目和比例。

当然，可以为第一正面光单元 710 和第二正面光单元 720 中的每一个提供相同数目的 LED 芯片。

图 7 中描述的 LCD 700 具有的部件功能类似于图 3 至图 5 中所示 LCD 的部件，这里省略了对它们的详细描述。图 7 的 LCD 还示出设置在第一正面光单元 710 中的光源 711，和设置在第二正面光单元 720 中的光源 721 和光导板 722。

图 8 示出了按照本发明第四实施例采用双面光单元的示例性 LCD 的示意性剖面图。

图 8 示出一 LCD 800，其包括通过在第一基板 831 和第二基板 832 之间夹有一液晶层 833 而形成的液晶面板 830。第一偏振板 804 和第二偏振板 805 附接在液晶面板 830 的相对的表面上。第一正面光单元 810 附接在液晶面板 830 的正面，而第二正面光单元 820 附接在液晶面板 830 的背面。

LCD 800 还包括设置在第一偏振板 804 和第一正面光单元 810 之间的第一薄膜 806，设置在第二偏振板 805 和第二正面光单元 820 之间的第二薄膜 807，以及附接在第一正面光单元 810 正面上方的局部反射器 808。局部反射器 808 具有可变化的反射率。

可以如图 9 所示示例性地设计可变化的反射局部反射器 808。然而，本发明并不限于这种设计，还可以使用任何合适的可变化的反射局部反射器。图 9

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表示可变化的反射局部反射器 808 的结构的剖面图。

图 9 所示的局部反射器 808 是一种反射率可随所施加电压而变化的反射器。局部反射器 808 可以通过耦合胆甾型液晶层 901 和 λ / 4 板 902 制备。胆甾型液晶层 901 具有可随所施加的电压而变化的反射率，而 λ / 4 板 902 将线性偏振的光转换为圆偏振光，或者将圆偏振转换为线性偏振。

在反射器中，胆甾型液晶层 901 的反射率随所施加的电压而变化。即，所施加的电压的大小改变了胆甾型液晶相的螺距（pitch）。当使用对应于液晶面板 830 背面的主窗口时，反射器处于关断状态，从而获得最大的反射率，这便使光效率最大化并提高了主窗口的亮度。

而且，当使用对应于液晶面板 830 正面的子窗口时，反射器处于导通状态，从而获得最大的透射率，从而减小了因反射引起的光损失，并且因为使用了第二正面光单元 820 而使功耗最小化。

第一正面光单元 810 和第二正面光单元 820 中的每一个都使用 LED 芯片。第一正面光单元 810 中 LED 芯片的数目与第二正面光单元 820 中 LED 芯片的数目不同能够最大限度地减小功耗。

例如，在第一正面光单元 810 中使用三个 LED 芯片用于向液晶面板 830 的背面提供光，而在第二正面光单元 820 中使用两个 LED 芯片用于向液晶面板 830 的正面提供光，作为一个子窗口。第一和第二正面光单元的芯片比例是 3 比 2（1.5）。然而，可以使用任何合适的比例和 LED 芯片的数目。

而且，可以为第一正面光单元 710 和第二正面光单元 720 中的每一个提供相同数目的 LED 芯片。

另外，当第一正面光单元 810 和第二正面光单元 820 处于关断状态时，位于液晶面板 830 正面的局部反射器 808 可以用作一反射镜。

图 8 中描述的 LCD 800 具有的部件功能类似于图 3 至图 5 中所示 LCD 的部件，这里省略了对它们的详细描述。图 8 还示出设置在第一正面光单元 810 中的光源 811，以及分别设置在第二正面光单元 820 中的光源 821 和光导板 822。

本领域的技术人员能够看出，无需脱离本发明的原理或范围还能对本发明中采用双发光单元的液晶显示装置进行各种各样的修改和变更。因此，本发明应该覆盖属于本发明权利要求书及其等效物范围内的修改和变更。

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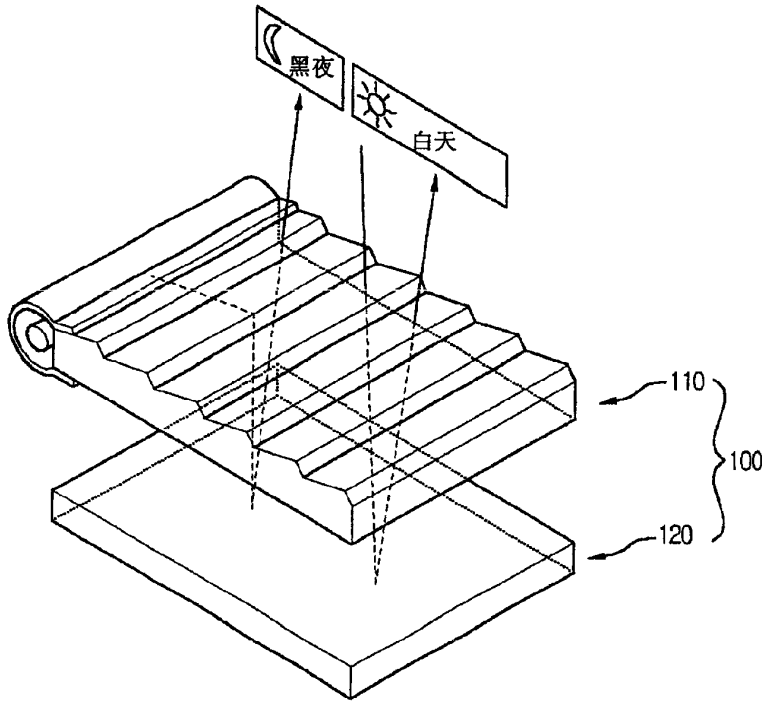


图 1

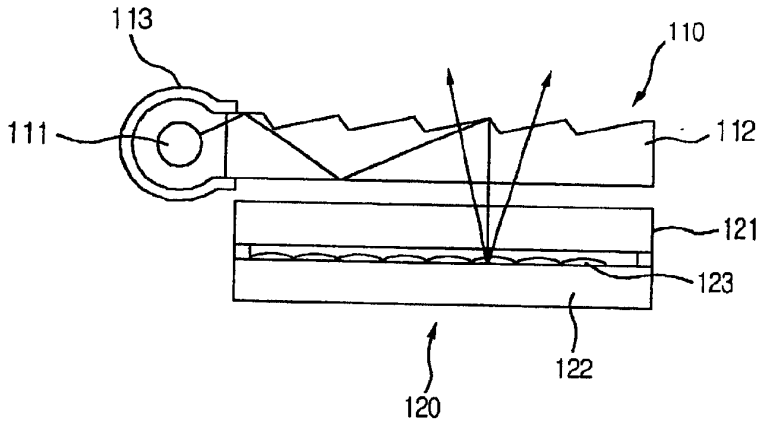


图 2

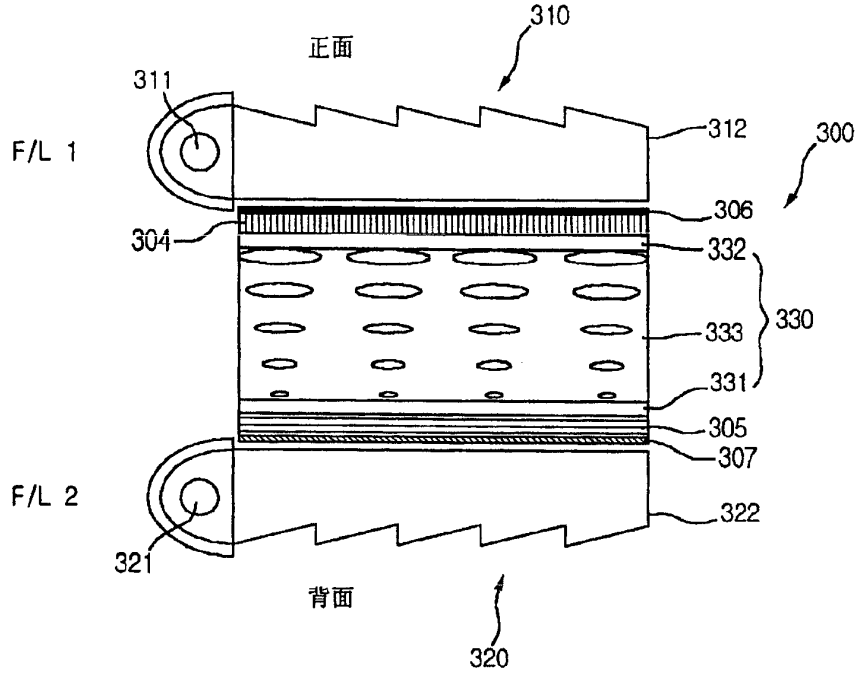

310
正面
311
F/L 1
312
300
306
304
332
330
333
331
305
307
F/L 2
322
321
背面
320

图 3

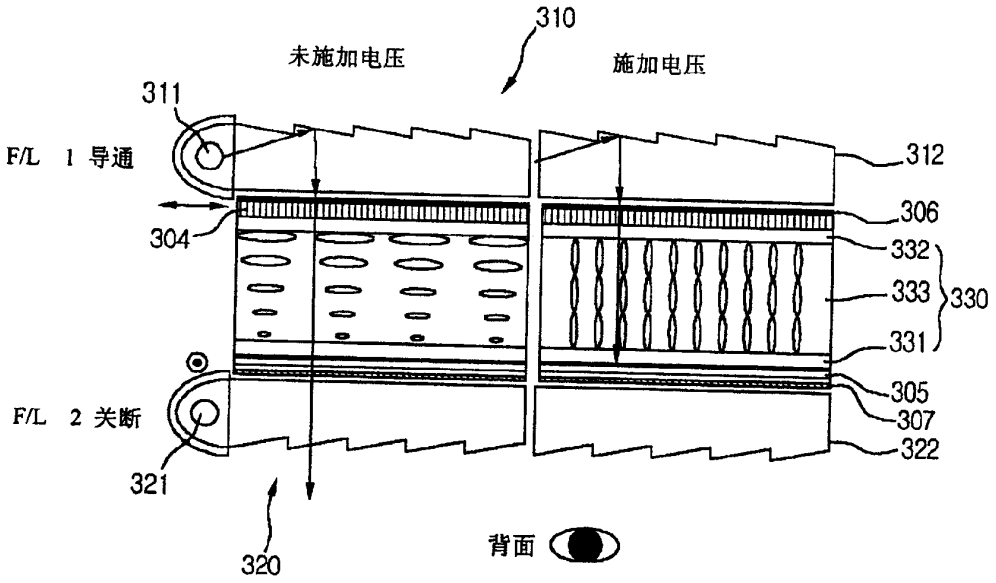

310
未施加电压
施加电压
311
F/L 1 导通
312
306
304
332
333
330
331
305
F/L 2 关断
307
322
321
320
背面

图 4

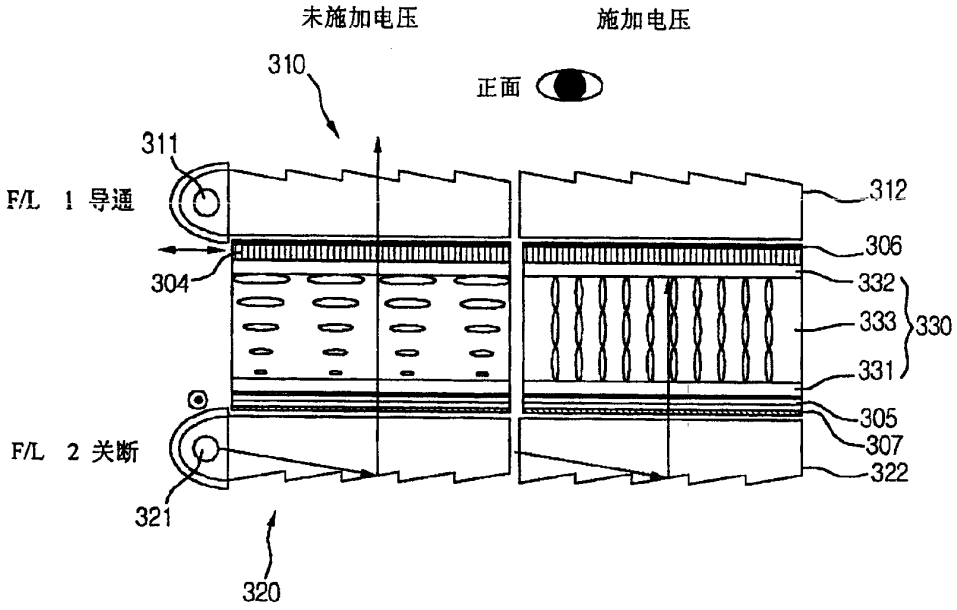

未施加电压
施加电压
310
正面
311
F/L 1 导通
312
306
304
332
333
330
331
305
307
F/L 2 关断
322
321
320

图 5

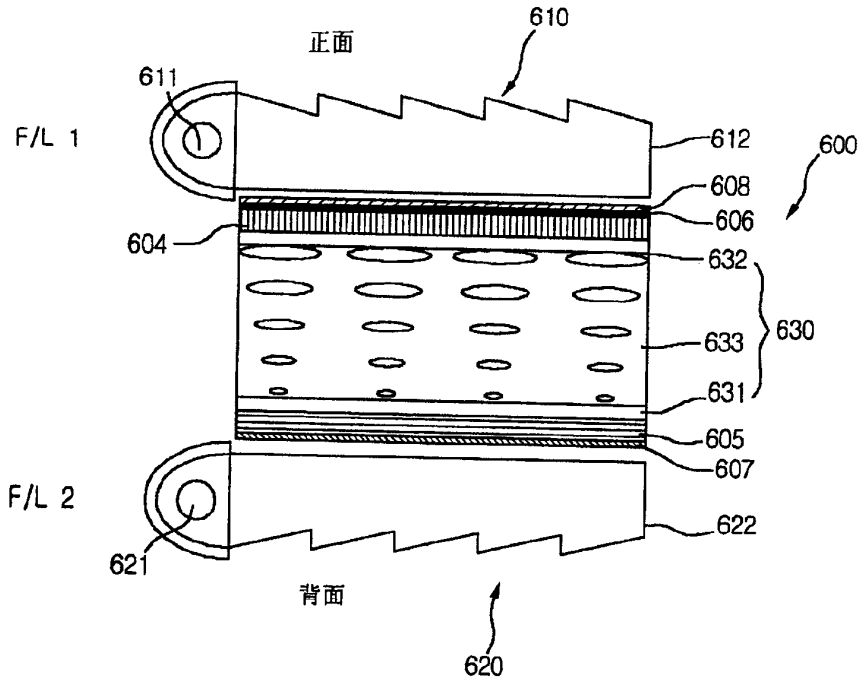

610
正面
611
F/L 1
612
600
608
606
604
632
630
633
631
605
607
F/L 2
622
621
背面
620

图 6

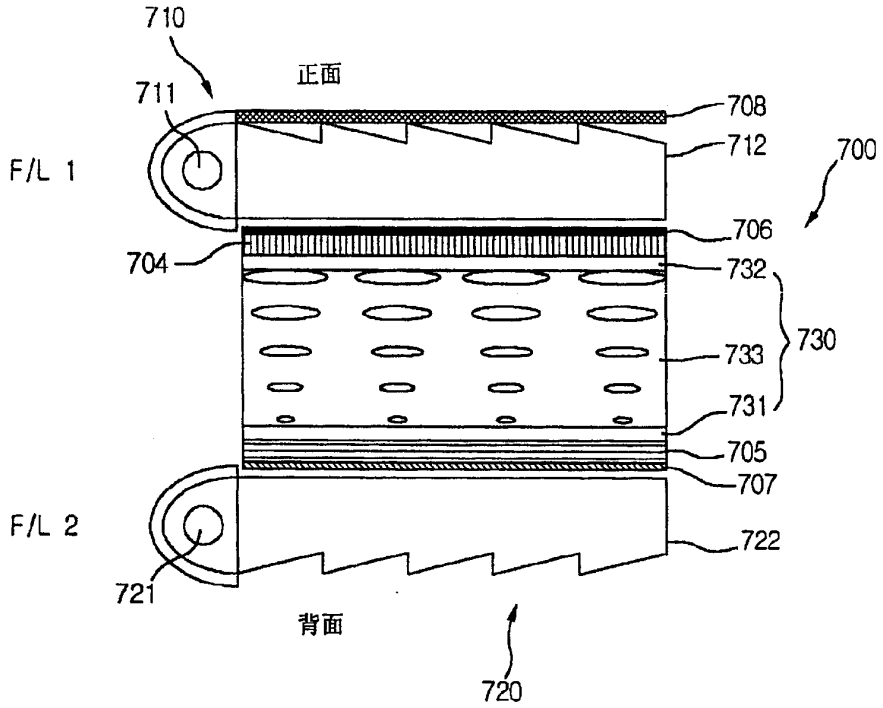

710
正面
711
708
712
700
F/L 1
706
704
732
730
733
731
705
707
F/L 2
722
721
背面
720

图 7

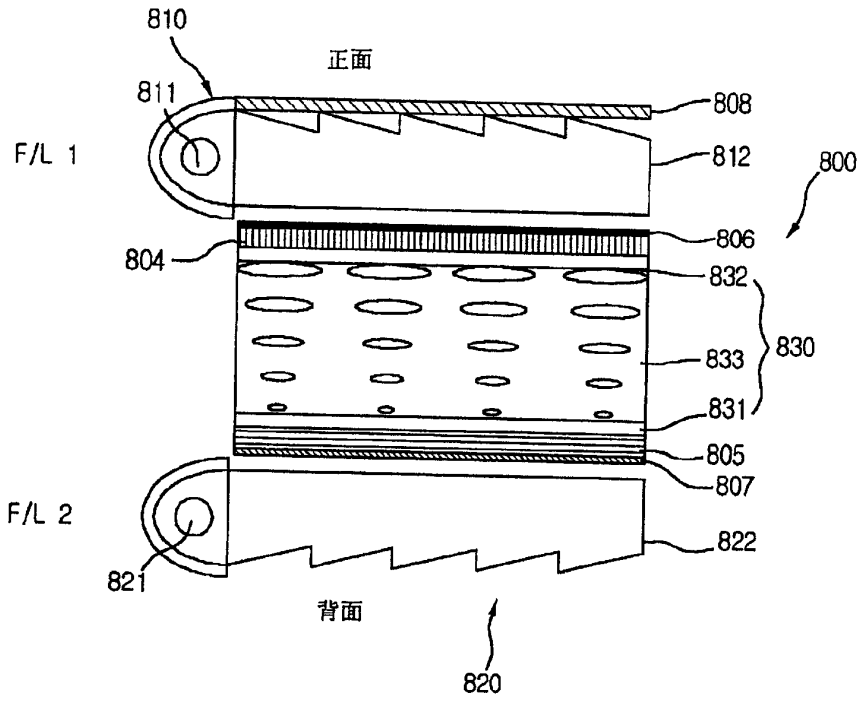

810
正面
811
808
F/L 1
812
800
806
804
832
830
833
831
805
807
F/L 2
822
821
背面
820

图 8

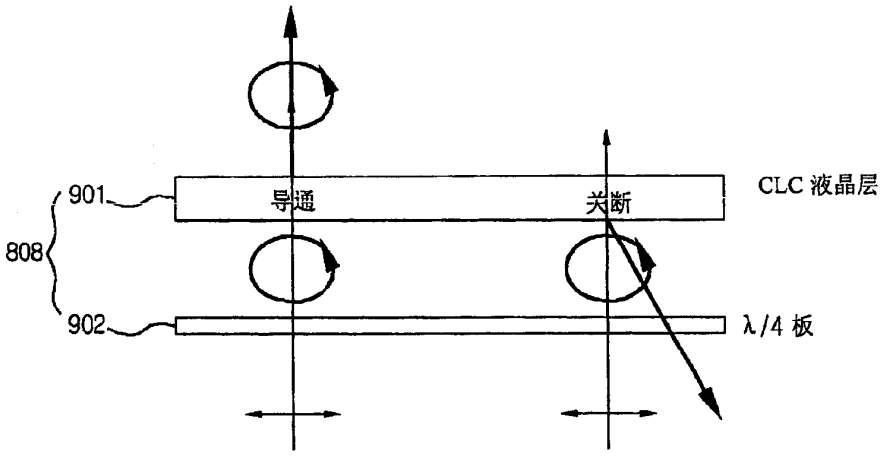


图 9

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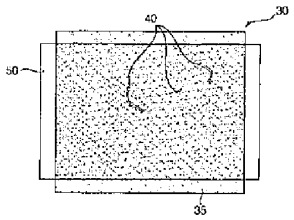
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(72)Inventor: JUNG, CHANG UK
KIM, SEONG HUN

(54) APPARATUS FOR INSPECTING BACK LIGHT UNIT

(57) Abstract:

PURPOSE: An apparatus for inspecting a back light unit is provided to easily detect defects by selectively transmitting light passing through a brightness enhancement film and the defects. CONSTITUTION: A CCFL (Cold Cathode Fluorescent Lamp) provides a linear light source. A light guide plate converts the linear light source into a surface light source. A diffusion plate diffuses the converted surface light source for equalizing the surface light source. A DBEF(Dual Brightness Enhancement Film)(35), which is a brightness enhancement film increases brightness of the equalized light source. A polarizing element (50) has a polarizing shaft vertical to the DBEF, so that the polarizing element interrupts light due to the DBEF while transmitting light by defects(40) generated at the DBEF.



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심사청구 : 있음

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요약

본 발명은 백 라이트 유닛 검사 장치에 관한 것으로서, 검사하려는 백 라이트 유닛에 휘도 향상용 필름이 형성되어 있는 경우 증가된 휘도로 인해 상기 백 라이트 유닛의 결함이 검출되지 않는 것을 방지하기 위하여 편광축이 상기 휘도 향상용 필름에 상기 휘도 향상용 필름과 동일하거나 90 도 차이가 나는 편광수단을 형성함으로써, 상기 휘도 향상용 필름과 결함을 통과하는 빛을 선택적으로 투과시켜 상기 결함이 존재하는 부분을 용이하게 검출할 수 있게 되는 효과가 있다.

대표도

도 4

색인어

백 라이트 유닛, 휘도 향상용 필름, 편광 수단

명세서

도면의 간단한 설명

도 1 은 일반적인 백 라이트 유닛의 구조가 도시된 도,

도 2 는 종래의 기술에 따른 백 라이트 유닛 검사 장치의 구성이 도시된 도,

도 3 은 본 발명에 적용되는 휘도 향상용 필름이 형성되는 백 라이트 유닛의 구조가 도시된 도,

도 4 및 도 5 는 본 발명에 따른 편광 수단을 포함한 백 라이트 유닛 검사 장치에 의해 검출된 결함이 도시된 도이다.

<도면의 주요 부분에 관한 부호의 설명>

30: 백 라이트 유닛 35: 휘도 향상용 필름

40: 결함 50: 편광 수단

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 백 라이트 유닛(Back Light Unit; BLU) 검사 장치에 관한 것으로서, 특히 액정디스플레이(Liquid Crystal Display; LCD)등의 평판 디스플레이(Flat Panel Display; FPD)의 후방에 설치되어 광원을 제공하는 BLU의 결함을 검출할 수 있도록 하는 BLU 검사 장치에 관한 것이다.

최근 들어 LCD등과 같은 FPD의 수요가 점차 증대되고 있으며, 이러한 상황에서 이들 제품의 품질을 관리하는 것은 매우 중요한 문제가 되고 있다. 따라서, 각 디스플레이 제조업체에서는 자동 검사 장치를 만들어 결함을 방지하고 있으며 특히, 상기 FPD 의 후방에 설치되어 광원을 제공하는 BLU는 상기 FPD 제품의 밝기 및 성능에 중요한 영향을 주기 때문에 상기 BLU의 결함을 사전에 검출하여 시판되는 디스플레이 제품의 품질을 향상시키고자 노력하고 있다.

일반적인 BLU의 구조는 도 1 에 도시된 바와 같이, 선광원을 제공하는 CCFL(Cold Cathode Fluorescent Lamp)(1)과, 상기 CCFL(1)의 선광원을 면광원으로 변환하는 도광판(2)과, 상기 도광판(2)에 의해 변환된 면광원을 확산시켜 균일해질 수 있도록 하는 확산판(3)과, 상기 확산판(3)에 의해 균일해진 면광원이 전방에 모일 수 있도록 하여 휘도가 높아지도록 하는 수직 및 수평 프리즘(4, 5)과, 상기 수직 및 수평 프리즘(4, 5)의 전방에 위치되고 투명재질로 이루어지는 보호판(6)으로 구성된다.

상기와 같이 구성되는 BLU의 결함을 검출할 수 있는 BLU 검사 장치는 도 2 에 도시된 바와 같이, 렌즈 및 CCD(Charge Coupled Device) 카메라로 이루어지며 BLU(10)의 연직 상방에 위치되어 이물질 검출할 수 있도록 상기 BLU(10)의 표면을 촬상하는 제 1 화상 획득부(21)와, 상기 BLU(10)의 표면 결함을 검출할 수 있도록 상기 BLU(10)에 일정 각도 기울어진 상측에 위치되어 상기 BLU(10)의 표면을 촬상 하는 제 2 화상 획득부(22)와, 상기 제 1 및 제 2 화상 획득부(21, 22)에 의해 촬상된 화상을 데이터화하는 화상 처리부(23)와, 상기 화상 처리부(23)에 의해 데이터화된 화상을 통해 상기 BLU(10)의 결함을 검출하는 결함 처리부(24)로 구성된다.

상기와 같이 구성되는 BLU 검사 장치를 이용하여 BLU(10)의 결함을 검출하는 방법은 상기 BLU(10)는 상기 수직 및 수평 프리즘(4, 5)로 인하여 상기 확산판(3)에 의해 균일해진 면광원은 직진성을 가지게 된다.

이때, 상기 BLU(10)와 일정 각도를 기울어지게 위치되어 상기 BLU(10)의 표면을 촬상하는 제 2 획득부(22)에 의해 촬상된 화상에서 결함이 존재하는 부분이 밝게 나타나게 되어 표면 결함을 검출할 수 있게 되는 것이다.

한편, 최근 디스플레이 시장에서 점차 고휘도의 LCD 가 요구되는 추세에 맞추기 위한 하나의 방법으로써 상기에서 설명된 BLU(10)에서 상기 수직 및 수평 프리즘(4, 5)를 제거하고 DBEF(Dual Brightness Enhancement Film)와 같은 휘도 향상용 필름을 사용함으로써 고휘도를 구현하고 있다.

그러나, 상기 휘도 향상용 필름이 형성된 BLU는 상기 수직 및 수평 프리즘이 없기 때문에 상기 확산판에 의해 확산된 면광원이 직진성이 아닌 산란성을 가지게 되고, 이로 인해 상기 휘도 향상용 필름과 상기 휘도 향상용 필름에 존재하는 결함을 통과한 빛의 휘도의 차이가 발생하지 않아 상기 제 2 화상 획득부에서 촬상한 화상을 이용하여 결함을 검출하기가 어렵다는 문제점이 있다.

발명이 이루고자 하는 기술적 과제

본 발명은 상기한 종래 기술의 문제점을 해결하기 위하여 안출된 것으로서, 그 목적은 백 라이트 유닛의 휘도를 증가시키기 위하여 향상용 필름을 사용하는 경우 빛의 산란성으로 인해 백 라이트의 결함이 검출되지 않는 것을 방지할 수 있도록 상기 휘도 향상용 필름과 상기 휘도 향상용 필름에 존재하는 결함을 통과하는 빛을 선택적으로 투과시키는

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편광 수단을 포함한 백 라이트 유닛의 검사 장치를 제공하는데 있다.

발명의 구성 및 작용

상기한 과제를 해결하기 위한 본 발명에 따른 백 라이트 유닛 검사 장치의 특징에 따르면, 평판 디스플레이의 후방에서 광원을 제공하며 상기 광원의 휘도가 증가될 수 있도록 하는 휘도 향상용 필름이 형성된 백 라이트 유닛의 결함을 검출하는 백 라이트 유닛 검사 장치에 있어서, 상기 백 라이트 유닛이 상기 휘도 향상용 필름을 사용하여 경우 빛의 산란성으로 인해 상기 결함이 검출되지 않는 것이 방지될 수 있도록 편광 수단을 포함하여 구성된다.

이하, 본 발명의 실시 예를 첨부된 도면을 참조하여 상세히 설명한다.

본 발명에 따른 BLU 검사 장치는 도 4 에 도시된 바와 같이, 휘도를 증가시키기 위하여 DBEF(Dual Brightness Enhancement Film)와 같은 휘도 향상용 필름(35)이 형성된 BLU(30)의 연직 상방에 위치되어 이물질을 검출할 수 있도록 상기 BLU(30)의 표면을 촬상하는 제 1 화상 획득부(21)와, 상기 BLU(30)의 표면 결함(40)을 검출할 수 있도록 상기 BLU(30)와 일정각도 기울어진 상측에 위치되어 상기 BLU(30)의 표면을 촬상하는 제 2 화상 획득부(22)와, 상기 제 1 및 제 2 화상 획득부(21, 22)가 촬상한 화상을 데이터화하는 화상 처리부(23)와 상기 화상 처리부(23)에 의해 데이터화된 화상을 통해 상기 BLU(30)의 결함(40)을 검출하는 결함 처리부(24)와, 상기 휘도 향상용 필름(35) 전방에 형성되어 상기 휘도 향상용 필름(35) 및 결함(40)을 통과하는 빛을 선택적으로 투과시키는 편광수단(50)으로 구성된다.

여기서, 상기 도 4 에서 미설명된 참조번호는 상기 도 2 의 도면번호와 동일한 참조번호를 사용한다.

상기와 같이 구성되는 본 발명에 따른 BLU 검사 장치에 적용되는 휘도 향상용 필름이 형성된 BLU(30)를 도 3 을 참고로 하여 보다 상세하게 설명하면, 선광원을 제공하는 CCFL(31)과, 상기 CCFL(31)에 제공된 선광원을 면광원으로 변환하는 도광판(32)과, 상기 도광판(32)에 의해 변환된 면광원을 확산시켜 균일해질 수 있도록 하는 확산판(33)과, 상기 확산판(33)에 의해 균일해진 명광원의 휘도가 증가될 수 있도록 하는 DBEF과 같은 휘도 향상용 필름(35)으로 이루어지게 된다.

이때, 상기 편광 수단(50)는 상기 휘도 향상용 필름(35)과 상기 휘도 향상용 필름(35)에 발생된 결함(40)을 통과하는 빛을 선택적으로 투과시키게 된다.

즉, 상기 편광 수단(50)의 편광축을 상기 휘도 향상용 필름(35)과 90 도 차이나도록 형성하게 되면, 도 4 에 도시된 바와 같이, 상기 휘도 향상용 필름(35)을 통해 발산되는 빛은 차단되나, 상기 BLU(30)의 결함(40)으로부터 발생되는 빛은 결 함(40)으로 인해 그 위상이 변화하게 된다.

따라서, 상기 결함(40)으로 발생되는 빛은 상기 편광수단(50)에 의해 완전히 차단되지 않고 투과되어 밝게 나타나게 되기 때문에 상기에서 설명된 BLU 검사 장치의 제 2 화상획득부(22)에서 상기 BLU(30)의 표면을 촬상하였을 경우 결함(40)이 존재하는 부분이 명확하게 나타나는 것이다.

만일, 상기 편광수단(50)의 편광축을 상기 휘도 향상용 필름(35)과 동일하게 형성하는 경우에는 도 5 에 도시된 바와 같이, 상기 휘도 향상용 필름(35)을 통한 빛은 투과되어 밝게 나타나게 되지만, 상기 결함(35)으로부터 발생되는 빛은 상기 결함(40)에 의해 그 위상이 변화되었기 때문에 상기 편광 수단(50)을 투과하지 못하여 상기 결함(40)이 존재하는 부분은 어둡게 나타나게 되어 결함(40)을 용이하게 검출해낼 수 있는 것이다.

상기 편광 수단(50)을 포함된 본 발명의 상기 BLU 검사 장치를 이용한 BLU(30)의 결함 검출 방법을 설명하면 다음과 같다.

먼저, 검사하려는 BLU(30)의 휘도 향상용 필름(35)에 편광 수단(50)을 위치시킨다. 즉, 상기 편광 수단(50)의 편광축을 상기 휘도 향상용 필름(35)과 동일하게 형성할것인지 90 도 차이나게 형성할것인지를 결정한다.

이때, 상기 편광 수단(50)의 편광축을 상기 휘도 향상용 필름(35)과 동일하게 형성한 경우에는 상기 휘도 향상용 필름(35)을 통과한 빛은 투과되고, 상기 결함(40)을 통과한 빛은 그 위상이 변화되어 상기 편광 수단(50)을 투과하지 못하고 차단된다.

한편, 상기 편광 수단(50)의 편광축을 상기 휘도 향상용 필름(35)과 90 도 차이나게 형성한 경우에는 상기 휘도 향상용 필름(35)을 통과한 빛은 차단되고, 상기 결함(40)을 통과한 빛은 완전하게 차단되지 않고 상기 편광 수단(50)을 통과하여 밝게 나타나게 된다.

마지막으로 상기에서 설명된 제 2 화상 획득부(4, 5)에서 상기 BLU(30)의 표면을 촬상하게 되고, 그 화상은 상기 화상 처리부(23)에 의해 데이터화되고, 상기 화상 처리부(23)에 의해 데이터화된 상기 화상은 상기 결함 검출부(24)에 의하여 결함이 검출되는 것이다.

결국, 본 발명에 따른 BLU 검사 장치는 기존의 BLU 검사 장치에 편광 수단을 사용함으로써, 기존의 BLU뿐만 아니라 휘도 향상용 필름이 형성된 BLU의 결함을 용이하게 검출할 수 있기 때문에 별도의 검사 장치를 제작하지 않고도 결함을 검출할 수 있는 것이다.

발명의 효과

상기와 같이 구성되는 본 발명에 BLU 검사 장치는 검사하려는 BLU에 휘도 향상용 필름이 형성되어 있는 경우 증가된 휘도로 인해 상기 BLU의 결함이 검출되지 않는 것을 방지하기 위하여 편광축이 상기 휘도 향상용 필름에 상기 휘도 향상용 필름과 동일하거나 90 도 차이가 나는 편광수단을 형성함으로써, 상기 휘도 향상용 필름과 결함을 통과하는 빛을 선택적으로 투과시켜 상기 결함이 존재하는 부분을 용이하게 검출할 수 있게 되는 효과가 있다.

(57) 청구의 범위

청구항 1.
평판 디스플레이의 후방에서 광원을 제공하며 상기 광원의 휘도를 증가시킬 수 있도록 하는 휘도 향상용 필름이 형성된 백 라이트 유닛의 결함을 검출하는 백 라이트 유닛 검사 장치에 있어서,

상기 백 라이트 유닛는 상기 휘도 향상용 필름을 통해 증가된 휘도로 인해 상기 결함이 검출되지 않는 것이 방지될 수 있도록 하는 편광 수단이 형성되는 것을 특징으로 하는 백 라이트 유닛 검사 장치.

청구항 2.
제 1 항에 있어서,

상기 편광 수단은 편광축이 상기 휘도 향상용 필름과 수직으로 형성되며,

상기 휘도 향상용 필름에 의한 빛은 차단하고, 상기 결함에 의한 빛은 투과시키는 것을 특징으로 하는 백 라이트 유닛 검사 장치.

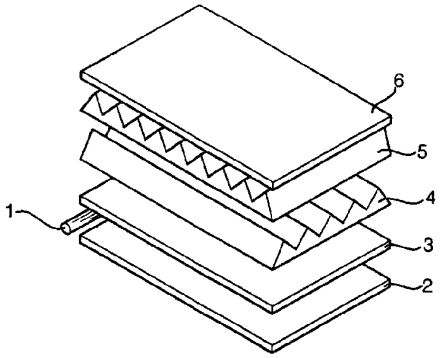
청구항 3.
제 1 항에 있어서,

상기 편광 수단은 편광축이 상기 휘도 향상용 필름과 동일하게 형성되며,

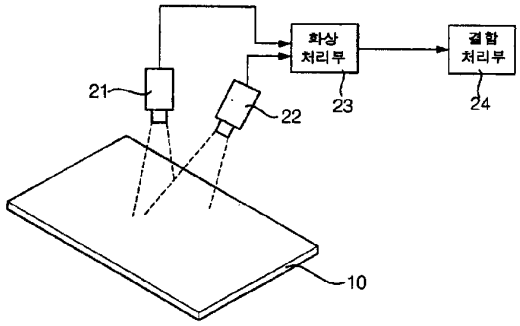
상기 휘도 향상용 필름에 의한 빛은 투과시키고, 상기 결함에 의한 빛은 차단하는 것을 특징으로 하는 백 라이트 유닛 검사 장치.

도면

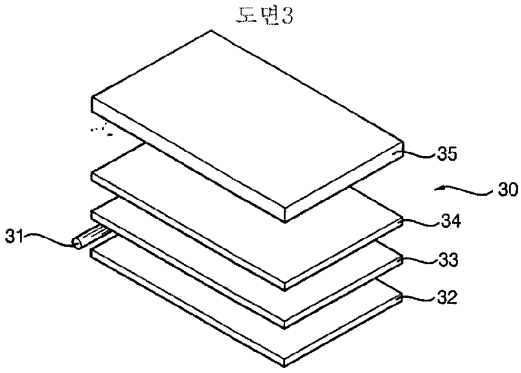
도면1



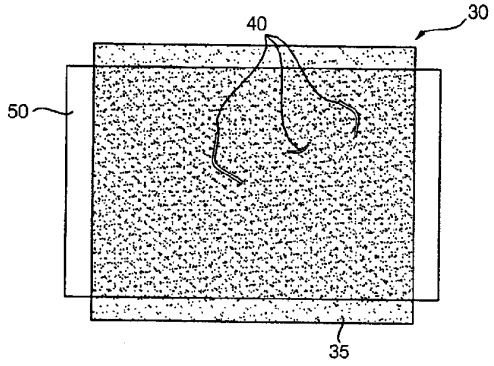
도면2



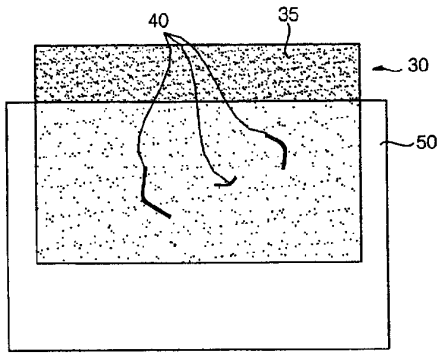
도면3



도면4



도면5



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EFS ID:	4420616
Application Number:	11909700
International Application Number:	
Confirmation Number:	7772
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol Ryu
Customer Number:	20575
Filer:	Hae-Chan Park/Wayne Helge
Filer Authorized By:	Hae-Chan Park
Attorney Docket Number:	1226-021
Receipt Date:	09-DEC-2008
Filing Date:	
Time Stamp:	15:39:46
Application Type:	U.S. National Stage under 35 USC 371

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	Power of Attorney	Power_of_Attorney.pdf	147446 d83ed4f485e0266102169dab3268f1da0f5c1508	no	2

Warnings:	
Information:	

2	Information Disclosure Statement (IDS) Filed (SB/08)	US_IDS_Form_SB_08a.pdf	34795 2913f654f0579f759d2cd221ef82917398c731f4	no	4
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	CN1584703.pdf	908969 1ea4eb1bba4444d666e1cb598a1026ecc6ad858d	no	23
Warnings:					
Information:					
4	Foreign Reference	KR10-2004-0000004.pdf	292338 333f23196cf395f663bb43265d6812f891d33d35	no	7
Warnings:					
Information:					
5	NPL Documents	Copy_of_Chinese_Office_Action.pdf	501187 bc285ab9a15eb9afe21d0e57f1e25e14095c64c4	no	10
Warnings:					
Information:					
			Total Files Size (in bytes):	1884735	

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PTO/SB/80 (01-06)
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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(b).

I hereby appoint:

[X] Practitioners associated with the Customer Number: 58027

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 assignment documents attached to this form in accordance with 37 CFR 3.73(b).

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OR

[ ] Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address

Seoul Semiconductor Co. Ltd.
148-29 Gasan-dong, Geumcheon-gu,
Seoul, Republic of Korea

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, 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	YCM YEASIN	Date	Aug. 18, 2008
Name	YEASIN, YCM	Telephone	82-10-4128-2684
Title	Director of IP & Legal Group		

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.**

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PTO/SB/96 (09-04)
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Seung Ryeol RYU, et al.

Application No./Patent No.: 11/909,700 Filed/Issue Date: September 25, 2007

Entitled: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHER

Seoul Semiconductor Co., Ltd., a Corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. ☒ the assignee of the entire right, title, and interest; or
2. ☐ an assignee of less than the entire right, title, and interest

The extent (by percentage) of its ownership interest is _____ %

in the patent application/patent identified above by virtue of either:

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The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/hae-chan park/	December 9, 2008
Signature	Date
Hae-Chan Park, Reg. 50,114	703-288-5105
Printed or Typed Name	Telephone Number
Attorney	
Title	

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.**

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Application No./Patent No.: 11/909,700 Filed/Issue Date: September 25, 2007

Entitled: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHER

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(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

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The extent (by percentage) of its ownership interest is _____ %

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The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/hae-chan park/	June 30, 2009
Signature	Date
Hae-Chan Park, Reg. 50,114	703-288-5105
Printed or Typed Name	Telephone Number
Attorney	
Title	

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EFS ID:	5612455
Application Number:	11909700
International Application Number:	
Confirmation Number:	7772
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol Ryu
Customer Number:	20575
Filer:	Hae-Chan Park/Richard Schachner
Filer Authorized By:	Hae-Chan Park
Attorney Docket Number:	1226-021
Receipt Date:	30-JUN-2009
Filing Date:	
Time Stamp:	15:01:20
Application Type:	U.S. National Stage under 35 USC 371

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	Power of Attorney	Power_of_Attorney.pdf	170088 6cb178399f828afa1aa21b4ec4b70aad8ead88f0	no	2

Warnings:	
Information:	

Total Files Size (in bytes):	170088

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Assignee Name and Address

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Application No./Patent No.: 11/909,700 Filed/Issue Date: September 25, 2007

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The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/hae-chan park/	March 24, 2010
Signature	Date
Hae-Chan Park, Reg. 50,114	703-288-5105
Printed or Typed Name	Telephone Number
Attorney	
Title	

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Application Number:	11909700
International Application Number:	
Confirmation Number:	7772
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First Named Inventor/Applicant Name:	Seung Ryeol Ryu
Customer Number:	20575
Filer:	Hae-Chan Park/Richard Schachner
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Attorney Docket Number:	1226-021
Receipt Date:	24-MAR-2010
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Time Stamp:	16:00:05
Application Type:	U.S. National Stage under 35 USC 371

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Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	Power_of_Attorney.pdf	68611 2da6d2c9b8cf8d643caa6bd3297dce4fe0a2fd6b	no	2

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PATENT APPLICATION FEE DETERMINATION RECORD

Effective December 8, 2004

Application or Docket Number: 11/909700

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
U.S. NATIONAL STAGE FEES		
BASIC FEE		
EXAMINATION FEE		
SEARCH FEE		
FEE FOR EXTRA SPEC. PGS.	minus 100 =	/ 50 =
TOTAL CHARGEABLE CLAIMS	16 minus 20 =	* —
INDEPENDENT CLAIMS	2 minus 3 =	* —
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐	RATE	FEE	OR	OTHER THAN SMALL ENTITY	RATE	FEE
	BASIC FEE		OR		BASIC FEE	300
	EXAM. FEE				EXAM. FEE	200
	SEARCH FEE				SEARCH FEE	400
	X $ 125 =				X $ 250 =	
	X $ 25 =		OR		X $ 50 =	
	X $ 100 =		OR		X $ 200 =	
	+ $ 180 =		OR		+ $ 360 =	
	TOTAL		OR		TOTAL	900

CLAIMS AS AMENDED - PART II

AMENDMENT A		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
	Total	*	Minus	**	=
	Independent	*	Minus	***	=
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY	RATE	ADDI-TIONAL FEE	OR	OTHER THAN SMALL ENTITY	RATE	ADDI-TIONAL FEE
	X $ 25 =		OR		X $ 50 =	
	X $ 100 =		OR		X $ 200 =	
	+ $ 180 =		OR		+ $ 360 =	
	TOTAL ADDIT. FEE		OR		TOTAL ADDIT. FEE	

AMENDMENT B		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
	Total	*	Minus	**	=
	Independent	*	Minus	***	=
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

	RATE	ADDI-TIONAL FEE	OR		RATE	ADDI-TIONAL FEE
	X $ 25 =		OR		X $ 50 =	
	X $ 100 =		OR		X $ 200 =	
	+ $ 180 =		OR		+ $ 360 =	
	TOTAL ADDIT. FEE		OR		TOTAL ADDIT. 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.

MULTIPLE DEPENDENT CLAIM
FEE CALCULATION SHEET
(FOR USE WITH FORM PTO-875)

SERIAL NO: 11/909700
FILING DATE:
APPLICANT(S):

CLAIMS

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
1	/		/			
2		/		/		
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TOTAL IND.	2	⬇	2	⬇		⬇
TOTAL DEP.	14		14			⬅
TOTAL CLAIMS	16		16			

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
51						
52						
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100						
TOTAL IND.		⬇		⬇		⬇
TOTAL DEP.		⬅		⬅		⬅
TOTAL CLAIMS						

PTO - 1360 (REV. 04/2009)

U.S. DEPARTMENT of COMMERCE
Patent and Trademark Office

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

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
11/909,700	Seung Ryeol Ryu	1226-021

58027
H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

INTERNATIONAL APPLICATION NO.	
PCT/KR06/00885	
I.A. FILING DATE	PRIORITY DATE
03/13/2006	03/31/2005

CONFIRMATION NO. 7772
371 ACCEPTANCE LETTER

OC000000041002454

Date Mailed: 04/09/2010

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

09/25/2007	09/25/2007
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Copy of the International Application filed on 09/25/2007
- Copy of the International Search Report filed on 09/25/2007
- Copy of IPE Report filed on 09/25/2007
- Preliminary Amendments filed on 09/25/2007
- Information Disclosure Statements filed on 12/09/2008
- Oath or Declaration filed on 09/25/2007
- Request for Immediate Examination filed on 09/25/2007
- U.S. Basic National Fees filed on 09/25/2007
- Priority Documents filed on 09/25/2007
- Power of Attorney filed on 12/09/2008

FORM PCT/DO/EO/903 (371 Acceptance Notice)

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

WINSTON M ALVARADO

Telephone: (703) 756-1466

FORM PCT/DO/EO/903 (371 Acceptance Notice)

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	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/909,700	09/25/2007	2875	900	1226-021	16	2

CONFIRMATION NO. 7772

58027
H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

FILING RECEIPT

OC000000041002453

Date Mailed: 04/09/2010

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Seung Ryeol Ryu, Bucheon-si, KOREA, REPUBLIC OF;
Seok Jin Kang, Gwangmyeong-si, KOREA, REPUBLIC OF;

Assignment For Published Patent Application

SEOUL SEMICONDUCTOR CO., LTD., Seoul, KOREA, REPUBLIC OF

Power of Attorney: The patent practitioners associated with Customer Number 58027

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/KR06/00885 03/13/2006

Foreign Applications

REPUBLIC OF KOREA 10-2005-0027133 03/31/2005

If Required, Foreign Filing License Granted: 04/06/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 11/909,700**

Projected Publication Date: 07/15/2010

Non-Publication Request: No

Early Publication Request: No

Title

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Preliminary Class

362

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where

the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/909,700	09/25/2007	Seung Ryeol Ryu	1226-021

CONFIRMATION NO. 7772

20575
MARGER JOHNSON & MCCOLLOM, P.C.
210 SW MORRISON STREET, SUITE 400
PORTLAND, OR 97204

POWER OF ATTORNEY NOTICE

OC000000041002400

Date Mailed: 04/09/2010

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/09/2008.

- 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).

/wmalvarado/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/909,700	09/25/2007	Seung Ryeol Ryu	1226-021

CONFIRMATION NO. 7772

58027
H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

POA ACCEPTANCE LETTER

OC000000041002426

Date Mailed: 04/09/2010

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/09/2008.

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.

/wmalvarado/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/909,700	09/25/2007	Seung Ryeol Ryu	P2630US00	7772

58027 7590 06/03/2010

H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

EXAMINER	
ALAVI, ALI	

ART UNIT	PAPER NUMBER
2875	

NOTIFICATION DATE	DELIVERY MODE
06/03/2010	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):

PATENT@PARK-LAW.COM

Office Action Summary	Application No.	Applicant(s)	
	11/909,700	RYU ET AL.	
	Examiner	Art Unit	
	ALI ALAVI	2875	

-- 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 _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ 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

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-4* is/are rejected.

7)☒ Claim(s) *5-16* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *25 September 2007* 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).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

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).

a)☒ All b)☐ Some * c)☐ None of:

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.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *9/25/07 and 12/09/08*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims1 and 3 are rejected under 35 U.S.C. 102(b) as being anticipated by Kim (KR 2001/0097147).

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 and 3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim (KR 2001/0097147).

Kim teaches a backlight panel, comprising: a light guide plate (13, figs 5-8) for emitting light incident from a side direction, the light guide emitting light through a top surface thereof; white light emitting diodes (LED 9, abstract) arranged at a side of the light guide plate to emit white light into the light guide plate, and a diffusion plate (10, abstract) positioned over the top surface of the light guide plate, wherein each of the white light emitting diodes includes a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip (figs 5-8, abstract). Kim doesn't explicitly teach the red and green phosphors. But Kim teaches a fluorescent (phosphrs) sheet over a blue LED to generate a white LED.

Claims 2 and 4 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim (KR 2001/0097147) in view of Jung et al (KR 2004/0000004).

Kim teaches the claimed invention except for the brightness enhancement film over the diffusion plate. However, Jung teaches a backlight device having an enhancement film (35, fig. 3, abstract) over diffusion plate in order to increase the brightness of the light emission from the backlight device. Therefor, it would have been obvious to an ordinary skill in the art to add an enhancement film over a diffusion plate to increase the brightness of the emission light.

Allowable Subject Matter

Claims 4-16 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Any inquiry concerning this communication or earlier communication from the examiner should be directed to **Ali Alavi** whose telephone number is **(571) 272-2365**. The examiner can normally be reached between 7:00 A.M. to 5:30 P.M. Tuesday to Friday. If attempts to reach the examiner by phone are unsuccessful, the examiner's supervisor, Sandy O'Shea can be reached at (571) 272-2378 or you may fax your inquiry to the **Central Fax at (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).

/Ali Alavi/

Primary Examiner, Art Unit 2875

Notice of References Cited	Application/Control No. 11/909,700	Applicant(s)/Patent Under Reexamination RYU ET AL.	
	Examiner ALI ALAVI	Art Unit 2875	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0254258	11-2005	Lee, Jong-Seo	362/612
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11909700	RYU ET AL.
	Examiner	**Art Unit**
	ALI ALAVI	2875

✓	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	05/27/2010								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	O								
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	8	O								
	9	O								
	10	O								
	11	O								
	12	O								
	13	O								
	14	O								
	15	O								
	16	O								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11909700	RYU ET AL.
	Examiner	Art Unit
	ALI ALAVI	2875

SEARCHED			
Class	Subclass	Date	Examiner
362	612, 614, 615, 617-619, 231, 84	5/20/10	AA
257	88, 100	5/25/10	AA

SEARCH NOTES		
Search Notes	Date	Examiner
Reviewed foriegn search report	5/25/10	AA
Searched inventor history	5/26/10	

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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BIB DATA SHEET

CONFIRMATION NO. 7772

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/909,700	09/25/2007	362	2875	P2630US00

APPLICANTS

Seung Ryeol Ryu, Bucheon-si, KOREA, REPUBLIC OF;
Seok Jin Kang, Gwangmyeong-si, KOREA, REPUBLIC OF;

**** CONTINUING DATA **************************

This application is a 371 of PCT/KR06/00885 03/13/2006

**** FOREIGN APPLICATIONS **************************

REPUBLIC OF KOREA 10-2005-0027133 03/31/2005

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04/06/2010

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /ALI ALAVI/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		KOREA, REPUBLIC OF	2	16	2

ADDRESS

H.C. PARK & ASSOCIATES, PLC
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SUITE 7500
VIENNA, VA 22182
UNITED STATES

TITLE

BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

FILING FEE RECEIVED		
900	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	3	backlight and light near guide near plate and white near3 led and diffusion near plate and brightness near film	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:14
S2	1257	362/612	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:21
S3	819	362/613	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:21
S4	403	362/614	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:21
S5	656	362/615	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:22
S6	300	362/616	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:22
S7	310	362/617	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:22
S8	237	362/618	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:22

S9	348	362/619	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:22
S10	2788	S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:23
S11	1717	S10 and backlight	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:23
S12	612	S11 and white near2 light	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:23
S13	5402862	S12 and diffus$4 nea2 plate	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:24
S14	244	S12 and diffus$4 near2 plate	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:24
S15	178	S14 and brightness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:25
S16	3	S15 and @py<"2006"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/15 22:27
S17	0	"20010097147"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/27 18:37
S18	2	"20040000004"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/27 18:38

S19	10	"1584703"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT	OR	ON	2010/05/27 18:39

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Receipt date: 09/25/2007

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	11/909,700
	Filing Date	
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	Alavi, A.
	Attorney Docket Number	1226-021

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	1	WO9805078	WO		1998-02-05	Nichia Kagaku Kogyo Kabushiki Kaisha		☐
	2	1020010097147	KR		2001-11-08	LS Tech Co., Ltd.		☐
	3	JP2004296830	JP		2004-10-21	Solidlite Corp.		☐

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /AA/

Receipt date: 09/25/2007	Application Number	11/909,700
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	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	Alavi, A.
	Attorney Docket Number	1226-021

	4	JP2004119743	JP		2004-04-15	Citizen Electronics		☐

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Receipt date: 12/09/2008
Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (11-08)
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	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	
	Art Unit	2875
	Examiner Name	~~Seung RYU~~ Alavi, A.
	Attorney Docket Number	P2630US00

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] ¡	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	1584703	CN		2005-02-23	LG Philips LCD Co., Ltd.		☐
	2	10-2004-0000004	KR		2004-01-03	LG Electronics Inc.		☐
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Receipt date: 12/09/2008	Application Number	11909700
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2007-09-25
	First Named Inventor	
	Art Unit	2875
	Examiner Name	~~Seung-Ryu~~ Alavi, A.
	Attorney Docket Number	P2630US00

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]
	1	Chinese Office Action dated August 29, 2008	☐

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Examiner Signature	/Ali Alavi/ (05/15/2010)	Date Considered	

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/909,700	09/25/2007	Seung Ryeol Ryu	P2630US00

CONFIRMATION NO. 7772

58027
H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

PUBLICATION NOTICE



Title:BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

Publication No.US-2010-0177534-A1
Publication Date:07/15/2010

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	Docket No.: P2630US00
Seung Ryeol RYU, *et al.*	
Serial No.: 11/909,700	Group Art Unit: 2875
Confirmation No.: 7772	
Filed: September 25, 2007	Examiner: ALAVI, ALI

For: **BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHER**

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY UNDER 37 C.F.R. § 1.111

Sir:

In response to the Non-Final Office Action dated June 3, 2010 ("Office Action"), Applicants respectfully request reconsideration of the application in view of the following Amendments and Remarks.

Amendments to the Claims begin on page 2.

Remarks begin on page 8.

A Petition for a one-month extension of time under 37 C.F.R. §1.136(a) is filed to extend the period for response through October 3, 2010. If further extensions of time are necessary to prevent abandonment of this application, then they are petitioned for under 37 C.F.R. § 1.136(a). Applicants submit a fee in the amount of $220.00 for the addition of 1 independent claim. Any fees required for further extensions of time or for the net addition of claims may be charged to our Deposit Account No. 50-3698.

AMENDMENTS TO THE CLAIMS

Please **CANCEL** claims 5, 9-11, 14, and 16 without prejudice or disclaimer.

Please **AMEND** claims 1, 3, 6-8, 12-13, and 15 as shown below.

Please **ADD** claims 17-18 as shown below.

This claim list replaces all prior claim lists in the application.

1. (Currently amended) A backlight panel, comprising:

a light guide plate for emitting light incident from a side direction, the light guide plate configured to emit ~~emitting~~ light through a top surface thereof;

white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and

a diffusion plate positioned over the top surface of the light guide plate,

wherein each of the white light emitting diodes comprises ~~includes~~ a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip, and

wherein the red phosphor is an alkaline earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

2. (Original) The backlight panel as claimed in claim 1, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

3. (Currently amended) A backlight panel, comprising:

a diffusion plate having a top surface and a bottom surface;

white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and

a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,

wherein each of the white light emitting diodes comprises ~~includes~~ a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip, and

wherein the red phosphor is an alkaline earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

4. (Original) The backlight panel as claimed in claim 3, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

5. (Canceled)

6. (Currently amended) A backlight panel, comprising:

a light guide plate for emitting light incident from a side direction, the light guide plate configured to emit light through a top surface thereof;

white light emitting diodes arranged at a side of the light guide plate to emit white light into the light guide plate; and

a diffusion plate positioned over the top surface of the light guide plate,

wherein each of the white light emitting diodes comprises a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip, and ~~The backlight panel as claimed in claim 1,~~

wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

7. (Currently amended) The backlight panel as claimed in claim 1, wherein

~~the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02, and~~

the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

8. (Currently amended) The backlight panel as claimed in claim [[2]]6, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula,

$A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02.

9-11. (Canceled)

12. (Currently amended) A backlight panel, comprising:

a diffusion plate having a top surface and a bottom surface;

white light emitting diodes arranged below the bottom surface of the diffusion plate at a predetermined interval from the diffusion plate; and

a reflection sheet positioned below light exit surfaces of the white light emitting diodes to allow light traveling in a direction opposite to the diffusion plate to be reflected toward the diffusion plate,

wherein each of the white light emitting diodes comprises a blue light emitting diode chip and red and green phosphors positioned over the blue light emitting diode chip, and ~~The backlight panel as claimed in claim 3,~~ wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

13. (Currently amended) The backlight panel as claimed in claim [[4]]3, wherein the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group

consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8.

14. (Canceled)

15. (Currently amended) The backlight panel as claimed in claim [[3]]12, wherein the red phosphor is an alkali earth metal sulfide-based red phosphor expressed as general formula, $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; z=x+2; x is set within a range of 2 to 5; and a/x is set within a range of 0.0005 to 0.02~~, and~~

~~the green phosphor is a thiogallate-based green phosphor expressed as general formula, $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$, where 0<x, y, x+y<1; A is at least one element selected from the group consisting of Ba, Sr and Ca; B is at least one element selected from the group consisting of Al, Ga and In; x is set within a range of 0.01 to 0.1 ; M^{I} is at least one element selected from the group consisting of Li, Na and K; M^{III} is at least one element selected from the group consisting of Sc, Y, Lu, Gd and La; and y is set within a range of 0.2 to 0.8~~.

16. (Canceled)

17. (New) The backlight panel as claimed in claim 6, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

18. (New) The backlight panel as claimed in claim 12, further comprising a brightness enhancement film and/or a dual brightness enhancement film over the diffusion plate.

REMARKS

Claims 1, 3, 6-8, 12-13, and 15 have been amended, claims 5, 9-11, 14, and 16 have been canceled without prejudice or disclaimer, and claims 17-18 have been added. Accordingly, claims 1-4, 6-8, 12-13, 15, and 17-18 are currently pending in the application, of which claims 1, 3, 6, and 12 are independent. Applicants appreciate the indication that claims 5-16 contain allowable subject matter.

Applicants respectfully submit that the above amendments do not add new matter to the application and are fully supported by the specification.

Applicants respectfully request reconsideration and timely withdrawal of the pending objections and rejections for the reasons discussed below.

Claim Objection

Claims 5-16 were objected to as being dependent upon a rejected base claim.

Independent claim 1 has been amended to incorporate the elements of claim 5, independent claim 3 has been amended to incorporate the elements of claim 9, claim 6 has been amended to be in independent form and incorporate the elements of claim 1, and claim 12 has been amended to be in independent form and incorporate the elements of claim 3. Claims 7-8, 13, and 15 depend from either independent claim 1, 3, 6, or 12. Claims 5, 9-11, 14, and 16 have been canceled without prejudice or disclaimer. Therefore, Applicants respectfully request the withdrawal of the objection to claims 5-16.

Rejections Under 35 U.S.C. § 102

Claims 1 and 3 stand rejected under 35 U.S.C. § 102(b) as being allegedly anticipated by Korean Patent Application Publication No. 2001-0097147 applied for by Kim ("Kim").

In order for a rejection under 35 U.S.C. § 102(b) to be proper, a single reference must disclose every claimed feature. To be patentable, a claim need only recite a single novel feature that is not disclosed in the cited reference. Thus, the failure of a cited reference to disclose one or more claimed features renders the 35 U.S.C. § 102(b) rejection improper.

Claim 1 has been amended to incorporate allowable claim 5, and claim 3 has been amended to incorporate allowable claim 9, thereby rendering the rejection of claims 1 and 3 moot.

Accordingly, Applicants respectfully request withdrawal of the 35 U.S.C. § 102(b) rejection of claims 1 and 3. Claims 2 and 4 depend from claims 1 and 3 respectively, and are allowable at least for this reason. Since none of the other prior art of record discloses or suggests all the features of the claimed invention, Applicants respectfully submit that independent claims 1 and 3, and all the claims that depend therefrom, are allowable.

Rejections Under 35 U.S.C. § 103

Claims 1 and 3 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Kim.

To establish an obviousness rejection under 35 U.S.C. § 103(a), four factual inquiries must be examined. The four factual inquiries include (a) determining the scope and contents of the prior art; (b) ascertaining the differences between the prior art and the claims in issue; (c) resolving the level of ordinary skill in the pertinent art; and (d) evaluating evidence of secondary consideration. *Graham v. John Deere*, 383 U.S. 1, 17-18 (1966).

In view of these four factors, the analysis supporting a rejection under 35 U.S.C. 103(a) should be made explicit, and should "identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements" in the manner claimed. *KSR Int'l. Co. v. Teleflex, Inc.*, 127 S. Ct. 1727, 82 USPQ2d 1385, 1396 (2007). The

Federal Circuit requires that "rejections on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).

Finally, even if the prior art may be combined, there must be a reasonable expectation of success, and the reference or references, when combined, must disclose or suggest every claimed feature. *See in re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Claim 1 has been amended to incorporate allowable claim 5, and claim 3 has been amended to incorporate allowable claim 9, thereby rendering the rejection of claims 1 and 3 moot.

Accordingly, Applicants respectfully request withdrawal of the 35 U.S.C. § 103(a) rejection of claims 1 and 3. Claims 2 and 4 depend from claims 1 and 3 respectively, and are allowable at least for this reason. Since none of the other prior art of record, whether taken alone or in any combination, discloses or suggests all the features of the claimed invention, Applicants respectfully submit that independent claims 1 and 3, and all the claims that depend therefrom, are allowable.

Claims 2 and 4 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Kim in view of Korean Patent Application Publication No. 2004-0000004 applied for by Jung, *et al*. ("Jung").

Applicants respectfully submit that claims 1 and 3 are allowable over Kim, and Jung fails to cure the deficiencies of Kim noted above with regard to claims 1 and 3. Hence, claims 2 and 4 are allowable at least because they depend from allowable claims 1 and 3 respectively.

Accordingly, Applicants respectfully request withdrawal of the 35 U.S.C. § 103(a) rejection of claims 2 and 4.

Allowable Subject Matter

Applicants appreciate the indication that claims 5-16 contain allowable subject matter. As stated above, claims 5-16 have either been amended to be in independent form, depend from an allowable independent claim, or have been canceled without prejudice or disclaimer.

Accordingly, Applicants submit that claims 6-8, 12-13, 15 are in condition for allowance.

CONCLUSION

A full and complete response has been made to the pending Office Action, and all of the stated objections and grounds for rejection have been overcome or rendered moot. Accordingly, all pending claims are allowable, and the application is in condition for allowance.

The Examiner is invited to contact Applicants' undersigned representative at the number below if it would expedite prosecution. Prompt and favorable consideration of this Reply is respectfully requested.

Respectfully submitted,

/hae-chan park/

Hae-Chan Park
Reg. No. 50,114

Date: September 30, 2010

CUSTOMER NUMBER: 58027
H.C. Park & Associates, PLC
8500 Leesburg Pike
Suite 7500
Vienna, VA 22182
Tel: 703-288-5105
Fax: 703-288-5139
HCP/BCR/ebs

PTO/SB/22 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARMENT OF COMMERCE
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) **FY 2009** ***(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)***	Docket Number (Optional) P2630US00
Application Number 11/909,700	Filed September 25, 2007
For BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE...	
Art Unit 2875	Examiner ALAVI, ALI

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	
☑	One month (37 CFR 1.17(a)(1))	$130	$65	$ 130
☐	Two months (37 CFR 1.17(a)(2))	$490	$245	$
☐	Three months (37 CFR 1.17(a)(3))	$1110	$555	$
☐	Four months (37 CFR 1.17(a)(4))	$1730	$865	$
☐	Five months (37 CFR 1.17(a)(5))	$2350	$1175	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☑ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 50-3698.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration Number 50114

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

/hae-chan park/	September 30, 2010
Signature	Date
Hae-Chan Park	703-288-5105
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). 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 6 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.

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.

PTO/SB/22 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) **FY 2009** ***(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)***	Docket Number (Optional) P2630US00
Application Number 11/909,700	Filed September 25, 2007
For BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE...	
Art Unit 2875	Examiner ALAVI, ALI

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

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		Fee	Small Entity Fee	
☑	One month (37 CFR 1.17(a)(1))	$130	$65	$ 130
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☐ Applicant claims small entity status. See 37 CFR 1.27.

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I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
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☑ attorney or agent of record. Registration Number 50114

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

/hae-chan park/	September 30, 2010
Signature	Date
Hae-Chan Park	703-288-5105
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.

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Electronic Patent Application Fee Transmittal

Application Number:	11909700
Filing Date:	25-Sep-2007
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol Ryu
Filer:	Hae-Chan Park/eun jo
Attorney Docket Number:	P2630US00

Filed as Large Entity

U.S. National Stage under 35 USC 371 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:				
Extension - 1 month with $0 paid	1251	1	130	130

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**130**

Electronic Acknowledgement Receipt	
EFS ID:	8531804
Application Number:	11909700
International Application Number:	
Confirmation Number:	7772
Title of Invention:	BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR
First Named Inventor/Applicant Name:	Seung Ryeol Ryu
Customer Number:	58027
Filer:	Hae-Chan Park/Richard Schachner
Filer Authorized By:	Hae-Chan Park
Attorney Docket Number:	P2630US00
Receipt Date:	30-SEP-2010
Filing Date:	25-SEP-2007
Time Stamp:	14:28:38
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$130
RAM confirmation Number	3511
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1		P2630US00_Reply.pdf	61456 154c4ef548d942832f31782fa02353c47b01d403	yes	11

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	7
Applicant Arguments/Remarks Made in an Amendment	8	11

Warnings:

Information:

2	Extension of Time	P2630US00_EoT.pdf	322303 fe54bb3411a1811a8de90362ba2a3b5a7cde8777	no	2

Warnings:

Information:

3	Fee Worksheet (PTO-875)	fee-info.pdf	30677 a7134cb61744fd4834cea1958a5676385eaf9224	no	2

Warnings:

Information:

Total Files Size (in bytes):	414436

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.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/909,700	09/25/2007	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			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 $250 ($125 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			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	09/30/2010	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	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.

Legal Instrument Examiner:
/MINNIE JACKSON/

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

58027 7590 11/30/2010

H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

EXAMINER	
ALAVI, ALI	
ART UNIT	PAPER NUMBER
2875	

DATE MAILED: 11/30/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/909,700	09/25/2007	Seung Ryeol Ryu	P2630US00	7772

TITLE OF INVENTION: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	02/28/2011

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 SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

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.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

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)

58027 7590 11/30/2010

H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

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.
11/909,700	09/25/2007	Seung Ryeol Ryu	P2630US00	7772

TITLE OF INVENTION: BACKLIGHT PANEL EMPLOYING WHITE LIGHT EMITTING DIODE HAVING RED PHOSPHOR AND GREEN PHOSPHOR

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	02/28/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
ALAVI, ALI	2875	362-231000

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).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

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.
11/909,700	09/25/2007	Seung Ryeol Ryu	P2630US00	7772

58027 7590 11/30/2010

H.C. PARK & ASSOCIATES, PLC
8500 LEESBURG PIKE
SUITE 7500
VIENNA, VA 22182

EXAMINER	
ALAVI, ALI	
ART UNIT	PAPER NUMBER
2875	

DATE MAILED: 11/30/2010

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 528 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 528 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. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	Application No.	Applicant(s)	
	11/909,700	RYU ET AL.	
	Examiner	Art Unit	
	ALI ALAVI	2875	

-- 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 on 9/30/10*.

2. ☒ The allowed claim(s) is/are *1-4,6-8,12,13,15,17 and 18*.

3. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   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.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ 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. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Applicant's amendment filed on 9/30/10 has been entered. Accordingly, claims 1, 3, 6, 7, 8, 12, 13, and 15 have been amended. Claims 5, 9-11, 14, and 16 have been canceled. Claims 17-18 are added.

Reasons for allowance

Claims 1-4, 6-8, 12-13, 15, and 17-18 are allowed.

The following is an examiner's statement of reasons for allowance: applicant's amendment by incorporating the allowable subject matter in claims1, 3, 6, 12, and 15 has persuaded the examiner to place this application in condition for allowance.

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."

Any inquiry concerning this communication or earlier communication from the examiner should be directed to Ali Alavi whose telephone number is (571) 272-2365. The examiner can normally be reached between 7:00 A.M. to 5:30 P.M. Tuesday to Friday. If attempts to reach the examiner by phone are unsuccessful, the examiner's supervisor, Sandy O'Shea can be reached at (571) 272-2378 or you may fax your inquiry to the **Central Fax at (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).

/Ali Alavi/

Primary Examiner, Art Unit 2875

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11909700	RYU ET AL.
	Examiner	**Art Unit**
	ALI ALAVI	2875

✓	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	05/27/2010	11/22/2010							
1	1	✓	=							
2	2	✓	=							
4	3	✓	=							
5	4	✓	=							
	5	O	-							
7	6	O	=							
3	7	O	=							
8	8	O	=							
	9	O	-							
	10	O	-							
	11	O	-							
10	12	O	=							
6	13	O	=							
	14	O	-							
11	15	O	=							
	16	O	-							
9	17		=							
12	18		=							

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11909700	RYU ET AL.
	Examiner	Art Unit
	ALI ALAVI	2875

ORIGINAL		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
362	231	F 2 1 V 9 / 00 (2006.01.01)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
362	84	97.1			
257	98				

☐ 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	9	17												
2	2	12	18												
4	3														
5	4														
	5														
7	6														
3	7														
8	8														
	9														
	10														
	11														
10	12														
6	13														
	14														
11	15														
	16														

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	12	
/ALI ALAVI/ Primary Examiner.Art Unit 2875	11/22/2010	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	5

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11909700	RYU ET AL.
	Examiner	Art Unit
	ALI ALAVI	2875

SEARCHED			
Class	Subclass	Date	Examiner
362	612, 614, 615, 617-619, 231, 84	5/20/10	AA
257	88, 100	5/25/10	AA
	updated	11/16/10	AA

SEARCH NOTES		
Search Notes	Date	Examiner
Reviewed foriegn search report	5/25/10	AA
Searched inventor history	5/26/10	

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner
All	Above PGPUB searched	11/15/10	AA

PTO/SB/30EFS (07-09)
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.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	11/909,700	Filing Date	2007-09-25	Docket Number (if applicable)	P2630US00	Art Unit	2875
First Named Inventor	Seung Ryeol Ryu			Examiner Name	ALAVI, ALI		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 503698

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
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.

Signature of Registered U.S. Patent Practitioner			
Signature	/hae-chan park/	Date (YYYY-MM-DD)	2011-02-28
Name	Hae-Chan Park	Registration Number	50114

This collection of information is required by 37 CFR 1.114. 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.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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 the Freedom of Information Act requires disclosure of these records.

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 inspections 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.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	11909700
Filing Date	2007-09-25
First Named Inventor	Seung Ryeol Ryu
Art Unit	2875
Examiner Name	ALAVI, ALI
Attorney Docket Number	P2630US00

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	6252254		2001-06-26	Soules et al.	
	2	4303913		1981-12-01	Tohda et al.	
	3	4563297		1986-01-07	Kukimoto et al.	
	4	5208462		1993-05-04	James M. O'Connor	
	5	5598059		1997-01-28	Sey-Shing Sun	
	6	6762551		2004-07-13	Shiiki et al.	
	7	3639254		1972-02-01	Peters	
	8	6617782		2003-09-09	Cheong, et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	ALAVI, ALI
	Attorney Docket Number	P2630US00

	9	6695982		2004-02-24	Ellens et al.	
	10	6417019		2002-07-09	Mueller et al.	
	11	5834053		1998-11-10	Dye et al.	
	12	6501102		2002-12-31	Mueller-Mach et al.	
	13	6521915		2003-02-18	Odaki et al.	
	14	6680569		2004-01-20	Mueller-Mach et al.	
	15	6686691		2004-02-03	Mueller et al.	
	16	6783700		2004-08-31	Tian et al.	
	17	4065688		1977-12-27	Thomton	

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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

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	ALAVI, ALI
	Attorney Docket Number	P2630US00

	1	20030228412		2003-12-11	Chen	
	2	20060082296		2006-04-20	Chua et al.	
	3	20040124758		2004-07-01	Danielson, et al.	
	4	20050236958		2005-10-27	Wang et al.	
	5	20050224828		2005-10-13	Oon et al.	
	6	20040104391		2004-06-03	Maeda et al.	
	7	20050046334		2005-03-03	Shinsuke Fujiwara	
	8	20050123243		2005-06-09	Steckl et al.	

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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	01/24229	WO		2001-04-05	Lumileds Lighting US. LLC.		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	ALAVI, ALI
	Attorney Docket Number	P2630US00

	2	10-2006-0028932	KR		2006-04-04	Seoul Semiconductor Co., Ltd.		☐
	3	10-0601200	KR		2006-07-13	Seoul Semiconductor Co., Ltd.		☐
	4	563261	TW		2003-11-21	Solidlite Corp.		☐
	5	03/081957	WO		2003-10-02	IFIRE TECHNOLOGY INC.		☐
	6	10028266	DE		2001-12-13	Patent-Treuhand-Gesellschaft... et al.		☐
	7	2005/026285	WO		2005-03-24	Sarnoff Corp.		☐
	8	02/098180	WO		2002-12-05	IFIRE TECHNOLOGY INC.		☐
	9	10-2001-0089508	KR		2001-10-06	Philips Lumileds Lighting Co., Ltd.		☐
	10	10-2002-0027538	KR		2002-04-13	Patent-Treuhand-Gesellschaft...		☐
	11	10-2004-0088418	KR		2004-10-16	Jae Ik PARK		☐
	12	2927279	JP		1999-05-14	Nichia Kagaku Kogyo KK		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	11909700
	Filing Date	2007-09-25
	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	ALAVI, ALI
	Attorney Docket Number	P2630US00

	13	2003/107441	WO		2003-12-24	Cree Inc.		☐
	14	02-11173	WO		2002-02-07	Osram Opto Semiconductors GMBH & Co., OHG et al.		☐
	15	10-2002-0067818	KR		2002-08-24	Eastwell Co., Ltd., et al.		☐
	16	03/080763	WO		2003-10-02	Koninklijke Philips Electronics N.V,		☐
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	First Named Inventor	Seung Ryeol Ryu
	Art Unit	2875
	Examiner Name	ALAVI, ALI
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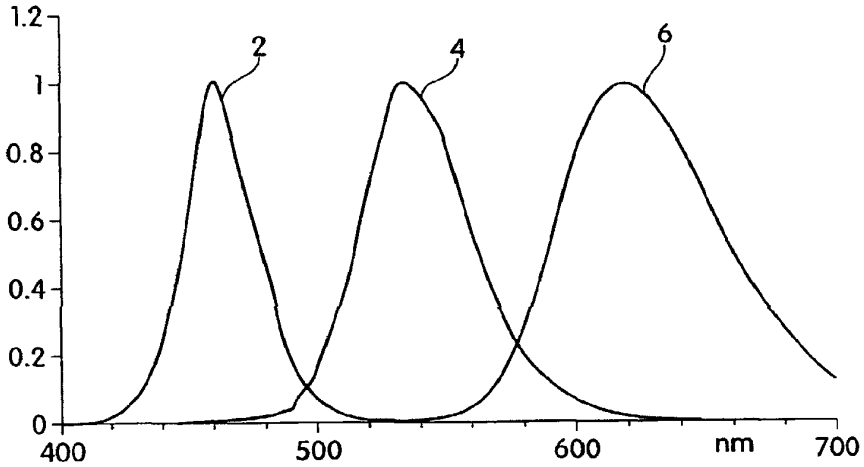
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(54) Title: TRI-COLOR, WHITE LIGHT LED LAMPS



(57) Abstract: The present invention relates to a tri-color lamp for generating white light. In particular, the invention relates to a phosphor mixture comprising two phosphors having host sulfide materials that can absorb radiation emitted by a light emitting diode, particularly a blue LED. This arrangement provides a mixing of three light sources - light emitted from the two phosphors and unabsorbed light emitted from the LED. The phosphors can contain the same dopant, such as a rare earth ion, to allow matching of the phosphors in relation to the LED emitted radiation. Power fractions of each of the light sources can be varied to achieve good color rendering. The present invention also relates to an alternative to a green LED comprising a single green phosphor that absorbs radiation from a blue LED. A resulting device provides green light of high absorption efficiency and high luminous equivalent values.

WO 01/24229 A2

TRI-COLOR, WHITE LIGHT LED LAMPS

FIELD OF INVENTION

The present invention relates to a tri-color lamp. The lamp comprises a mixture of two phosphors and a light emitting diode for an excitation energy source. In particular, the lamp employs a blue LED and a mixture of red and green phosphors for the production of white light.

BACKGROUND OF THE INVENTION

There is an ongoing need to generate new phosphor compositions to improve efficiency and color quality in luminescent devices, particularly in the production of white light. Phosphors are luminescent materials that can absorb an excitation energy (usually radiation energy) and store this energy for a period of time. The stored energy is then emitted as radiation of a different energy than the initial excitation energy. For example, "down-conversion" refers to a situation where the emitted radiation has less quantum energy than the initial excitation radiation. Thus, the energy wavelength effectively increases, and this increase is termed a "Stokes shift." "Up-conversion" refers to a situation where the emitted radiation has greater quantum energy than the excitation radiation ("Anti-Stokes shift").

Improvements in efficiency and color quality in phosphor-based devices are constantly being developed. "Efficiency" relates to a fraction of photons emitted with respect to a number of photons initially provided as excitation energy. Inefficient conversion results when at least a portion of the energy is consumed by non-radiative processes. Color "quality" can be measured by a number of different rating systems. "Chromaticity" defines color by hue and saturation. "CIE" is a chromaticity coordinate system developed by Commission Internationale de l'Eclairage (international commission on illumination). The CIE Chromaticity Coordinates are coordinates that define a color in "1931 CIE" color space. These coordinates are defined as x, y, z and are ratios of the three standard primary colors, X, Y, Z (tristimulus values), in relation to the sum of the three tristimulus values. A CIE chart contains a plot of the x, y and z ratios of the tristimulus values versus their sum. In the situation where the reduced coordinates x, y, z add to 1, typically, a two-dimensional CIE (x, y) plot is used.

White-like colors can be described by a "correlated color temperature" (CCT). For example, when a metal is heated, a resulting light is emitted which initially glows as a red color. As the metal is heated to increasingly higher temperatures, the emitted light shifts to higher quantum energies, beginning with reddish light and shifting to white light and ultimately to a bluish-white light. A system was developed to determine these color changes on a standard object known as a blackbody radiator. Depending on the temperature, the blackbody radiator will emit white-like radiation. The color of this white-like radiation can then be described in the CIE chromaticity chart. Thus, the correlated color temperature of a light source to be evaluated is the temperature at which the blackbody radiator produces the chromaticity most similar to that of the light source. Color temperature and CCT are expressed in degrees Kelvin.

A "color rendering index" (CRI) is established by a visual experiment. The correlated color temperature of a light source to be evaluated is determined. Then eight standard color samples are illuminated first by the light source and then by a light from a blackbody having the same color temperature. If a standard color sample does not change color, then the light source has a theoretically perfect special CRI value of 100. A general color rendering index is termed "Ra", which is an average of the CRIs of all eight standard color samples.

Older white lamps involved emission of light over a broad wavelength range. It was then discovered that a white-like color can be simulated by a mixture of two or three different light colors, where each emission comprised a relatively narrow wavelength range. These lamps afforded more control to manipulate the white color because emissive properties (emission energy and intensity) of the individual red, green and blue light sources can be individually tailored. This method thus provided the possibility of achieving improved color rendering properties.

An example of a two-color lamp comprises one phosphor and an excitation energy source. Light emitted by the phosphor combines with unabsorbed light from the excitation source to produce a white-like color. Further improvements in fluorescent lamps involved three different light colors (i.e. a tri-color lamp) resulting in white light at higher efficiencies. One example of a tri-color lamp involved blue, red and green light-emitting phosphors. Other previous tri-color lamps comprised a combination of light from two phosphors (a green and red phosphor) and unabsorbed light from a mercury plasma excitation source.

Previous tri-color lamps involving a mercury plasma excitation source, however, suffer many disadvantages including: (1) a need for high voltages which can result in gaseous discharge with energetic ions; (2) emission of high energy UV quanta; and (3) correspondingly low lifetimes. Thus, there is an ongoing need for devices that overcome these deficiencies.

Finally there remains a continued challenge to uncover phosphor compositions and mixtures of these compositions to provide improved properties, including improved efficiency, color rendering (e.g. as measured by high color rendering indices) and luminance (intensity), particularly in a tri-color, white lamp.

SUMMARY OF THE INVENTION

One aspect of the present invention provides a composition comprising a mixture of a first phosphor and a second phosphor. Each phosphor comprises a host sulfide material and a rare earth dopant and each phosphor is capable of being excited by a common light emitting diode.

Another aspect of the present invention provides a composition comprising a mixture of a first phosphor and a second phosphor. Each phosphor comprises a host material and a rare earth dopant. The first phosphor is capable of being excited by a light emitting diode and the second phosphor is capable of being excited by an emission of the first phosphor.

Another aspect of the present invention provides a device comprising a light emitting diode, for emitting a pattern of light. The device further comprises a composition comprising a mixture of a first phosphor and a second phosphor. Each phosphor comprises a host sulfide material and a rare earth dopant and the composition is positioned in the light pattern.

Another aspect of the present invention provides a device comprising a green phosphor and a blue light emitting diode, for providing an excitation radiation to the phosphor.

Other advantages, novel features, and objects of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings, which are schematic and which are not intended to be drawn to scale. In the figures, each identical or nearly identical component that is illustrated in various figures is represented by a single numeral. For purposes of clarity, not every component is labeled in every figure, nor is every

component of each embodiment of the invention shown where illustration is not necessary to allow those of ordinary skill in the art to understand the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an overlay of normalized spectra of $SrGa_2S_4$:Eu and SrS:Eu upon excitation by a blue LED at 460 nm;

FIG. 2 shows a simulation of spectra of a mixture of $SrGa_2S_4$:Eu and SrS:Eu upon excitation by a blue LED at 460 nm at different color temperatures; and

FIG. 3 shows a schematic of a tri-color lamp comprising a two-phosphor mixture positioned in a pathway of light emitted by an LED.

DETAILED DESCRIPTION

The invention relates, in part, to the discovery that a tri-color lamp employing specific red and green phosphors excitable by a common light emitting diode (LED) can achieve white light at higher efficiencies with superior color rendering over previous fluorescent lamps.

One aspect of the present invention provides a composition comprising a mixture of a first phosphor and a second phosphor, each phosphor capable of being excited by a common light emitting diode, i.e. only one light emitting diode is used to excite both phosphors, as opposed to each phosphor requiring a separate energy source.

An advantageous feature of the present invention involves the use of an LED as an excitation source. An LED has a p-n junction between doped semiconductor regions. Upon application of a current, there can exist sufficient energy to allow electrons and holes to cross the p-n junction such that a resulting recombination of electrons and holes cause emission of radiation. Advantages of LEDs over other excitation energy sources include small size, low power consumption, long lifetimes and low amounts of thermal energy emitted. In addition, LEDs have small dimensions that allow miniaturization of devices.

In one embodiment, the common LED is a blue LED. The use of blue light as an excitation radiation over other light sources has been found to be particularly advantageous in that conversion efficiency to visible light is higher. In one embodiment, each phosphor is capable of being excited by a common LED which emits radiation at a wavelength from about 450 nm to about 480 nm. It has been found that color rendering can decrease at excitation energies below 450 nm whereas absorption by the phosphors

decreases at excitation energies greater than 480 nm. An example of a blue LED that emits radiation in the above-mentioned energy ranges is a (In,Ga)N diode.

A blue light source can provide inherent advantages over UV excitation sources in that power efficiency is increased for red and green phosphors excited by blue light. The present phosphor materials generally require lesser Stokes shifts than phosphors of the previous devices. For example, certain tri-color prior art fluorescent lamps incorporate mercury plasmas which provide a UV emission centered at approximately 4.9 eV. This UV light excites blue, red and green phosphors such that resulting emission spectra show maximum intensities at energies of approximately 2.8 eV (unabsorbed light), 2.3 eV (green) and 2.0 eV (red) respectively. Significant Stokes shifts are obviously involved in this situation. Power efficiency, however, is limited by quantum deficit, which is the difference of the quantum energies of exciting and emitted quanta. Thus, for the example described above, power efficiency of the green light is, on average, (4.9 eV-2.3 eV)/4.9 eV = 53%. In contrast, green (2.3 eV) and red (2.0) phosphors excited by a blue LED with an emission of about 2.7 eV (~ 460 nm) exhibit smaller Stokes shifts and quantum deficits, and accordingly power efficiency is greater.

Phosphors comprise host materials and dopant ions. Typically, the host material has an inorganic, ionic lattice structure (a "host lattice") in which the dopant ion replaces a lattice ion. The dopant is capable of emitting light upon absorbing excitation radiation. Ideal dopants strongly absorb excitation radiation and efficiently convert this energy into emitted radiation. In one embodiment, the dopant is a rare earth ion. Rare earth ions absorb and emit radiation via 4f-4f transitions, i.e. electronic transitions involving f-orbital energy levels. While f-f transitions are quantum-mechanically forbidden, resulting in weak emission intensities, it is known that certain rare earth ions, such as Eu^{2+} or Ce^{3+}, strongly absorb radiation through allowed 4f-5df transitions (via d-orbital/f-orbital mixing) and consequently produce high emission intensities.

The emissions of certain dopants can be shifted in energy depending on the host lattice in which the dopant ion resides. Thus, this aspect of the invention lies, in part, in the discovery that certain rare earth dopants efficiently convert blue light to visible light when incorporated into an appropriate host material. In one embodiment, the first and second phosphors comprise a host sulfide material, i.e. a lattice which includes sulfide ions. Preferred host sulfide materials include CaS, SrS and a thiogallates such as $SrGa_2S_4$.

Another advantageous feature of the present invention is to provide a phosphor mixture excitable by one common blue energy source of a relatively narrow linewidth, to emit light at two different energy ranges (e.g. red and green). Strategies to provide appropriate phosphors are disclosed here. In one embodiment, the dopant is the same in the first and second phosphor. The red and green emissions of the two phosphors can be tuned by selecting an appropriate host material. In one embodiment, the green phosphor is $SrGa_2S_4$:Eu. In another embodiment, the red phosphor is selected from the group consisting of SrS:Eu and CaS:Eu.

FIG. 1 is an overlay of emission spectra from two different phosphors having the same dopant capable of being excited by one common (In,Ga)N LED at 460 nm. The phosphors are provided as a mixture in an encapsulant. The spectra have been normalized to an intensity of 1. Spectrum 2 corresponds to an emission of the blue LED with a maximum intensity at ~ 460 nm, spectrum 4 corresponds to an emission from a green phosphor material, $SrGa_2S_4$:Eu with a maximum intensity at ~ 520 nm, and spectrum 6 corresponds to an emission from a red phosphor material, SrS:Eu with a maximum intensity at ~ 620 nm.

Alternatively, the first and second phosphors can have different dopants. The same host material can be used, or the first and second phosphors can have different host materials. One of ordinary skill in the art can screen potential phosphor candidates by selecting phosphors that can be excited by radiation between about 450 nm and about 480, and observing whether they emit red or green light.

In one embodiment, the amount of dopant present in the host lattice is from about 0.1 mol% to about 8 mol%. Preferred amounts of dopant may depend on the type of host lattice. For example, a dopant concentration in $SrGa_2S_4$ is preferably from about 2 mol% to about 4 mol%, whereas a dopant concentration in SrS is preferably from about 0.3 mol% to about 0.8 mol%.

The present invention also relates to another tri-color system, in which a first phosphor is excited by an LED source, and the emission of the first phosphor is capable of exciting a second phosphor. Thus, another aspect of the present invention provides a mixture of a first phosphor and a second phosphor, each phosphor comprising a host material and a rare earth dopant. The first phosphor is capable of being excited by a light emitting diode and the second phosphor is capable of being excited by an emission of the first phosphor. In one embodiment, the LED is a blue LED. The first phosphor can be a green phosphor with an emission capable of exciting a red phosphor (second phosphor).

This aspect allows the use of only one LED source in the event that only one phosphor is capable of being excited by the LED.

Another aspect of the present invention provides a device comprising a phosphor mixture, as described previously, and a light emitting diode. The LED emits a local light pattern, the pattern defining either a volume or an area of light. A composition comprising a mixture of a first phosphor and a second phosphor is positioned in the light pattern. Each phosphor comprises a host sulfide material and a rare earth dopant, having compositions and concentrations as described previously. This arrangement allows light emitted from the LED to: (1) be absorbed by the composition; and (2) mix effectively with light emitted from the phosphor mixture such that good homogeneity of color rendering is achieved. This arrangement eliminates unwanted "demixing" of the various light sources. Demixing occurs when separate fractions of radiation are emitted from the device due to the LED and the phosphor mixture, i.e. there is minimal mixing of the different light components.

In one embodiment, the device is a lamp. In one embodiment, the lamp emits white light. In this embodiment, the first phosphor is a green phosphor and the second phosphor is a red phosphor, where the white color is achieved by effectively mixing the green and red light with unabsorbed blue light provided by the LED. In one embodiment, the lamp containing the phosphor mixture comprises a 5 mm LED lamp design of Hewlett-Packard.

The white light lamp of the present invention is particularly advantageous in that the color rendering properties are far superior than those of any previous white lamps. In one embodiment, the lamp is capable of emitting radiation having a color rendering index, Ra of at least about 60 at a color temperature from about 2700 K to about 8000 K, preferably an Ra of at least about 70, more preferably an Ra of at least about 80 and even more preferably an Ra of at least about 90. In a preferred embodiment, the lamp generates a CRI, Ra of greater than 70 for CCT values of less than 6000 K.

FIG. 2 shows a simulation of emission spectra of a tri-color lamp comprising a mixture of $SrGa_2S_4$:Eu and SrS:Eu phosphors excited by a blue (In,Ga)N LED at 460 nm. Emission intensity or radiance is indicated in the ordinate axis. This system exhibits superior color rendering properties over a wide range of color temperatures. Spectrum 10 (3000 K), spectrum 12 (3800 K) and spectrum 14 (4400 K) each correspond to an Ra of 94 whereas spectrum 16 (4900 K) corresponds to an Ra of 92. Ra values of greater than 90 for white LEDs have not been previously observed. It is a feature of the present

invention to mix respective amounts of the phosphors and to illuminate these phosphors with a blue LED to closely match these desired simulated spectra.

By varying optical properties of each source of light in the device, the device can be designed to have desired characteristics depending on a particular application. For example, certain devices may be required to generate light of high intensity and only adequate color rendering is needed, whereas other applications may require high color rendering properties, at the expense of efficiency. Alternatively, color rendering can be sacrificed for higher efficiency. For example, a 50% increase in efficiency can be achieved by decreasing Ra down to about 60. Such properties can be varied by changing relative power fractions of each light source. A "power fraction" is the fraction of light from each source that provides the final light color. Power fractions can be varied by, for example, changing a relative amount of phosphor material present in the device, varying dopant concentration or changing the host lattice or dopant.

It is understood that the phosphor mixture can comprise more than two phosphors, so long as optimal color rendering properties are achieved.

In one embodiment, the device further comprises a polymer for encapsulating the phosphor composition. In this embodiment, the phosphor mixture should exhibit high stability properties in the encapsulant. Preferably, the polymer is optically clear to prevent significant light scattering. In one embodiment, the polymer is selected from the group consisting of epoxy and silicone. A variety of polymers are known in the LED industry for making 5 mm LED lamps. Encapsulation can be performed by adding the phosphor mixture to a liquid that is a polymer precursor. For example, the phosphor mixture can be a powder. Introducing phosphor particles into a polymer precursor liquid results in formation of a slurry (i.e. a suspension of particles). Upon polymerization, the phosphor mixture is fixed rigidly in place by the encapsulation. In one embodiment, both the composition and the LED are encapsulated in the polymer.

Although the role of phosphor grain size (mean diameter of phosphor particles) is not completely understood, weight fractions may change depending on a particular grain size. Preferably, grain sizes are less than about 15μm, and more preferably, less than about 12 μm, to avoid clogging of devices which dispose the phosphors. In one embodiment, the grain size of each phosphor type varies. In certain specific embodiments, the grain size of $SrGa_2S_4$:Eu is less than about 10 μm and the grain size of

SrS:Eu is less than about 12 μm. Other devices, however, can be prepared with larger grain sizes.

Although unabsorbed light emitted from the LED contributes to color rendering, unabsorbed light can sometimes escape without mixing with light emitted from the phosphors, resulting in a reduced overall efficiency of the device. Thus, in one embodiment, the LED and composition are positioned within a reflector cup. A reflector cup can be any depression or recess prepared from a reflecting material. By positioning the LED and phosphor particles in a reflector cup, unabsorbed/unmixed LED-emitted light can be reflected either back to the phosphor particles to eventually be absorbed, or mixed with light emitted from the phosphors.

FIG. 3 shows a schematic of the device of the present invention. Lamp 20 comprises LED 22. LED 22 is positioned in a reflector cup 28. LED 22 emits light in a pattern indicated by lines 26. A phosphor mixture 24 is positioned in the pattern 26. It can be seen that some unabsorbed light emitted by LED 22 can reflect from walls of reflector cup 28 and back to phosphor mixture 24. In this example, reflector cup 28 can modify light pattern 26 if light is reflected into a space not previously covered by the initial light pattern (e.g. in the case of a parabolic reflector). It is understood that one of ordinary skill in the art can provide reflector cup 28 in any shape that optimizes reflection of light back to mixture 24, or optimizes positioning of LED 22 to provide a light pattern for efficient conversion. For example, the walls of reflector cup 28 can be parabolic.

Another aspect of the present invention provides an alternative design to a green LED. Green LEDs have been developed only recently. Current green LEDs, however, are notoriously more inefficient than blue LEDs. In addition, emitted radiation from green LEDs exhibits wavelength shifts with an increase in temperature, which is an undesired characteristic.

Thus, this aspect of the present invention provides a device comprising a green phosphor and a blue light emitting diode, for providing an excitation radiation to the phosphor. By taking advantage of down-conversion, the blue light can be converted to green light via the green phosphor. This device is comparable to a green LED yet eliminates the disadvantages of green LEDs, such as providing comparable efficiencies to blue LEDs and minimizing radiation energy shifts with increasing temperature. In one embodiment, the green phosphor is $SrGa_2S_4$:Eu. High luminous equivalents values of ~ 575 lm/W can be achieved with this phosphor at a maximum wavelength of about 535 nm, which is far superior to any other green LED or alternative. High absorption of

excitation radiation is preferred to eliminate a significant amount of blue LED radiation which may spoil efficiency and/or color saturation.

The function and advantage of these and other embodiments of the present invention will be more fully understood from the examples below. The following examples are intended to illustrate the benefits of the present invention, but do not exemplify the full scope of the invention.

Example 1: Preparation of $SrGa_2S_4$:Eu and SrS:Eu Phosphor Mixture

$SrGa_2S_4$:Eu was produced by the method of P. Benalloul, et al., J.Alloys Compounds 227 (1998), 709, and references cited therein.

The powders of the two phosphors are stirred in weighted amounts, which correspond to the desired power fractions of the three colors, into a liquid polymer precursor. A preferred polymer precursor is a standard precursor for 5 mm LED lamps, 'Hysol ST'.

Example 2: Adjusting power fractions

This example illustrates a method for adjusting power fractions at desired correlated different color temperatures, and these power fractions are listed in Table 1. Starting from known or measured spectra of a (In,Ga)N LED, the green ($SrGa_2S_4$:Eu) and the red (SrS:Eu) emitting phosphor, a first approximation is made about respective power fractions of each color to obtain a desired spectrum that will result in optimal CCT/CRI values. This is achieved typically by performing a best estimate of the respective weights of the two phosphors. The mixture is then prepared and the mixture is illuminated with the LED. In this example, the wavelength of radiation is 460 nm. A trial spectrum is then obtained.

If the first trial spectrum does not achieve the CCT/CRI values of the desired spectrum, small amounts of the appropriate phosphors can be added and a new trial spectrum can be obtained. This step is repeated until the trial spectrum closely matches the desired spectrum.

Table 1 is generated by adding spectra of the three components: the LED, $SrGa_2S_4$:Eu, and SrS:Eu, with respective coefficients which correspond tot he power fractions. A composite spectrum is then obtained. The composite spectrum is evaluated using CIE recommended software (e.g. CIE 13.3-1995) for calculating CCT and CRI values. By this procedure, the desired CCT/CRI is converted into a desired spectrum. If CCT and Ra do not agree with the expectation within acceptable tolerances, a second iteration is performed to modify the power fractions in a systematical way. Subsequent

iterations can be accomplished by numerical optimization, e.g. Simplex or Variable Metric Method can be used for automating the procedure.

Table 1 shows example power fractions for the phosphor mixture of Example 1.

Table 1

Color Temperature (K)	$SrGa_2S_4$:Eu (green)	SrS:Eu (red)	LED (blue)
2700	28	61	11
3000	32	55	13
4000	34	45	21
5000	35	39	26
6400	37	31	32
8000	34	29	37

The luminous equivalent of the resulting emitted light is about 310 (±4) lm/W.

Example 3: 5 mm LED LAMP

An example of a lamp of the present invention is described here. An Hysol ST slurry comprising a phosphor mixture of 7.6 wt% of $SrGa_2S_4$:Eu and 10.4 wt% SrS:Eu was positioned in a reflector cup in a 5 mm lamp design of Hewlett-Packard. The average particle size of $SrGa_2S_4$:Eu was about 9 μm and the average particle size of SrS:Eu was about 11.5 μm. Using a blue (In,Ga)N LED with an excitation radiation of 460 nm, a CCT of 4000K and a CRI of 91 was achieved.

Those skilled in the art would readily appreciate that all parameters listed herein are meant to be examples and that actual parameters will depend upon the specific application for which the methods and apparatus of the present invention are used. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, the invention may be practiced otherwise than as specifically described.

CLAIMS

What is claimed:

1. A composition comprising:
a mixture of a first phosphor and a second phosphor, each phosphor comprising a host sulfide material and a rare earth dopant and each phosphor capable of being excited by a common light emitting diode.

2. The composition of claim 1, wherein the dopant is selected from the group consisting of Eu^{2+} and Ce^{3+}.

3. The composition of claim 2, wherein the dopant is the same in the first and second phosphor.

4. The composition of claim 3, wherein the dopant is Eu^{2+}.

5. The composition of claim 3, wherein the dopant is Ce^{3+}.

6. The composition of claim 1, wherein the sulfide is selected from the group consisting of CaS, SrS and a thiogallate.

7. The composition of claim 6, wherein the thiogallate is $SrGa_2S_4$.

8. The composition of claim 1, wherein the first phosphor is a green phosphor and the second phosphor is a red phosphor.

9. The composition of claim 8, wherein the first phosphor is $SrGa_2S_4$:Eu.

10. The composition of claim 8, wherein the second phosphor is selected from the group consisting of SrS:Eu and CaS:Eu.

11. The composition of claim 3, wherein the dopant is present in a concentration from about 0.1 mol% to about 8 mol%.

12. The composition of claim 11, wherein the first phosphor comprises a $SrGa_2S_4$ host material and the dopant is present in a concentration from about 2 mol% to about 4 mol%.

13. The composition of claim 12, wherein the second phosphor comprises a SrS host material and the dopant is present in a concentration from about 0.3 mol% to about 0.8 mol%.

14. The composition of claim 1, wherein the common light emitting diode is a blue light emitting diode.

15. The composition of claim 14, wherein each phosphor is capable of being excited by radiation at a wavelength from about 450 nm to about 480 nm.

16. The composition of claim 1, wherein the composition is particulate.

17. A lamp comprising the phosphor of claim 1.

18. A composition comprising:

a mixture of a first phosphor and a second phosphor, each phosphor comprising a host material and a rare earth dopant, the first phosphor capable of being excited by a light emitting diode and the second phosphor capable of being excited by an emission of the first phosphor.

19. The composition of claim 18, wherein each phosphor is capable of being excited by a blue light emitting diode.

20. The composition of claim 19, wherein the first phosphor is a green phosphor and the second phosphor is a red phosphor.

21. A device comprising:

a light emitting diode, for emitting a pattern of light; and

a composition comprising a mixture of a first phosphor and a second phosphor, each phosphor comprising a host sulfide material and a rare earth dopant, the composition being positioned in the light pattern.

22. The device of claim 21, wherein the light emitting diode has an emission at a wavelength from about 450 nm to about 480 nm.

23. The device of claim 22, wherein the device is a lamp.

24. The device of claim 23, wherein the lamp is a white light lamp.

25. The device of claim 24, wherein the lamp is capable of emitting radiation having a color rendering index, Ra of at least about 70 at a color temperature from about 2700 K to about 8000 K.

26. The device of claim 24, wherein the lamp is capable of emitting radiation having a color rendering index, Ra of at least about 80 at a color temperature from about 2700 K to about 8000 K.

27. The device of claim 24, wherein the lamp is capable of emitting radiation having a color rendering index, Ra of at least about 90 at a color temperature from about 2700 K to about 8000 K.

28. A device comprising a green phosphor and a blue light emitting diode, for providing an excitation radiation to the phosphor.

29. The device of claim 28, wherein the green phosphor is $SrGa_2S_4$.

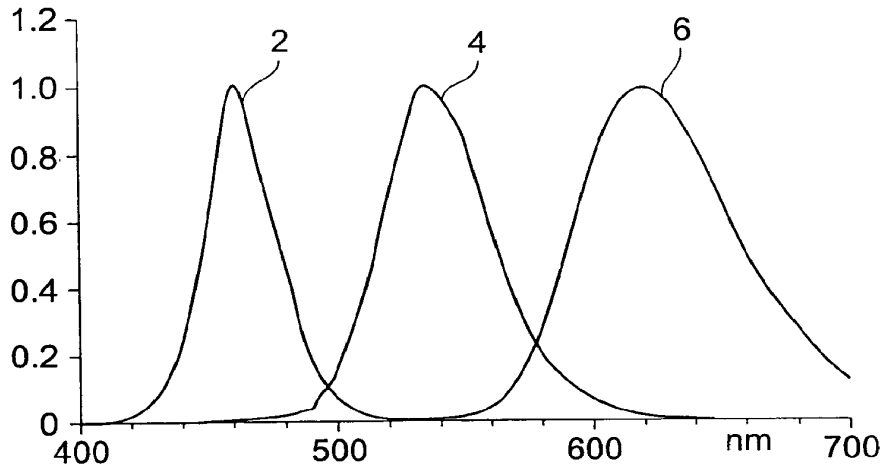

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500
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Fig. 1

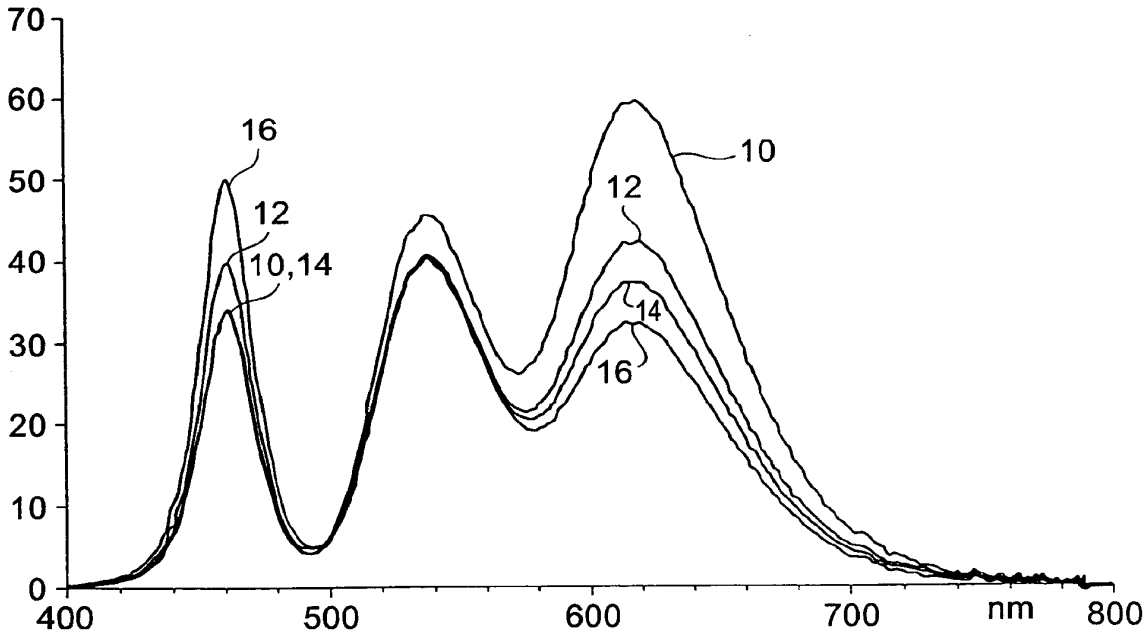

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Fig. 2

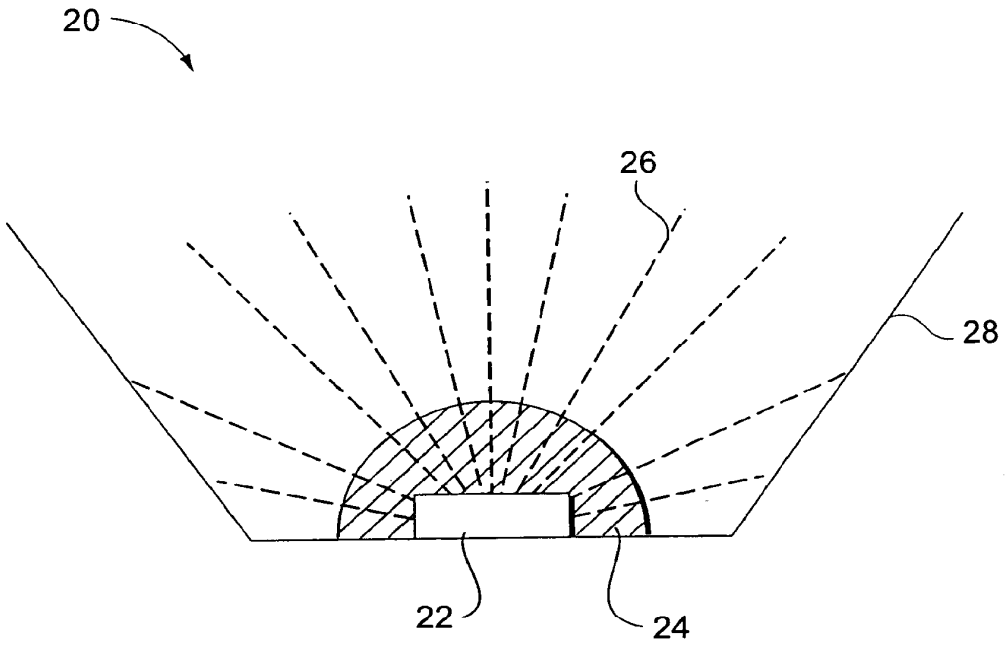


Fig. 3

Please Click here to view the drawing

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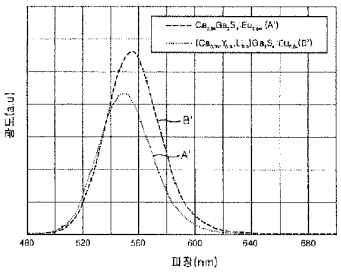
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(54) PHOSPHOR AND LIGHT EMITTING DIODE USING PHOSPHOR WITH IMPROVED OPTICAL EFFICIENCY

(57) Abstract:

PURPOSE: A phosphor and a light emitting diode using the phosphor are provided to improve optical efficiency by using a synthesized phosphor of a thiogallate group having a chemical formula of (A1-x-yEux(M^I0.5M^III0.5)y)B2S4. CONSTITUTION: A phosphor of a thiogallate group has a chemical formula of (A1-x-yEux(M^I0.5M^III0.5)y)B2S4, wherein A is selected from a group consisting of Ba, Sr, and Ca, B is selected from a group consisting of Al, Ga, and In, M^I is selected from a group consisting of Li, Na, and K, and M^III is selected from a group consisting of Sc, Y, Lu, Gd, and La.



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심사청구 : 있음

(54) 형광체 및 이를 이용한 발광 다이오드

요약

본 발명은 형광체 조성에 관한 것으로서, 더욱 상세하게는 발광소자(LED)의 광을 흡수하여 백색광 구현에 적합한 광을 방출하는 여기발광특성을 갖는 $(A_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$ 형광체에 관한 것이다.

상기 형광체의 일반식에서 A와 B는 반드시 동시에 포함되며, M^{I}는 Li,Na,K 그룹으로부터 적어도 하나의 원소가 선택되고, M^{III}는 Sc,Y,La,Gd,Lu의 그룹으로부터 적어도 하나의 원소가 선택된다. 상기 일반식에서 M^{I},M^{III}는 전자가의 균형을 만족하기 위해 항상 동일한 양이 포함되며, M^{I},M^{III} 의 범위인 y는 $0 \le y \le 0.995$ 이고, 활성중심원소인 Eu의 농도는 $0.005 \le x \le 0.9$ 의 범위를 만족하며 $x + y \le 1$ 이다.

또한 본 발명은 백색 발광 다이오드에 관한 것이며, 보다 우수한 광효율을 가지는 백색 발광 다이오드를 제조함에 그 목적이 있다.

대표도

도 4

색인어

발광 다이오드, 형광체, 광도, 광량, 백색 발광, 광효율

명세서

도면의 간단한 설명

도 1 은 $(Sr,Ba)_2SiO_4$:Eu, $(Y,Gd)_3Al_5O_{12}$:Ce 또는 $CaGa_2S_4$:Eu 의 여기 스펙트럼.

도 2 는 460㎚ 파장에 의해 여기된 $(Sr,Ba)_2SiO_4$:Eu, $(Y,Gd)_3Al_5O_{12}$:Ce 또는 $CaGa_2S_4$:Eu 형광체의 발광 스펙트럼.

도 3 은 종래의 $CaGa_2S_4$:Eu 티오갈레이트와 본 발명에 의해 합성된 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 또는 $(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 의 여기 스펙트럼.

도 4 는 종래의 $CaGa_2S_4$:Eu 티오갈레이트와 본 발명에 의해 합성된 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 의 발광 스펙트럼.

도 5 는 청색광 LED와 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 에 의해 제조된 백색 발광 다이오드의 발광 스펙트럼.

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 형광체와 이를 이용한 발광 다이오드에 관한 것으로서, 더욱 상세하게는 발광소자(light emitting diode; 이하 'LED'라 약칭함) 칩의 광을 흡수하여 백색광 구현에 적합한 광을 방출하는 여기발광특성을 갖는 형광체로 이루어진 발광 다이오드에 관한 것이다.

일반적으로 백색 발광 다이오드는 화합물 반도체의 PN 접합 다이오드로 전압을 인가하여 빛을 발광하는 발광소자로서, 단일 칩 또는 멀티 칩을 사용하여 백색광을 구현할 수 있다.

멀티칩을 사용하여 백색광을 구현하는 경우는 적, 녹, 청색의 발광원으로 각각의 발광 다이오드를 사용함으로서 색의 연색성은 매우 뛰어나지만, 적, 녹, 청색의 휘도차에 따른 색혼합이 용이하지 않고, 각각의 칩마다 동작전압이 불균일하며, 주변 온도에 따라 각각 칩의 출력이 변하여 색 좌표가 달라지게 되는 문제점이 발생한다.

한편, 단일 칩의 경우, 화합물 반도체의 LED 칩과 형광체를 결합하여 백색광을 구현한다. 이를 위해 청색으로 발광하는 LED 칩 위에 그 광의 일부를 여기원으로서 황록색 또는 황색 발광하는 형광체를 부착시켜 LED 칩의 청색 발광과 형광체의 황록색 또는 황색 발광에 의해 백색을 얻는 것이다. 현재 실용화되고 있는 형광체는 일본국 특허 번호 제2927279호에 표시되어 있는 이트륨 알루미늄 가넷계 형광체 또는 칼라 TV용에 사용되고 있는 녹색 및 적색 형광체를 혼합한 것이다.

즉, 백색 발광 다이오드는 430 내지 480㎚ 파장범위 내의 GaN 반도체 성분으로 이루어진 청색광 LED 칩과 청색광을 여기원으로 하여 황색광을 발생시킬 수 있는 형광체의 조합으로 이루어진다. 이런 구조의 백색 발광 다이오드는 가격이 싸고, 원리적 및 구조적으로 매우 간단하기 때문에 일반적으로 널리 이용되고 있다.

상기 백색 발광 다이오드에 이용되는 형광체로는 대표적으로 청색광에 의한 여기 능력이 우수한 이트륨 알루미늄 가넷계(YAG:Ce), Sr_2SiO_4:Eu로 대표되는 화학구조식을 가진 오소실리케이트(orthosolicate)와 $CaGa_2S_4$:Eu로 대표되는 티오갈레이트(thiogallate)가 주로 사용되고 있다.

하지만 상기 이트륨 알루미늄 가넷계 및 오소실리케이트의 두 그룹의 형광체의 합성에는 높은 온도의 열처리 조건과 매우 정교한 순도 조절 그리고 엄격한 화학정량이 요구되어 진다. 또한 발광 다이오드를 일반 조명용으로 사용하기 위해서는 보다 높은 광효율과 발광강도를 가지는 형광체의 출현이 필요하다. 현재 전 세계적으로 상기 문제점을 보완하고 보다 경제적인 합성방법을 개발하기 위한 연구와 더불어 이트륨 알루미늄 가넷계와 오소실리케이트를 대체할 수 있는 형광체 개발이 활발하게 진행되고 있다.

상기의 문제점을 보완하기 위해 사용되는 티오갈레이트(thiogallate) 형광체는 일반식 AB_2S_4:Eu로 표현되며 A는 Ca,Sr,Ba 그룹으로부터, B는 Al,Ga,In 그룹으로부터 적어도 하나의 원소가 선택된다. 특히 $SrGa_2S_4$:Eu와 $CaGa_2S_4$:Eu 형광체는 각각 비교적 강한 녹색광과 황색광을 방출한다.

티오갈레이트 형광체는 이트륨 알루미늄 가넷계나 오소실리케이트 그룹의 형광체와 마찬가지로 기지내의 원소와 활성중심원소의 종류 및 농도 조절에 의해 다양한 발광색을 나타내는 장점을 가지고 있다.

티오갈레이트 형광체에 관한 종래 기술로 미국특허공보 제3639254호에는 유러퓸(europium, Eu), 납(lead, Pb), 세륨(cerium, Ce)이 활성중심원소인 티오갈레이트 형광체와 이의 제조방법이 개시되어 있다. 여기에서는 활성중심원소의 종류와 농도에 따라 넓은 범위의 발광색을 제공하는 여러 조성의 실시예를 보이고 있다. 또한 미국특허공보 제5834053호에는 결정질의 미세구조(crystalline micro-structure)를 갖는 청색 발광 티오갈레이트 형광체와 화학기상증착(chemical vapor deposition;CVD)에 의한 형광체의 제조방법이 개시되어 있다. 특히, 종래 고온의 어닐링(annealing) 단계를 제거함으로서 유리-세라믹의 특수 기판이 아닌 일반 유리 기판을 사용할 수 있는 저온 공정을 제공하여 박막의 적층 구조를 갖는 전계발광 디바이스(electroluminescent devices)를 제조할 수 있는 방법이 설명되어 있다.

이처럼 상기 상술한 미국특허공보 제3639254호 및 제5834053호는 이미 티오갈레이트를 게시하고 있으며, 이것의 발광 스펙트럼은 청색 또는 녹색 스펙트럼 영역에 존재한다. 이들 형광체는 AGa_2S_4에 따르며, 여기에서 A는 알칼리 토금속, 특히 Ca, Ba, Sr 또는 Zn으로 구성된 군으로부터 선택된 하나 이상의 원소를 포함한다. 활성중심원소는 유러퓸(Eu), 납(Pb) 또는 세륨(Ce)이다.

그러나 고효율 광을 요구하는 응용분야(예를 들어, 조명 공학)에 대하여, 상기 형광체의 발광 효율은 매우 낮다.

또다른 종래기술로서 미국특허공보 제6695982호에서는 상기의 낮은 발광 효율의 문제점을 해결하기 위해 티오갈레이트를 사용한 고효율의 형광체와 그의 제조방법이 개시되어 있다. 이 발명에서는 티오갈레이트 형광체의 일반식 AB_2S_4에 기초하여 수행한 3가 이온(B)에 대한 2가 이온(A)의 비가 비율 A:B=1:2와 상이하도록 선택하여 높은 발광 효율을 갖고 상이한 발광 파장 및 색 위치를 달성하도록 하였다.

그러나 상기 특허에서는 진하 균형만을 고려하여 A자리에 Zn, Mg와 같이 Ca보다 이온 크기가 현저하게 작은 이온을, 또 B자리에 Y과 같이 Ga보다 월등히 큰 사이즈의 치환을 언급하고 있다. 이와 같은 이온 크기의 불일치는 결정이 뒤틀리고 왜곡되는 원인이 되며 이에 따라 발광특성은 급격하게 감소하게 된다.

발명이 이루고자 하는 기술적 과제

따라서 본 발명에서는 상기의 문제점을 해결하기 위하여 정교하게 의도된 이온 치환방법에 의해 오소실리케이트 그룹, 이트륨 알루미늄 가넷계 또는 기존의 티오갈레이트 그룹의 형광체와 비교하여 보다 형광특성이 우수한 $(A_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$의 새로운 조성을 갖는 티오갈레이트 그룹의 형광체를 합성하여 광효율과 발광강도가 우수한 발광다이오드의 제조를 목적으로 한다.

발명의 구성 및 작용

본 발명에 따른 하기 <화학식 1>로 표시되는 형광체를 제공한다.

<화학식 1>

$$(A_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$$

[상기 식에서,

상기 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 B는 Al, Ga, In 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 M^{I} 은 Li, Na, K 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 M^{III}는 Sc, Y, Lu, Gd, La 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 x와 y는 $x+y \leq 1$ 이다.]

여기서, 상기 A와 B는 동시에 포함하며, 상기 M^{I} 와 M^{III}는 동일한 양으로 동시에 포함한다.

상기 형광체의 <화학식 1> 에서 상기 x는 $0.005 \leq x \leq 0.9$ 이며, 상기 y는 $0 \leq y \leq 0.995$ 의 범위를 갖는다.

상기 <화학식 1>은 <화학식 2> $(Ca_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)Ga_2S_4$ 로 표현된다.

또한, 상기 <화학식 2>은 하기 <화학식 3> 내지 <화학식 6>중 어느 하나로 표현된다.

<화학식 3>

$(Ca_{1-x-y}Eu_X(Y_{0.5}Li_{0.5})_y)Ga_2S_4$

<화학식 4>

$(Ca_{1-x-y}Eu_X(Sc_{0.5}Li_{0.5})_y)Ga_2S_4$

<화학식 5>

$(Ca_{1-x-y}Eu_X(Sc_{0.5}Na_{0.5})_y)Ga_2S_4$

<화학식 6>

$(Ca_{1-x-y}Eu_X(Y_{0.5}Na_{0.5})_y)Ga_2S_4$

상기 <화학식 3> 은 <화학식 7> $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 이고 상기 <화학식 4> 는 <화학식 8> $(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 로 표현되는 형광체를 제공한다.

또한 본 발명은 LED 칩의 광을 흡수하여 백색광 구현에 적합한 광을 방출하는 여기발광특성을 갖는 형광체를 포함하는 발광 다이오드에 있어서, 상기 상술한 형광체를 포함하는 발광 다이오드를 제공한다. 상기 LED 칩은 420 내지 480㎚의 피크 파장을 갖는다.

이하, 첨부된 도면을 참조하여 본 발명의 실시예를 더욱 상세히 설명하기로 한다. 그러나 본 발명은 이하에서 개시되는 실시예에 한정되는 것이 아니라 서로 다른 다양한 형태로 구현될 것이며, 단지 본 실시예들은 본 발명의 개시가 완전하도록 하며, 통상의 지식을 가진 자에게 발명의 범주를 완전하게 알려주기 위해 제공되는 것이다. 도면상에서 동일 부호는 동일한 요소를 지칭한다.

형광체는 임자결정(Host Lattice)과 적절한 위치에 불순물이 혼입된 활성이온으로 구성되는데, 활성이온들의 역할은 발광과정에 관여하는 에너지 준위를 결정함으로써 발광색을 결정하며, 그 발광색은 결정구조 내에서 활성이온이 갖는 기저상태와 여기 상태의 에너지 차(Energy Gap)에 의해 결정된다. 즉, 활성이온을 갖는 형광체가 갖는 발광 중심색은 궁극적으로 활성이온들의 전자상태 즉, 에너지 준위에 의해 결정된다. 예를 들어, Tb^{3+} 이온의 경우 임자 결정 내에서 5d →7f 천이가 가장 용이하여 녹황색 발광형상을 나타낸다.

이러한 에너지 차를 이용한 형광체는 그 종류가 매우 다양하고, 이를 이용하여 다양한 발광 색을 갖는 발광 다이오드를 제조할 수 있으며, 특히, 백색 발광 다이오드를 제조할 수 있다.

이트륨 알루미늄 가넷계 형광체는 400 내지 500nm의 발광소자를 여기원으로 하여 특성이 우수한 백색 발광 다이오드의 제조가 가능하다. 또한, Sr_2SiO_4:Eu로 대표되는 오소실리케이트 그룹의 형광체는 자외선 파장부터 청색 가시광까지 여기원으로 사용할 수 있으며, Sr 원소자리에 Ba 원소를 치환하여 녹색 형광체의 합성이 가능하고, Sr 원소자리에 Ca 원소를 치환함으로서 황색 형광체를 합성할 수 있는 큰 장점을 가지고 있다.

또한, AB_2S_4의 일반식을 가지는 기존의 티오갈레이트(thiogallate)의 경우 우수한 형광특성과 더불어 오소실리케이트와 마찬가지로 A 원소 자리에 Ba, Sr, Ca을, B 원소자리에 Al, Ga, In의 적절한 조성비율에 따라 청색부터 적색에 이르는 형광체의 합성이 가능한 장점을 가지고 있다. 특히 기지의 종류와 농도 뿐 아니라 Eu와 같은 활성 중심원소의 종류와 농도에 의해 결정된다.

Eu^{2+} 발광은 $4f^65d^1$ 여기상태에서 $4f^7$ 바닥상태로의 전이를 통해 나타나는데, 발광색을 결정하는 $4f^65d^1$ 여기상태의 위치는 기지내에서 Eu 이온의 주위 환경과 결정 필드(crystal field)에 의해 좌우된다. LED 시장에서 상대적으로 중요성이 높은 황색발광은 $CaGa_2S_4$:Eu 조성에서 나타난다. 또한 380-500nm의 자외선에서 청색 가시광 영역의 발광소자를 여기원으로 사용하여 특성이 우수한 백색 발광 다이오드의 구현이 가능하다.

도 1 및 도 2 에서 A는 $(Sr,Ba)_2SiO_4$:Eu로 표현되는 오소실리케이트 그룹의 형광체이며, B는 $(Y,Gd)_3Al_5O_{12}$:Ce로 표현되는 이트륨 알루미늄 가넷계의 형광체이며, C는 $CaGa_2S_4$:Eu로 표현되는 티오갈레이트 그룹의 형광체이다.

도 1 에서는 $(Sr,Ba)_2SiO_4$:Eu, $(Y,Gd)_3Al_5O_{12}$:Ce 또는 $CaGa_2S_4$:Eu 의 여기 스펙트럼을 나타낸다. 즉, 오소실리케이트 그룹, 이트륨 알루미늄 가넷계와 티오갈레이트 그룹의 형광체의 여기 스펙트럼을 비교한 것이며, $(Sr,Ba)_2SiO_4$:Eu 와 $(Y,Gd)_3Al_5O_{12}$:Ce 와 유사하게 $CaGa_2S_4$:Eu 도 청색 여기부분(420 내지 470㎚)에서 우수한 여기특성을 가지고 있음을 알 수 있다..

도 2 에서는 460㎚ 파장에 의해 여기된 $(Sr,Ba)_2SiO_4$:Eu, $(Y,Gd)_3Al_5O_{12}$:Ce 또는 $CaGa_2S_4$:Eu 형광체의 발광 스펙트럼을 보여준다. 460㎚의 청색광 파장에 의해 여기된 에너지가 황색 발광으로 전환되었음을 확인할 수 있으며, 오소실리케이트 그룹, 이트륨 알루미늄 가넷계와 티오갈레이트 그룹의 형광체는 모두 높은 발광특성을 나타낸다. 특히, 티오갈레이트 그룹의 형광체는 상기 다른 두 그룹의 형광체에 비교하여 더욱 높은 발광 강도를 나타냄을 볼 수 있다.

상기 기존의 티오갈레이트 일반식에서 언급된 A 자리에 Sr,Ba 원소를, 또는 B 자리에 Al,In 원소의 치환에 의해 발광색과 발광강도가 크게 변화하는 것과 달리, 본 발명에서 사용된 새로운 이온의 치환 및 치환방법은 기존의 발광색을 그대로 유지한 채 우수한 발광강도를 나타낸다.

본 발명의 기술적인 관점은 2가 전자가가 요구되는 A자리에 먼저 이온크기가 비슷하지만 3가의 전자가를 가진 이온을 치환하고, 이를 보상하기 위해 A자리에 마찬가지로 크기가 비슷한 1가의 이온을 3가의 양과 동일하게 치환하여 2가의 전자가가 필요한 A자리에 전체 전하균형을 유지하면서 우수한 발광특성을 갖는 형광체를 합성하는 방법이다.

즉, 본 발명의 이온 치환은 전기음성도와 전하균형 그리고 이온 크기의 고려에 의해서 이루어졌다. 기존 티오갈레이트 형광체의 특허 중에는 전하균형만을 고려하여 A자리에 Zn, Mg와 같이 Ca보다 이온 크기가 현저하게 작은 이온을, 또 B 자리에 Y과 같이 Ga보다 월등히 큰 사이즈의 치환을 언급하고 있다. 하지만 이와 같은 이온 크기의 불일치는 결정이 뒤틀리고 왜곡되는 원인이 되며 이에 따라 발광특성은 급격하게 감소하게 된다. 왜냐하면 Zn, Mg과 같은 이온은 A 자리의 8배위수를 형성하기에 너무 작고, Y와 같은 과잉크기의 이온은 B 자리의 4배위수를 형성하기 어렵기 때문이다.

따라서 본 발명의 형광체는 하기 <화학식 1>과 같은 구조를 갖는다.

화학식 1

$$(A_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$$

상기 식에서, A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 적어도 하나의 원소가 선택되고, 상기 B는 Al, Ga, In 으로 이루어진 그룹으로부터 적어도 하나의 원소가 선택된다. 또한 상기 식에서, M^{I}은 Li,Na,K 그룹으로부터, M^{III}는 Sc,Y,Lu,Gd,La 그룹으로부터 적어도 하나의 원소가 선택되며, M^{I}와 M^{III}가 동일한 양으로 동시에 치환된다. 즉, 기존의 티오갈레이트 형광체의 일반식 AB_2S_4에서, 2가 전자가가 요구되는 A자리에 먼저 이온크기가 비슷하지만 3가의 전자가를 가진 M^{III}을 치환하고, 이를 보상하기 위해 A자리에 마찬가지로 크기가 비슷한 1가의 M^{I}을 3가의 양과 동일하게 치환하여 2가의 전자가가 필요한 A자리에 전체 전하균형을 유지하면서 우수한 발광특성을 갖는 형광체를 합성한다.

결과적으로 이러한 이중치환은 동일한 크기의 이온의 치환을 고려하였기 때문에 결정격자의 왜곡을 야기시키지 않으면서도 기존의 티오갈레이트와 동일한 전하균형을 유지하게 된다. 따라서 전체 전하균형을 유지하면서 우수한 광효율과 발광강도를 갖는 형광체를 합성할 수 있다.

또한 상기 <화학식 1> 에서 상기 x는 $0.005 \leq x \leq 0.9$ 이며, 상기 y는 $0 \leq y \leq 0.995$ 의 범위를 갖는다. 더욱 바람직하게는 $0.01 \leq x \leq 0.1$ 이며, 상기 y는 $0.2 \leq y \leq 0.8$ 의 범위를 갖는 것이 효과적이다.

상기 형광체의 <화학식 1>은 하기 <화학식 2>로 표현될 수 있다. 즉, 상기 <화학식 1> 에서 A의 자리에 Ca 원소를, B의 자리에 Ga 원소를 선택하였다.

화학식 2

$$(Ca_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)Ga_2S_4$$

상기 <화학식 2> 에서, M^{I}은 Li,Na,K 그룹으로부터, M^{III}는 Sc,Y,Lu,Gd,La 그룹으로부터 적어도 하나의 원소를 선택할 수 있으며, 하기 <화학식 3> 내지 <화학식 6> 으로 표현된다.

화학식 3

$$(Ca_{1-x-y}Eu_x(Y_{0.5}Li_{0.5})_y)Ga_2S_4$$

화학식 4

$$(Ca_{1-x-y}Eu_x(Sc_{0.5}Li_{0.5})_y)Ga_2S_4$$

화학식 5

$$(Ca_{1-x-y}Eu_x(Sc_{0.5}Na_{0.5})_y)Ga_2S_4$$

화학식 6

$$(Ca_{1-x-y}Eu_x(Y_{0.5}Na_{0.5})_y)Ga_2S_4$$

본 발명에서는 상기 <화학식 3> 및 <화학식 4> 에서 M^{I}, M^{III} 의 범위인 y는 0.6이고, 활성중심원소인 Eu의 농도는 0.04인 하기 <화학식 7> 및 <화학식 8>로 표현되는 형광체를 제공한다.

화학식 7

$$(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$$

화학식 8

$$(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$$

상기 형광체 합성에는 Eu 산화물, 황화물, Sc 산화물, Ni, Y 산화물, 희토류 산화물, Ga 산화물, 황화물 또는 리튬 탄산염 등이 이용되었다. 원하는 조성과 일치되게 원료를 혼합한 후 H_2S가 포함된 가스분위기 하에 800 내지 1000℃ 온도로 열처리 하였다. 일차 열처리를 마친 형광체는 경우에 따라 특성향상을 위해 분쇄와 재혼합을 마치고 이차 열처리를 하였다.

이하, 도 3 및 도 4 에서 기존의 티오갈레이트 그룹의 형광체(A')와 본 발명에 의해 합성된 새로운 조성의 티오갈레이트 그룹의 형광체(B',C')의 여기 스펙트럼 및 발광 스펙트럼을 비교하였다. A'은 $CaGa_2S_4$:Eu로 표현되는 기존의 티오갈레이트 그룹의 형광체이며, B'은 본 발명에 의해 합성된 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$ 이며, C'은 본 발명에 의해 합성된 $(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$ 이다.

도 3 에는 기존의 $CaGa_2S_4$:Eu 티오갈레이트와 본 발명에 의해 합성된 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$ 또는 $(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$의 여기 스펙트럼을 나타내었다. 본 발명에 의해 합성된 형광체는 UV대역에서부터 청색광에 이르기까지 종래의 티오갈레이트보다 상당히 우수한 여기특성을 보유하고 있어, 청색광을 이용한 백색 발광 다이오드 뿐 아니라 UV광을 이용한 백색 발광 다이오드 제조에서도 우수한 광원으로 이용될 수 있다.

도 4 에서는 기존의 $CaGa_2S_4$:Eu 티오갈레이트와 본 발명에 의해 합성된 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$의 발광 스펙트럼을 비교하여 나타내었다. 종래의 티오갈레이트인 $CaGa_2S_4$:Eu 와 비교하여 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$ 은 460㎚에서의 여기에 의해 높은 발광 특성을 나타냄을 알 수 있다.

이하, 상술한 형광체를 포함하는 발광 다이오드에 대하여 설명한다.

발광 다이오드는 전기적 신호를 입력받는 전극이 형성된 인쇄 회로 기판상에 LED 칩을 실장하고 LED 칩상에 형광체를 코팅한 다음, LED 칩을 봉지하는 몰딩부를 형성하여 제조한다. 청색 발광하는 LED 칩상에 그 광의 일부를 여기원으로서 황록색 또는 황색 발광하는 <화학식 1> $(A_{1-x-y}Eu_x(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$로 표현되는 형광체를 코팅하여 LED 칩의 청색 발광과 형광체의 황록색 또는 황색 발광에 의해 백색을 얻을 수 있다. 즉, 백색 발광 다이오드는 420 내지 480㎚의 피크파장 범위를 갖는 청색광 LED 칩과 청색광을 여기원으로 하여 황색광을 발생시킬 수 있는 형광체의 조합으로 이루어진다.

도 5 에서는 본 발명에 의한 발광 다이오드의 발광 스펙트럼을 나타내었다. 즉, 청색 LED와 $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4$:$Eu_{0.04}$ 에 의해 제조된 백색 발광 다이오드의 발광 스펙트럼으로서, 우수한 발광 강도를 나타냄을 볼 수 있다.

상술한 바와 같은 본 발명의 형광체가 포함된 발광 다이오드는 광도가 향상되고, 광도의 향상을 통해 발광 다이오드 백라이트가 내장된 LCD 디스플레이(Display) 밝기를 향상시켜 보다 밝은 화면을 보장할 수 있으며 에너지 절감도 가능하다. 뿐만 아니라, 보다 높은 광효율과 발광강도를 가지는 형광체의 향상된 특성으로 휴대폰, LCD, TV의 백라이트 뿐만 아니라 진광판, 응급지시판, 장식용, 도로용, 점포용, 주거용, 공장용 등에 사용되는 일반조명에 응용될 수 있다. 또한, 일반조명에 사용함에 있어 광도가 향상된 발광 다이오드 광원은 형광등을 대처할 수 있는 가능성을 포진하게 된다. 본 발명은 가까운 미래에 형광등을 대체하여 주거용, 점포용 공장용등의 일반 조명에 사용될 발광 다이오드의 광 특성 및 광량 개선에 기여할 것으로 생각되며 보다 높은 광유량을 요구하는 응용에도 고려될 수 있을 것이다.

발명의 효과

상술한 바와 같이, 본 발명은 이온의 치환방법에 의한 새로운 조성을 사용하여 백색 발광 다이오드를 제작할 수 있고, 발광 다이오드의 광효율을 향상시킬 수 있다.

또한, 본 발명에 의해 합성된 형광체는 UV 대역에서부터 청색광에 이르기까지 종래의 티오갈레이트보다 상당히 우수한 여기특성을 보유하고 있어, 청색광을 이용한 백색 발광 다이오드 뿐 아니라 UV광을 이용한 백색 발광 다이오드 제조에서도 우수한 광원으로 이용될 수 있다.

또한, 본 발명에 의한 발광 다이오드를 사용하면 종래의 발광 다이오드에 비하여 광도를 증가시킬 수 있으므로, 발광 다이오드를 보다 많은 분야에 적용시킬 수 있다는 장점이 있다.

(57) 청구의 범위

청구항 1.

하기 <화학식 1>로 표시되는 형광체.

<화학식 1>

$(A_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)B_2S_4$

[상기 식에서,

상기 A는 Ba, Sr, Ca 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 B는 Al, Ga, In 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 M^{I}은 Li, Na, K 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 M^{III}는 Sc, Y, Lu, Gd, La 으로 이루어진 그룹으로부터 적어도 하나의 원소를 선택하고;

상기 x와 y는 $x+y \leq 1$ 이다.]

청구항 2.

제 1 항에 있어서,

상기 A와 B는 동시에 포함되는 형광체.

청구항 3.

제 1 항에 있어서,

상기 x는 $0.005 \leq x \leq 0.9$ 이며, 상기 y는 $0 \leq y \leq 0.995$ 의 범위를 갖는 형광체.

청구항 4.

제 1 항에 있어서,

상기 <화학식 1>은 <화학식 2> $(Ca_{1-x-y}Eu_X(M^{I}_{0.5}M^{III}_{0.5})_y)Ga_2S_4$ 인 형광체.

청구항 5.

제 4 항에 있어서,

상기 <화학식 2>이 하기 <화학식 3> 내지 <화학식 6>중 어느 하나로 표시되는 형광체.

<화학식 3>

$(Ca_{1-x-y}Eu_X(Y_{0.5}Li_{0.5})_y)Ga_2S_4$

<화학식 4>

$(Ca_{1-x-y}Eu_X(Sc_{0.5}Li_{0.5})_y)Ga_2S_4$

<화학식 5>

$(Ca_{1-x-y}Eu_X(Sc_{0.5}Na_{0.5})_y)Ga_2S_4$

<화학식 6>

$(Ca_{1-x-y}Eu_X(Y_{0.5}Na_{0.5})_y)Ga_2S_4$

청구항 6.

제 5 항에 있어서,

상기 <화학식 3> 은 <화학식 7> $(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 이고 상기 <화학식 4> 는 <화학식 8> $(Ca_{0.36}Sc_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ 인 형광체.

청구항 7.

LED 칩과 형광체를 포함하는 발광 다이오드에 있어서,

제 1 항 내지 제 6 항의 어느 하나의 형광체를 포함하는 발광 다이오드.

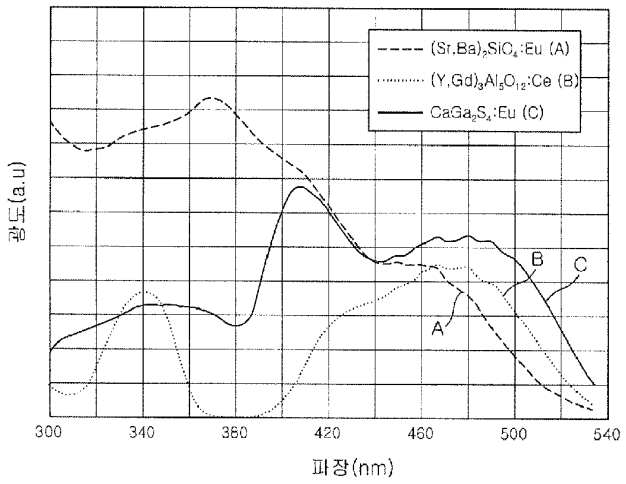
청구항 8.

제 7 항에 있어서,

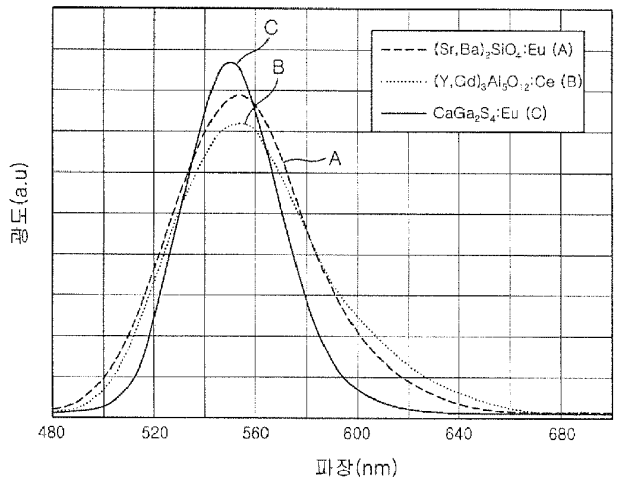
상기 LED 칩은 420 내지 480㎚의 피크 파장을 갖는 발광 다이오드.

도면

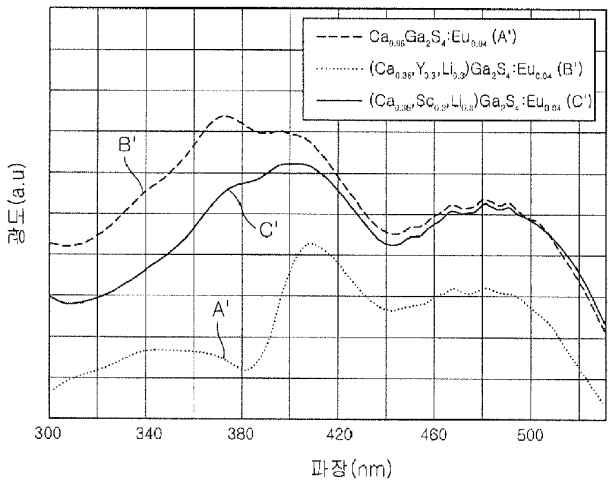
도면1


(Sr,Ba)2SiO4:Eu (A)
(Y,Gd)3Al5O12:Ce (B)
CaGa2S4:Eu (C)
광도(a.u)
파장(nm)
300
340
380
420
460
500
540
A
B
C

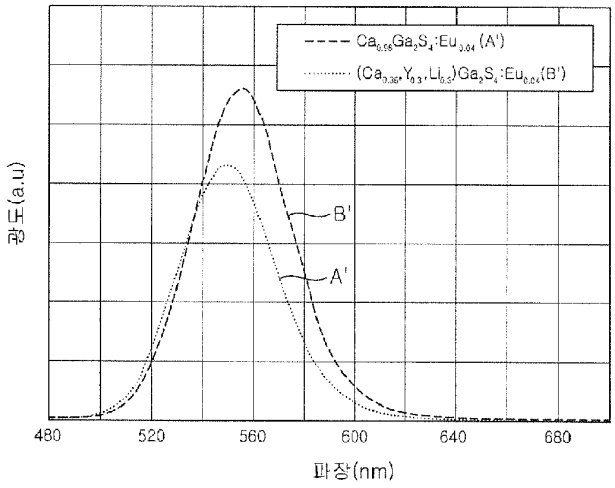
도면2


(Sr,Ba)2SiO4:Eu (A)
(Y,Gd)3Al5O12:Ce (B)
CaGa2S4:Eu (C)
광도(a.u)
파장(nm)
480
520
560
600
640
680
A
B
C

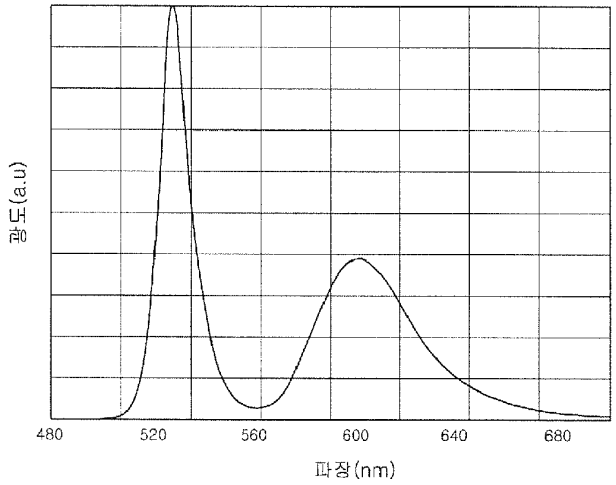
도면3


Ca0.96Ga2S4:Eu0.04 (A')
(Ca0.36,Y0.33,Li0.3)Ga2S4:Eu0.04 (B')
(Ca0.36,Sc0.3,Li0.3)Ga2S4:Eu0.04 (C')
광도(a.u)
파장(nm)
300
340
380
420
460
500
A'
B'
C'

도면4


$Ca_{0.96}Ga_2S_4:Eu_{0.04}$ (A')
$(Ca_{0.36}Y_{0.3}Li_{0.3})Ga_2S_4:Eu_{0.04}$ (B')
B'
A'
광도(a.u)
480
520
560
600
640
680
파장(nm)

도면5


광도(a.u)
480
520
560
600
640
680
파장(nm)

KOREAN PATENT ABSTRACTS

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(54) RED FLUORESCENT SUBSTANCE AND LIGHT-EMITTING DIODEUSING THE SAME

ABSTRACT

The present invention relates to the fluorescent substance and the light emitting diode using the same. Fluorescent substance of the present invention is the fluorescent substance absorbing a part of the light-emitted light from the light source and can emit the light of the different wave length and the absorbed light. The fluorescent substance contains the fluorescent material of the alkaline earth metal - germanium metal - sulfur including SR, and one or more element and GE selected from CA and is activated to EU. Fluorescent substance increases the color rendering of the general for llghting white light emitting diode. The light emitting diode using this fluorescent substance has the advantage of being suitable for the antique look reproducibility replacing the athode fluorescent lamp as to the medium-to large-sized LCD TV and the white light emitting diode backlight system for display device having the high white uniformity.

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* 심사관에 의하여 인용된 문헌

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(54) 적색 형광체와 이를 이용한 발광 다이오드

요약

본 발명은 형광체와 이를 이용한 발광 다이오드에 관한 것이다. 본 발명의 형광체는 광원으로 부터 발광된 광의 일부를 흡수하여 흡수된 광과 상이한 파장의 광을 방출할 수 있는 형광체로서, 상기 형광체는 Sr, Ca로부터 선택된 적어도 하나의 원소와 Ge를 포함하고 Eu으로 활성화된 알카리토금속 - 저마늄금속 - 황의 형광물질을 함유한다. 본 발명에 따른 형광체는 일반조명용 백색광 발광 다이오드의 연색성(CRI, Color rendering index for white light LED)을 증가시키고, 이러한 형광체를 사용한 발광 다이오드는 중대형 LCD TV에 있어서 냉음극 형광램프(CCFL, Cold Cathode Fluorescent Lamp)을 대체할 고 색 재현성과 높은 백색 균일도를 갖는 백색광 발광 다이오드 배면 조명장치에 적합한 장점을 가진다.

대표도

도 6

색인어

형광체, 발광소자, 알카리토금속, 저마늄금속, 자외선

명세서

도면의 간단한 설명

도 1은 Sr/Ge의 비율이 2 ~ 5의 값일 때의 Sr_3GeS_5:Eu 형광체의 발광 및 여기 스펙트럼을 나타내는 그래프.

도 2는 Sr/Ge 비율에 따른 발광강도를 나타내는 그래프.

도 3은 (Sr,Ca)S:Eu과, (Sr,Ca)S:Eu 내에 원하는 양의 Ge 도입이 이루어진 형광체의 발광을 비교한 스펙트럼을 나타내는 그래프.

도 4는 동일한 발광 피크를 갖는 종래기술에 따른 적색 형광체와 본 발명에 따른 적색 형광체의 발광 스펙트럼을 나타내는 그래프.

도 5는 동일한 발광 피크를 갖는 종래기술 및 본 발명에 따른 적색 형광체를 에폭시와 함께 도포한 발광 다이오드 패키지의 색 변화에 대한 신뢰성의 결과값에 대한 색좌표를 나타내는 그래프.

도 6은 본 발명에 따른 백색광 발광 다이오드의 일실시예에 대한 단면도.

<도면의 주요 부분에 대한 부호의 설명>

10: 기판 20, 25: 전극

30: 접착제 40: InGaN계 청색 발광 다이오드 칩

50: 와이어 60a: (Sr,Ca)-Ge-S:Eu 그룹의 적색 형광체

70: 에폭시 수지

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 형광체와 이를 이용한 발광 다이오드에 관한 것으로서, 특히 백색광 발광 다이오드 구현에 적합하고 뛰어난 효율을 갖는 특정 조성의 적색광 형광체와 이를 이용한 백색광 발광 다이오드에 관한 것이다.

일반적으로 백색광 발광 다이오드를 구현하는 방법은 청색광 발광 다이오드 칩과 청색광으로부터 여기가 가능한 황색광 형광체의 조합으로 이루어지거나, 청색광으로부터 여기가 가능한 녹색, 적색광 형광체의 조합으로 이루어진다. 전자의 경우에는 연색성 구현에 한계가 있으며, 후자의 경우에는 85 이상의 높은 연색성 구현이 가능하다.

상기 백색광 발광 다이오드의 구조를 살펴보면, GaInN 반도체 구조로서 430㎚ ~ 470㎚의 최대 발광파장을 갖는 청색광 발광 다이오드 칩과 청색광의 일부분에 의해 여기 되어 황색광으로 변환이 가능한 형광체, 또는 청색광의 일부분에 의해 여기 되어 녹색과 적색광으로 변환이 가능한 형광체의 조합으로 이루어진다. 녹색광 형광체의 조성은 청색광에 의해 여기 되어 녹색부터 황색광까지 발광할 수 있는 티오갈라이트 그룹이 사용된다. 대표적인 티오 갈라이트그룹의 조성은 $(Ca,Sr,Ba)(Al,Ga,In)_2S_4$:Eu(or Ce)으로 표현된다. 이 중에서 $SrGa_2S_4$:Eu 형광체는 높은 발광강도를 갖는 녹색광 형광체이다. 한편, 적색광 형광체는 SrS:Eu, (Sr,Ca)S:Eu, CaS:Eu 등이 청색광을 여기원으로 한 적색 스펙트럼의 발광원으로 이용된다.

하지만, (Sr,Ca)S:Eu 적색광 형광체는 발광강도가 충분히 높지 않은 점과 수분에 대한 화학적 안정성이 떨어지는 심각한 문제점을 갖고 있으며, LCD 배면 백색 조명장치에 적용할 경우 스펙트럼의 반치폭이 넓어서 녹색광 스펙트럼과 겹치게 되고 결과적으로 색필터 여과 후에 NTSC(National Television Standard Committee)에 규정되어 있는 녹색 및 적색 색좌표 구현에 어려움이 있다. 적색광 형광체와 이를 사용한 발광 다이오드가 개시되어 있는 미국 특허 번호 6,252,254, 6,521,915, 6,501,102, 6,680,569, 6,686,691, 6,783,700 등에서도 이러한 이유로 화학적 안정성과 고효율을 크게 기대할 수 없으며, 그에 따라 일반조명과 LCD 배면 조명장치에 적용할 수 없다는 문제점이 있다.

발명이 이루고자 하는 기술적 과제

본 발명의 목적은 상기의 문제점을 해결하고자 제안된 것으로서, 알카리토금속-저마늄금속-황의 구조를 갖는 새로운 적색 형광체의 개발을 통해 일반조명용 백색광 발광 다이오드의 연색성을 증가시킬 수 있는 형광체와 이를 이용한 발광 다이오드를 제공하는 데 있다.

본 발명의 다른 목적은 중대형 LCD TV에 있어서 냉음극 형광램프(CCFL, Cold Cathode Fluorescent Lamp)을 대체할 수 있는 높은 색 재현성과 백색 균일도를 갖는 백색광 발광 다이오드 배면 조명장치에 적용할 수 있는 발광 다이오드를 제공하는 데 있다.

발명의 구성 및 작용

상기와 같은 목적을 달성하기 위한 본 발명의 형광체는, 광원으로 부터 발광된 광의 일부를 흡수하여 흡수된 광과 상이한 파장의 광을 방출할 수 있는 형광체로서, 상기 형광체는 Sr, Ca로부터 선택된 적어도 하나의 원소와 Ge를 포함하고 Eu으로 활성화된 알카리토금속 - 저마늄금속 - 황의 형광물질을 함유하는 것을 특징으로 하는 형광체이다.

또한, 본 발명의 형광체는 일반식이 $A_{(x-a)}Eu_{(a)}GeS_{(z)}$로 표시되고, 상기 식에서 A는 Sr 및 Ca 중 선택된 적어도 하나의 원소이고, 상기 x는 $2 \leq x \leq 5$이고, 상기 a는 $0.0005 \leq a/x \leq 0.02$이고, 상기 z는 $z=x+2$ 이다.

상기 형광체 합성에 있어서 $2.5 \leq x \leq 4$ 와 $0.001 \leq a/x \leq 0.01$ 이 바람직하고, 보다 바람직한 조성범위는 $2.5 \leq x \leq 3.5$ 와 $0.003 \leq a/x \leq 0.007$이다.

본 발명의 발광 다이오드는 발광 다이오드 칩과, 상기 전술된 형태의 형광체를 포함한다.

상기 발광 다이오드 칩은 자외선 또는 청색광을 방출할 수 있다. 이때, 상기 발광 다이오드의 형광체는 $(Ba,Sr,Ca)_2SiO_4$:Eu 또는 $SrGa_2S_4$:Eu를 더 포함할 수 있다.

전술한 바와 같이 (Sr,Ca)S:Eu 적색광 형광체는 청색광 발광 다이오드의 여기에 의해 백색광을 방출할 수 있는 적색광 방출 성분으로 널리 사용되고 있다. 그러나 상기 형광체는 수분과 쉽게 반응하여 화학적 구조가 이황화 수소와 알카리 토금속 황산화물로 변형된다. 그 결과 발광다이오드 소자 내에 봉지제와 함께 사용된 (Sr,Ca)S:Eu 적색광 형광체는 화학반응으로 인해 적색광의 스펙트럼이 점차 소멸되며, 부산물로 생긴 이황화수소는 발광다이오드 소자 내의 금속성분을 부식시키는 등 광특성이 급격하게 열화되는 현상이 나타난다.

화합물의 반응성에 대한 이해는 이온장력에 관한 이론으로 설명될 수 있으며 이온장력이란 다음과 같이 표현된다.

이온장력 (Ionic Field Strength) = m/b^2

여기서 m은 전자가이며 b는 금속과 음이온간의 거리이다.

주기율표에서 일반적으로 전자가 높은 원소일수록 이온장력이 커지게 되며, 비슷한 값을 가지는 물질 간에는 고용체가 형성되고 이온장력의 차이가 큰 물질 간의 조합에서는 화합물이 형성되는 경향이 나타난다. SrS:Eu 형광체에서 Sr 일부가 Ca으로 치환된 (Sr,Ca)S:Eu는 이온크기 차이에 의한 결정장력의 변화에 의해 발광색이 장파장으로 이동하지만 결정구조는 동일하기 때문에 물질의 화학적 특성 차이를 야기시키지 않는다.

본 발명에서는 이온장력이론을 바탕으로 SrS:Eu에 Sr과 비교하여 이온장력의 차이가 비교적 큰 물질인 Ge을 도입하여 결정구조가 변화된(Sr,Ca)-Ge-S:Eu 그룹의 형광체를 합성하여 (Sr,Ca)에 Ge 원소의 도입을 통해 기존의 (Sr,Ca)S:Eu보다 발광효율과 수분에 대한 화학적 안정성이 우수한 새로운 조성의 형광체를 합성하였다.

본 발명을 통해 새롭게 합성된 형광체는 $A_{x-a}Eu_aGeS_z$로 표시되고, A는 Sr, Ca또는 이들의 조합이고, x는 $2 \leq x \leq 5$이고, a는 $0.0005 \leq a/x \leq 0.02$이고, z는 $z=x+2$ 이다. 소량의 Eu은 f-d 여기준위에서 f 바닥상태로 전자의 에너지 전이를 통해 발광을 일으키는 발광중심원소이다. 상기 형광체의 조성에서 Sr/Ca와 (Sr 또는 Ca)/Ge 등의 비율은 발광피크의 변화를 가능하게 하며, 600㎚ ~ 660㎚까지 파장이 변환되며 대표적인 형광체 조성은 $Sr_{2.985}Eu_{0.015}GeS_5$, $Sr_{2.185}Ca_{0.8}Eu_{0.015}GeS_5$, $Ca_{2.98}Eu_{0.02}GeS_5$ 등이다.

본 발명에서 우수한 결과가 나타난 형광체의 합성방법의 출발물질로는 $SrCO_3$, $CaCO_3$, Eu_2O_3, GeO_2 등이 사용된다. 먼저, 원하는 조성의 몰비를 바탕으로 알카리 토금속인 $SrCO_3$와 $CaCO_3$ 그리고 활성제인 Eu_2O_3를 질산이나 염산에 완전하게 녹인 후, 과량의 $(NH_4)_2CO_3$ 혹은 $(NH_4)_2C_2O_4$ 등을 첨가하여 각각의 출발물질의 분산이 이상적인 상태에서 함께 침전시킨다. 침전물을 완전하게 건조시킨 후 원하는 조성에 해당하는 GeO_2를 혼합한다. 혼합물은 일반 산화분위기하에 섭씨 1000 ~ 1200도 사이의 온도에서 2시간 ~ 5시간 정도의 열처리를 통해 탄소를 제거함과 동시에 산화물 형태의 화합물을 만든다. 상기 산화물은 이산화황 분위기하에 섭씨 900 ~ 1250도 사이의 온도에서 1시간 ~ 5시간 정도의 열처리 과정의 반복을 통해 산화물에서 황화물로의 전환을 마치게 된다. 대부분의 경우에서는 이산화황 분위기하에 섭씨 900 ~ 1250도 사이에서 열처리가 된 형광체에서 2 ~ 10㎛의 입자 분포를 가지면서 높은 적색광 발광강도를 나타낸다.

본 발명에서 가장 우수한 특성을 나타낸 형광체의 조성은 Sr과 Ge비율에 대한 최적화를 진행한 후, 가장 적합한 Eu 농도를 선정한다. 마지막으로 Ca 원소를 Sr 자리에 일부 치환시켜 원하는 발광피크를 갖는 적색광 형광체를 합성하고, 광특성은 (Sr,Ca)S:Eu 형광체와 비교하여 발광강도 및 발광피크를 통해 평가된다.

Eu의 농도를 Sr 대비 1 원자백분율(atomic %)로 고정시키고 Sr/Ge의 비율이 변화된 형광체 합성 실험에서, Sr/Ge의 비율은 2 ~ 5라는 값을 가질 때, 발광강도가 뛰어난 형광체가 합성되고, 도 1에서는 이러한 범위 내에서 청색광에 대한 여기능이 가장 우수한 특성을 나타낸 Sr_3GeS_5:Eu 형광체의 발광 및 여기 스펙트럼을 나타낸다.

도 2는 Sr/Ge 비율에 따른 발광강도의 변화를 나타낸다.

Sr/Ge 값이 1 이하인 영역은 발광특성이 급격하게 소멸되고, 5 이상인 영역에서는 발광색이 균일하지 못하고 발광특성도 현저하게 떨어지는 결과가 나타난다.

도 3은 (Sr,Ca)S:Eu과, (Sr,Ca)S:Eu 내에 원하는 양의 Ge의 도입이 이루어진 형광체의 발광을 비교한 스펙트럼이고, 발광피크를 비교했을 때, 후자의 경우에서 Ge 도입에 의해 결정구조가 변화되고 이러한 결정구조의 변화가 Eu 발광중심원소에 영향을 미쳐 발광피크가 장파장 쪽으로 이동되는 현상이 발생된다.

Eu 농도를 고려할 때, Sr_3GeS_5 조성을 기본으로 하여 다양한 조성의 Eu 농도를 갖는 형광체를 합성한다. Sr의 일부를 치환하는 방식으로 Eu을 첨가하고, Sr 대비 0.05%의 Eu 농도에서는 Eu이온의 결핍으로 발광이 충분히 이루어지지 못하고, 반대로 2% 이상의 Eu농도에서도 발광강도의 저하가 나타난다. 바람직한 Eu 조성범위는 0.1% ~ 1.0%이고, 보다 바람직한 조성범위는 0.3% ~ 0.7%이다.

이러한 Eu의 최적범위는 Sr/Ge 비율이 다르거나 Sr/Ca 비율이 다른 여러 가지 형광체에서 일관된 결과로 나타나고, 가장 우수한 발광강도를 갖는 Eu 농도의 최적값은 Sr 대비 0.5 원자백분율로 나타난다.

Sr 이온을 치환할 수 있는 높은 가능성을 갖는 같은 족 원소인 Mg, Ba, Ca의 일부 치환을 고려한 경우, Mg과 Ba의 치환은 현저한 발광강도의 저하를 야기시키고, Ca이온의 치환만이 발광강도의 큰 변화없이 일반적인 현상과 마찬가지로 발광피크의 장파장 쪽으로의 변화를 성공적으로 이룰 수 있다.

도 4는 동일한 발광피크를 갖는 상용의 $Sr_{0.597}Ca_{0.4}Eu_{0.003}S$와 본 발명의 $Sr_{2.185}Ca_{0.8}Eu_{0.015}GeS_5$ 형광체의 발광스펙트럼이다.

Ge 도입에 의해 상대적으로 적은 양의 Ca에도 불구하고 동일한 발광피크를 가지며, 발광강도가 약 10% 정도 높은 것으로 나타난다. 또한, 도면을 통해 본 발명의 형광체가 (Sr,Ca)S:Eu 형광체의 반치폭보다 좁은 것을 확인할 수 있는데, 이러한 점은 반치폭이 좁아질수록 사람의 색감각과의 차이가 적어지기 때문에 필터링 이후에 색 재현성을 높이기 위한 LCD 배면 백색조명장치에 상당히 유리한 장점이 될 수 있다.

도 5는 (Sr,Ca)S:Eu와 Ge이 도입된 (Sr,Ca)S:Eu 두 형광체를 각각 발광 다이오드 패키지 내에 에폭시와 함께 도포한 후 색 변화에 대한 신뢰성 시험 진행 결과를 초기값 대비 색좌표 x값의 변화로 나타내었다. 색좌표 x값의 변화는 형광체의 조성이 수분과의 반응으로 인해 분해되면서 광특성이 상실됨에 따라 좌표가 청색광으로 이동되는 현상을 나타낸다. 60℃ 온도의 90% 수분을 갖는 외부환경하에서 신뢰성 시험을 진행한 결과 본 발명의 Ge이 도입된 형광체의 색좌표 x값 변화가 (Sr,Ca)S:Eu 형광체보다 상당히 적은 것을 알 수 있다.

도 6은 본 발명에 따른, 백색광 발광 다이오드에 대한 실시예의 종단면도이다.

본 발명의 백색광 발광다이오드는 기판(10)과, 기판(10)에 형성된 한 쌍의 전극(20, 25)과, 하나의 전극(20) 상에 도전성 접착제(30)를 통해서 실장된 청색 발광 다이오드 칩(40)과, 상기 칩(40)과 전극(20)을 서로 연결시키는 와이어(50)와, (Sr,Ca)-Ge-S:Eu 그룹의 적색 형광체(60a) 및 $(Ba,Sr,Ca)_2SiO_4$:Eu 또는 $SrGa_2S_4$:Eu 녹색 형광체(60b)와 함께 몰딩된 에폭시 수지(70)로 구성된다. 상기 (Sr,Ca)-Ge-S:Eu 그룹의 형광체(60a) 및 $(Ba,Sr,Ca)_2SiO_4$:Eu 또는 $SrGa_2S_4$:Eu 녹색 형광체(60b)가 청색 발광 다이오드 칩(40)에서 발산되는 청색광을 받아 백색광을 발산한다. 상기 청색광 발광 다이오드(40)는 InGaN계 발광 소자가 사용될 수 있다. 본 실시예에서는 칩온보드(Chip on board, COB) 타입으로 발광 다이오드를 설명하였으나, 본 발명의 발광 다이오드는 이에 한정되지 않고, 램프형 등 일 수도 있다. 상기 실시예에서는 백색광을 얻기 위하여 본 발명에 따른 적색 형광체를 녹색 형광체와 함께 청색 발광 다이오드에 적용하였으나, 백색이 아닌 다른 색의 광을 얻고자 할 때에는 다른 형광체와 다른 색의 발광 다이오드를 조합하여 사용할 수 있음은 물론이다. 예를 들어, 본 발명의 형광체는 상기 청색 발광 다이오드 칩에서 발산된 청색광의 일부를 적색광으로 변환하여 자주 또는 분홍 계열의 광을 방출 할 수 있다.

일반조명을 위한 백색광 발광 다이오드에서는 자연광과 얼마만큼 유사한가를 나타내는 척도인 연색성의 개선이 요구된다. 이를 위하여 청색광 발광 다이오드칩(40)을 기본으로 하여 본 발명의 (Sr,Ca)-Ge-S:Eu 그룹의 적색 형광체(60a)와 $SrGa_2S_4$:Eu 또는 $(Ba,Sr,Ca)_2SiO_4$:Eu 녹색광 형광체(60b)를 에폭시 수지에 혼합하여 이를 발광 다이오드 칩 상에 몰딩할 수 있다. 이 경우, 일반적으로 85 이하의 연색성 값을 갖는 청색광 발광 다이오드 칩과 황색광 형광체인 YAG:Ce의 조합으로 이루어진 백색광 발광 다이오드보다 최대 10% 정도 증가한 90까지 얻을 수 있다. 이는 일반조명을 위한 적색 스펙트럼의 발광원으로 적합할 것으로 판단된다.

본 발명의 권리는 위에서 설명된 실시예에 한정되지 않고 청구범위에 기재된 바에 의해 정의되며, 본 발명의 기술분야에서 통상의 지식을 가진 자가 청구범위에 기재된 권리범위 내에서 다양한 변형과 개작을 할 수 있다는 것은 자명하다.

발명의 효과

상기에서 설명한 바와 같이 본 발명은, 알카리토금속-지마늄금속-황의 구조를 갖는 새로운 적색 형광체의 개발을 통해 일반조명용 백색광 발광 다이오드의 연색성 증가에 큰 효과가 있으며, 중대형 LCD TV에 있어서 냉음극 형광램프를 대체할 고 색 재현성과 높은 백색 균일도를 갖는 백색광 발광 다이오드 배면 조명장치와 다양한 색상의 발광 다이오드 제조에 적합하다.

(57) 청구의 범위

청구항 1.

광원으로 부터 발광된 광의 일부를 흡수하여 흡수된 광과 상이한 파장의 광을 방출할 수 있는 형광체로서, 상기 형광체는 Sr, Ca로부터 선택된 적어도 하나의 원소와 Ge를 포함하고 Eu으로 활성화된 알카리토금속 - 지마늄금속 - 황의 형광물질을 함유하는 것을 특징으로 하는 형광체.

청구항 2.

일반식이 $A_{(x-a)}Eu_{(a)}GeS_{(z)}$이고,

상기 식에서, A는 Sr 및 Ca 중 선택된 적어도 하나의 원소이고,

상기 x는 $2 \leq x \leq 5$이고,

상기 a는 $0.0005 \leq a/x \leq 0.02$이고,

상기 z는 $z=x+2$인 것을 특징으로 하는 형광체.

청구항 3.

청구항 2에 있어서,

상기 x는 $2.5 \leq x \leq 4$이고,

상기 a는 $0.001 \leq a/x \leq 0.01$인 것을 특징으로 하는 형광체.

청구항 4.

청구항 2에 있어서,

상기 x는 $2.5 \leq x \leq 3.5$이고,

상기 a는 $0.003 \leq a/x \leq 0.007$인 것을 특징으로 하는 형광체.

청구항 5.

발광 다이오드에 있어서,

발광 다이오드 칩;및

청구항 1 내지 청구항 4 중 어느 한 항에 따른 형광체를 포함하는 것을 특징으로 하는 발광 다이오드.

청구항 6.

청구항 5에 있어서, 상기 발광 다이오드 칩은 자외선 또는 청색광을 방출하는 것을 특징으로 하는 발광 다이오드.

청구항 7.

청구항 5에 있어서, 상기 발광다이오드 칩은 청색광을 방출하고, 녹색광 형광체를 더 포함하는 백색 발광다이오드인 것을 특징으로 하는 발광 다이오드.

청구항 8.

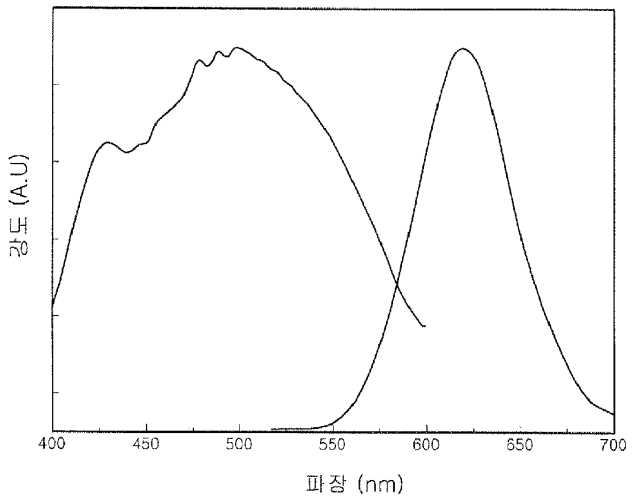
청구항 7에 있어서, 상기 녹색광 형광체는 $(Ba,Sr,Ca)_2SiO_4$:Eu를 포함하는 것을 특징으로 하는 발광 다이오드.

청구항 9.

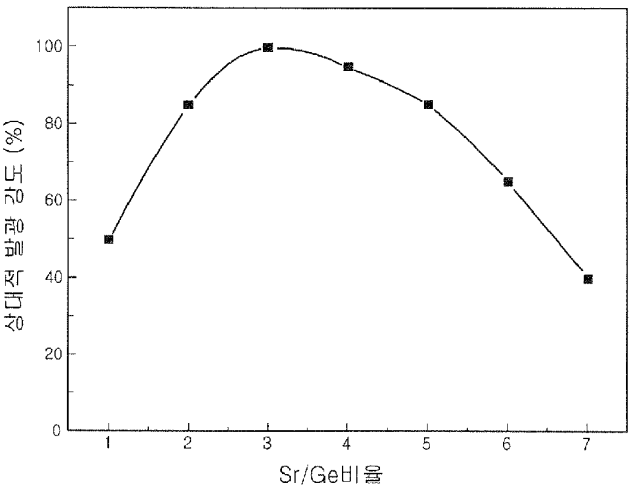
청구항 7에 있어서, 상기 녹색광 형광체는 $SrGa_2S_4$:Eu를 포함하는 것을 특징으로 하는 발광 다이오드.

도면

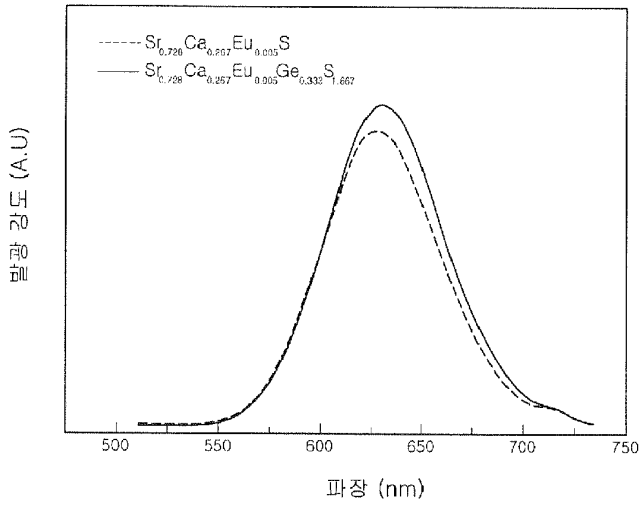
도면1



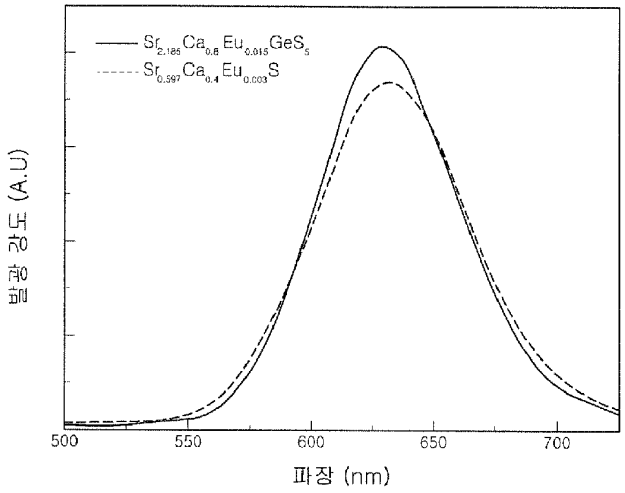
도면2



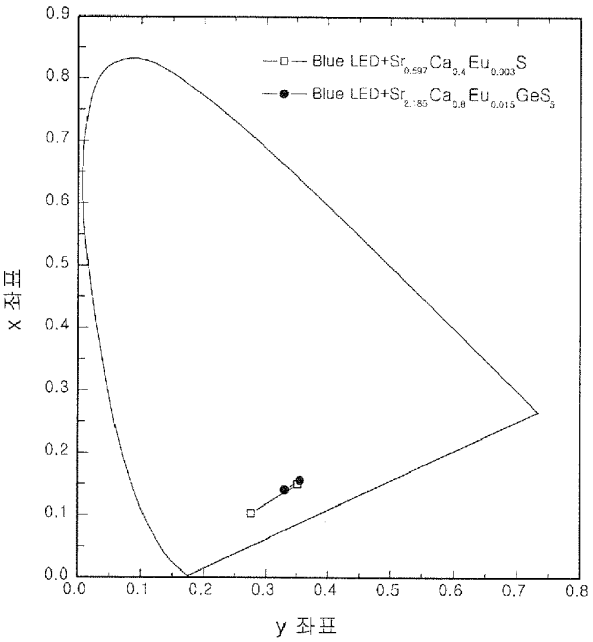
도면3


$Sr_{0.728}Ca_{0.267}Eu_{0.005}S$
$Sr_{0.728}Ca_{0.267}Eu_{0.005}Ge_{0.333}S_{1.667}$
발광 강도 (A.U)
500
550
600
650
700
750
파장 (nm)

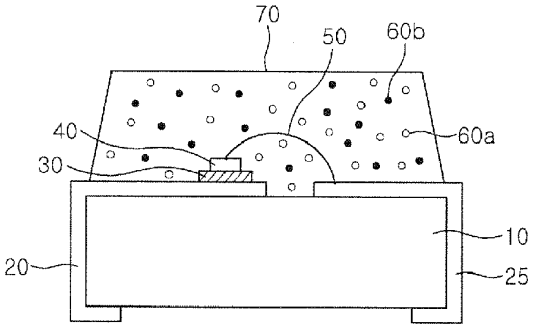
도면4


$Sr_{2.185}Ca_{0.8}Eu_{0.015}GeS_5$
$Sr_{0.597}Ca_{0.4}Eu_{0.003}S$
발광 강도 (A.U)
500
550
600
650
700
파장 (nm)

도면5


Blue LED+Sr0.597Ca0.4Eu0.003S
Blue LED+Sr2.185Ca0.8Eu0.015GeS5
x 좌표
y 좌표
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

도면6


70
50
60b
40
60a
30
10
20
25

Patent/Publication No.	563261
Title	A method and of manufacture for tri-color white LED
Publication Date	2003/11/21
Application Date	2002/06/07
Application No.	091112585
Certification_Number	191805
IPC	***H01L-033/00***
Inventor	CHEN, HSING TW
Applicant	SOLIDLITE CORPORATION TW
Abstract	One of the manufacturing methods of white LED in the prior art is to add YAG yellow phosphor powder into blue LED die, there is only two wavelengths of white light, so it can only be applied in pointer and cannot be actually applied in illumination. The other one of the manufacturing methods is to use ultraviolet light to excite the tri-color phosphor powder to generate tri-color white light, since the decay time of ultraviolet LED die is very short, and there is no transparent resin solely for ultraviolet packaging, its lifetime and quality are quite depressed. The manufacturing method of tri-color white LED of the present invention is to choose a blue LED die with wavelength between 420nm and 475nm; coat red, green phosphor bodies on the die; excite red, green phosphor bodies by blue light to generate white light with three wavelengths of red, blue, green. It is the best choice to fabricate the white LED with a single die for generating high-luminance tri-wavelength.
Individual	Y

Patent Right Change

Application Number	091112585
Date of Update	20090520
Licensing	No
Mortgage	No
Transfer	No
Succession	No
Trust	No
Opposition	No
Invalidation	No

Cessation	
Revocation	
Issue date of patent right	20031121
Patent Grant date	20220606
Maintainance fee due	20091120
Years of maintenance paid	006

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[44]中華民國　92年 (2003)　11月21日
發明　　全10頁

[51] Int.Cl.[7] ： H01L33/00

[54]名　稱：三波長白光ＬＥＤ之製造方法

[21]申請案號：091112585　[22]申請日期：中華民國　91年 (2002)　06月07日

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[74]代 理 人：

1

2

[57]申請專利範圍：

1.一種三波長白光LED之製造方法，係包含一藍光LED晶粒及一可受此LED晶粒發光所能激發之包含紅色、綠色混合螢光體，該紅色、綠色混合螢光體係吸收上述藍光LED晶粒所發出藍光的一部分，激發出與原吸收光相異波長的紅色及綠色波長光，再與原來藍光LED晶粒所發出的藍光混合，即可產生三波長白光LED，上述紅色螢光體至少包含以下任一種的螢光物質：

Li_2TiO_3：Mn；

或$LiAlO_2$：Mn；

或$6MgO \cdot As_2O_5$：Mn^{4+}；

或$3.5MgO \cdot 0.5MgF_2 \cdot GeO_2$：$Mn^{4+}$；

綠色螢光體至少包含以下任一種的螢光物質：

$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce(0<x<1)；

或$La_2O_3 \cdot 11Al_2O_3$：Mn；

或$Ca_8Mg(SiO_4)_4Cl_2$：Eu，Mn。

2.如申請專利範圍第1項所述之三波長白光LED之製造方法，其中藍光LED晶粒波長為420~475nm。

3.如申請專利範圍第1項所述之三波長白光LED之製造方法，其中調配不同的紅色、綠色螢光體的比例，可調製成各種中間色系的LED，如粉紅、淡藍、淺綠、乳白等顏色。

4.如申請專利範圍第1項所述之三波長

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白光 LED 之製造方法，其中可在藍光 LED 晶粒上添加單一色紅色螢光體而調配成藍、紅混合光。

5.如申請專利範圍第 1 項所述之三波長白光 LED 之製造方法，其中可在藍光 LED 晶粒上添加單一色綠色螢光體而調配成藍、綠混合光。

6.如申請專利範圍第 1 項所述之三波長白光 LED 之製造方法，其中封裝結構可為燈型(Lamp)LED 或表面黏著型(SMD)LED 。

7.如申請專利範圍第 1 項所述之三波長白光 LED 之製造方法，其中所述藍光 LED 晶粒為 InGaN 型或 SiC 型或 ZnSe 型。

圖式簡單說明：

第一圖為日本日亞化學公司以藍光激發 YAG 黃色螢光粉之兩波長白光 LED 發射光譜。

第二圖為白光燈型(Lamp)LED 封裝方法之結構圖。

第三圖為白光表面黏著型(SMD) LED 封裝方法之結構圖。

第四圖為本發明三波長白光 LED 之製造方法中La_2O_3 ‧ $11Al_2O_3$：Mn綠色螢光粉激發光譜與發射光譜圖。

第五圖為本發明三波長白光 LED 之製造方法中$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce(0<x<1)綠色螢光粉激發光譜圖。

第六圖為本發明三波長白光 LED 之製造方法中$Y_3(Ga_xAl_{1-x})_5O_{12}$：Ce(0<x<1)綠色螢光粉發射光譜圖。

第七圖為本發明三波長白光 LED 之製造方法中$Ca_8Mg(SiO_4)_4Cl_2$：Eu ，Mn 綠色螢光粉激發光譜圖。

第八圖為本發明三波長白光 LED 之製造方法中$Ca_8Mg(SiO_4)_4Cl_2$：Eu ，Mn 綠色螢光粉發射光譜圖。

第九圖為本發明三波長白光 LED 之製造方法中Li_2TiO_3：Mn 紅色螢光粉激發光譜圖。

第十圖為本發明三波長白光 LED 之製造方法中Li_2TiO_3：Mn 紅色螢光粉發射光譜圖。

第十一圖為本發明三波長白光 LED之製造方法中$LiAlO_2$：Mn紅色螢光粉激發光譜圖。

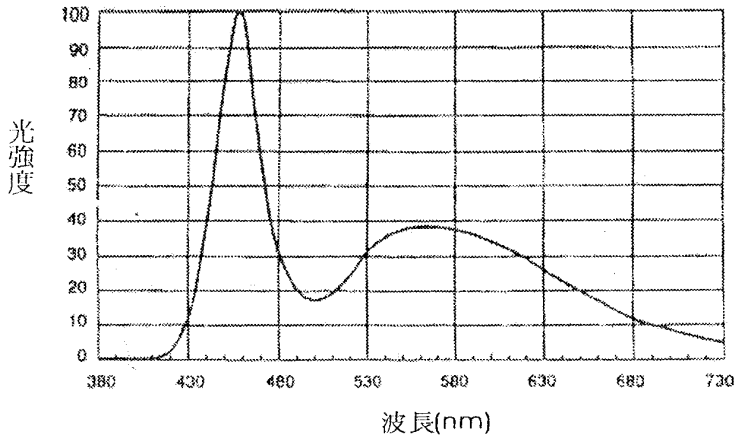
第十二圖為本發明三波長白光 LED之製造方法中$LiAlO_2$：Mn紅色螢光粉發射光譜圖。

第十三圖為本發明三波長白光 LED 之製造方法中 6MgO ‧ As_2O_5：Mn^{4+} 紅色螢光粉激發光譜與發射光譜圖。

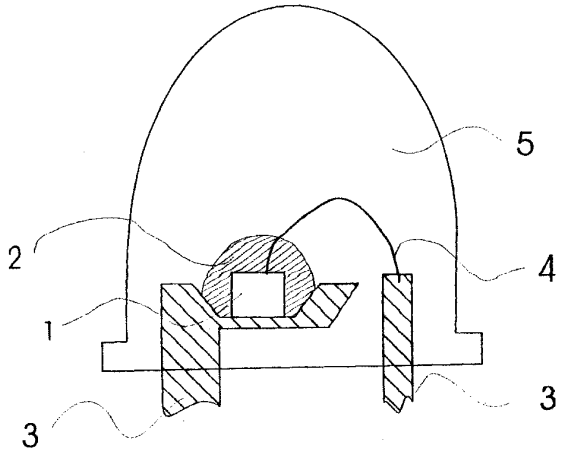
第十四圖為本發明三波長白光 LED 之製造方法中 3.5MgO ‧ $0.5MgF_2$ ‧ GeO_2：Mn^{4+} 紅色螢光粉激發光譜與發射光譜圖。

第十五圖為本發明三波長白光 LED 之製造方法實施例一之光譜圖。

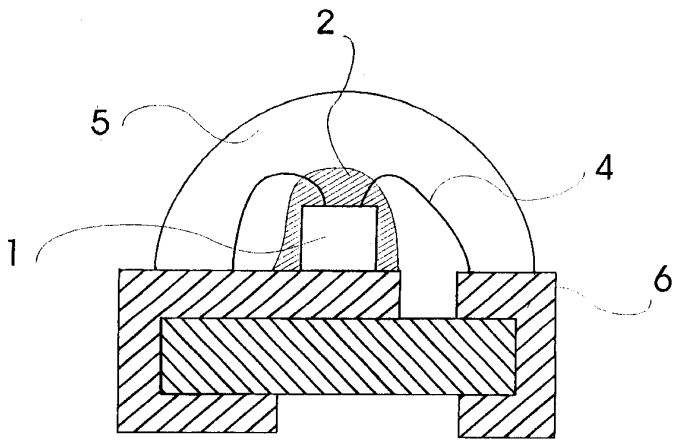
第十六圖為本發明三波長白光 LED 之製造方法另一實例光譜圖。


光強度
100
90
80
70
60
50
40
30
20
10
0
380
430
480
530
580
630
680
730
波長(nm)

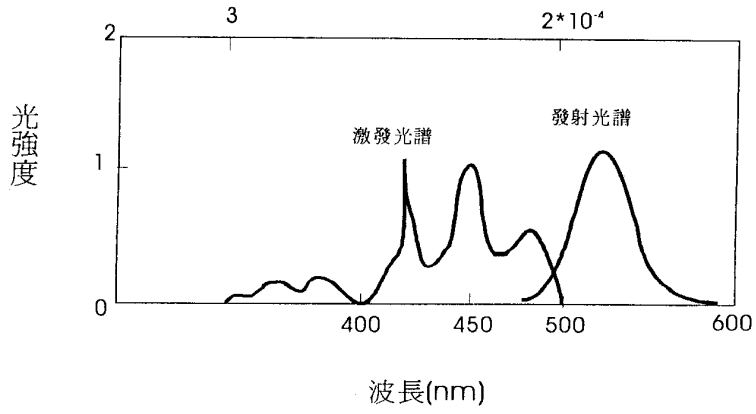
第一圖


5
2
4
1
3
3

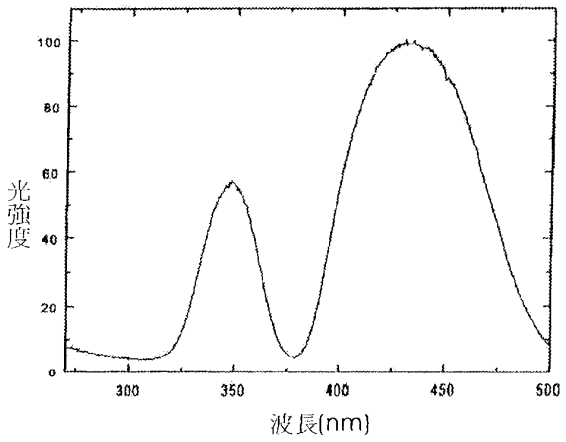
第二圖



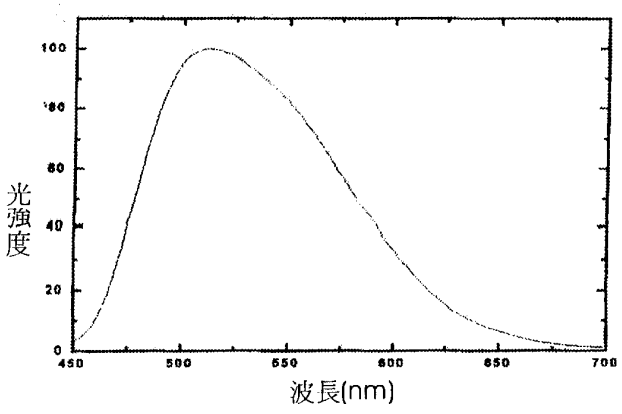
第三圖



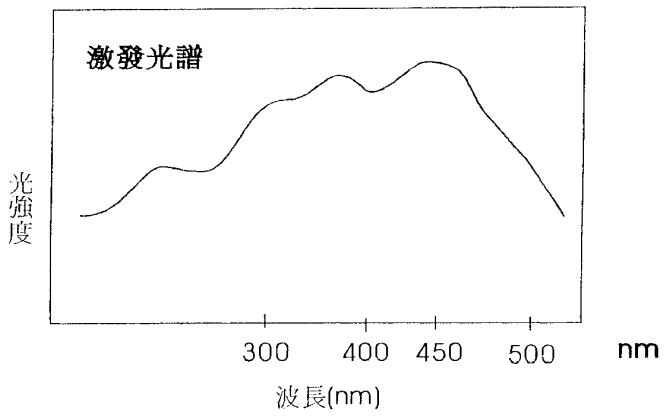
第四圖


光強度
100
80
60
40
20
0
300
350
400
450
500
波長(nm)

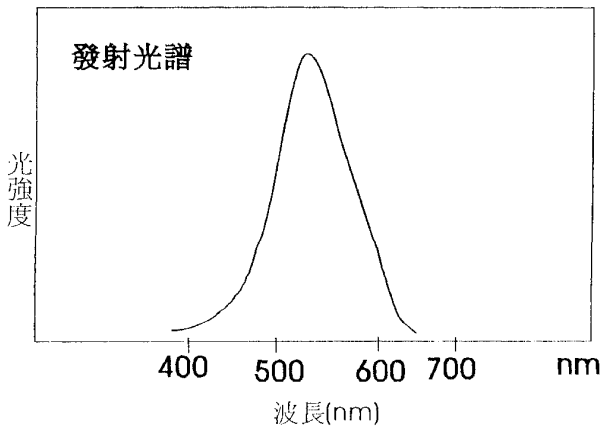
第五圖


光強度
100
80
60
40
20
0
450
500
550
600
650
700
波長(nm)

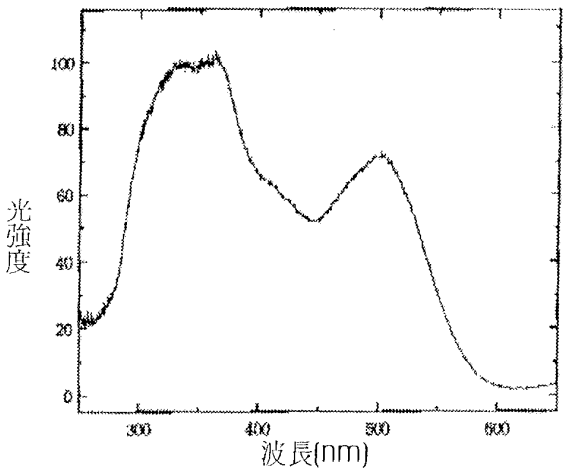
第六圖


激發光譜
光強度
300
400
450
500
nm
波長(nm)

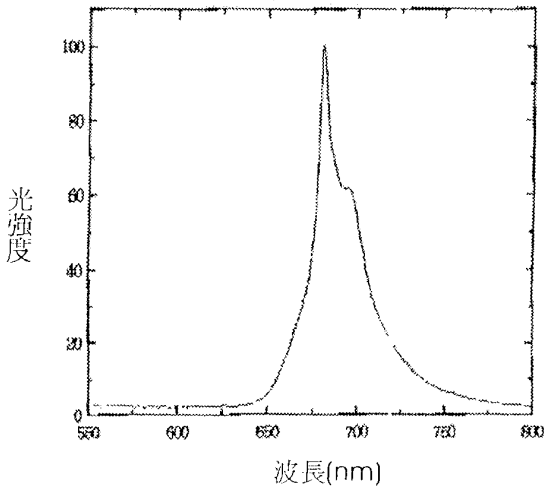
第七圖


發射光譜
光強度
400
500
600
700
nm
波長(nm)

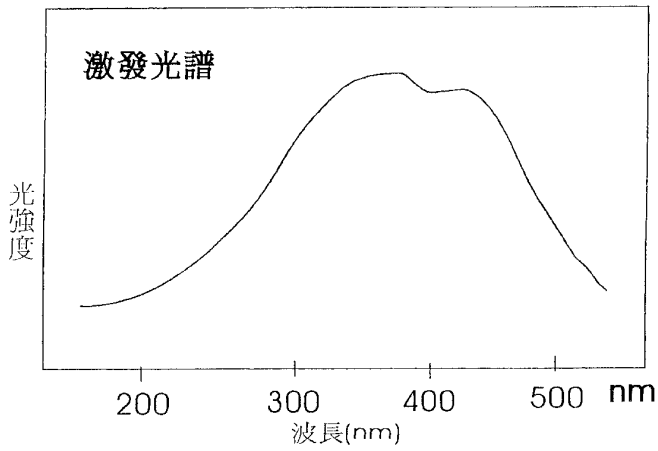
第八圖


光強度
100
80
60
40
20
0
300
400
500
600
波長(nm)

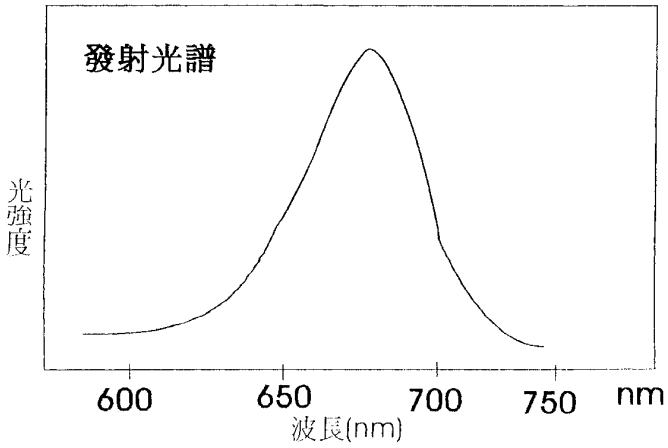
第九圖


光強度
100
80
60
40
20
0
550
600
650
700
750
800
波長(nm)

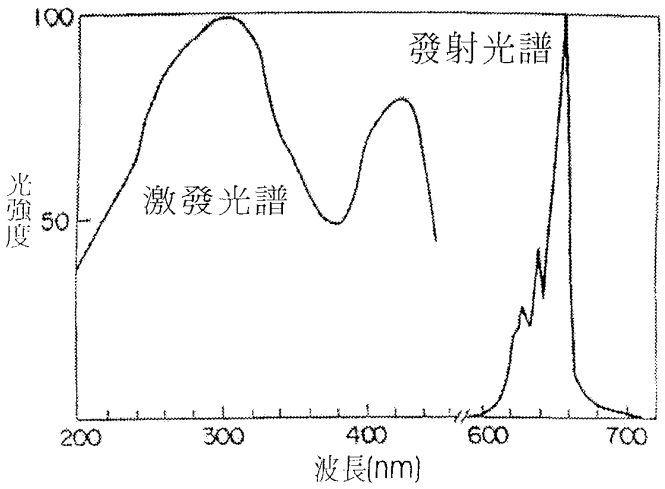
第十圖


激發光譜
光強度
200
300
400
500
nm
波長(nm)

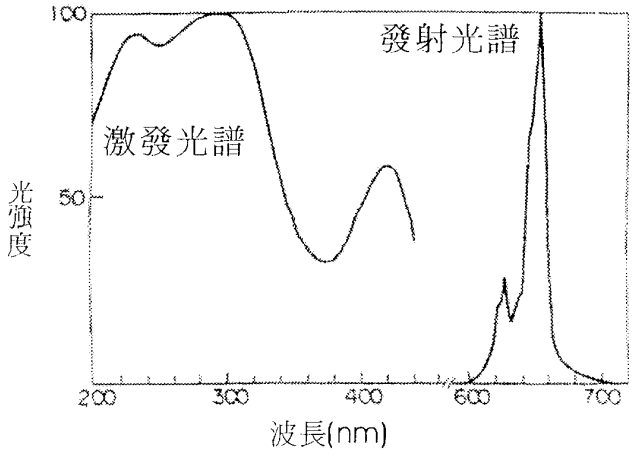
第十一圖


發射光譜
光強度
600
650
700
750
nm
波長(nm)

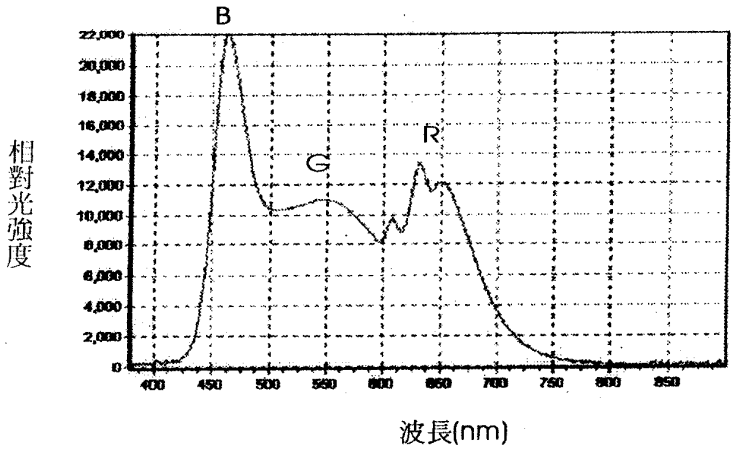
第十二圖


100
50
光強度
發射光譜
激發光譜
200
300
400
600
700
波長(nm)

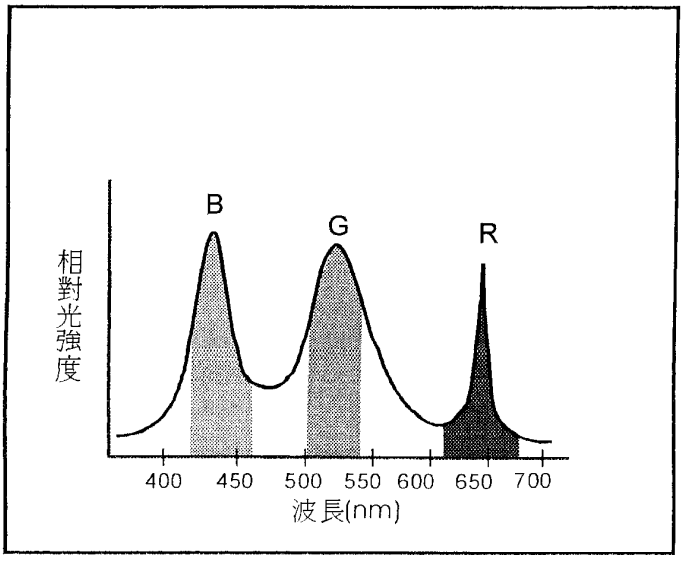
第十三圖


100
50
光強度
發射光譜
激發光譜
200
300
400
600
700
波長(nm)

第十四圖



第十五圖



第十六圖

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WO 03/081957 A1

(54) Title: YTTRIUM SUBSTITUTED BARIUM THIOALUMINATE PHOSPHOR MATERIALS

(57) Abstract: A thin film phosphor for an electroluminescent device, the phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements. The phosphor being activated by a rare earth metal and containing a Group IIIB element as a partial substitute for a portion of aluminum, gallium or indium of said thiogallate, thioindate and thioaluminate. The phosphor provides improved luminance. An electroluminescent device comprising the thin film phosphor on a substrate is also described.

Yttrium Substituted Barium Thioaluminate Phosphor Materials

Field of the Invention

The present invention relates to phosphor materials which are used as thin films in electroluminescent displays. More specifically, the invention relates to yttrium substitution in such phosphor materials and in particular, yttrium substituted barium thioaluminate phosphor materials.

The invention also relates to improving the luminance of and optimizing the emission spectra of the phosphor materials when they are used for full color electroluminescent displays, particularly those employing thick film dielectric layers with a high dielectric constant.

Background to the Invention

Thick film dielectric structures provide for superior resistance to dielectric breakdown, as well as a reduced operating voltage, compared to thin film electroluminescent (TFEL) displays e.g. as exemplified by U.S. patent 5,432,015. The thick film dielectric structure when it is deposited on a ceramic substrate will withstand higher processing temperatures than TFEL devices, which are typically fabricated on glass substrates. This increased high temperature tolerance facilitates annealing of phosphor films at higher temperatures to improve their luminosity. With these advantages and with recent advances in blue-emitting phosphor materials, displays have approached the luminosity and color coordinates required to achieve the technical performance of traditional cathode ray tube (CRT) displays. Nevertheless, further improvement in blue phosphor performance is required to simplify display design, to improve display reliability by lowering operating voltages and to keep pace with a trend towards higher color temperature specifications for displays.

Cerium-activated strontium sulphide phosphor materials have traditionally been used in electroluminescent displays for blue colors while

manganese-activated zinc sulphide have been employed for red and green colors. The optical emission from these phosphor materials must be passed through an appropriate chromatic filter to achieve the necessary color coordinates for red, green and blue sub-pixels, resulting in a loss of luminance and energy efficiency. The manganese-activated zinc sulphide phosphor has a relatively high electrical to optical energy conversion efficiency of up to about 10 lumens per Watt of input power. Cerium-activated strontium sulphide phosphor has an energy conversion efficiency of 1 lumen per Watt, which is relatively high for blue emission. However, the spectral emission for these phosphors is quite wide, with spectral emission for the zinc sulphide-based phosphor material spanning the color spectrum from green to red and that for the strontium sulphide-based material spanning the range from blue to green. This necessitates the use of the optical filters. The spectral emission of the cerium-activated strontium sulphide phosphor can be shifted to some degree towards the blue by controlling the deposition conditions and activator concentration, but not to the extent required to eliminate the need for an optical filter.

Alternative blue phosphor materials having narrower emission spectra to provide the color coordinates required for a blue sub-pixel have also been developed. These phosphor materials include cerium-activated alkaline earth thiogallate compounds which provide good blue color coordinates, but exhibit relatively poor luminosity and stability. Higher luminosity and excellent color coordinates for blue pixels have been achieved with europium-activated barium thioaluminate phosphor materials.

More recently europium activated lanthanum thioaluminate has been shown to have utility as a blue light emitting electroluminescent phosphor. European Patent Application 1,148,111 discloses a thin film phosphor of this composition incorporated into a thick dielectric electroluminescent device for which a luminance of 300 candelas per m^2

was realized when a 1 kHz electric field was applied across the device. While this application suggests the use of yttrium as a possible choice of cation for thioaluminate based phosphor materials, it does not suggest a partial substitution of yttrium for any metallic species in the phosphor.

Yttrium has been used as a co-activator to enhance the luminosity of rare earth-activated sulphide phosphor materials in thin film electroluminescent devices. U.S. Patents 6,043,602 and 5,939,825 teach the use of yttrium as one of a series of co-activator species that may enhance the luminance of green and blue light-emitting calcium, strontium, barium or magnesium sulfide phosphor materials. These phosphors also include a metal dopant such as copper or lead, and in the case of U.S. 6,043,602, a halogen selected from fluorine, chlorine or iodine. U.S. Patent 5,662,831 teaches a method for the preparation of an europium activated yttrium oxy-sulfide material as a cathodoluminescent phosphor material. The phosphor is provided as a slurry further pulverized to attain small particle sizes. These aforementioned patents simply disclose yttrium as a dopant or co-dopant in a binary alkaline earth sulfide or alternatively, as the sole cation of the host material. These aforementioned patents do not teach or suggest the use of yttrium for controlled partial substitution of the metallic species of the phosphor.

There remains a need in the art for new phosphors having improved properties that have use as thin films in electroluminescent displays. The present invention fulfills this and other needs.

Summary of the Invention

In accordance with an aspect of the present invention there is provided a thin film phosphor for an electroluminescent device, said phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said

phosphor being activated by a rare earth metal and containing a Group IIIB element as a partial substitute for a portion of aluminum, gallium or indium of said thiogallate, thioindate and thioaluminate.

In accordance with another aspect of the present invention there is provided a thin film phosphor for an electroluminescent device, the phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said phosphor being activated by a rare earth metal and wherein a portion of the aluminum, gallium or indium of the thioaluminate, thiogallate or thioindate is replaced with yttrium.

According to another aspect of the present invention is a phosphor material having the formula:

$A_{1-w} D_w [Y_x Z_{1-x}]_y S_4$, wherein

A is a Group IIA or Group IIB cation;

D is a rare earth metal;

Z is selected from Al, Ga and In;

$0<x<0.2$;

$y= 2$; and

$0.005<w<0.1$.

The invention provides for a partial substitution of yttrium for the metal species selected from aluminum, gallium and indium where such substitution does not substantially alter the crystal lattice structure of the phosphor.

In a preferred embodiment of the present invention, the phosphor is a thioaluminate.

In another embodiment, said rare earth metal is selected from europium and/or cerium, most preferably europium.

In another preferred embodiment, the cation is barium.

In further embodiments, the phosphor contains europium in an amount in the range of 1-10 atomic percent of the Group IIA or IIB cation

present and yttrium in an amount in the range of about 0.1-20 atomic percent of the aluminum, gallium or indium. Preferably, the amount of europium is between about 2-7 atomic percent of the Group IIA or IIB cation present and yttrium replaces between about 1-7 atomic percent of the aluminum, gallium or indium content.

According to another aspect of the present invention is a phosphor material having the formula:

$A_{1-w} D_w [M_x Z_{1-x}]_y S_4$, wherein

A is a Group IIA or Group IIB cation;

D is a rare earth metal;

M is a Group IIIB metal selected from Y, Sc, La and Ac;

Z is selected from Al, Ga and In;

$0<x<0.2$;

$y= 2$; and

$0.005<w<0.1$.

According to a further aspect of the present invention is an electroluminescent device comprising a thin film phosphor as described herein on a substrate structure.

According to still another aspect of the present invention is a method for making a phosphor material selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said phosphor being activated by a rare earth metal and wherein a portion of the aluminum, gallium or indium is replaced with yttrium.

According to yet a further aspect of the present invention is a method for making a phosphor material having the formula:

$A_{1-w} D_w [Y_x Z_{1-x}]_y S_4$, wherein

A is a Group IIA or Group IIB cation;

D is a rare earth metal;

Z is selected from Al, Ga and In;

$0<x<0.2$;

$y= 2$; and

$0.005<w<0.1$.

Other features and advantages of the present invention will become apparent from the following detailed description. It should be understood, however, that the detailed description and the specific examples while indicating embodiments of the invention are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from said detailed description.

Brief Description of the Drawings

The present invention will be described with reference to the embodiments shown in the drawings, in which:

Figure 1 is a schematic representation of a section of an electroluminescent element comprising a thick film dielectric layer and a phosphor composition typical of the present invention;

Figure 2 is a schematic representation of a plan view of a full color electroluminescent pixel and its constituent sub-pixels;

Figure 3 is a graphical representation of photoexcitation and photoluminescence spectra for several barium yttrium thioaluminate powders doped with europium;

Figure 4 is a graphical representation of x-ray diffraction patterns for several yttrium substituted barium thioaluminate phosphor materials;

Figure 5 is a graphical representation of luminosity as a function of applied voltage for similar electroluminescent devices having phosphor films with and without added yttrium;

Figure 6 is a graphical representation of the luminance and the phosphor efficiency of a electroluminescent device with a europium activated barium thioaluminate phosphor containing yttrium;

Figure 7 is a graphical representation of luminosity as a function of applied voltage for several electroluminescent devices with a barium yttrium thioaluminate phosphor; and

Figure 8 is a graphical representation of the luminosity of electroluminesacent devices as a function of the yttrium concentration in the phosphor material.

Detailed Description of the Invention

The present invention relates to the partial replacement of aluminum, gallium or indium in a rare earth metal activated thioaluminate, thiogallate or thioindate phosphor with a group IIIB element wherein such partial replacement does not substantially distort or affect the crystal lattice structure of the phosphor material.

In one embodiment, the present invention relates to yttrium as a partial replacement for aluminum in europium activated alkaline earth thioaluminate phosphors, and especially to the incorporation of yttrium in such phosphors when they are deposited as thin films in electroluminescent displays. Such partial replacement provides several advantages with respect to the phosphor material and the electroluminescent display incorporating such phosphor material. In one aspect, the yttrium functions to lower the maximum temperature required in a heat treatment process (annealing) to form a preferred crystal phase.

Furthermore, the luminescence of the phosphor composition is enhanced with the partial replacement or substitution of aluminum.

While it is desirable to partially replace aluminum with yttrium, it is within the scope of the present invention to partially replace aluminum, gallium or indium with yttrium or its related Group IIIB species which includes scandium, lanthanum and actinium so long as such substitution does not substantially distort or affect the crystal lattice structure of the phosphor in a manner that affects the function and properties of the phosphor.

In embodiments, and as exemplified herein, the electroluminance of europium-activated barium thioaluminate, a blue emitting phosphor, is increased by a factor of more than two when about three atomic percent of the aluminum is replaced with yttrium. There is a corresponding increase in the electrical to optical energy conversion efficiency of the device from less than 1 lumen per Watt without yttrium to 2 lumens per Watt with three atomic percent yttrium, a very high value for a blue emitting pixel. The optical emission spectrum is also shifted towards the blue with yttrium addition.

The present invention is particularly directed to use of a partially yttrium substituted and europium activated alkaline earth thioaluminate host material to form a phosphor. The invention is applicable to ternary, quaternary and higher thioaluminate, thiogallate and thioindate phosphors, and composites thereof synthesized with cation(s) for these compounds. Suitable cations are selected from Groups IIA and IIB of the Periodic Table of Elements which are known to those of skill in the art. Examples of such cations include barium, calcium, strontium, magnesium and zinc.

A variety of rare earth activators known to those of skill in the art may be used in the phosphor material in conjunction with substitute species, for example cerium and europium. The preferred activator used in conjunction with yttrium is europium. In preferred embodiments of the

invention, are partially yttrium substituted barium thioaluminate ($BaAl_2S_4$) phosphors, which emit blue light.

The present invention is suited for use in an electroluminescent display or device shown in Figures 1 and 2. Figure 1 shows a cross-section of an electroluminescent device utilizing a phosphor of the present invention. Figure 2 shows a plan view of the electroluminescent device. The electroluminescent device, generally indicated by 10, has a base substrate 12 on which is located row electrode 14. Thick film dielectric 16 has thin film dielectric 18 thereon. Thin film dielectric 18 is shown with three pixel columns, referred to as 20, 22 and 24, located thereon. The pixel columns contain phosphors to provide the three basic colors viz. red, green and blue. Pixel column 20 has red phosphor 26 located in contact with thin film dielectric 18. Another thin film dielectric 28 is located on red phosphor 26, and column electrode 30 is located on thin film dielectric 28. Similarly, pixel column 22 has green phosphor 32 on thin film dielectric 18, with thin film dielectric 34 and column electrode 36 thereon. Pixel column 24 has blue phosphor 38 on thin film dielectric 18, with thin film dielectric 40 and column electrode 42 thereon.

The electroluminescent device of the present invention may incorporate a variety of substrate structures as will be understood by persons skilled in the art. In particular, the substrate structure comprises a thick film ceramic material having a base substrate which is a ceramic sheet having an electrically conductive film deposited thereon with a thick film layer deposited on the film. Examples of suitable base substrates are ceramic sheet materials that include but are not limited to alumina, metal ceramic composites, glass ceramic materials and high temperature glass materials. Suitable electrically conductive films are known to those of skill in the art such as, but not limited to, gold and silver alloy. The thick film layer comprises ferroelectric material. Suitable ferroelectric materials may be selected from lead magnesium niobate titanate, lead zirconate titanate, barium titanate and mixtures thereof. The thick film layer may also

comprise one or more thin film layers thereon.

The deposition of the composition may be carried out in an atmosphere of H_2S, sulphur or other volatile sulphur bearing compounds that will not contaminate the phosphor film as it is deposited if there is a tendency for the deposited compound to be deficient in sulphur. In one embodiment, the deposition is done in a hydrogen sulphide atmosphere so that deposited species in the film can react with sulphide derived from the hydrogen sulphide to adequately saturate the deposited film with sulphide and achieve the desired film composition. However, in some instances, it may be possible to operate the method in a low pressure inert gas atmosphere without H_2S Thus, a strict oxygen-free environment may not be necessary.

The deposition of the phosphor may be done using a variety of methods. For example, phosphor deposition can be done by electron beam evaporation, particularly dual source electron beam evaporation as exemplified in Applicant's co-pending U.S. patent application 09/747,315 filed December 22, 2000 (the entirety of which is incorporated herein by reference). Deposition may also be carried out by dual source rf magnetron sputtering wherein there is a facility for injecting and exhausting gases including hydrogen sulphide. In this sputtering process the deposition substrate has a heating means and aluminum sulphide or metallic aluminum is present in one of the sputtering targets, the latter as exemplified in Applicant's U.S. patent application 09/867,080 filed May 29, 2001 (the entirety of which is incorporated herein by reference). Alternatively deposition can be conducted using thermal evaporation. One of skill in the art would readily comprehend how to deposit the phosphor of the present invention using different methods.

Alkaline earth thioaluminates have been reported to have utility as electroluminescent phosphors, but with low luminosity. It has now been demonstrated that improved control of the stoichiometry of the host material facilitates an electroluminescent element with higher luminance.

It is presently demonstrated that the use of yttrium as a partial substitute for aluminum facilitates an electroluminescent element with still higher luminance than previously known phosphors.

The above disclosure generally describes the present invention. A more complete understanding can be obtained by reference to the following specific Examples. These Examples are described solely for purposes of illustration and are not intended to limit the scope of the invention. Changes in form and substitution of equivalents are contemplated as circumstances may suggest or render expedient. Although specific terms have been employed herein, such terms are intended in a descriptive sense and not for purposes of limitation.

Examples

The examples are described for the purposes of illustration and are not intended to limit the scope of the invention.

Methods of chemistry, photochemistry and spectrometry referred to but not explicitly described in this disclosure and examples are reported in the scientific literature and are well known to those skilled in the art.

Example 1

A series of europium-doped magnesium barium yttrium thioaluminate powders were prepared by blending powders of barium sulphide, yttrium trisulphide, aluminum sulphide and europium sulphide in various ratios. The barium yttrium thioaluminate phosphor powders had the nominal composition $Ba_{0.97}Eu_{0.03}(Y_xAl_{1-x})_2S_4$. Samples were prepared with (i) x = 0.0, (ii) x = 0.05 and (iii) x = 0.10

The blended powders were pressed to form pellets with a diameter of 1.3 cm and a height of 0.75 cm. The pellets were heat treated by placing them in an alumina boat and passing them through a belt furnace in a nitrogen environment with a peak temperature of about 950°C for 10 minutes. The actual temperatures of the pellet may have been moderately lower due to the large thermal loading introduced by the alumina boat.

The photoluminescence and excitation spectra of the resultant phosphors were measured using a Model 814 photomultiplier detection system and an A-1010B Arc Lamp xenon flash lamp from Photon Technology International of London, Ontario, Canada. A monochromator was used to select the excitation wavelength.

The photoluminescence and excitation spectra are shown in Figure 3. The emission spectra have peaks near 480 nm, with a tendency for a shift to shorter wavelength at higher yttrium content. These spectra, especially the shorter wavelength ones, are capable of providing CIE coordinates suitable for full color displays with minimal filtering. The

excitation spectra for the sample with no yttrium has two peaks, one near 300 nm and the other near 350 nm. The samples containing yttrium had excitation spectra with the 300 nm peak reduced in magnitude, but with the 350 nm peak essentially unchanged as compared to that of the sample containing no yttrium.

Example II

A series of europium-doped magnesium barium yttrium thioaluminate powders were prepared by blending powders of barium sulphide, yttrium trisulphide, aluminum sulphide and europium sulphide in various ratios. The barium yttrium thioaluminate phosphor powders had the nominal composition $Ba_{0.97}Eu_{0.03}(Y_xAl_{1-x})_2S_4$. Samples were prepared with (i) x = 0.0, (ii) x = 0.02 (iii) x = 0.05, (iv) x = 0.10 and (v) x = 0.20. The samples were fired in a belt furnace as in Example 1, except that the maximum temperature was about 1000°C rather than about 950°C. Powder x-ray diffraction (XRD) patterns of the samples were obtained that could be indexed to the XRD pattern for cubic $BaAl_2S_4$. These patterns are shown in Figure 4. The addition of yttrium caused the widths of the XRD peaks to become sharper, indicating a higher degree of crystallinity, a lower crystal defect density or a larger grain size for these materials. The angles for the peaks were unchanged, however, for the yttrium substituted materials, no substantial change in the crystal unit cell dimensions with yttrium substitution was indicated. For a yttrium content of x = 0.1 or higher, however, additional XRD peaks appeared that may be barium sulfide, yttrium trisulfide or aluminum yttrium sulfide phases.

Example III

Two thick dielectric electroluminescent devices incorporating thin film phosphor layers comprising yttrium substituted barium thioaluminate activated with europium were constructed. The thick film substrate was comprised of a 5 cm by 5 cm alumina substrate having a thickness of 0.1

cm. A gold electrode was deposited on the substrate, followed with a thick film high dielectric constant dielectric layer in accordance with the methods exemplified in Applicant's co-pending international application PCT CA00/00561 filed May 12, 2000. A thin film dielectric layer consisting of barium titanate, with a thickness of about 100-200 nanometers, was deposited on top of the thick film dielectric layer using the sol gel technique described in Applicant's co-pending U.S. Patent Application 09/761,971 filed January 17, 2001 (the entirety of which is incorporated herein by reference).

The phosphor film was electron beam evaporated on top of the barium titanate layer using dual source electron beam evaporation, according to the methods described in Applicant's co-pending U.S. Patent Application 09/747,315 filed December 22, 2000 (the entirety of which is incorporated herein by reference). The two evaporation sources were aluminum sulphide and a fused mixture of barium sulphide and europium sulphide. For one of the devices, yttrium trisulphide was also added to the fused mixture in a quantity corresponding to x = 0.05 in the formula $Ba_{0.97}Eu_{0.03}(Y_xAl_{1-x})_2S_4$. For both samples, each evaporation source was in the form of a pellet, which was prepared using the method outlined in Example I.

The phosphor deposition was carried out in a low pressure atmosphere of hydrogen sulphide at a pressure of about 8×10^{-5} to about 2×10^{-4} torr and with the substrate at a temperature in the range of about 350°C to 500°C. The deposition was carried out by electron beam evaporation using the dual sources. The deposition rate of the aluminum sulphide, as measured in the absence of the remaining constituents using a quartz crystal monitor, was in the range of 5 to 7 Angstroms per second and the deposition rate of the remaining constituents in the absence of aluminum sulphide, also as measured using a quartz crystal monitor, was

in the range of 3.5 to 5.5 Angstroms per second. The deposited phosphor film thickness was in the range 3000 to 4500 Angstroms.

Following deposition, the phosphor-coated substrates were annealed under a nitrogen atmosphere in a temperature of about 650°C to 700°C for about 2 minutes. A 50 nanometer thick alumina thin film and an indium tin oxide transparent conductor were deposited over the phosphor to provide a second electrode.

The resultant devices were tested using alternating polarity 32 microsecond wide square-wave pulses and a frequency of 120 Hz giving 240 light pulses per second. The pulse amplitude was varied in increments of 10 volts up to 260 volts and comparative data is shown in Figure 5 for the two devices. As can be seen from Figure 5, the luminance for the device with the phosphor containing yttrium is about twice that for the device not containing yttrium. The luminance increases linearly with the incremental voltage above the threshold voltage for the onset of luminance, and so the increased luminance with the yttrium additive can be realized without increasing the applied voltage. Figure 6 also shows the phosphor efficiency for the device having a phosphor containing yttrium. A peak efficiency of 2.4 lumens per Watt is realized, a new record for blue phosphor luminance in this wavelength range.

Example IV

Several thick dielectric devices with phosphors containing containing yttrium at a concentration corresponding to x = 0.05 were constructed and tested. Figure 7 shows the dependence of the realized luminance as a function of the applied voltage. As can be seen from Figure 7, the luminance performance of these devices were quite similar to one another, illustrating the repeatability of the device performance.

Example V

Five more thick dielectric electroluminescent devices were constructed according to the methods of Example III, except that the yttrium concentration in the phosphor was varied. The first of the devices had a phosphor film with a europium concentration of about 3 atomic percent with respect to barium and a yttrium concentration of zero atomic percent with respect to aluminum. The second device had a phosphor film with a europium concentration of about 3 atomic percent with respect to barium and a yttrium concentration of about one atomic percent with respect to aluminum. The third device had a phosphor film with a europium concentration of about 3 atomic percent with respect to barium and a yttrium concentration of about 3 atomic percent with respect to aluminum. The fourth device had a phosphor film with europium concentration of about 3 atomic percent with respect to barium and a yttrium concentration of about 5 atomic percent with respect to aluminum. The fifth device had a phosphor film with a europium concentration of about 3 atomic percent with respect to barium and a yttrium concentration of about 10 atomic percent with respect to aluminum. The measured luminance for these devices is shown in Figure 8 as a function of the yttrium concentration in the phosphor. The luminance is seen to increase as the value of x is increased.

Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention.

CLAIMS:

1. A thin film phosphor for an electroluminescent device, said phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said phosphor being activated by a rare earth metal and containing a Group IIIB element as a partial substitute for a portion of aluminum, gallium or indium of said thiogallate, thioindate and thioaluminate.

2. The thin film phosphor of Claim 1, wherein said Group IIIB element is selected such that it does not substantially distort or affect the crystal lattice structure of said phosphor.

3. The thin film phosphor of Claim 2, wherein said Group IIIB element is selected from the group consisting of scandium, yttrium, lanthanum and actinium.

4. The thin film phosphor of Claim 3, wherein said element is yttrium.

5. The thin film phosphor of Claim 4, wherein said phosphor is a thioaluminate.

6. The thin film phosphor of Claim 4, wherein said phosphor is a thiogallate.

7. The thin film phosphor of Claim 4, wherein said phosphor is a thioindate.

8. The thin film phosphor of any one of Claims 1 to 7, wherein said rare earth metal is selected from the group consisting of europium and cerium.

9. The thin film phosphor of Claim 8, wherein said rare earth metal is europium.

10. The thin film phosphor of Claim 9, wherein said cation is barium.

11. The thin film phosphor of Claim 10, wherein said phosphor contains europium in an amount in the range of about 1-10 atomic percent of barium and yttrium is present in an amount in the range of about 0.1 - 20 atomic percent of aluminum.

12. The thin film phosphor of Claim 10, wherein said phosphor contains europium in an amount in the range of about 2 -7 atomic percent of barium and yttrium is present in an amount in the range of about 1-7 atomic percent of aluminum.

13. 13. The thin film phosphor of claim 11 or 12, wherein said phosphor is $Ba_{0.97}Eu_{0.03}(Y_xAl_{1-x})_2S_4$, wherein $0<x<1.0$.

14. An electroluminescent device comprising a thin film phosphor of claim 1 or 12 on a substrate structure.

15. The device of claim 14, wherein said substrate structure comprises a thick film ceramic material.

16. The device of claim 15, wherein said thick film ceramic material comprises a base substrate having an electrically conductive film

deposited thereon and a thick film layer deposited on said electrically conductive film.

17. The device of claim 16, wherein said base substrate comprises a ceramic material selected from the group consisting of a ceramic sheet, a metal ceramic composite, a glass ceramic and a high temperature glass.

18. The device of claim 17, wherein said ceramic sheet is alumina.

19. The device of claim 18, wherein said electrically conductive thin film is selected from the group consisting of gold and silver alloy.

20. The device of claim 19, wherein said thick film layer comprises ferroelectric material.

21. The device of claim 20, wherein said ferroelectric material is selected from the group consisting of lead magnesium niobate titanate, lead zirconate titanate, barium titanate and mixtures thereof.

22. The device of claim 20, wherein said substrate structure additionally comprises one or more thin film dielectric layers on the thick film layer.

23. The device of claim 22, wherein device additionally comprises a thin film dielectric layer on top of said thin-film phosphor.

24. A phosphor material having the formula:
$A_{1-w} D_w [Y_x Z_{1-x}]_y S_4$, wherein
A is a Group IIA or Group IIB cation;

D is a rare earth metal;
Z is selected from Al, Ga and In;
$0<x<0.2$;
$y= 2$; and
$0.005<w<0.1$

25. The phosphor of Claim 24, wherein Z is aluminum.

26. The phosphor of Claim 24 or 25, wherein D is selected from the group consisting of europium and cerium.

27. The phosphor of Claim 26, wherein said rare earth metal is europium.

28. The phosphor of Claim 27, wherein said cation is barium.

29. The phosphor of claim 28, wherein said phosphor is $Ba_{0.97}Eu_{0.03}(Y_xAl_{1-x})_2S_4$, wherein $0<x<0.1$

30. An electroluminescent device comprising a phosphor of claim 24 on a substrate structure.

31. The device of claim 30, wherein said substrate structure comprises a thick film ceramic material.

32. The device of claim 31, wherein said thick film ceramic material comprises a base substrate having an electrically conductive film deposited thereon and a thick film layer deposited on said electrically conductive film.

33. The device of claim 32, wherein said base substrate comprises a ceramic material selected from the group consisting of a ceramic sheet, a metal ceramic composite, a glass ceramic and a high temperature glass.

34. The device of claim 33, wherein said ceramic sheet is alumina.

35. The device of claim 34, wherein said electrically conductive thin film is selected from the group consisting of gold and silver alloy.

36. The device of claim 35, wherein said thick film layer comprises ferroelectric material.

37. The device of claim 36, wherein said ferroelectric material is selected from the group consisting of lead magnesium niobate titanate, lead zirconate titanate, barium titanate and mixtures thereof.

38. The device of claim 36, wherein said substrate structure additionally comprises one or more thin film dielectric layers on the thick film layer.

39. The device of claim 38, wherein device additionally comprises a thin film dielectric layer on top of said thin-film phosphor.

40. A phosphor material having the formula:
$A_{1-w} D_w [M_x Z_{1-x}]_y S_4$, wherein
A is a Group IIA or Group IIB cation;
D is a rare earth metal;
M is a Group IIIB metal selected from Y, Sc, La and Ac;
Z is selected from Al, Ga and In;

$0<x<0.2$;

$y= 2$; and

$0.005<w<0.1$

41. The phosphor of claim 40, wherein M is yttrium, A is barium, D is europium and Z is aluminum.

Figure 1

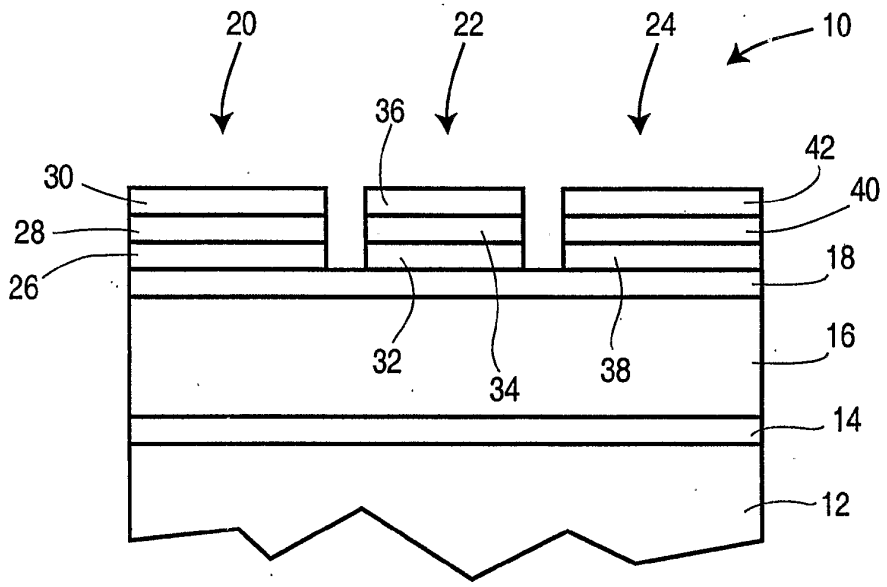


Figure 2

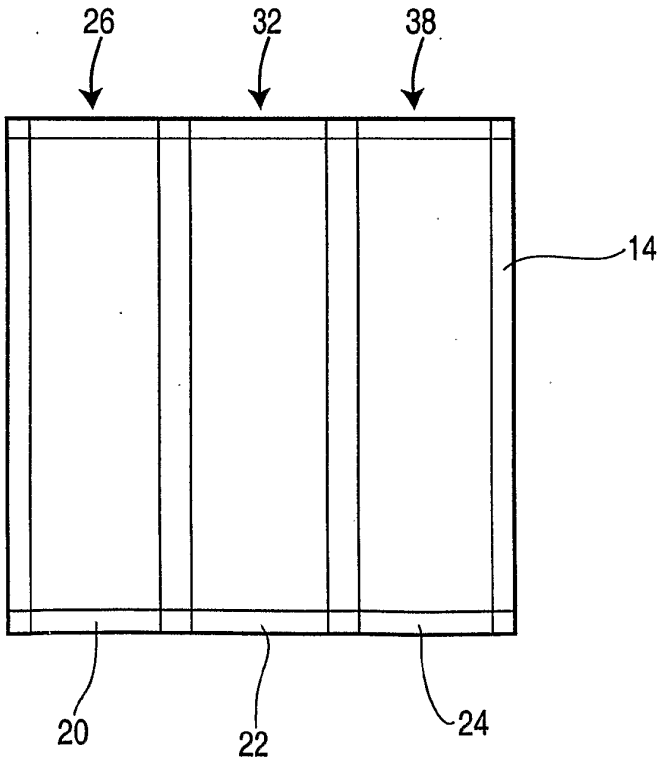


Figure 3

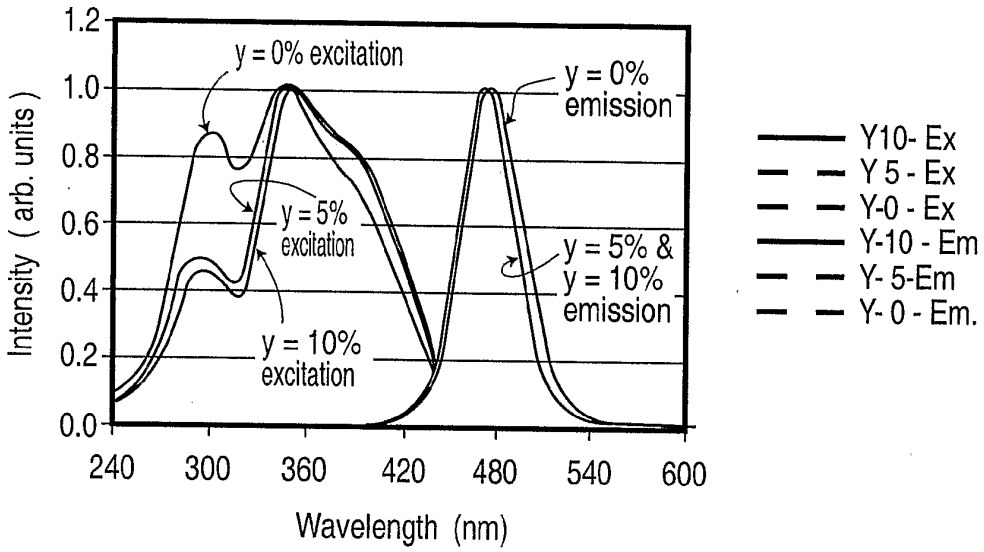


Figure 4

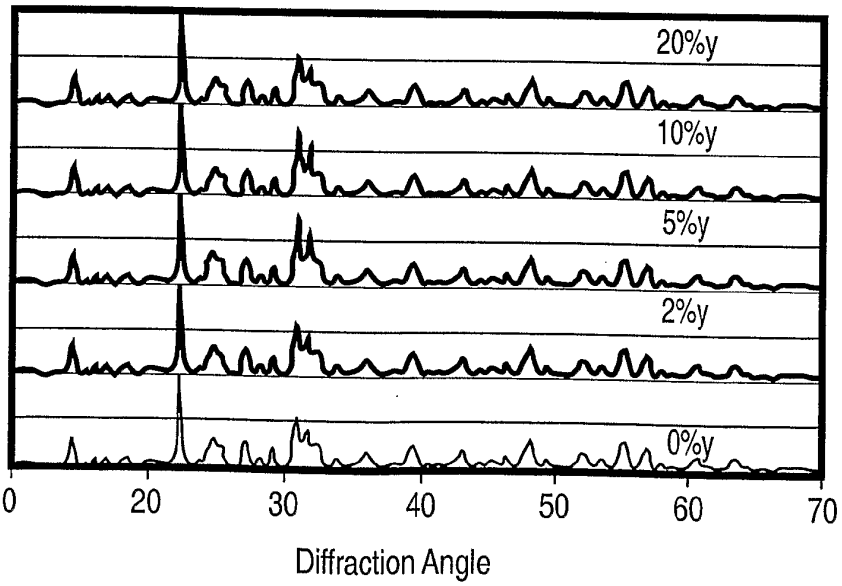


Figure 5

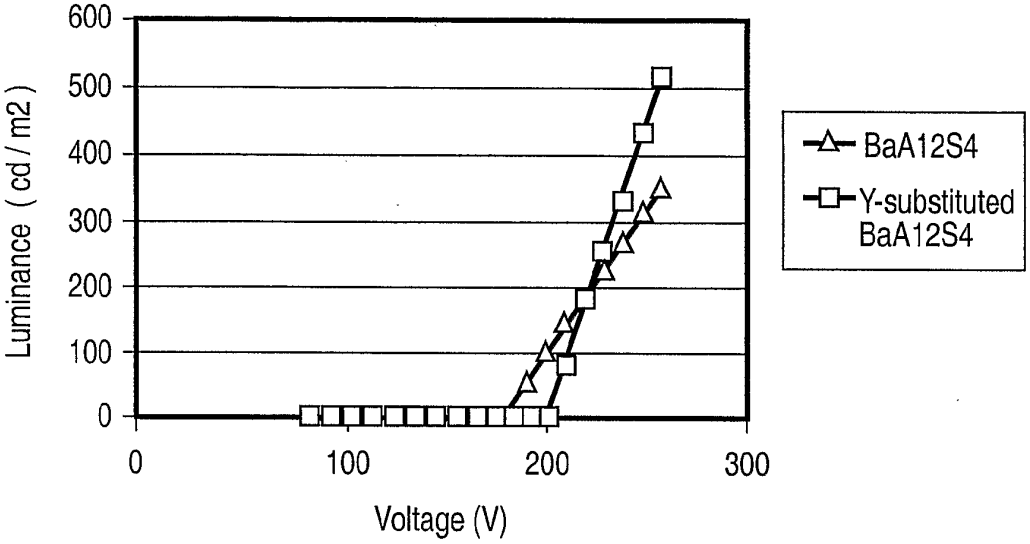


Figure 6

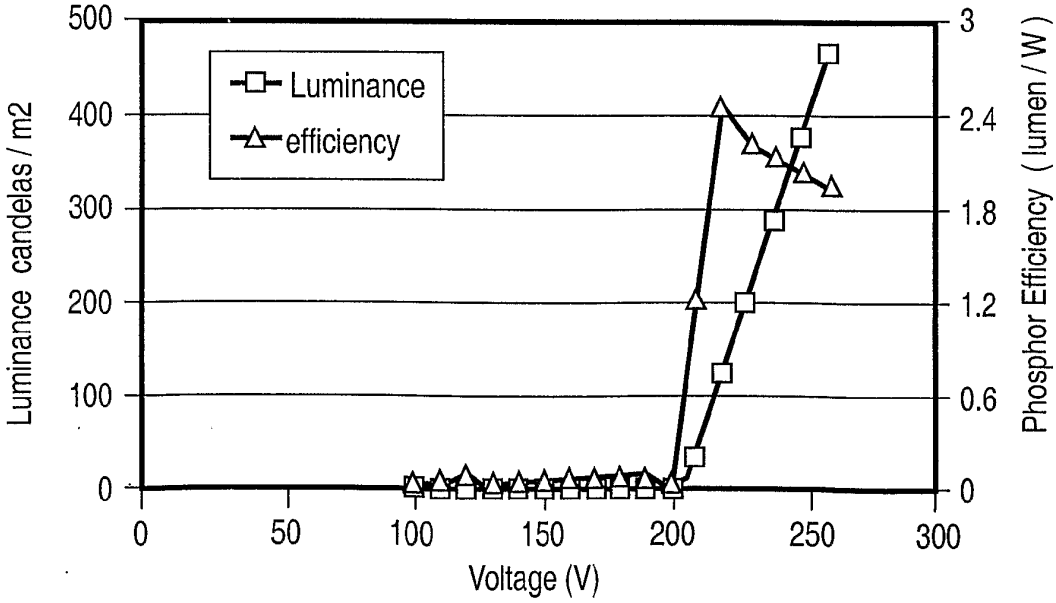


Figure 7

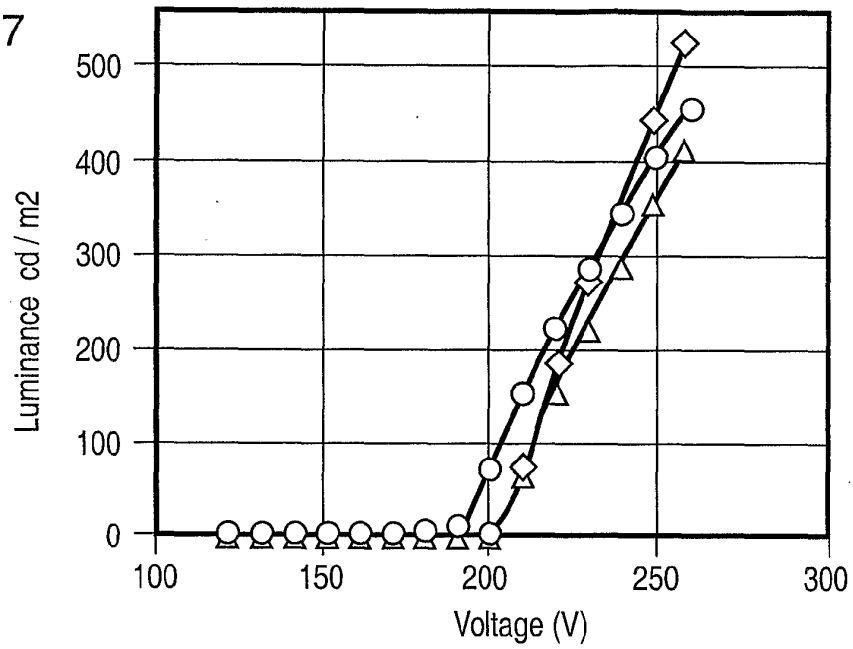
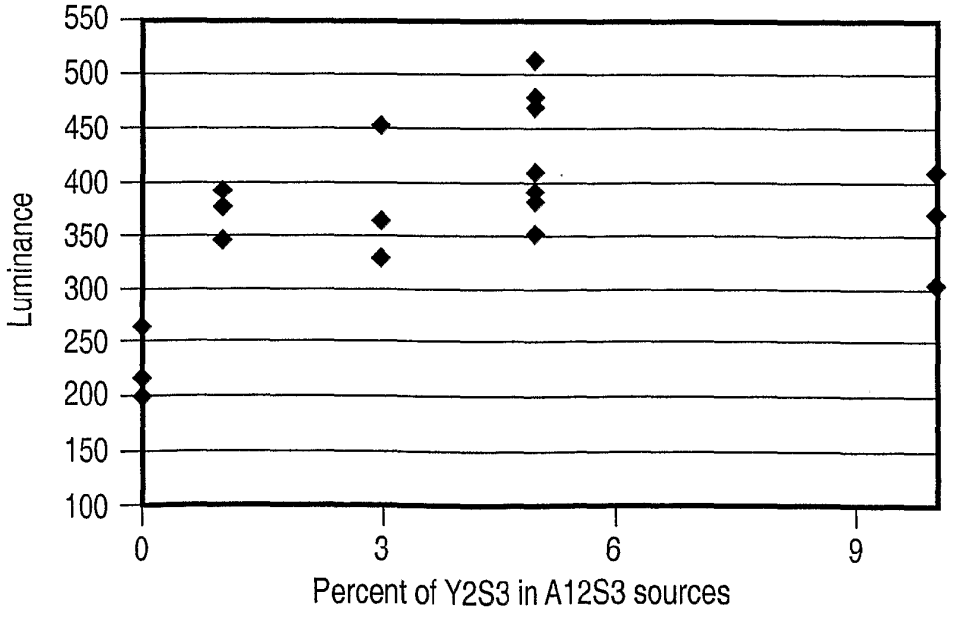


Figure 8



INTERNATIONAL SEARCH REPORT

Interna Application No
PCT/CA 03/00424

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/14 H05B33/22 H05B33/26 C09K11/84

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)
IPC 7 C09K H05B

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 practical, search terms used)
EPO-Internal, PAJ, WPI Data, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US 2002/180346 A1 (NAKUA M ABDUL ET AL) 5 December 2002 (2002-12-05) the whole document	1-41
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 01, 31 January 1996 (1996-01-31) & JP 07 242869 A (MITSUI MINING & SMELTING CO LTD;OTHERS: 01), 19 September 1995 (1995-09-19) abstract	1-41

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 2003	25/06/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Drouot-Onillon, M-C

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

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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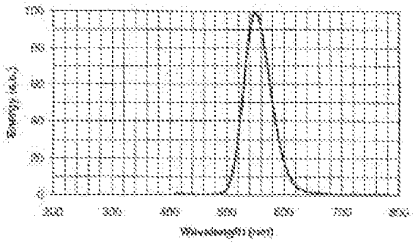
Luminescent material used for emitting green light is of the thiogallate class

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Abstract of **DE 10028266 (A1)**

Luminescent material of the thiogallate class has the formula (I) Luminescent material of the thiogallate class has the formula (I): A1-xGa2S4-y x = 0 <= x <= 0.3; y = 0 <= y <= 0.3.



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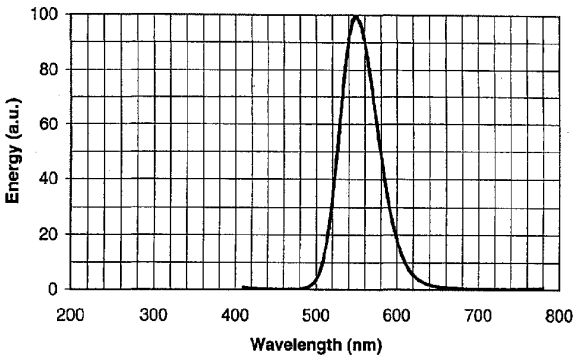
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Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Hocheffizienter Leuchtstoff

(57) Leuchtstoff aus der Klasse der Thiogallate, wobei das Thiogallat unterstöchiometrisch angesetzt ist, entsprechend der Formel $A_{1-x}Ga_2S_{4-y}$ mit $0 < x < 0,3$ und $0 < y < 0,3$.



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Beschreibung

Technisches Gebiet

[0001] Die Erfindung geht aus von einem Leuchtstoff aus der Klasse der Thiogallate gemäß dem Oberbegriff des Anspruchs 1. Es handelt sich dabei insbesondere um Thiogallate, die im Grünen leuchten.

Stand der Technik

[0002] Aus der US 3 639 254 und der US 5 834 053 sind bereits Thiogallate bekannt, die im Blauen oder Grünen leuchten. Diese Leuchtstoffe folgen der Formel AGa_2S_4, wobei A ein Alkali- oder Erdalkalimetall darstellt. Übliche Dotierungen sind Europium, Blei oder Cer. Nachteilig ist die relativ geringe Effizienz.

Darstellung der Erfindung

[0003] Es ist Aufgabe der vorliegenden Erfindung, einen Leuchtstoff gemäß dem Oberbegriff des Anspruchs 1 bereitzustellen, dessen Effizienz möglichst hoch ist.

[0004] Diese Aufgabe wird durch die kennzeichnenden Merkmale des Anspruchs 1 gelöst. Besonders vorteilhafte Ausgestaltungen finden sich in den abhängigen Ansprüchen.

[0005] Erfindungsgemäß wird die Zusammensetzung des Leuchtstoffs so gewählt, dass der Anteil an zweiwertigen Kationen kleiner ist als es der idealen Formel AGa_2S_4 entspricht. A ist dabei insbesondere als zweiwertig angenommen. Es handelt sich also um einen Leuchtstoff der Zusammensetzung $A_{1-x}Ga_2S_{4-y}$, wobei $0 < x < 0,3$ ist und $0 < y < 0,3$.

[0006] Insbesondere ist für x und y ein Mindestwert von 0,02 vorteilhaft. Bevorzugt ist x = y gewählt wegen der Ladungsträgerkompensation. Als Metalle A kommen vornehmlich Mg, Ca, Sr in Frage, einzeln oder in Kombination. Besonders bewährt hat sich der Einsatz aller drei. Als Dotierstoffe (der als Ersatz für A wirkt) kommen vornehmlich Europium und Cer, einzeln oder in Kombination in Frage. Die Dotierstoffe können mit Terbium und/oder Mangan kodotiert sein. Das Gallium kann teilweise (bis zu 50%) durch Aluminium ersetzt sein.

[0007] Besonders gute Ausbeute zeigt ein System basierend auf folgenden Komponenten:
$A_{1-x}Ga_2S_{4-x}$ wobei $A = Mg_aCa_bSr_cEu_d$ mit
$0,4 < a < 0,7$
$0,1 < b < 0,4$
$0 < c < 0,4$
$0,01 < d < 0,1$
wobei a+b+c+d = 1. Gallium kann durch Aluminium (bis 20%) ersetzt sein.

Figuren

[0008] Im folgenden soll die Erfindung anhand eines Ausführungsbeispiels näher erläutert werden. Es zeigen:

[0009] **Fig.** 1 ein Emissionsspektrum eines nicht stöchiometrischen, genauer gesagt unterstöchiometrischen Thiogallates

[0010] **Fig.** 2 das Remissionsspektrum dieses Thiogallates

Beschreibung der Zeichnungen

[0011] Ein konkretes Beispiel für den unterstöchiometrischen Leuchtstoff der Thiogallat-Klasse ist $(Mg_{0,63}Ca_{0,21}Sr_{0,105}Eu_{0,055})_{0,9}Ga_2S_{3,9}$. In anderer Darstellung entspricht dies einer Zusammensetzung von etwa $Mg_{0,57}Ca_{0,185}Sr_{0,095}Euo_{0,049}Ga_2S_{3,9}$.

[0012] Die Herstellung erfolgt in der üblichen Weise, wobei jedoch die Ausgangsstoffe für Schwefel und Metall A entsprechend der später gewünschten unterstöchiometrischen Anteile zugesetzt werden.

[0013] **Fig.** 1 zeigt das Emissionsspektrum dieses Leuchtstoffs. Es liegt im Grünen zwischen etwa 500 und 620 nm. Das Maximum liegt bei 548 nm, die mittlere Wellenlänge bei 557 nm. Die Farbort ist x = 0,366; y = 0,618. Die Quanteneffizienz liegt bei 81% bei Anregung durch 400 nm. Der visuelle Nutzeffekt ist 0.874. Im Vergleich dazu liegt die Quanteneffizienz des gleichen stöchiometrischen Leuchtstoffs (entsprechend x = y = 0) bei weniger als 70%.

[0014] Dieser Leuchtstoff ist gut durch kurzwellige Strahlung zwischen 300 und 500 nm anregbar. Besonders gut ist er für den Einsatz bei LEDs zur Farbkonversion geeignet. Dabei wird eine UV-emittierende LED mittels eines oder mehrerer Leuchtstoffe in sichtbares Licht (hier grün oder blaugrün) oder weißes Licht (rot, grün und blau emittierender Leuchtstoff gleichzeitig) umgewandelt. Eine zweite Variante ist bei Verwendung einer blauen LED einen oder zwei Leuchtstoffe (gelb bzw. grün und rot) dazuzumischen, so dass auch hier weißes Licht entstehen kann.

Patentansprüche

1. Hocheffizienter Leuchtstoff aus der Klasse der Thiogallate, **dadurch gekennzeichnet**, dass das Thiogallat unterstöchiometrisch angesetzt ist entsprechend der Formel $A_{1-x}Ga_2S_{4-y}$, wobei $0 < x < 0,3$ ist und $0 < y < 0,3$.
2. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass x = y.
3. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass $x > 0,02$ und $y > 0,02$.
4. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass Gallium teilweise durch Aluminium ersetzt ist.
5. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass als Metall A Mg, Ca, Sr einzeln oder in Kombination gewählt ist.
6. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass als Dotierstoff (der als Ersatz für A wirkt) Europium und/oder Cer gewählt ist.
7. Thiogallat-Leuchtstoff nach Anspruch 1, dadurch gekennzeichnet, dass als Ko-Dotierstoff Mangan und/oder Terbium gewählt ist.
8. Thiogallat-Leuchtstoff nach Anspruch 5, dadurch gekennzeichnet, dass als Thiogallat $A_{1-x}Ga_2S_{4-x}$ gewählt ist, wobei $A = Mg_aCa_bSr_cEu_d$ mit
$0,4 < a < 0,7$,
$0,1 < b < 0,4$,
$0 < c < 0,4$,
$0,01 < d < 0,1$, wobei a+b+c+d = 1.

Hierzu 1 Seite(n) Zeichnungen

- Leerseite -

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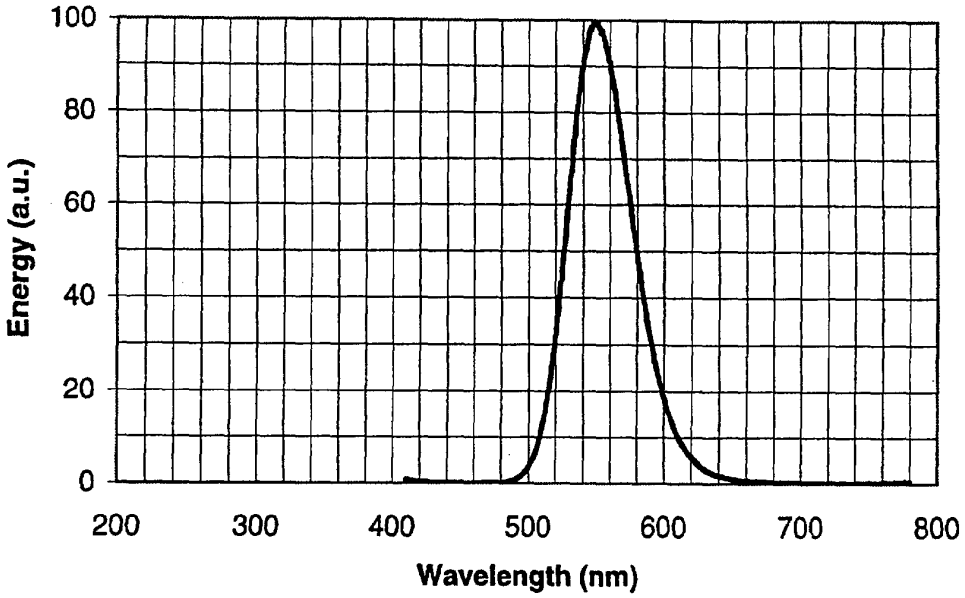


FIG. 1

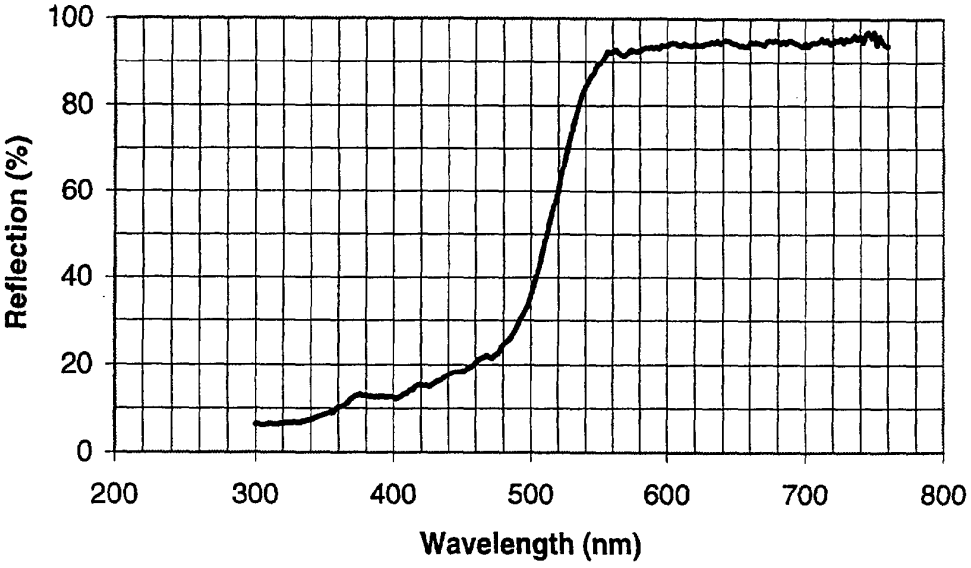


FIG. 2

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(54) Title: HIGH EFFICIENCY ALKALINE EARTH METAL THIOGALLATE-BASED PHOSPHORS

(57) Abstract: Provided, among other things, is a strontium calcium thiogallate phosphor doped with divalent europium, and having the following formula: $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3$, where x is 0.0001 to 1, y is a value defining sufficient Eu^{2+} to provide luminescent emission, and z is 0.0001 to 0.2 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}$.

High Efficiency Alkaline Earth Metal Thiogallate-Based Phosphors

[1] This application claims the priority of U.S. Provisional Application No. 60/463,883, filed April 21, 2003

[2] The present invention relates to green emitting phosphors for light emitting diode lighting applications.

[3] Phosphors, including alkaline earth metal thiogallate-based phosphors ($MGaS_4$) activated with divalent europium, divalent praseodymium, trivalent cerium, and the like are known. For example, Peters et al., J. Electrochem Soc. 119: 230 et seq., 1972 describes phosphors made by solid state reaction from alkaline earth sulfides, gallium sulfide and rare earth sulfides that emit in the green to yellow region of the spectrum. These phosphors have low emission efficiency. For use in color shifting for LED devices and the like, higher photoluminescence efficiency phosphors are desirable.

[4] U.S. Patent 6,544,438 discloses alkaline earth metal thiogallate phosphors having a small excess of gallium sulfide. These phosphors are made by mixing soluble alkaline earth salts with a gallium nitrate solution to produce an excess of gallium, precipitating the resulting sulfate salts, and firing these salts in hydrogen sulfide to form the thiogallate sulfide phosphors. The resulting green phosphors have improved efficiency, but emit at about 530 nm. However, for certain applications such as liquid crystal displays (LCDs) illuminated by backlighting, the green component should have a higher emission peak such as 535 nm to 560 nm.

Exemplary Embodiments

[5] The phosphors of the invention are strontium calcium thiogallate doped with divalent europium, and having the following formula I:

$$Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3, \quad (I)$$

Where x is 0.0001 to 1, y is a value defining sufficient Eu^{2+} to provide luminescent emission (or, for example, 0.001 to 0.1 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}$), and z is 0.0001 to 0.2 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4$.

[6] Without being limited to theory, it is believed that the zGa_2S_3 component resides in a distinct phase, i.e., distinct crystalline domains in the phosphor body host.

[7] Preferably, the phosphors of the present invention have an emission efficiency (i.e., quantum efficiency) of 50% or higher, or 65% or higher, or 75% or higher, or 85% or higher.

[8] In certain embodiments, the range of x is from one of the following lower endpoints (inclusive) or from one of the following upper endpoints (inclusive). The lower endpoints are 0.0001, 0.001, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. The upper endpoints are 0.001, 0.1, 0.2, 0.3; 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0.

[9] In certain embodiments, the range of y is from one of the following lower endpoints (inclusive) or from one of the following upper endpoints (inclusive). The lower endpoints are 0.001, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08 and 0.09. The upper endpoints are 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09 and 0.1. For example, the range can be 0.01 to 0.08 or 0.01 to 0.04.

[10] In certain embodiments, the range of z is from one of the following lower endpoints (inclusive) or from one of the following upper endpoints (inclusive). The lower endpoints are 0.0001, 0.001, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18 and 0.19. The upper endpoints are 0.001, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19 and 0.2. In certain embodiments, z is 0.0001 to 0.1, or 0.001 to 0.2, or 0.001 to 0.1.

[11] The emission peak is measured with the emission source being light at 440 nm ± 40 nm. In certain embodiments, the range is from one of the following lower endpoints (inclusive) or from one of the following upper endpoints (inclusive). The lower endpoints are 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558 or 559 nm. The upper endpoints are 560, 559, 558, 557, 556, 555, 554, 553, 552, 551, 550, 549, 548, 547, 546, 545, 544, 543, 542, 541, 540, 539, 538, 537 or 536 nm.

[12] In one embodiment, the invention relates to light emitting device comprising: a light output; a light source producing light including wavelengths of 530 nm or less; and a wavelength transformer located between the light source and the light output, comprising $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3$, where x is 0.0001 to 1, y is a value defining sufficient Eu^{2+} to provide luminescent emission, and z is 0.0001 to 0.2 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4$, the wavelength transformer effective to increase the light at the

light output having wavelength between 535 nm and 560 nm. In certain embodiments, the device is used with one or more of the compositions described in this application.

[13] In another embodiment, the invention relates to a method of making a strontium calcium thiogallate phosphor of formula $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3$, where x is 0.0001 to 1, y is a value defining sufficient Eu^{2+} to provide luminescent emission, and z is 0.0001 to 0.2 based on the mole amount of Srl xCaxGa2S4, the method comprising: forming a composition of sulfate salts of gallium, divalent europium, calcium and, if x is not 1, strontium; and firing the composition under hydrogen sulfide. In certain embodiments, the method is used to create one or more of the compositions described in this application.

Brief Description of the Drawings

[14] Figure 1 displays a spectrum of a phosphor of the invention.

[15] Figure 2 shows a xrd spectrum of a phosphor of the invention.

[16] Figure 3 shows spectra of two phosphors of the invention, and a strontium thiogallate phosphor.

[17] Figure 4A and 4B show micrographs of phosphors of the invention.

Detailed Description of the Invention

[18] In formula I, the component $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}$, or "component Ia", forms a first crystalline component in the formulation, while the zGa_2S_3 is believed to form a second crystalline component, or "component Ib". The precise nature of the physical relationship between the two forms in the composition is not known, but the relative amounts of the two forms can be determined from the X-ray diffraction data. The variable "y" is determined by composition.

[19] Where possible, z is determined by quantitative phase analysis of the X-ray diffraction using a Rietveld refinement procedure, which procedure is often called the *whole pattern fitting* procedure. Experience and a number of round robin comparisons published in the scientific literature have shown the method to be very accurate and is often quoted as the "gold standard" of quantitative analyses. The Rietveld method is based on a least-squares fit of a theoretical calculation of the whole diffraction pattern to an experimental pattern from the actual mixture of two or more phases ["Quantitative X-Ray Diffractometry" by Lev. S. Zevin and Giora Kimmel, Springer, New

York/Berlin/Heidelberg, 1995, ISBN 0-387-94541-5; "Fundamentals of Powder Diffraction and Structural Characterization of Materials" by Vitalij K. Pecharsky and peter Y. Zavalij, Kluwer Academic Publishers, Boston/Dordrecht/London , 2003, ISBN 1-4020-7365-8.]. To perform such a refinement, information on the structure of each phase is used. For example, the chemistry, the unit cell parameters, the atomic positions within the crystal structure, the magnitude of the thermal vibrations about the equilibrium position, and the site occupancy are used. In addition to the structural parameters, information about the shape of the diffraction profiles is used. Based upon these data and known scattering physics of X-rays, a diffraction pattern is computed from first principles. Once this has been done, a residual can be computed as the difference between the pattern and experimental patterns. The Rietveld method then consists of minimizing the residual error by refining the structural model and the weight fraction of each phase until a stable minimum of the residual is obtained. A number of databases exist that contain the required information for the structural model. The two most widely used are the Inorganic Crystal Structure Database (ICSD) [*Inorganic Crystal Structure Database*, Fachinformationzentrum Energie Physik Mathematik, Karlsruhe, Germany, published annually] for inorganic materials and the Cambridge Structure Data base (CSD) [*Cambridge Structure Data Base*, Cambridge Crystallography Data Centre, Cambridge, England, published annually] for organic phases.

[20] In particular, the method used to determine z was (where possible):

1) Phase identification was accomplished by comparing the experimental data to the powder Diffraction File [*Powder Diffraction File*, International Centre for Diffraction Data, Swarthmore, PA, USA, published annually] to determine which phases were present;
2) Structural information was taken from the ICSD database once the phases were identified;
3) A Rietveld refinement was run using the Jade software v. 6.5 software package produced by Materials Data Inc. (Livermore, CA, USA). The structural parameters that were refined were the weight fraction, lattice parameters, and line profile shape functions, instrumental systematic errors, and isotropic thermal parameters. The other structural parameters such as atomic positions and site occupancies were not refined, since

experience has shown that these parameters should not be refined when the sample contains mixtures.

[21] One way to estimate the quality of the Rietveld refinement is to look at the weighted profile residual R_{wp}. Good quality fits are found when $R_{wp} < 10\%$, which is often considered the threshold for publication quality results. For samples prepared using the invention, R_{wp} values were in the range of 6% - 9%, indicating that the proper structural model was used.

[22] Generally, the emission peak inversely correlates with the value of parameter x. As x increases, the wavelength of the emission peak decreases.

[23] Preferably, the emission peak has a bandwidth of 50 nm or less under excitation with an emission source at 440 nm ± 40 nm. The emission peak ranges for example from 535 nm to 560 nm.

[24] One useful method of making the phosphors of the invention is as follows:

1.	Dissolving gallium metal in an acid solution to form a first aqueous solution of trivalent gallium, such as gallium nitrate, where the amount of gallium is tuned, for example, to the range of 0.1 to 7 % in excess of the stoichiometric amount of component Ia. Or, the amount can be tuned, for example to 1 to 7 % in excess of the stoichiometric amount of component Ia.
2a.	Dissolving a soluble salt of europium (such as europium nitrate) to form a second aqueous solution, and adding this second solution to the first solution to form a third aqueous solution. The amount of this dopant is tuned, for example, to the range of 1 to 4 % of the stoichiometric amount of component Ia.
2b.	Precipitating the metal salts with base (such as ammonium hydroxide) to create a gel-like solid. For example: $Ga(NO_3)_2 + Eu(NO_3)_2 \rightarrow Ga(OH)_3/Eu(OH)_3 \downarrow$
3a.	In a separate reactor, dissolving a soluble calcium salt (such as calcium nitrate) and, if anticipated according to formula I, a soluble strontium salt (such as strontium nitrate) in dilute nitric acid.
3b.	Precipitating the metal salts in crystalline form with sulfuric acid. For example: $Ca(NO_3)_2/Sr(NO_3)_2 + H_2SO_4 \rightarrow CaSO_4/SrSO_4\downarrow$. Pre-made powders of $CaSO_4$ and $SrSO_4$ can be used instead.

4.	Mixing the solids from steps 2b and 3b, drying the solids, and pulverizing the solids. The solids can be mixed in suspension.
5.	Firing the mixed solids, for example at a temperature from 500 to 850 degrees C. under hydrogen sulfide, for example for five hours. Or, the temperature is 700 to 750 degrees C. or 650 to 750 degrees C., or 680 to 720 degrees C.
6.	A heating step is applied, typically in a distinct heating step, to improve the crystallization of the product of step 5, for example at a temperature 750 to 950 degrees C. or 750 to 850 degrees C., or 780 to 820 degrees C. The time period is typically shorter than in the first firing, such as two hours. The product of step 5 can be re-ground prior to the second firing.

[25] The fired product can be re-ground and sieved.

[26] Other methods can be used. For example, a soluble strontium or calcium salt, such as the nitrates, can be dissolved in dilute nitric acid. The desired amount of europium salt (e.g., 1 – 6 mol percent) is added as a soluble aqueous solution. The europium salt can be, for example, the nitrate. The resulting solution can be precipitated by adding base such as ammonium carbonate. Thus, for example:

$$Sr(NO_3)_2 + Ca(NO_3)_2 + Eu(NO_3)_2 + (NH_4)_2CO_3 \rightarrow Sr_xCa_{1-x}CO_3\downarrow + Eu(OH)_3\downarrow + NH_4OH$$

The co-precipitated carbonates can be fired with an excess of ammonium sulfate (e.g., 25% molar excess) at, for example, about 200 degrees C., followed for example by firing at a higher temperature, such as about 1100 degrees C., to convert the carbonates to their sulfates. An acidic solution of a gallium salt, such as the nitrate salt, can be added to a solution of the sulfates. The pH can be brought to neutral or further to basic (for example using ammonium hydroxide), causing fine particles to precipitate. The resulting powder can be dried, ground, placed in a refractory boat (e.g., of alumina), and fired in hydrogen sulfide, e.g., for five hours in a tube furnace at about 800 degrees C. The resultant product has the formula:

$$Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3, \qquad \text{(Ic)}$$

where z is, for example, 0.0001 to 0.1 (or 0.01 to 10 mol percent). To increase uniformity, the product can be, for example, ground to a powder and re-fired in hydrogen sulfide at about 900 degrees C. for about two hours.

[27] To avoid the difficulty of converting the gallium oxide to an oxide-free sulfide with hydrogen sulfide, the oxide is not recommended as a starting material.

[28] The phosphors prepared as above are typically fine yellow powders. The fluorescence spectra of a phosphor of the invention, measured in both excitation (ME) and emission (E) mode, is shown in Figure 1. The excitation spectrum was recorded by measuring emission intensity at 560 nm as a function of the excitation wavelength (350 nm to 520 nm). The main band in the excitation spectrum is centered at about 470 nm, and has a bandwidth (at half height) of about 75 nm. The emission spectrum was obtained by excitation at 460 nm. An emission maximum can be seen at 557±0.7 nm. The quantum efficiency was 55%.

[29] A phosphor of the invention provided the X-ray powder diffraction spectrum shown in Figure 2. The major diffractions were at 2 theta = 16.6, 24.5, 30.3, 31.6, 35.5 and 38.9, indicating that the primary crystal was of the orthorhombic class. The diffraction symmetry and systematic absence are consistent with a space group D_{2h}^{24}. This crystal is isomorphous to strontium thiogallate.

[30] Figure 3 shows the emission spectrum of strontium thiogallate ($SrGa_2S_4:Eu^{2+}\bullet zGa_2S_3$, solid lines), strontium calcium thiogallate (SCTG, $Sr_{0.6}Ca_{0.4}Ga_2S_4:Eu^{2+}\bullet zGa_2S_3$, dotted line) and calcium thiogallate ($CaGa_2S_4:Eu^{2+}\bullet zGa_2S_3$, dashed line). The value for z was 0.07.

[31] Scanning electron micrographs of a phosphor of the invention are shown in Figures 4A and 4B. The grains of the phosphor are largely agglomerates with a size of 3-40 microns. Irregularly shaped primary particles range in size from 2-4 microns, with interconnects between the primary particles. Figure 3A is shown in relation to a 100 micron solid bar, while Figure 3B is shown in relation to a 10 micron solid bar.

[32] Phosphors of the type here described are typically used in light producing devices in thin films, the manufacturing of which is well known in the art. Phosphors located between a phosphor of the invention and a more primary light source can serve to modify the light reaching the phosphors of the invention. Hence, in relation to the phosphors of the invention, the light modified in this way is the relevant source light. Devices can include mirrors, such as dielectric mirrors, to direct light produced by the phosphors to the light output rather than the interior of the device (such as the primary light source). Construction of relevant devices is described in, for example, US Patent Publication 2002/0030444 and US Patent 6,069,440.

[33] Temperatures described herein for processes involving a substantial gas phase are of the oven or other reaction vessel in question, not of the reactants per se.

[34] The following examples further illustrate the present invention, but of course, should not be construed as in any way limiting its scope.

Example

[35] A process for making the phosphors of the invention (SCTG phosphors) is outlined as follows:

[36] A solution of an acid-soluble gallium salt, such as the nitrate, is made. The amount of gallium used is of 3% in excess of the stoichiometric metal thiogallate formulation.

[37] A solution of europium nitrate is added to the above made aqueous nitrate. The dopant level is 4%. After combining the Eu solution with the Ga solution, the pH of the aqueous system was brought to a neutral regime with ammonium hydroxide. Consequently, a gel-like solid precipitates out. An organic solvent then is added to the precipitate to disperse the gel.

$$Ga(NO_3)_3 + Eu(NO_3)_3 + NH_4OH \rightarrow Ga(OH)_3/Eu(OH)_3\downarrow \text{ (gel-like)} \quad (1)$$

[38] A pre-made strontium sulfate powder is added to the $Ga(OH)_3/Eu(OH)_3$ suspension. The solid is then filtered out.

[39] A pre-made calcium sulfate powder is added to the filtered solid followed by a mixing step.

[40] The solid from the above two steps is oven dried and ground. It is then fired in hydrogen sulfide atmosphere for about five hours in a tube furnace. The temperature for the firings are ~700 °C for conversion and ~800 °C for crystallization, respectively. In the phosphor product, a minor crystalline phase of Ga_2S_3 exists in addition to the SCTG phase.

$$CaSO_4 + Ga(OH)_3/Eu(OH)_3 + H_2S \rightarrow CaGa_2S_4{:}Eu\bullet xGa_2S_3 \quad (3)$$

[41] The phosphor powders are refined and sieved.

[42] By selecting the strontium/calcium ratios, the following formulations are obtained:

No.	Sr/Ca Ratio	Formula	Emission Peak Wavelength, nm
1	6/4	$Sr_{0.6}Ca_{0.4}Ga_2S_4{:}Eu^{2+}\bullet zGa_2S_3$	546
2	5/5	$Sr_{0.5}Ca_{0.5}Ga_2S_4{:}Eu^{2+}\bullet zGa_2S_3$	547

3	4/6	$Sr_{0.4}Ca_{0.6}Ga_2S_4:Eu^{2+}\bullet zGa_2S_3$	549
4	3/7	$Sr_{0.3}Ca_{0.7}Ga_2S_4:Eu^{2+}\bullet zGa_2S_3$	550
5	2/8	$Sr_{0.2}Ca_{0.8}Ga_2S_4:Eu^{2+}\bullet zGa_2S_3$	551

[43] The value of z in the above formulations was 0.07.

[44] Publications and references, including but not limited to patents and patent applications, cited in this specification are herein incorporated by reference in their entirety in the entire portion cited as if each individual publication or reference were specifically and individually indicated to be incorporated by reference herein as being fully set forth. Any patent application to which this application claims priority is also incorporated by reference herein in the manner described above for publications and references.

[45] While this invention has been described with an emphasis upon preferred embodiments, it will be obvious to those of ordinary skill in the art that variations in the preferred devices and methods may be used and that it is intended that the invention may be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications encompassed within the spirit and scope of the invention as defined by the claims that follow.

What is claimed:

1. A strontium calcium thiogallate phosphor doped with divalent europium, and having the following formula:

$$Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}\bullet zGa_2S_3,$$

where x is 0.0001 to 1, y is a value defining sufficient Eu^{2+} to provide luminescent emission, and z is 0.0001 to 0.2 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4:yEu^{2+}$.

2. The phosphor of claim 1, wherein z is 0.001 to 0.2.

3. The phosphor of claim 1, wherein z is 0.001 to 0.1.

4. The phosphor of claim 1, wherein y is 0.001 to 0.1 based on the mole amount of $Sr_{1-x}Ca_xGa_2S_4$.

5. The phosphor of claim 4, wherein y is 0.01 to 0.08

6. The phosphor of claim 4, wherein y is 0.01 to 0.04.

7. The phosphor of claim 1, wherein the phosphor has an emission peak of 535 nm to 560 nm.

8. The phosphor of claim 7, wherein the emission peak has a bandwidth of 50 nm or less under excitation with an emission source at 440 nm ± 40 nm.

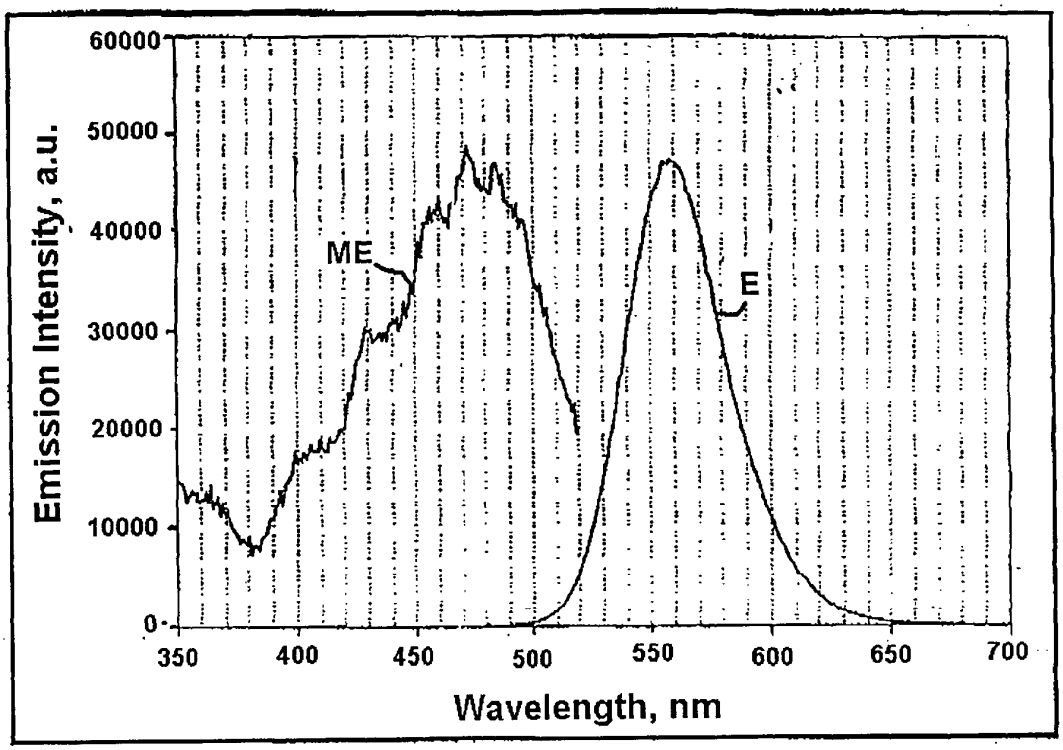

Emission Intensity, a.u.
60000
50000
40000
30000
20000
10000
0
ME
E
350
400
450
500
550
600
650
700
Wavelength, nm

Fig. 1

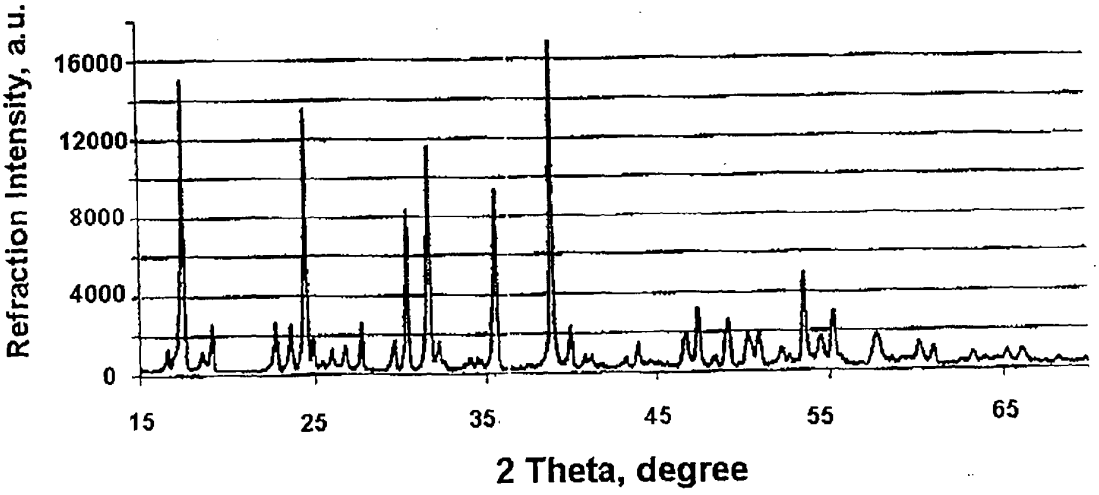

Refraction Intensity, a.u.
16000
12000
8000
4000
0
15
25
35
45
55
65
2 Theta, degree

Fig. 2

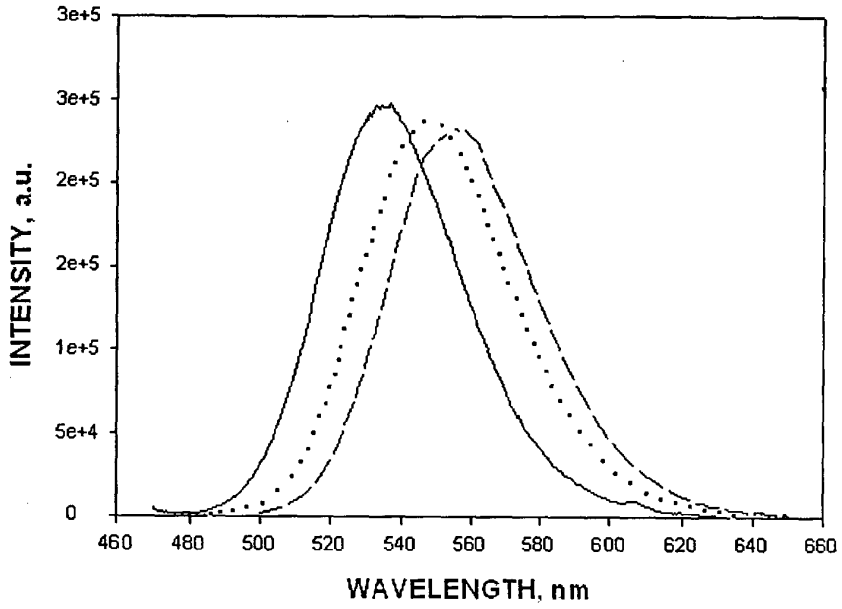

3e+5
3e+5
2e+5
2e+5
1e+5
5e+4
0
INTENSITY, a.u.
460
480
500
520
540
560
580
600
620
640
660
WAVELENGTH, nm

Fig. 3

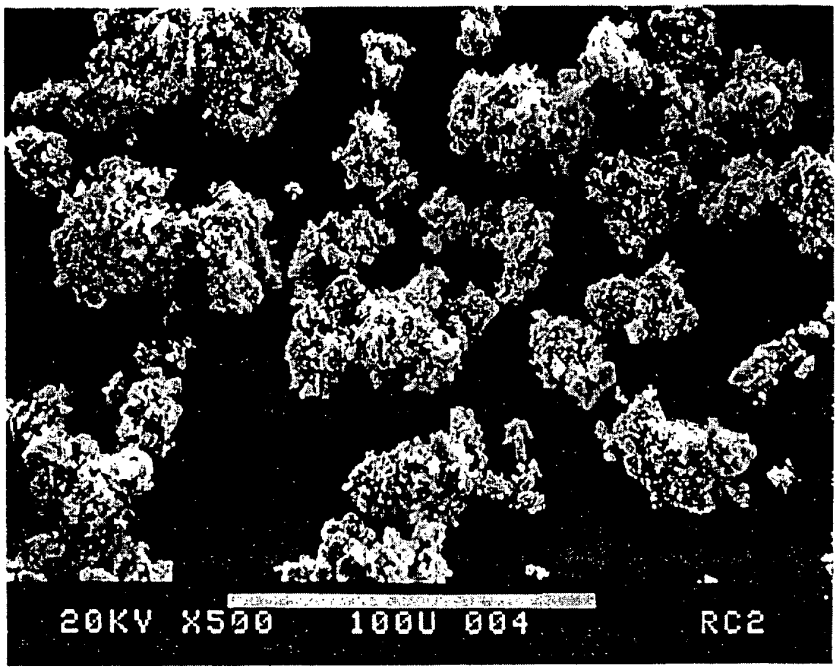


Fig. 4A

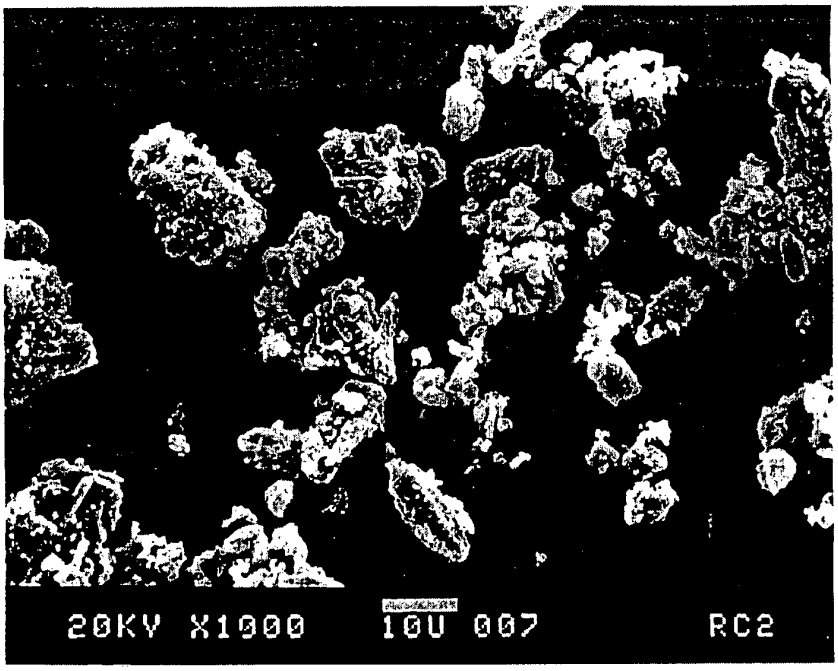


Fig. 4B

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(54) Title: THIOALUMINATE PHOSPHOR MATERIAL WITH A GADOLINIUM CO-ACTIVATOR

(57) Abstract: A thin film phosphor for an electroluminescent device, in which the phosphor is selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements. The phosphor is activated by a rare earth metal and co-activated with gadolinium. The phosphor provides improved luminance. An electroluminescent device comprising the thin film phosphor on a substrate is also described. Further aspects provide an electroluminescent device in which the thin film phosphor is adjacent to a thin film of zinc sulphide, preferably sandwiched between thin films of zinc sulphide.

Title

Thioaluminate Phosphor Material with a Gadolinium Co-activator

Field of the Invention

The present invention relates to alkaline earth thioaluminate phosphor materials that contain gadolinium as a co-activator. In particular, the present invention relates to the use of gadolinium as co-activator for such phosphors when deposited as thin films in electroluminescent displays. The present invention also relates to improving the luminance of phosphor materials used for full colour ac electroluminescent displays, particularly those employing thick film dielectric layers with a high dielectric constant.

Background to the Invention

Thick film dielectric structures provide for superior resistance to dielectric breakdown, as well as a reduced operating voltage, compared to thin film electroluminescent (TFEL) displays e.g. as exemplified by U.S. patent 5,432,015. The thick film dielectric structure when it is deposited on a ceramic substrate will withstand higher processing temperatures than TFEL devices, which are typically fabricated on glass substrates. This increased high temperature tolerance facilitates annealing of phosphor films at higher temperatures to improve their luminosity. With these advantages and with recent advances in blue-emitting phosphor materials, displays have approached the luminosity and colour coordinates required to achieve the technical performance of traditional cathode ray tube (CRT) displays. Nevertheless, further improvement in green and blue phosphor performance is required to simplify display design, to improve display reliability by lowering operating voltages and to keep pace with a trend towards higher colour temperature specifications for displays.

Traditionally, the phosphor materials of choice for full colour electroluminescent displays have been cerium-activated strontium sulphide for blue and manganese-activated zinc sulphide for red and green colours.

The optical emission from these phosphor materials must be passed through an appropriate chromatic filter to achieve the necessary colour coordinates for red, green and blue sub-pixels, resulting in a loss of luminance and energy efficiency. The manganese-activated zinc sulphide phosphor has a relatively high electrical to optical energy conversion efficiency of up to about 10 lumens per watt of input power. Cerium-activated strontium sulphide phosphor has an energy conversion efficiency of 1 lumen per watt, which is relatively high for blue emission. However, the spectral emission for these phosphors is quite wide, with spectral emission for the zinc sulphide-based phosphor material spanning the colour spectrum from green to red and that for the strontium sulphide-based material spanning the range from blue to green. This necessitates the use of the optical filters. The spectral emission of the cerium-activated strontium sulphide phosphor can be shifted to some degree towards the blue by controlling the deposition conditions and activator concentration, but not to the extent required to eliminate the need for an optical filter.

Alternate blue phosphor materials that have narrower emission spectra tuned to provide the colour coordinates required for a blue sub-pixel have been evaluated. The materials include cerium-activated alkaline earth thiogallate compounds, which give good blue colour coordinates, but have relatively poor luminosity and stability. Higher luminosity and excellent colour coordinates for blue pixels have been achieved with europium-activated barium thioaluminate phosphor materials. Higher luminosity and excellent colour coordinates for green pixels have been achieved with europium-activated calcium thioaluminate phosphor materials.

The use of gadolinium as a co-activator to enhance the luminosity of rare earth-activated zinc sulphide phosphor materials in thin film electroluminescent devices is known. In particular, U.S. Patent 4,967,251 teaches the use of a red light emitting samarium-activated zinc sulphide phosphor layer in a thin film electroluminescent device. Co-doping of the phosphor material with less than 2 atomic percent of gadolinium resulted in the luminosity being increased by about two-fold. Use of a gadolinium co-

activated thulium-activated zinc sulphide phosphor for blue light emission was also described. However, even with the co-activator, the blue luminance was insufficient for use in commercial electroluminescent displays.

Gadolinium is known to function as an activator for the emission of ultraviolet light in a zinc magnesium sulphide phosphor material. For instance, U.S. Patent 5,670,839 teaches an electroluminescent device with a gadolinium-activated $Zn_{1-x}Mg_xS$ phosphor layer where $0.33 < x < 1$. The phosphor emits ultraviolet light with a wavelength of 310 nanometers. The zinc magnesium sulphide material is said to have a sufficiently large band gap that it does not absorb the ultraviolet light generated by the gadolinium activator. Use of such an ultraviolet emitting phosphor in conjunction with a second adjacent phosphor film that can be photostimulated by the ultraviolet light to emit visible light and thereby create a display is also disclosed. The visible light emitting activators were in a different material from the gadolinium activators.

Summary of the Invention

One aspect of the present invention provides a thin film phosphor for an electroluminescent device, said phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said phosphor being activated by a rare earth metal and co-activated with gadolinium.

In a preferred embodiment of the present invention, the phosphor is a thioaluminate.

In another embodiment, said rare earth metal is europium or cerium, especially europium.

In another preferred embodiment, the cation is calcium.

In further embodiments, the phosphor contains europium in an amount in the range of 1 to 10 atomic percent and gadolinium in an amount in the range of 1 to 5 atomic percent. Preferably, the amount of europium is between

two and eight percent and the amount of gadolinium is between two and four atomic percent.

Aspects of the present invention also provide an electroluminescent device comprising a thin film phosphor as described herein on a substrate.

Further aspects of the present invention provide an electroluminescent device in which the thin film phosphor is adjacent to a thin film of zinc sulphide. Preferably, the thin film phosphor is sandwiched between thin films of zinc sulphide.

Brief Description of the Drawings

The present invention will be described with reference to the embodiments shown in the drawings, in which:

Fig. 1 is a schematic representation of a section of an electroluminescent element comprising a thick film dielectric layer and a phosphor composition typical of the present invention;

Fig. 2 is a schematic representation of a plan view of a full colour electroluminescent pixel and its constituent sub-pixels;

Fig. 3 is a graphical representation of photoluminescence spectra for several calcium magnesium thioaluminate powders doped with europium and co-doped with gadolinium;

Fig. 4 is a graphical representation of luminosity as a function of applied voltage for several electroluminescent devices with calcium thioaluminate phosphors having different europium activator and gadolinium co-activator concentrations;

Fig. 5 is a graphical representation of luminosity of similar electroluminescent devices where the phosphor layer is sandwiched between un-doped zinc sulphide films;

Fig. 6 is a graphical representation of luminosity of electroluminescent devices made with and made without gadolinium co-activator;

Fig. 7 is a graphical representation of energy efficiency of electroluminescent devices having different activator and co-activator concentrations;

Fig. 8 is a graphical representation of charge injection as a function of applied voltage across electroluminescent devices having different activator and co-activator concentrations; and

Fig. 9 is a graphical representation of the luminosity of electroluminescent devices having phosphors of different thickness.

Detailed Description of the Invention

The present invention relates to gadolinium as a co-activator in alkaline earth thioaluminate phosphors, and especially to the incorporation of gadolinium as a co-activator in such phosphors when they are deposited as thin films in electroluminescent displays. In embodiments, and as exemplified herein, the electroluminance of europium-activated calcium thioaluminate, a green emitting phosphor, is increased by a factor of about two when it is co-doped with about three atomic percent of gadolinium. The CIE colour coordinates of the phosphor are relatively unaffected by the addition of gadolinium as co-activator. Further aspects of the invention relate to the encapsulation of the gadolinium co-doped thin film phosphors between thin films of zinc sulphide to further improve performance. As exemplified, the zinc sulphide layers increase the slope of the luminescence versus voltage curve for electroluminescent devices as compared to similar devices having the same phosphor at the same thickness but without the zinc sulphide layers.

The present invention is particularly directed to use of gadolinium co-activator and a rare earth activator in an alkaline earth thioaluminate host material to form a phosphor. It is believed that the invention is applicable to ternary, quaternary and higher thioaluminate, thiogallate and thioindate phosphors, and composites thereof synthesized, with cation(s) for these compounds selected from Groups IIA and IIB of the Periodic Table of Elements. Examples of such cations include barium, calcium, strontium, magnesium and zinc. A variety of rare earth activators may be used in conjunction with gadolinium in the phosphors, especially europium and

cerium. The preferred activator used in conjunction with gadolinium is europium. In preferred embodiments of the invention, gadolinium is used as co-activator of calcium thioaluminate ($CaAl_2S_4$) phosphors, which emit green light. In embodiments of the invention, the activator is europium in amounts of 1-10 atomic percent, preferably 2-8 atomic percent, and the amount of gadolinium used as co-activator is 1-5 atomic percent and preferably 2-4 atomic percent, especially with calcium thioaluminate as the phosphor.

The present invention is further illustrated by the embodiment shown in Figures 1 and 2. Figure 1 shows a cross-section of an electroluminescent device utilizing a phosphor of the present invention. Figure 2 shows a plan view of the electroluminescent device. The electroluminescent device, generally indicated by 10, has a substrate 12 on which is located row electrode 14. Thick film dielectric 16 has thin film dielectric 18 thereon. Thin film dielectric 18 is shown with three pixel columns, referred to as 20, 22 and 24, located thereon. The pixel columns contain phosphors to provide the three basic colours viz. red, green and blue. Pixel column 20 has red phosphor 26 located in contact with thin film dielectric 18. Another thin film dielectric 28 is located on red phosphor 26, and column electrode 30 is located on thin film dielectric 28. Similarly, pixel column 22 has green phosphor 32 on thin film dielectric 18, with thin film dielectric 34 and column electrode 36 thereon. Pixel column 24 has blue phosphor 38 on thin film dielectric 18, with thin film dielectric 40 and column electrode 42 thereon.

A variety of substrates may be used, as will be understood by persons skilled in the art. The preferred substrate is a substrate that is opaque in the visible and infrared regions of the electromagnetic spectrum. In particular, the substrate is a thick film dielectric layer on a ceramic substrate. Examples of such substrates include alumina, and metal ceramic composites.

The deposition of the composition may be carried out in an atmosphere of H_2S, sulphur or other volatile sulphur bearing compounds that will not contaminate the phosphor film as it is deposited if there is a tendency for the deposited compound to be deficient in sulphur. In particular, the deposition is done in a hydrogen sulphide atmosphere so that deposited species in the film

can react with sulphide derived from the hydrogen sulphide to adequately saturate the deposited film with sulphide and achieve the desired film composition. However, in some instances, it may be possible to operate the method in a low pressure inert gas atmosphere without H_2S.

The deposition can be done by electron beam evaporation, particularly dual source electron beam evaporation as exemplified by U.S. patent application 09/747,315 or by rf magnetron sputtering wherein there is a facility for injecting and exhausting gases including hydrogen sulphide and wherein the deposition substrate has a heating means.

Alkaline earth thioaluminates have been reported to have utility as electroluminescent phosphors, but with low luminosity. It has been found that improved control of the stoichiometry of the host material facilitates an electroluminescent element with higher luminance. It has now been found that the use of gadolinium as a co-activator facilitates an electroluminescent element with still higher luminance.

In further aspects of the invention, the gadolinium co-doped thin film phosphor is located adjacent to a thin film of zinc sulphide. In particularly preferred embodiments, the gadolinium co-doped thin film phosphor is encapsulated or sandwiched between thin films of zinc sulphide. As exemplified, the zinc sulphide layers increase the slope of the luminescence versus voltage curve for electroluminescent devices as compared to similar devices having the same phosphor at the same thickness but without the zinc sulphide layer

The present invention is illustrated by the following examples.

Example I

A series of europium-doped magnesium calcium thioaluminate powders were prepared by blending powders of calcium sulphide, magnesium sulphide, aluminum sulphide, europium sulphide and gadolinium fluoride in various ratios. The calcium magnesium thioaluminate phosphor powders had the nominal composition $Ca_{0.8}Mg_{0.2}Al_2S_4$:x Eu, y Gd. Samples were

prepared with (i) x = 0.03 and y = 0.01, (ii) x = 0.03 and y = 0.03, (iii) x = 0.07 and y = 0.01 and (iv) x = 0.07 and y = 0.03.

The blended powders were pressed to form pellets with a diameter of 1.3 cm and a height of 0.75 cm. The pellets were annealed in an alumina boat in a nitrogen environment at about 900°C for 10 minutes. However, the actual temperatures of the pellet may have been lower due to the large thermal loading introduced by the alumina boat.

The photoluminescence spectra of the resultant phosphors were measured using a Model 814 photomultiplier detection system and an A-1010B Arc Lamp xenon flash lamp from Photon Technology International of London, Ontario, Canada.

The photoluminescence spectra are shown in Fig. 3. The spectra have two peaks, one at about 520 nanometers i.e. a green emission, and the other at about 660 nanometers i.e. a red emission. For the two samples with y = 0.01 i.e. 1 atomic % gadolinium, the ratio of the height of the 520 nanometer peak to that of the 660 nanometer peak is about 1.5:1. For the samples with y = 0.03 i.e. 3 atomic % gadolinium, the ratio of these peaks is increased to about 9:1. Thus, it is evident that an increased gadolinium content causes a suppression of the red emission relative to the green emission. This is beneficial in two respects. First, the green luminosity is increased, thereby providing a more efficient green phosphor. Secondly, a filter would not be required to eliminate red emission, thereby potentially reducing the cost of a display and eliminating attenuation of the green emission by the filter.

Example II

Three europium-activated and gadolinium co-activated calcium thioaluminate phosphor films were formed on a thick film substrate. The thick film substrate was comprised of a 5 cm by 5 cm alumina substrate having a thickness of 0.1 cm. A gold electrode was deposited on the substrate, following which a thick film high dielectric constant dielectric layer was deposited in accordance with the methods exemplified by WO 00/70917 of Wu et al. A thin film dielectric consisting of barium titanate, with a thickness of

100-200 nanometers, was deposited on top of the thick film dielectric using the sol gel technique described in U.S. Patent Application 09/761,971.

The phosphor film was electron beam evaporated on top of the barium titanate layer using dual source electron beam evaporation according to the methods described in U.S. Patent Application 09/747,315. The two evaporation sources were aluminum sulphide and a fused mixture of calcium sulphide, europium sulphide and gadolinium fluoride. Both evaporation sources were in the form of pellets, which were prepared using the method outlined in Example I.

The phosphor deposition was carried out in a low pressure atmosphere of hydrogen sulphide at a pressure of 0.1 millitorr, and with the substrate at a temperature of 200°C. The deposition was carried out by electron beam evaporation using dual sources, one of aluminum sulphide, and the other containing the remaining constituents of the phosphor material. The deposition rate of the aluminum sulphide, as measured in the absence of the remaining constituents using a quartz crystal monitor, was 6 Angstroms per second and the deposition rate of the remaining constituents in the absence of aluminum sulphide, also as measured using a quartz crystal monitor, was 3 Angstroms per second. The deposited phosphor film thickness was 4000 Angstroms.

The first of the phosphor films had (Sample A) a europium concentration of seven atomic percent and a gadolinium concentration of zero atomic percent. The second phosphor film (Sample B) had a europium concentration of three atomic percent and a gadolinium concentration of three atomic percent. The third phosphor film (Sample C) had a europium concentration of 7 atomic percent and a gadolinium concentration of 3 atomic percent.

Following deposition, the phosphor-coated substrate was annealed under a nitrogen atmosphere at a temperature of 650°C for 5 minutes. A 50 nanometer thick alumina thin film and an indium tin oxide transparent conductor were deposited over the phosphor to provide a second electrode.

The resultant devices were tested using alternating polarity 32 microsecond wide square-wave pulses and a frequency of 240 Hz. The pulse amplitude was varied in increments of 10 volts up to 260 volts. The results are shown in Fig. 4.

The device with the phosphor film having seven atomic percent europium and no gadolinium showed a green emission with CIE colour coordinates of x = 0.185 and y = 0.634 and a maximum luminosity of about 1000 candelas per square meter. The device with the phosphor film having three atomic percent europium and three atomic percent gadolinium had similar CIE coordinates of x = 0.180 and y = 0.605, and a maximum luminosity of about 1400 candelas per square meter. The third substrate with a phosphor film having seven atomic percent of europium and three atomic percent of gadolinium again had similar CIE coordinates of x = 0.193 and y = 0.632. However, as seen in Fig .4, the highest maximum luminosity was 1700 candelas per square meter. All devices had an optical threshold voltage, above which light is emitted, of about 120 volts and a fairly gradual onset of luminosity above the threshold voltage.

In summary, the addition of 3 atomic percent of gadolinium to a phosphor activated with seven atomic percent of europium yielded an increase in luminosity of about 70 percent. Increasing the concentration of europium from three atomic percent to seven atomic percent in the presence of three atomic percent gadolinium gave rise to a luminosity increase of about 20 percent.

Example III

Four devices similar to those in Example II were fabricated and tested except that additional un-doped zinc sulphide layers were interposed between the phosphor film and the encapsulating dielectric layers. Two of these devices (Samples D and E) had phosphor films doped with three atomic percent europium and three atomic percent gadolinium and the remaining two devices (Samples F and G) had phosphor films doped with seven atomic percent europium and three atomic percent gadolinium. The lower zinc

sulphide layer, which was adjacent to the thick film layer, had a thickness of 1000 Angstroms thick. The other (upper) zinc sulphide layer was 500 Angstroms thick. Both were deposited at a rate of 10 Angstroms per second using electron beam evaporation. The thickness of the phosphor layer was 4000 Angstroms, as in Example II.

The resultant devices were tested using the procedure of Example II, and the results obtained are shown in Fig. 5. The two sets of nominally identical devices had very similar behaviour. The devices with the higher europium concentration had a luminance that was about 20 percent greater than the devices with the lower europium concentration. This is consistent with the proportional improvement noted for devices with similar phosphor compositions described in Example II.

It is to be particularly noted that the devices of Example III show an overall higher luminance than the devices in Example II. The latter devices did not have zinc sulphide layers sandwiching the phosphor layer.

Comparison of the results in Fig.s 4 and 5 reveals an increase in luminance at a specified voltage and phosphor composition of about 60 percent for devices that have the zinc sulphide layers. The devices with the zinc sulphide layers also show a sharper onset of luminance above the threshold voltage, thus facilitating easier gray scale control and reduced power consumption for the display panel. While not being bound by any theory, these improvements may be related to the zinc sulphide layers acting as acceleration layers to increase the density and energy of electrons injected into the phosphor layer, thereby minimizing the thickness of the dead layer in the phosphor that does not emit light due to an insufficient density of electrons with the energy required to cause light emission.

Example IV

In order to separate effects of performance variations caused by random or uncontrolled variation in process or fabrication conditions, luminance versus applied voltage curves for a large number of nominally

identical devices with and without gadolinium co-activation were reviewed. The measurement of luminance was as described herein.

The highest luminance performance observed for the devices with and without gadolinium as co-activator is shown graphically in Fig. 6.

The results show that gadolinium co-activation provides a significant increase in luminance for a specified operating voltage.

Example V

The efficiency, in lumens per watt of input electrical energy, was measured for devices similar to those in the previous examples.

Fig. 7 shows efficiency data for devices having phosphors with (i) seven atomic percent europium and no gadolinium (Sample H) (ii) three atomic percent europium and three atomic percent gadolinium (Sample I) and (iii) seven atomic percent europium and three atomic percent gadolinium (Sample J). The data shows that addition of three atomic percent gadolinium to devices with phosphors containing seven atomic percent europium resulted in a two fold increase in efficiency. The increase in efficiency is a reflection of the increase in luminance.

It will be noted that in this example the highest electroluminescent intensity is obtained for 7 atomic percent europium, whereas the highest photoluminescent intensity was obtained for 3 atomic percent europium. It is to be understood that the mechanisms for photoluminescence are different from those for electroluminescence. Photoluminescence likely depends significantly on the surface morphology of the samples, so this observed difference is not believed to be surprising and therefore should not be interpreted as being significant.

Fig. 8 shows the associated charge injection data for these devices. The injected charge was measured by applying a square-wave voltage signal having a 32 microsecond pulse width and a repetition rate of 240 Hz to the device, and measuring the resulting current using a Tektronix P6022 current probe in series with the device.

The data shows that the efficiency increase is due not only to an increase in luminance, but also to a reduction in the charge injected into the devices at a specified operating voltage.

An increase in efficiency was observed, which is a reflection of the observed increase in luminance for the samples in this example.

Example VI

In a comparative test, a device similar to that in Example II was constructed, except that (i) gadolinium was not added and (ii) three atomic percent europium was added in the form of europium fluoride rather than europium sulphide.

It was found that there was no increase in luminosity over that for a similar device where the europium was added as europium sulfide.

This example shows that the luminosity enhancement according to the present invention is due to co-activation with gadolinium, rather than the inclusion of fluoride in the phosphor.

Example VII

A device with a phosphor having seven atomic percent europium and three atomic percent gadolinium and similar to that in Example III was constructed, except that the thickness of the phosphor layer was 6000 Angstroms rather than 4000 Angstroms. The comparative test results for the devices with layers with thicknesses of 6000 Angstroms and 4000 Angstroms are shown in Figure 9.

The device with the thicker layer has a higher threshold voltage. However, the slope of the luminance against voltage curve for this device is more linear and substantially steeper, facilitating a higher ultimate luminance, compared to the device with the thinner layer. Both devices show the same luminance at about 225 volts, but the characteristics of the device with the thicker layer facilitates the use of a lower column voltage to operate a matrix addressed display. As explained in U.S. patent application 09/504,472, the use of lower column voltages increases the energy efficiency of matrix

addressed electroluminescent displays, while ensuring that the display exhibits a high contrast ratio.

CLAIMS:

1. A thin film phosphor for an electroluminescent device, said phosphor being selected from the group consisting of thioaluminates, thiogallates and thioindates having at least one cation selected from elements of Groups IIA and IIB of the Periodic Table of Elements, said phosphor being activated by a rare earth metal and co-activated with gadolinium.

2. The thin film phosphor of Claim 1 in which the phosphor is a thioaluminate.

3. The thin film phosphor of Claim 2 in which said rare earth metal is europium or cerium.

4. The thin film phosphor of Claim 3 in which the rare earth metal is europium.

5. The thin film phosphor of Claim 4 in which the cation is calcium.

6. The thin film phosphor of Claim 5 in which the phosphor contains europium in an amount in the range of 1 to 10 atomic percent and gadolinium in an amount in the range of 1 to 5 atomic percent.

7. The thin film phosphor of Claim 6 in which the amount of europium is between 2 and 8 atomic percent and the amount of gadolinium is between 2 and 4 atomic percent.

8. An electroluminescent device comprising a thin film phosphor of Claim 1 on a substrate.

9. The electroluminescent device of Claim 8 in which the phosphor is a thioaluminate.

10. The electroluminescent device of Claim 9 in which said rare earth metal is europium or cerium.

11. The electroluminescent device of Claim 9 in which the rare earth metal is europium.

12. The electroluminescent device of Claim 11 in which the cation is calcium.

13. The electroluminescent device of Claim 12 in which phosphor contains europium in an amount in the range of 1 to 10 atomic percent and gadolinium in an amount in the range of 1 to 5 atomic percent.

14. The electroluminescent device of Claim 13 in which the amount of europium is between 2 and 8 atomic percent and the amount of gadolinium is between 2 and 4 atomic percent.

15. The electroluminescent device of Claim 8 in which the thin film phosphor is adjacent to a thin film of zinc sulphide.

16. The electroluminescent device of Claim 13 in which the thin film phosphor is sandwiched between thin films of zinc sulphide.

17. The electroluminescent device of Claim 15 in which the phosphor is a thioaluminate.

18. The electroluminescent device of Claim 17 in which said rare earth metal is europium or cerium.

19. The electroluminescent device of Claim 18 in which the rare earth metal is europium.

20. The electroluminescent device of Claim 19 in which the cation is calcium.

21. The electroluminescent device of Claim 20 in which phosphor contains europium in an amount in the range of 1 to 10 atomic percent and gadolinium in an amount in the range of 1 to 5 atomic percent.

22. The electroluminescent device of Claim 21 in which the amount of europium is between 2 and 8 atomic percent and the amount of gadolinium is between 2 and 4 atomic percent.

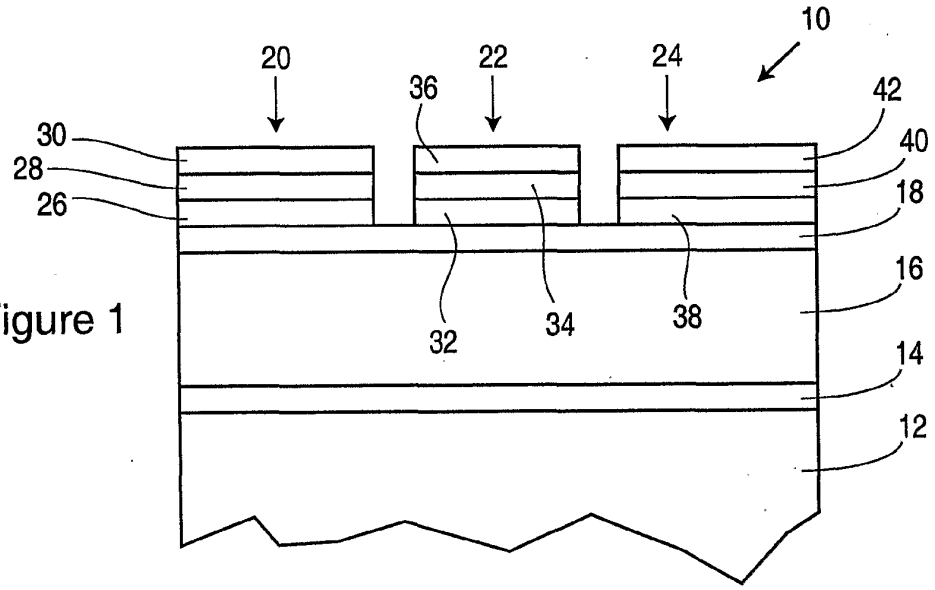


Figure 1

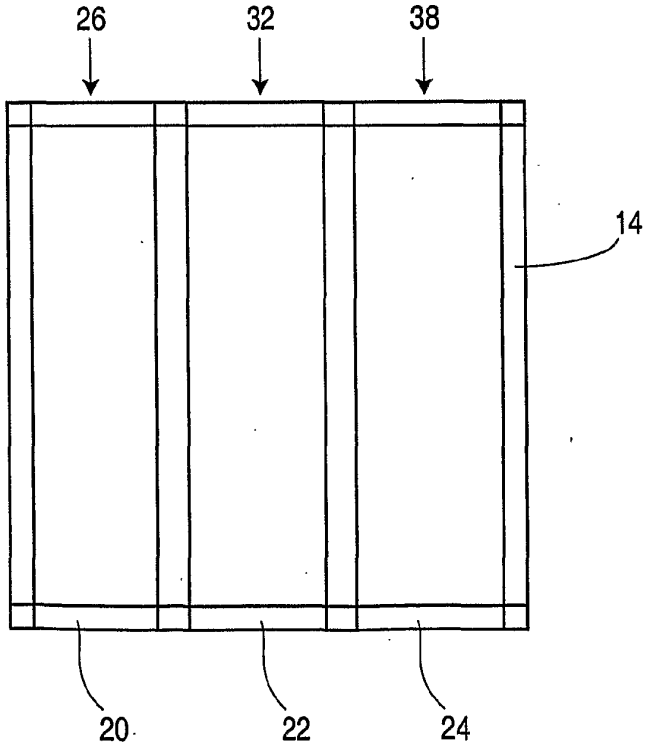


Figure 2

Figure 3

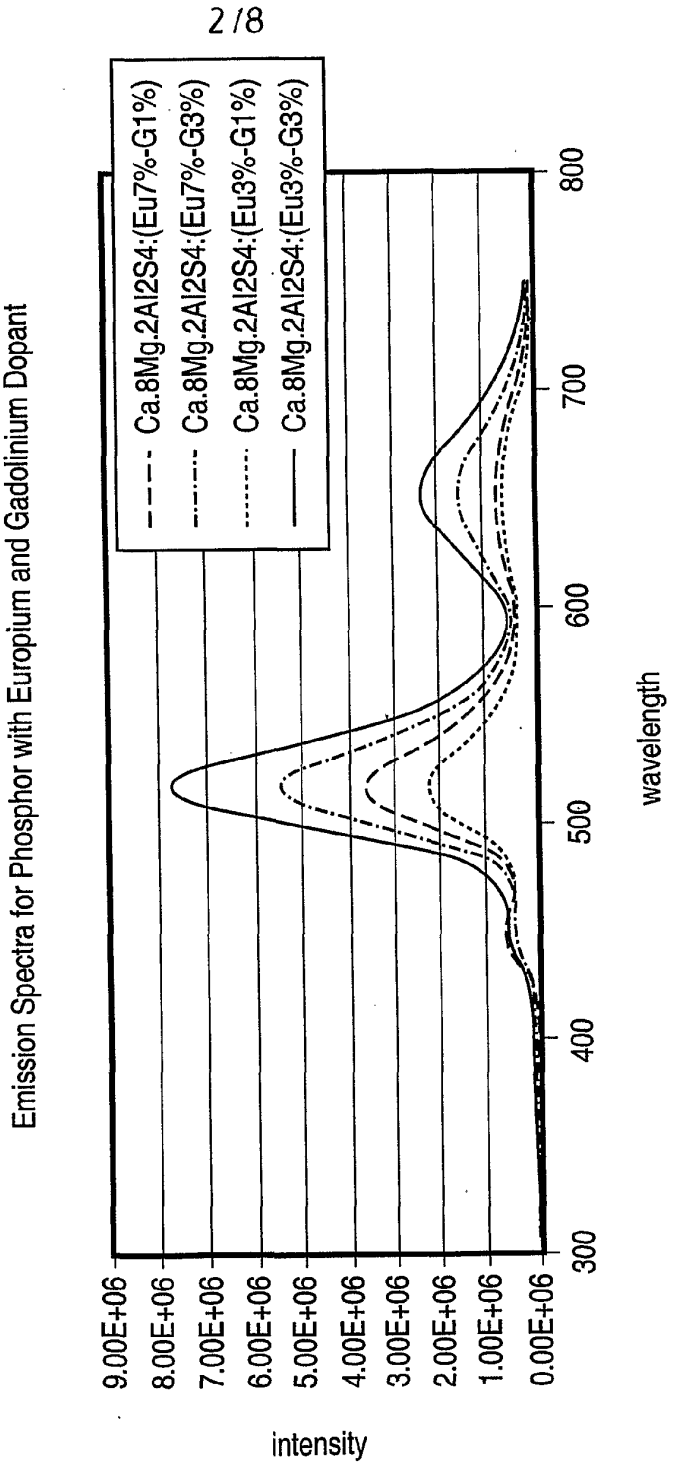
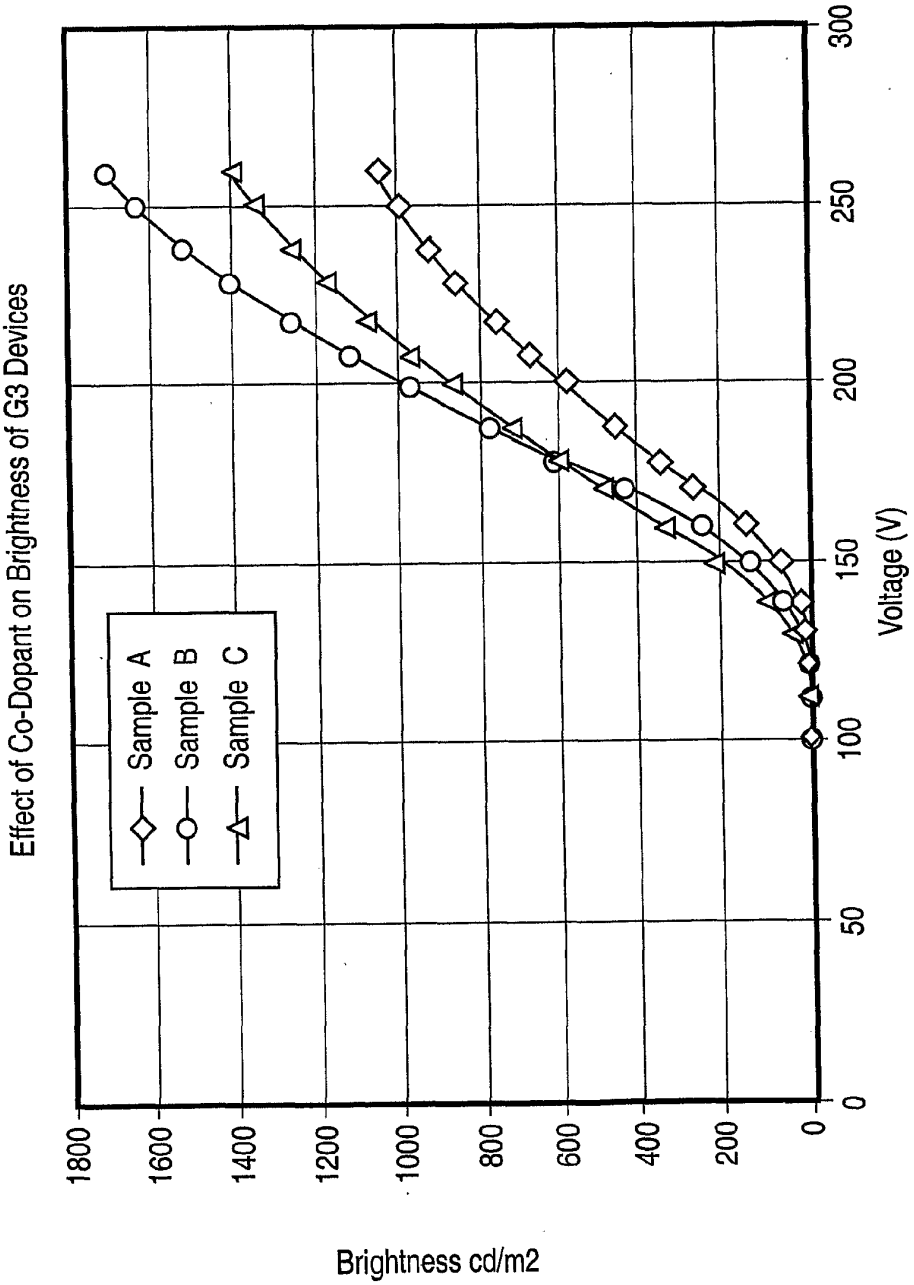

Emission Spectra for Phosphor with Europium and Gadolinium Dopant
Ca.8Mg.2Al2S4:(Eu7%-G1%)
Ca.8Mg.2Al2S4:(Eu7%-G3%)
Ca.8Mg.2Al2S4:(Eu3%-G1%)
Ca.8Mg.2Al2S4:(Eu3%-G3%)
intensity
9.00E+06
8.00E+06
7.00E+06
6.00E+06
5.00E+06
4.00E+06
3.00E+06
2.00E+06
1.00E+06
0.00E+06
300
400
500
600
700
800
wavelength

Figure 4


Effect of Co-Dopant on Brightness of G3 Devices
Sample A
Sample B
Sample C
Brightness cd/m2
Voltage (V)
1800
1600
1400
1200
1000
800
600
400
200
0
300
250
200
150
100
50
0

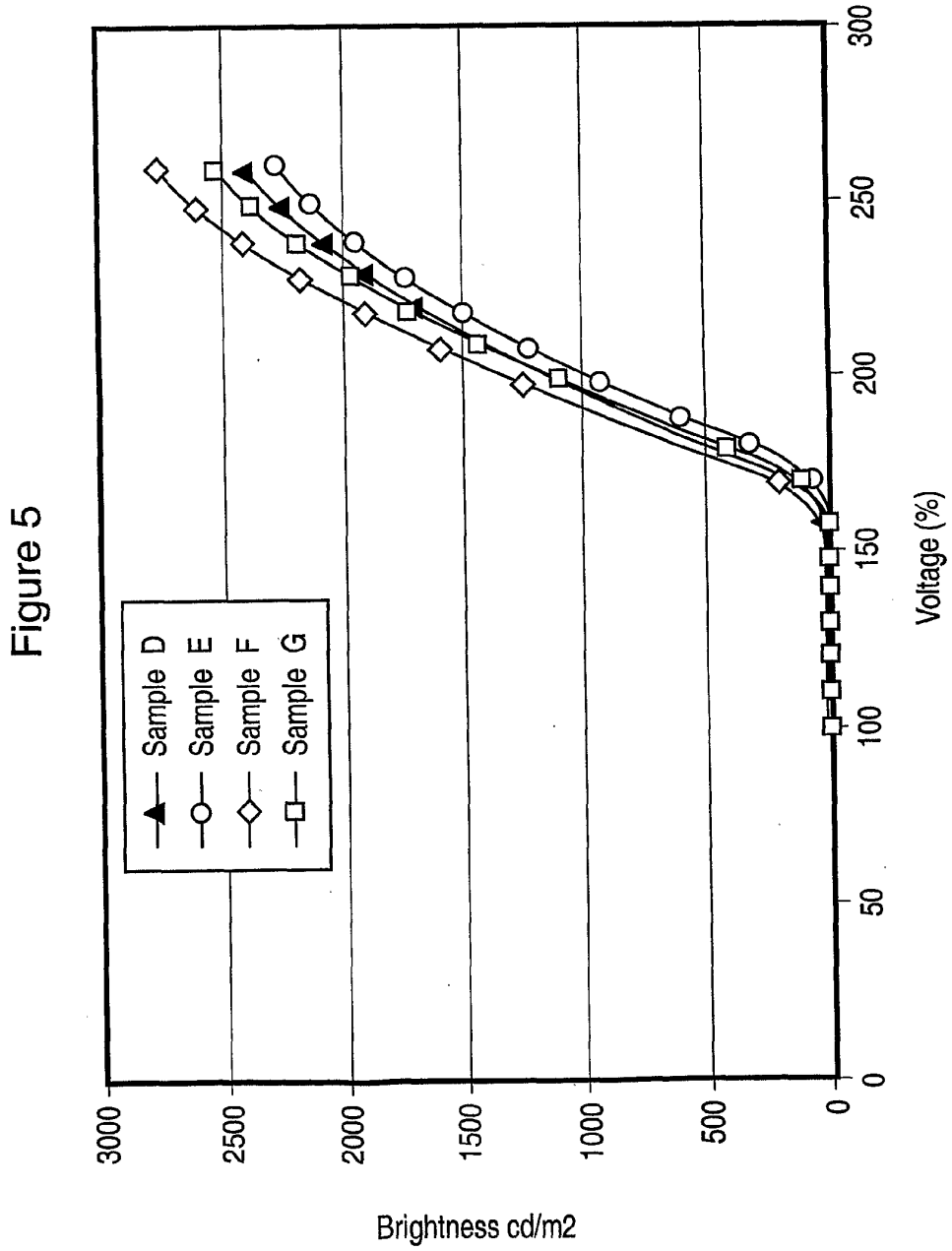
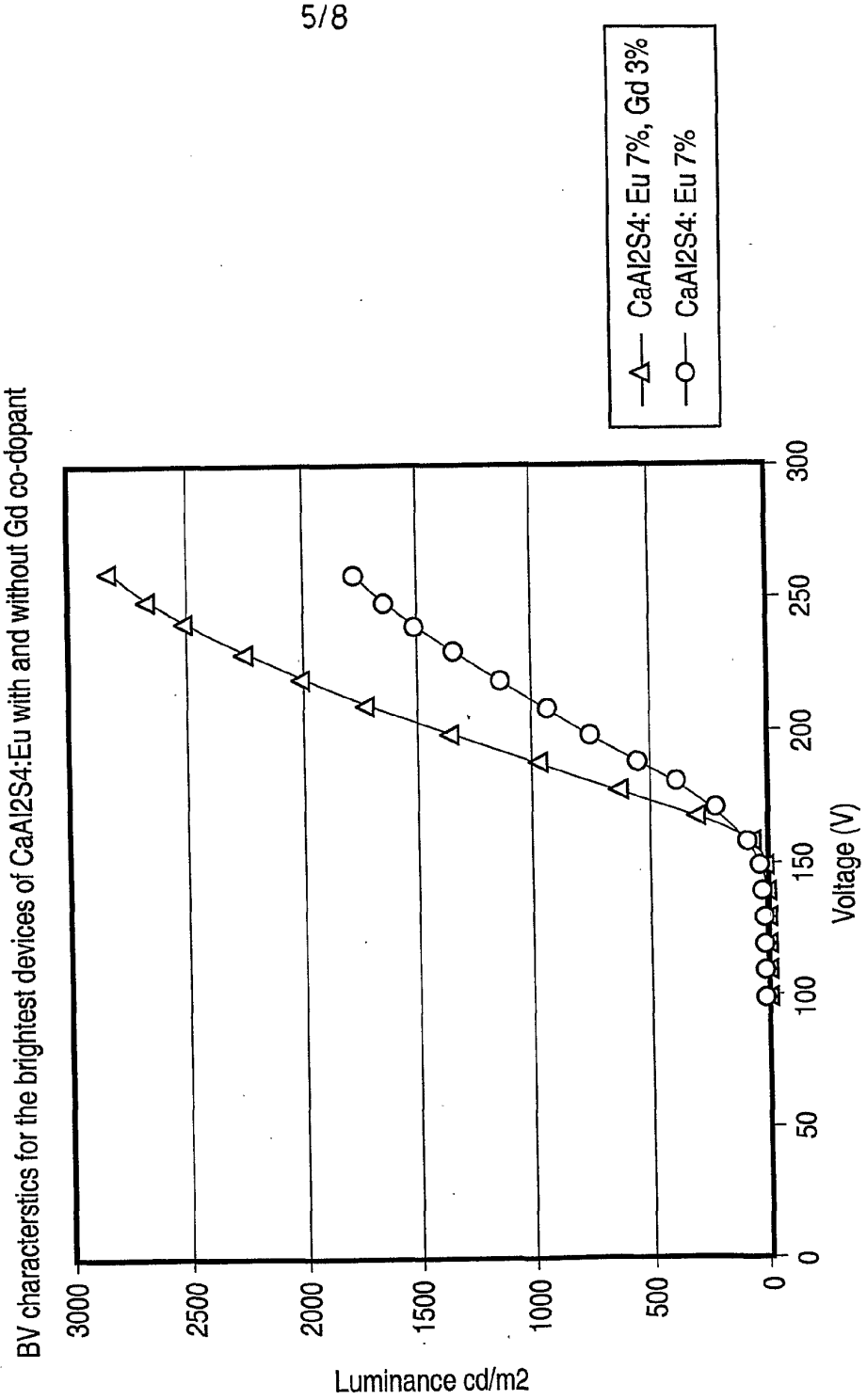

Sample D
Sample E
Sample F
Sample G
3000
2500
2000
1500
1000
500
0
Brightness cd/m2
300
250
200
150
100
50
0
Voltage (%)

Figure 5

Figure 6


BV characterstics for the brightest devices of CaAl2S4:Eu with and without Gd co-dopant
CaAl2S4: Eu 7%, Gd 3%
CaAl2S4: Eu 7%
Luminance cd/m2
Voltage (V)
0
500
1000
1500
2000
2500
3000
0
50
100
150
200
250
300

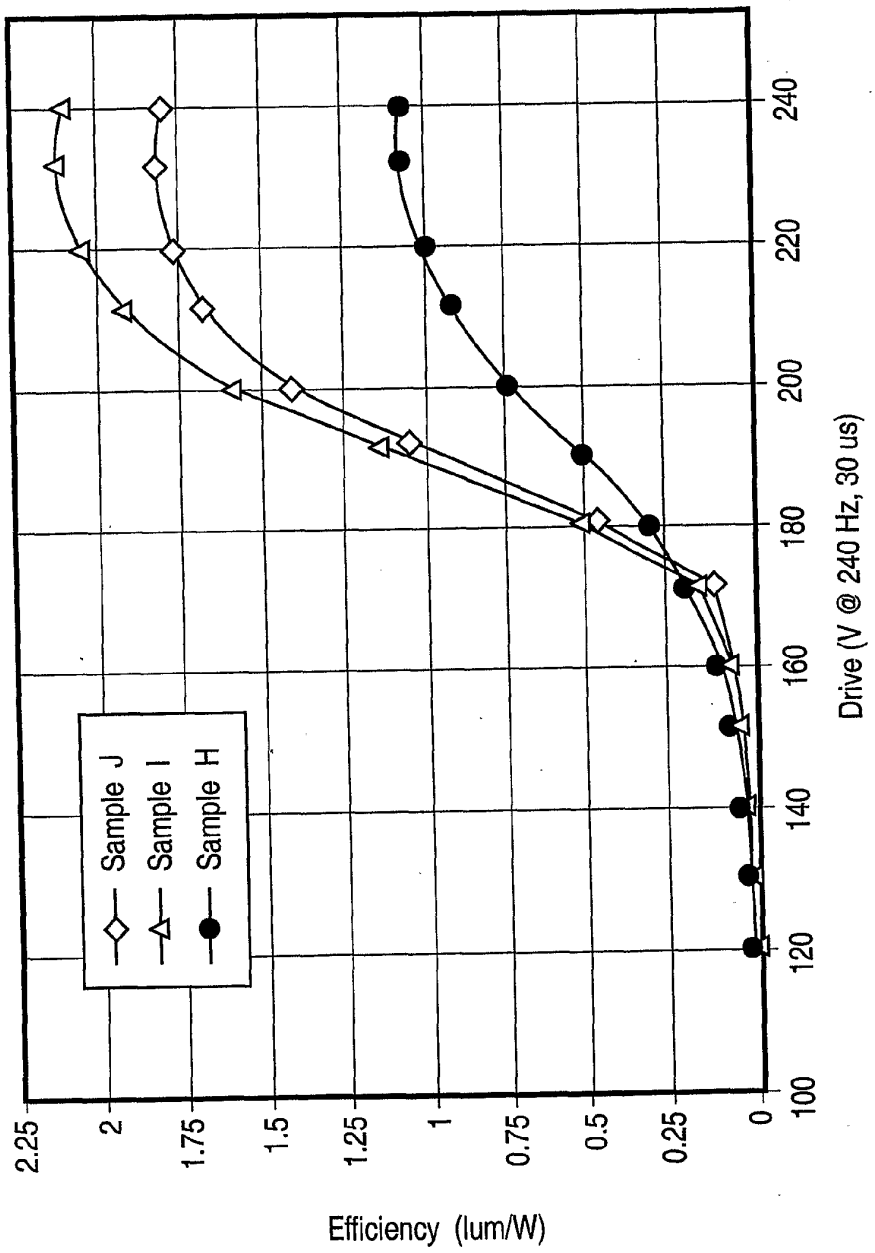

Sample J
Sample I
Sample H
Efficiency (lum/W)
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
Drive (V @ 240 Hz, 30 us)
100
120
140
160
180
200
220
240

Figure 7

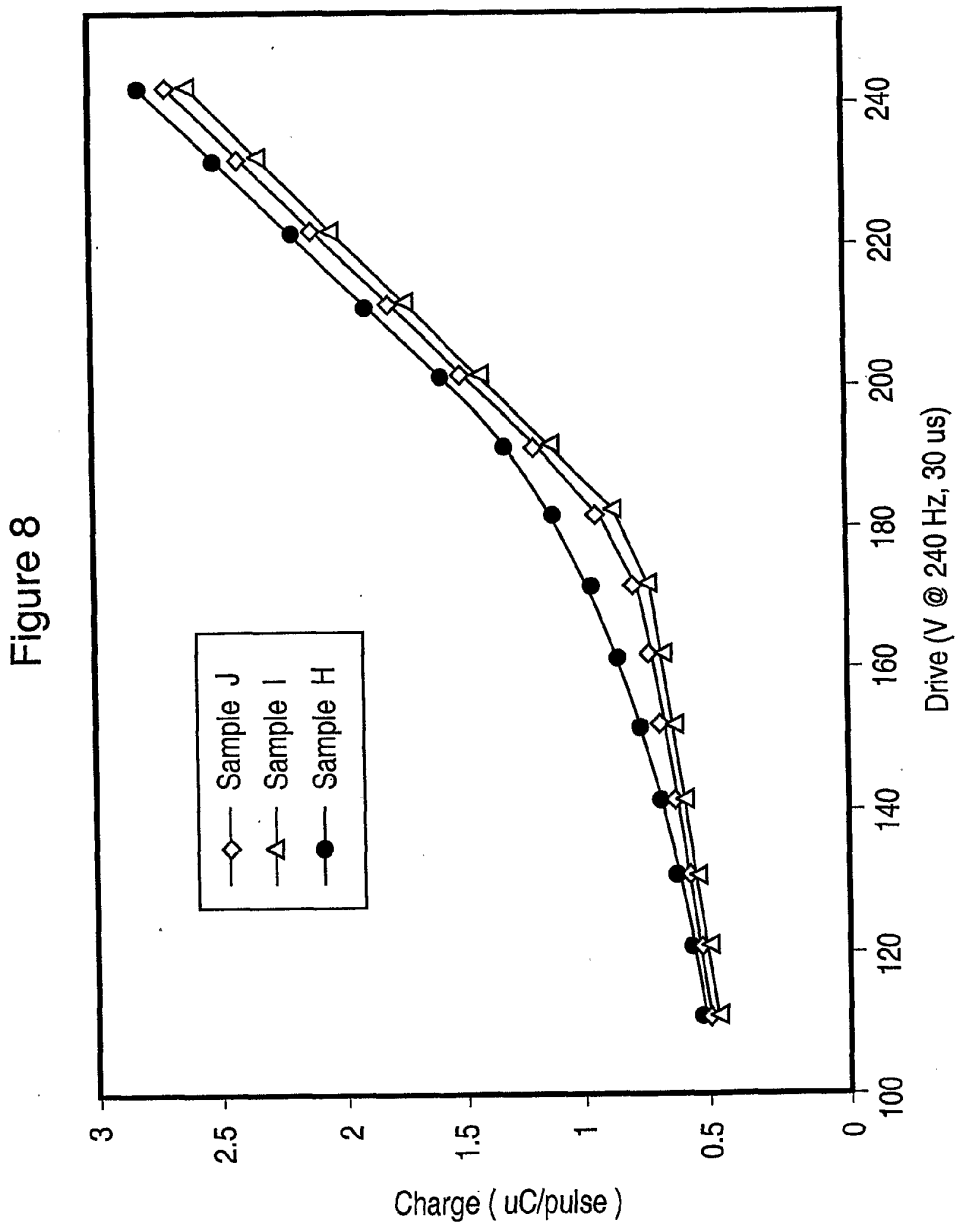
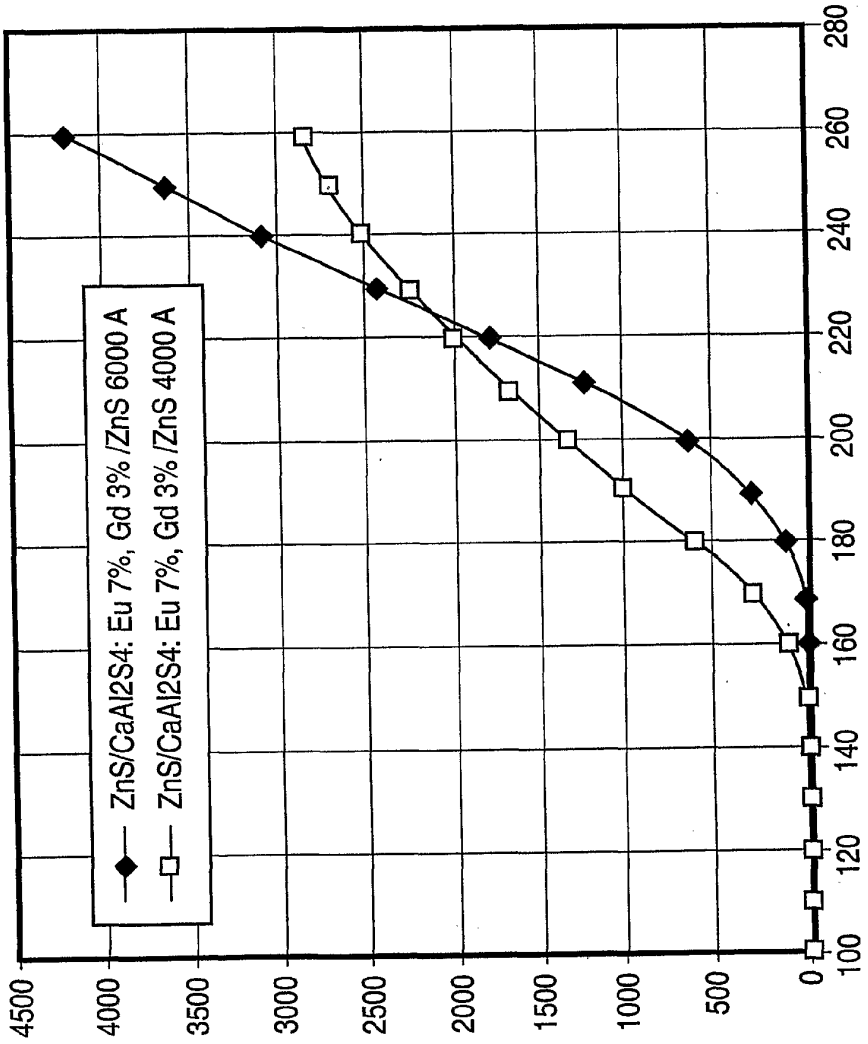

Sample J
Sample I
Sample H
Charge (uC/pulse)
Drive (V @ 240 Hz, 30 us)
3
2.5
2
1.5
1
0.5
0
100
120
140
160
180
200
220
240

Figure 8

Figure 9


ZnS/CaAl2S4: Eu 7%, Gd 3% /ZnS 6000 A
ZnS/CaAl2S4: Eu 7%, Gd 3% /ZnS 4000 A
4500
4000
3500
3000
2500
2000
1500
1000
500
0
100
120
140
160
180
200
220
240
260
280

INTERNATIONAL SEARCH REPORT

In ional Application No
PCT/CA 02/00690

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/14 C09K11/84

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)
IPC 7 C09K H05B

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 practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC, IBM-TDB, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 02 23957 A (WU XINGWEI ;CHEONG DAN DAEWEON (CA); IFIRE TECHNOLOGY INC (CA)) 21 March 2002 (2002-03-21) the whole document	1-14
A	US 6 025 677 A (MOSS III THOMAS S ET AL) 15 February 2000 (2000-02-15) the whole document	1,8,15
A,P	DE 100 28 266 A (PATRA PATENT TREUHAND ;OSRAM OPTO SEMICONDUCTORS GMBH (DE)) 13 December 2001 (2001-12-13) the whole document	1,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"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

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Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2002	04/09/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Drouot-Onillon, M-C

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INTERNATIONAL SEARCH REPORT

Information on patent family members

In ional Application No
PCT/CA 02/00690

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 0223957 A1	21-03-2002
US 6025677 A	15-02-2000	NONE	
DE 10028266 A	13-12-2001	DE 10028266 A1	13-12-2001
		WO 0195400 A1	13-12-2001

Form PCT/ISA/210 (patent family annex) (July 1992)

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(30)Priority: 27.09.1999 US1999 405947

(51)Int. Cl C09K 11/78

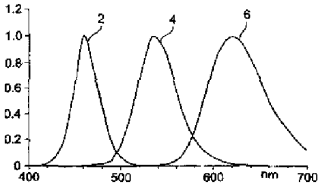
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(72)Inventor: MUELLER GERD O.
MUELLER MACH REGINA B.
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(54) **PHOSPHOR AND WHITE LIGHT LED LAMP USING THE PHOSPHOR**

(57) Abstract:

The present invention relates to a tri- color lamp for generating white light. In particular, the invention relates to a phosphor mixture comprising two phosphors having host sulfide materials that can absorb radiation emitted by a light emitting diode, particularly a blue LED. This arrangement provides a mixing of three light sources - light emitted from the two phosphors and unabsorbed light emitted from the LED. The phosphors can contain the same dopant, such as a rare earth ion, to allow matching of the phosphors in relation to the LED emitted radiation. Power fractions of each of the light sources can be varied to achieve good color rendering. The present invention also relates to an alternative to a green LED comprising a single green phosphor that absorbs radiation from a blue LED. A resulting device provides green light of high absorption efficiency and high luminous equivalent values.



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Legal Status
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Notification date of refusal decision (00000000)
Final disposal of an application (registration)
Date of final disposal of an application (20080513)
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국제출원일자 2000년09월25일
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09/405,947 1999년09월27일 미국(US)
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JP08096958 A*
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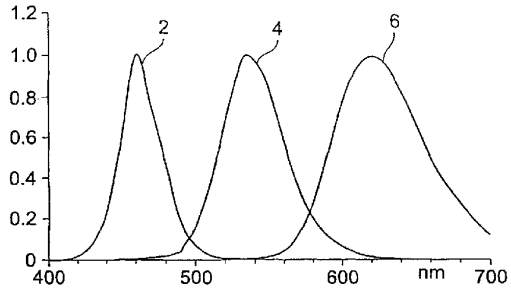
전체 청구항 수 : 총 21 항 심사관 : 이옥주

(54) 조성물 및 램프 장치

(57) 요 약

본 발명은 백색광을 발생하는 3색 램프에 관한 것이다. 특히, 본 발명은 발광 다이오드, 특히 청색 LED에 의해 방출되는 복사선을 흡수할 수 있는 호스트 황화물 재료를 갖는 2개의 형광물질로 이루어진 형광물질 혼합물에 관한 것이다. 이러한 배치는 3개의 광원, 즉 상기 2개의 형광물질에서 방출된 광 및 상기 LED로부터 방출된 비흡수광의 혼합물을 제공한다. 상기 형광물질은 희토류 이온 등의 동일한 도펀트를 포함하여 상기 LED 방출 복사선에 관하여 상기 형광물질을 정합할 수 있다. 상기 각 광원의 전력 비율은 양호한 색 랜더링을 달성하기 위하여 변화될 수 있다. 본 발명은 청색 LED로부터 복사선을 흡수하는 녹색 형광물질을 포함하는 녹색 LED의 대안에 관한 것이다. 그 결과로 만들어진 장치는 높은 흡수 효율 및 고광도 값을 제공한다.

대표도



(81) 지정국

국내특허 : 아랍에미리트, 안티구와바부다, 알바니아, 아르메니아, 오스트리아, 오스트레일리아, 아제르바이잔, 보스니아 헤르체고비나, 바베이도스, 불가리아, 브라질, 벨라루스, 벨리즈, 캐나다, 스위스, 중국, 코스타리카, 쿠바, 체코, 독일, 덴마크, 도미니카, 에스토니아, 스페인, 핀란드, 영국, 그라나다, 그루지야, 가나, 감비아, 크로아티아, 헝가리, 인도네시아, 이스라엘, 인도, 아이슬랜드, 일본, 케냐, 키르키즈스탐, 북한, 대한민국, 카자흐스탄, 세인트루시아, 스리랑카, 리베이라, 레소토, 리투아니아, 룩셈부르크, 라트비아, 모로코, 몰도바, 마다가스카르, 마케도니아공화국, 몽고, 말라위, 멕시코, 노르웨이, 뉴질랜드, 폴란드, 포르투칼, 루마니아, 러시아, 수단, 스웨덴, 싱가포르, 슬로베니아, 슬로바키아, 시에라리온, 타지키스탄, 투르크맨, 터어키, 트리니아드토바고, 탄자니아, 우크라이나, 우간다, 우즈베키스탄, 베트남, 세르비아 앤 몬테네그로, 남아프리카, 짐바브웨, 모잠비크

AP ARIPO특허 : 가나, 감비아, 케냐, 레소토, 말라위, 모잠비크, 수단, 시에라리온, 스와질랜드, 탄자니아, 우간다, 짐바브웨

EA 유라시아특허 : 아르메니아, 아제르바이잔, 벨라루스, 키르키즈스탐, 카자흐스탄, 몰도바, 러시아, 타지키스탄, 투르크맨

EP 유럽특허 : 오스트리아, 벨기에, 스위스, 사이프러스, 독일, 덴마크, 스페인, 핀란드, 프랑스, 영국, 그리스, 아일랜드, 이탈리아, 룩셈부르크, 모나코, 네덜란드, 포르투칼, 스웨덴

OA OAPI특허 : 부르키나파소, 베닌, 중앙아프리카, 콩고, 코트디브와르, 카메룬, 가봉, 기니, 기니 비사우, 말리, 모리타니, 니제르, 세네갈, 차드, 토고

특허청구의 범위

청구항 1

제 1 형광물질 및 제 2 형광물질의 혼합물(24)을 포함하되,

상기 제 1 형광물질과 상기 제 2 형광물질 각각은 호스트 황화물 재료(host sulphide material) 및 희토류 도펀트(rare earth dopant)를 포함하고 공통 발광 다이오드(22)에 의해 여기될 수 있으며,

상기 제 1 형광물질은 Eu^{2+} 도핑된 디오갈레이트(thiogallate)인 것을 특징으로 하는 조성물.

청구항 2

제 1 항에 있어서,

상기 제 2 형광물질의 상기 희토류 도펀트는 Eu^{2+} 및 Ce^{3+}로 이루어진 군으로부터 선택되는 조성물.

청구항 3

삭제

청구항 4

삭제

청구항 5

삭제

청구항 6

제 1 항에 있어서,

상기 제 2 형광물질의 호스트 황화물 재료는 CaS, SrS 및 디오갈레이트로 이루어진 군으로부터 선택되는 조성물.

청구항 7

제 6 항에 있어서,

상기 제 1 형광물질 및 상기 제 2 형광물질의 디오갈레이트는 $SrGa_2S_4$인 조성물.

청구항 8

제 1 항에 있어서,

상기 제 1 형광물질은 녹색 형광물질이고, 상기 제 2 형광물질은 적색 형광물질인 조성물.

청구항 9

제 8 항에 있어서,

상기 제 1 형광물질은 $SrGa_2S_4$:Eu인 조성물.

청구항 10

제 8 항에 있어서,

상기 제 2 형광물질은 SrS:Eu 및 CaS:Eu로 이루어진 군으로부터 선택되는 조성물.

청구항 11

제 2 항에 있어서,

상기 제 1 형광물질 및 상기 제 2 형광물질의 상기 희토류 도펀트들은 0.1 몰% 내지 8 몰%의 농도로 존재하는 조성물.

청구항 12

제 7 항에 있어서,

상기 제 1 형광물질의 상기 희토류 도펀트는 2 몰% 내지 4 몰%의 농도로 존재하는 조성물.

청구항 13

제 12 항에 있어서,

상기 제 2 형광물질은 SrS 호스트 재료를 포함하고, 상기 제 2 형광물질의 상기 희토류 도펀트는 0.3 몰% 내지 0.8 몰%의 농도로 존재하는 조성물.

청구항 14

제 1 항에 있어서,

상기 공통 발광 다이오드는 청색 발광 다이오드인 조성물.

청구항 15

삭제

청구항 16

제 1 항에 있어서,

상기 조성물은 15㎛ 미만의 알갱이 크기를 갖는 미립자인 조성물.

청구항 17

삭제

청구항 18

각각이 호스트 황화물 재료 및 희토류 도펀트를 포함하는 제 1 형광물질 및 제 2 형광물질의 혼합물(24)을 포함하되,

상기 제 1 형광물질은 발광 다이오드(22)에 의해 여기될 수 있고,

상기 제 2 형광물질은 상기 제 1 형광물질의 방출에 의해 여기될 수 있으며,

상기 제 1 형광물질은 Eu^{2+} 도핑된 디오갈레이트인 것을 특징으로 하는 조성물.

청구항 19

삭제

청구항 20

삭제

청구항 21

삭제

청구항 22

삭제

청구항 23

삭제

청구항 24

삭제

청구항 25

삭제

청구항 26

삭제

청구항 27

삭제

청구항 28

삭제

청구항 29

삭제

청구항 30

제 14 항에 있어서,

상기 각각의 형광물질은 450㎚ 내지 480㎚의 파장에서 복사선에 의해 여기될 수 있는 조성물.

청구항 31

광 패턴(26)을 방출하는 발광 다이오드(20)와,

제 1 항, 제 2 항, 제 6 항 내지 제 14 항, 제 16 항, 제 18 항 또는 제 30 항 중 어느 한 항에 따른 조성물을 포함하되,

상기 조성물은 상기 광 패턴(26)으로 배치되는 장치.

청구항 32

제 31 항에 있어서,

상기 발광 다이오드는 450㎚ 내지 480㎚의 파장으로 방출하는 장치.

청구항 33

제 32 항에 있어서,

상기 장치는 램프인 장치.

청구항 34

제 33 항에 있어서,

상기 램프는 백색 램프인 장치.

청구항 35

제 34 항에 있어서,

상기 램프는 2700K 내지 8000K의 색 온도에서 적어도 70의 색 랜더링 지수(Ra)를 갖는 복사선을 방출할 수 있는 장치.

청구항 36

제 35 항에 있어서,

상기 램프는 2700K 내지 8000K의 색 온도에서 적어도 80의 색 랜더링 지수(Ra)를 갖는 복사선을 방출할 수 있는 장치.

청구항 37

제 36 항에 있어서,

상기 램프는 2700K 내지 8000K의 색 온도에서 적어도 90의 색 랜더링 지수(Ra)를 갖는 복사선을 방출할 수 있는 장치.

명 세 서

기 술 분 야

<1> 본 발명은 2개의 형광물질의 혼합물 및 여기 에너지 소스용 발광 다이오드를 포함하는 3색 램프에 관한 것으로써, 특히 백색광을 발생하는 적색 형광물질 및 녹색 형광물질의 혼합물과 청색 LED를 채용한 램프에 관한 것이다.

배 경 기 술

<2> 특히 백색광의 생성시에 형광 장치에서 효율 및 색 품질을 개선하기 위하여 새로운 형광물질 조성물을 생성할 지속적인 필요성이 있다. 형광물질은 여기 에너지(일반적으로 방사 에너지)를 흡수하여 일정 시간 동안 저장할 수 있는 형광 재료(luminescent materials)이다. 그 저장된 에너지는 초기 여기 에너지와는 다른 에너지의 복사선으로써 방출된다. 예컨대, "다운 변환(down-conversion)"은 그 방출된 복사선이 초기의 여기 복사선보다 양자 에너지를 적게 갖는 상황을 나타낸다. 따라서, 그 에너지 파장은 효율적으로 증가하고, 이러한 증가는 "스토키 쉬프트(Stokes shift)"라 한다. "업 변환(Up-conversion)"은 그 방출된 복사선이 상기 여기 복사선보다 큰 양자 에너지를 갖는 상황을 나타낸다("안티 스토키 쉬프트)(Anti-Stokes shift).

<3> 형광물질 기반 디바이스에서 효율 및 색상 품질의 개선은 지속적으로 이루어져 왔다. "효율"은 여기 에너지로써 초기에 제공된 복수의 광자와 방출된 광자간의 비율과 관련이 있다. 비효율적인 변환은 에너지의 적어도 일부분이 비 복사 공정에 의해 소비될 때 발생한다. 색 "품질"은 복수의 다른 등급 시스템에 의해 측정될 수 있다. "색도"는 색조 및 포화에 의한 색을 정의한다. "CIE"는 커미션 인터내셔날 델 이클레러지(국제 조명 위원회)에 의해 구현된 색도 좌표 시스템이다. 상기 CIE 색도 좌표는 "1931 CIE" 색상 공간내의 색을 정의하는 좌표이다. 이러한 좌표는 x, y, z축으로써 정의되고, 3개의 3자극값의 합에 대한 3개의 표준 원색[X, Y, Z(3자극값)]의 비율이다. CIE 표는 3자극값 대 그 합의 x, y, z 비율의 플롯을 포함한다. 축소된 좌표(x, y, z)가 1을 증가시키는 상황에서는, 통상적으로 2차원 CIE(x,y) 플롯이 이용된다.

<4> 백색 유형의 색은 상관된 색 온도(CCT)에 의해 설명될 수 있다. 예컨대, 금속이 가열되면, 그 결과 초기에 붉은 색을 발산하는 광이 방출된다. 상기 금속을 가열하여 온도가 상승함으로써, 그 방출된 광은 적색 광에서 시작하여 백색광으로 전이되고, 궁극적으로 푸른빛을 띤 백색광으로 전이되는 높은 양자 에너지로 전이된다. 흑체 라디에이터로서 알려진 표준 객체 상에서 이러한 색의 변경을 판정하기 위한 시스템이 개발되었다. 온도에 따라, 이러한 흑체 라디에이터는 백색 복사선을 방출할 것이다. 이러한 백색 복사선의 색깔은 CIE 색도표에서 설명될 수 있다. 따라서, 평가될 광원의 상관형 색 온도는 흑체 라디에이터가 광원의 색도와 가장 비슷한 색도를 발생하는 온도이다. 색 온도 및 CCT는 켈빈 온도로 표현된다.

<5> 색 랜더링 지수(color redering index)(CRI)는 가시적인 실험에 의해 설정된다. 평가되는 광원의 상관형 색 온도가 판정된다. 8개의 표준 색 샘플은, 우선, 광원에 의해 조사된 다음, 동일한 색 온도를 갖는 흑체로부터의 광에 의해서 조사된다. 표준 색 샘플이 색을 변경하지 못하면, 그 광원은 이론적으로 완전한 특정 CRI 값인 100을 갖는다. 일반적인 색 랜더링 지수를 "Ra"라 하며, 이것은 모든 8개의 표준 색 샘플의 CRI들의 평균이다.

<6> 보다 오래된 백색 램프는 광파장 범위에 걸쳐 광을 방출시키는 것을 포함하였다. 백색 유형의 색은 2개 또는 3

개의 다른 색과의 혼합에 의해 모의 실험될 수 있다는 것을 알았다. 여기서, 각각의 방출은 상대적으로 좁은 파장 범위를 포함한다. 이러한 램프들은 개별적인 적, 녹, 청 광원의 방출 특성(방출 에너지 및 세기)이 개별적으로 조정될 수 있기 때문에 백색을 조작하기 위해서 많은 제어를 해야할 여지가 있었다.

<7> 예를 들어, 2색 램프는 한 개의 형광물질 및 여기 에너지원을 포함한다. 형광물질에 의해 방출된 광은 여기원으로부터의 비흡수광과 결합하여 백색 유형의 색을 발생한다. 형광 램프의 다른 개선점은, 높은 효율의 백색광으로 되는 3개의 다른 광 색(즉, 3색 램프)을 포함한다. 예를 들어, 3색 램프는 청, 녹 및 적색 광 방출 형광물질을 포함한다. 다른 이전의 3색 램프는 2개의 형광물질(녹색 형광물질 및 적색 형광물질)로부터 발생된 광의 결합 및 수은 플라즈마 여기원으로부터 발생된 비흡수광을 포함한다.

<8> 그러나, 수은 플라즈마 여기원을 포함하는 이전의 3색 램프는 (1) 에너지 이온으로 가스 방전을 할 수 있는 고전압에 대한 필요성, (2) 고 에너지 UV 양자의 방출 및 (3) 짧은 수명과 같은 많은 단점을 제공한다. 따라서, 이러한 결함을 극복하는 장치가 지속적으로 필요하다.

<9> 최종적으로, 형광물질 조성물 및 이러한 조성물의 혼합물을 노출시켜, 특히 3색 백색 램프에서 개선된 효율, (예컨대, 높은 색 랜더링 지수에 의해 측정된) 색 랜더링 및 루미넌스(강도)를 포함하는 개선된 특성을 제공하기 위한 끊임없는 과제가 있다.

발명의 상세한 설명

<10> 본 발명의 일 측면은 제 1 형광물질 및 제 2 형광물질의 혼합물을 포함하는 조성물을 제공한다. 각 형광물질은 호스트 황화물 재료 및 희토류 도펀트를 포함하고, 각 형광물질은 통상의 발광 다이오드에 의해 여기될 수 있다.

<11> 본 발명의 다른 측면은 제 1 형광물질 및 제 2 형광물질의 혼합물을 포함하는 조성물을 제공한다. 각 형광물질은 호스트 재료 및 희토류 도펀트를 포함한다. 상기 제 1 형광물질은 상기 발광 다이오드에 의해 여기될 수 있고, 제 2 형광물질은 상기 제 1 형광물질의 방출에 의해 여기될 수 있다.

<12> 본 발명의 또 다른 측면은 광의 패턴을 방출하는 발광 다이오드를 포함하는 장치를 제공한다. 그 장치는 제 1 및 제 2 형광물질의 혼합물을 포함하는 조성물을 포함한다. 각 형광물질은 호스트 황화물 재료와 희토류 도펀트를 포함하고, 그 조성물은 광 패턴으로 배치된다.

<13> 본 발명의 다른 측면은 형광물질에 여기 복사선을 제공하는 청색 발광 다이오드와 녹색 형광물질을 포함하는 장치를 제공한다.

<14> 본 발명의 다른 장점, 신규한 특성 및 목적은 축척으로 도시된 것은 아닌 첨부한 도면을 토대로 발명의 상세한 설명으로부터 이해할 수 있을 것이다. 도면에 있어서, 여러 도면에 도시된 각각의 동일하거나 거의 동일한 구성요소는 단일 참조 번호로 표시된다. 명확성을 위해, 모든 도면에 모든 구성 요소가 라벨링되지는 않으며, 당업자가 본 발명을 이해하는데, 본 발명의 각 실시예의 모든 구성 요소에 대한 설명이 필요한 것은 아니다.

실 시 예

<18> 공통 발광 다이오드(LED)에 의해 여기할 수 있는 특정 적색 및 녹색 형광물질을 채용한 본 발명의 3색 램프는 이전의 형광 램프보다 우수한 색 랜더링을 가진 높은 효율의 백색 광을 이룰 수 있다.

<19> 본 발명의 일 측면은 제 1 형광물질 및 제 2 형광물질의 혼합물을 포함하는 조성물을 제공한다. 각각의 형광물질은 공통 발광 다이오드, 즉 하나의 발광 다이오드에 의해 여기될 수 있고, 개별적인 에너지원이 각각 필요한 형광물질과는 다르게, 두 형광물질을 여기하는데 이용된다.

<20> 본 발명의 장점은 여기원으로써 LED를 사용하는 것을 포함한다. LED는 도핑된 반도체 영역간에 p-n 접합을 가진다. 전류를 인가하면, 전자와 정공이 p-n 접합을 가로질러 흘러 전자와 정공의 재결합에 의해 복사에너지가 방출되기에 충분한 에너지가 존재할 수 있다. 다른 여기 에너지원에 비해 LED는 크기가 작고, 전력 소비가 작으며, 수명이 길고, 방출된 열에너지의 양이 작다는 장점이 있다. 또한, LED는 크기를 작게 하여 장치를 소형화할 수 있다.

<21> 일 실시예에 있어서, 상기 공통 LED는 청색 LED이다. 다른 광원보다도, 여기 복사선으로서 청색 광을 사용하면 가시광으로의 변환 효율이 높은 장점이 있다는 것을 알았다. 일 실시예에서, 각 형광물질은 약 450㎚ 내지 480㎚의 파장으로 복사선을 방출하는 공통 LED에 의해 여기될 수 있다. 색 랜더링이 450㎚ 이하의 여기 에너지에서

감소하는 반면, 형광물질에 의한 흡수는 480㎚ 이상의 여기 에너지에서 감소함을 알게 되었다. 전술한 에너지 범위에서 복사선을 방출하는 청색 LED는, 예를 들어, (In, Ga)N 다이오드이다.

<22> 청색 광원은, UV 여기원에 비해, 청색광에 의해 여기되는 적색 형광물질 및 녹색 형광물질에 대하여 전력 효율이 증가된다는 점에서 고유의 장점을 제공할 수 있다. 현재의 형광물질 재료는 이전 장치의 형광물질보다 낮은 스토크 쉬프트를 요구한다. 예컨대, 종래의 특정 3색 형광 램프는 약 4.9V에서 중심을 가진 UV 방출을 제공하는 수은 플라즈마를 포함한다. 이러한 UV광은 청색, 적색 및 녹색 형광물질을 여기시킴으로써 결과하는 방출 스펙트럼이 대략 2.8 eV(비흡수광), 2.3 eV(녹색) 및 2.0 eV(적색)의 에너지에서 최대의 강도를 나타내도록 한다. 이러한 상황에서는 큰 스토크 시프트가 수반된다. 그러나, 전력 효율은 여기 및 방출 양자들의 양자 에너지의 차이인 양자 결함에 의해 제한된다. 따라서, 상술한 예시의 경우, 녹색광의 전력 효율은 평균 (4.9 eV-2.3 eV)/4.9 eV = 53% 이다. 반대로, 대략 2.7 eV(~460㎚)로 방출하는 청색 LED에 의해 여기된 녹색(2.3 eV) 및 적색(2.0) 형광물질은 보다 작은 스토크 쉬프트 및 양자 결함을 발생하며 그에 따라 전력 효율이 커진다.

<23> 형광물질은 호스트 재료 및 도펀트 이온을 포함한다. 통상적으로, 호스트 재료는 도펀트 이온이 격자 이온을 대신하는 무기(inorganic)의 이온 격자 구조("호스트 격자")를 갖는다. 도펀트는 여기 복사선을 흡수할 때 광을 방출할 수 있다. 이상적인 도펀트는 여기 복사선을 강하게 흡수하여 이러한 에너지를 방출된 복사선으로 효율적으로 변환한다. 일 실시예에 있어서, 상기 도펀트는 희토류 이온이다. 희토류 이온은 4f-4f 천이, 즉 f 궤도 에너지 레벨을 수반하는 전자 천이를 통해 복사선을 흡수하고 방출한다. f-f 천이가 양자 기계적으로 방해를 받아 방출 강도가 약해지면, Eu^{2+} 또는 Ce^{3+} 등의 특정 희토류 이온이 허용된 4f-5d 천이를 통하여(d 궤도/f 궤도 혼합을 통해) 복사선을 강하게 흡수하고 결과적으로 높은 방출 세기를 발생함을 알게 된다.

<24> 특정 도펀트가 방출되면 도펀트 이온이 잔류하는 호스트 격자에 따라 에너지가 시프트될 수 있다. 따라서, 본 발명의 이러한 특징은 특정 희토류 도펀트가, 적합한 호스트 재료에 포함될 때, 청색광을 가시광으로 효율적으로 변환시킨다는 점에 있다. 일 실시예에서, 상기 제 1 및 제 2 형광물질은 호스트 황화물 재료, 즉 황화물 이온을 포함하는 격자를 포함한다. 바람직한 호스트 황화물 재료는 CaS, SrS 및 $SrGa_2S_4$ 등의 티오갈레이트(thiogallate)를 포함한다.

<25> 본 발명의 다른 장점은 상대적으로 협소한 선폭의 하나의 공통 청색 에너지원에 의해 여기할 수 있는 형광물질 혼합물을 제공함으로써, 2개의 다른 에너지 범위(예컨대, 적색 및 녹색)에서 광을 방출한다는 것이다. 적절한 형광물질을 제공하기 위한 방식이 본 명세서에 개시된다. 일 실시예에 있어서, 도펀트는 제 1 및 제 2 형광물질에서와 동일하다. 두 형광물질의 적색 및 녹색 방출은, 적절한 호스트 재료를 선택함으로써 튜닝될 수 있다. 일 실시예에서, 녹색 형광물질은 $SrGa_2S_4$: Eu 이다, 다른 실시예에 있어서, 적색 형광물질은 SrS:Eu 및 CaS:Eu로 이루어지는 군으로부터 선택된다.

<26> 도 1은 460㎚ 하나의 공통 (In, Ga) LED에 의해 여기될 수 있는 동일한 도펀트를 갖는 2개의 다른 형광물질로부터의 방출 스펙트럼의 오버레이를 나타낸 도면이다. 형광물질은 밀봉재내의 혼합물로써 제공된다. 스펙트럼은 1의 강도로 정규화된다. 스펙트럼 2는 ~460 ㎚에서 최대의 강도를 갖는 청색 LED의 방출에 대응하고, 스펙트럼(4)은 ~520 ㎚에서 최대의 세기를 갖는 녹색 형광물질 재료, 즉 $SrGa_2S_4$: Eu에서의 방출에 대응하고, 스펙트럼(6)은 ~620 ㎚에서 최대의 강도를 갖는 적색 형광물질 재료, 즉 SrS:Eu 에 대응한다.

<27> 선택적으로, 제 1 및 제 2 형광물질은 다른 도펀트를 가질 수 있다. 동일한 호스트 재료가 이용될 수 있고, 또는 제 1 및 제 2 형광물질이 다른 호스트 재료를 가질 수 있다. 당업자라면 약 450㎚ 및 480㎚사이의 복사선에 의해 여기될 수 있는 형광물질을 선택하고, 그들이 적색 또는 녹색 광을 방출하는지 여부를 관찰함으로써 잠재적인 형광물질 후보를 스크린할 수 있을 것이다.

<28> 일 실시예에서, 상기 호스트 격자내에 존재하는 도펀트 양은 약 0.1 몰% 내지 8 몰% 이다. 도펀트의 바람직한 양은 호스트 격자의 유형에 의존할 수 있다. 예컨대, $SrGa_2S_4$ 의 도펀트 농도는 약 2 몰% 내지 4 몰%인 것이 바람직하지만, SrS의 도펀트 농도는 약 0.3 몰% 내지 0.8 몰% 인 것이 바람직하다.

<29> 또한, 본 발명은 제 1 형광물질이 LED원에 의해 여기되고, 상기 제 1 형광물질의 방출이 제 2 형광물질을 여기시킬 수 있는 다른 3색 시스템과 관련이 있다. 따라서, 본 발명의 다른 특징은 제 1 형광물질 및 제 2 형광물질의 혼합물을 제공하는 데, 각각의 형광물질은 호스트 재료 및 희토류 도펀트를 포함한다. 제 1 형광물질은 발광 다이오드에 의해 여기될 수 있고, 제 2 형광물질은 제 1 형광물질의 방출에 의해 여기될 수 있다. 일 실시예에 있어서, LED는 청색 LED이다. 제 1 형광물질은 적색 형광물질(제 2 형광물질)를 여기할 수 있게 방출하는 녹색

형광물질일 수 있다.

<30> 이러한 측면에 의해 단지 하나의 형광물질이 LED에 의해 여기될 수 있는 경우에 하나의 LED 소스만을 사용할 수 있게 된다.

<31> 본 발명의 다른 특징은 이전에 기술된 바와 같은 형광물질 혼합물 및 발광 다이오드를 포함하는 장치를 제공한다. LED는 국부적인 광 패턴을 방출하는데, 그 패턴은 광의 체적 또는 면적을 정의한다. 제 1 형광물질 및 제 2 형광물질의 혼합물을 포함하는 조성물은 상기 광 패턴으로 배치된다. 각 형광물질은 이전에 기술된 조성물 및 농도를 갖는 호스트 황화물 및 희토류 도펀트를 포함한다. 이러한 배치에 의해 LED로부터 방출된 광이 (1) 상기 조성물에 의해 흡수되고, (2) 색 랜더링의 양호한 균질성이 만들어지도록, 형광물질 혼합물로부터 방출된 광과 효율적으로 혼합된다. 이러한 배치는 여러 광원의 원하지 않는 "디믹싱(demixing)"을 제거한다. 디믹싱은 LED 및 형광물질 혼합물에 의해 장치로부터 복사선의 일부분이 방출될 때 발생한다. 즉, 다른 광 구성 요소의 최소의 혼합이 있다.

<32> 일 실시예에 있어서, 장치는 램프이다. 일 실시예에 있어서, 램프는 백색 광을 방출한다. 이러한 실시예에 있어서, 제 1 형광물질은 녹색 형광물질이고, 제 2 형광물질은 적색 형광물질인데, 그 백색은 녹색광 및 적색광을 LED에 의해 제공된 비흡수 청색광과 효율적으로 혼합함으로써 수행된다. 일 실시예에 있어서, 형광물질 혼합물을 함유하는 램프는 휴렛 패커드의 5㎜ LED 램프 고안을 포함한다.

<33> 본 발명의 백색광 램프는 색 랜더링 특성이 이전의 백색 램프의 랜더링 특성보다 훨씬 우수하다는 장점이 있다. 일 실시예에 있어서, 상기 램프는 약 2700K 내지 8000K의 색 온도에서 적어도 약 60의 색 랜더링 지수(Ra), 바람직하게는 적어도 약 70의 Ra, 더욱 바람직하게는 적어도 약 80의 Ra 및 더더욱 바람직하게는 적어도 약 90의 Ra를 갖는 복사선을 방출할 수 있다.

<34> 도 2는 460㎚의 청색(In, Ga)N LED에 의해 여기된 $SrGa_2S_4$: Eu 및 SrS:Eu 의 혼합물을 구비한 3색 램프의 방출 스펙트럼의 모의 실험도이다. 방출 강도 또는 발산도는 세로 축에 표시된다. 이러한 시스템은 광범위한 색 온도의 우수한 색 랜더링 특성을 나타낸다. 스펙트럼(10)(3000K), 스펙트럼(12)(3800K) 및 스펙트럼(14)(4400K)은 94의 Ra에 대응하는 반면, 스펙트럼(16)(4900K)은 92의 Ra에 대응한다. 백색 LED에 대해 90보다 큰 Ra값은 이전에는 관찰되지 않았다. 본 발명의 특징은 형광물질의 각 분량을 혼합하고, 이러한 원하는 모의 실험된 스펙트럼을 근사하게 정합하기 위하여 청색 LED로 이러한 형광물질을 조사한다는 것이다.

<35> 장치의 각 광원의 광학 특성을 변경함으로써, 그 장치는 특정 애플리케이션에 따라 원하는 특성을 갖도록 설계될 수 있다. 예컨대, 특정 장치는 세기가 강한 광을 발생하는 데 필요하고, 적합한 색 랜더링만이 필요할 수 있는 반면, 다른 애플리케이션은 효율성 있는 비용으로 높은 색 랜더링 특성을 요구할 수 있다. 대안적으로, 색 랜더링은 효율을 보다 높이기 위하여 희생될 수 있다. 예컨대, 효율의 50% 증가는 Ra를 약 60으로 감소시킴으로써 성취될 수 있다. 그러한 특성은 각 광원의 상대적인 전원 비율을 변경함으로써 가변할 수 있다. "전원 비율"은 최종 광 색을 제공하는 각 광원으로부터의 광 비율이다. 광 비율은, 예를 들어, 장치내의 형광물질 재료의 상대적인 양을 변경하거나, 도펀트 농도를 변경하거나, 호스트 격자 또는 도펀트를 변경하는 것에 의해 가변할 수 있다.

<36> 최적의 색 랜더링 특성이 달성되는 한, 형광물질 혼합물이 2개 이상의 형광물질을 포함할 수 있다는 것을 이해할 것이다.

<37> 일 실시예에서, 장치는 형광물질 조성물을 밀봉하는 중합체를 포함한다. 이러한 실시예에서, 형광물질 혼합물은 밀봉시에 높은 안정 특성을 나타낸다. 바람직하게, 중합체는 큰 광 산란을 명확하게 광학적으로 방지한다. 중합체는 에폭시 및 실리콘으로 이루어지는 군으로부터 선택된다. 다양한 중합체는 5㎜ LED 램프를 만드는 LED 산업에 공지되어 있다. 밀봉은 중합체 선구 물체(precursor)인 액체에 형광물질 혼합물을 부가함으로써 실행될 수 있다. 예컨대, 형광물질 혼합물은 분말일 수 있다. 형광물질 입자를 중합체 선구 물체 액체에 도입하여 슬러리를 형성한다(즉, 입자의 부유). 중합화시, 형광물질 혼합물은 밀봉에 의해 적소에 확실하게 고정된다. 일 실시예에 있어서, 조성물 및 LED는 중합체내에 밀봉된다.

<38> 형광물질 알갱이 크기(형광물질 입자의 평균 직경)의 역활이 완전히 이해되지 않더라도, 중량 비율은 특정 알갱이의 크기에 따라 가변할 것이다. 바람직하게, 알갱이 크기는 15㎛미만이고, 더욱 바람직하게는 약 12㎛ 미만이되어, 형광물질을 배치하는 장치의 클로깅(clogging)을 피한다. 일 실시예에 있어서, 각 형광물질 유형의 알갱이 크기는 가변한다. 특정 실시예에 있어서, $SrGa_2S_4$: Eu의 알갱이 크기는 약 10㎛ 미만이고, SrS:Eu의 알갱이

크기는 약 12㎛ 미만이다. 그러나, 다른 장치에서는 알갱이가 큰 것이 마련될 수 있다.

<39> 상기 LED로부터 방출된 비흡수광이 색 랜더링에 기여하더라도, 비흡수광은 때때로 상기 형광물질로부터 방출된 광과 혼합 없이 벗어나서, 장치의 전체 효율을 줄인다. 따라서, 일 실시예에 있어서, 상기 LED 및 조성물은 반사기 컵 내에 위치된다. 반사기 컵은 반사 재료로부터 마련된 디프레션(depression) 또는 리세스(recess)일 수 있다. 반사기 컵에 LED 및 형광물질 입자를 위치시킴으로써, 비흡수/비혼합 LED 방출광은 형광물질 입자에 역반사되어 결국에는 흡수되거나 상기 형광물질로부터 방출된 광으로 혼합될 수 있다.

<40> 도 3은 본 발명의 장치의 개략도이다. 램프(20)는 LED(22)를 포함한다. LED(22)는 반사기 컵(28)내에 위치된다. LED(22)는 선(26)으로 표시된 패턴으로 광을 방출한다. 형광물질 혼합물(24)은 그 패턴(26)으로 배치된다. LED(22)에 의해 방출된 일부의 비흡수광이 반사기 컵(28)의 벽으로부터 반사되어 형광물질 혼합물(24)로 되돌아갈 수 있음을 알 수 있을 것이다. 이러한 예에서, 반사기 컵(28)은 초기 광 패턴에 의해 이전에 커버되지 않은 공간으로 광이 반사되는 경우(예를 들어, 파라볼릭 반사기의 경우) 광 패턴(26)을 수정할 수 있다. 당업자라면 혼합물(24)에 되돌아가는 광의 반사를 최적화하거나, LED(22)의 배치를 최적화하는 형상으로 반사기 컵(28)을 제공하여 광 패턴에 효율적인 변환을 제공할 수 있다. 예컨대, 반사기 컵(28)의 벽은 파라볼릭일 수 있다.

<41> 본 발명의 다른 특징은 녹색 LED에 대안적인 고안을 제공한다. 녹색 LEDs는 최근에 개발되었다. 그러나, 현재의 녹색 LED는 청색 LED보다 더욱 비효율적이다. 또한, 녹색 LED로부터 방출된 복사선은 온도의 증가에 따른 파장 시프트를 나타내는데 이것은 원하지 않는 특성이다.

<42> 따라서, 본 발명의 이러한 특성은 녹색 형광물질, 및 형광물질에 여기 복사선을 제공하는 청색 발광 다이오드를 포함하는 장치를 제공한다. 다운 변환의 장점을 취함으로써, 청색광은 녹색 형광물질을 통하여 녹색광으로 변환될 수 있다. 이러한 장치는 청색 LED에 상당한 효율을 제공하고 온도의 증가에 따라 복사선 시프트를 최소화하는 것과 같이 녹색 LED의 단점을 제거하면서, 녹색 LED에 필적한다. 일 실시예에 있어서, 녹색 형광물질은 $SrGa_2S_4$: Eu 이다. ~575 lm/W의 높은 발광 등가값은 약 535㎚의 최대 파장에서 이러한 형광물질을 이용하여 성취될 수 있는데, 이것은 다른 녹색 LED 또는 다른 것보다 훨씬 우수하다. 여기 복사선의 높은 흡수는 효율 및/또는 색 포화를 방해할 수 있는 청색 LED 복사선의 상당량을 제거하는 데 적합하다.

<43> 본 발명의 다른 실시예의 기능 및 장점은 아래의 예로부터 더욱 이해될 것이다. 다음과 같은 예는 본 발명의 장점을 도시하지만, 본 발명의 범위를 예시하는 것을 아니다.

<44> 예 1 : $SrGa_2S_4$: Eu 및 SrS:Eu 형광물질 혼합물의 준비

<45> $SrGa_2S_4$: Eu는 P.Benalloul, et al., J.Alloys compounds 227(1998)의 방법과 거기에 인용된 참조 문헌에 의해 생성되었다.

<46> 2개의 형광물질의 분말은 액체 중합체 선구 물체로 3색의 원하는 파워 비율에 대응하는 가중량으로 섞어진다. 바람직한 중합체 선구 물체는 5㎜ LED 램프, 즉 "Hysol ST"용 표준 선구 물체이다.

<47> 예 2 : 파워 비율을 조정

<48> 이러한 예는 소정의 상관된 다른 색 온도에서 파워 비율을 조정하는 방법을 나타낸 것으로, 이러한 파워 비율은 표 1에 목록된다. (In, Ga)N LED, 녹색 ($SrGa_2S_4$: Eu) 및 적색(SrS:Eu) 방출 형광물질의 공지되거나 측정된 스펙트럼으로부터 시작하면, 최적의 CCT/CRI 값을 도출하는 소정의 스펙트럼을 획득하기 위해 각 색의 파워 비율에 대해 제 1 근사가 이루어진다. 이것은 2개의 형광물질의 각 가중치의 최적의 평가를 실행함으로써 통상 성취된다. 혼합물이 준비된 다음, 그 혼합물은 LED에 의해 조사된다. 이러한 예로서, 복사선의 파장은 460㎚이다. 그 다음, 시행 스펙트럼이 얻어진다.

<49> 제 1 시행 스펙트럼이 원하는 스펙트럼의 CCT/CRI 값을 성취하지 못하면, 소량의 적절한 형광물질이 부가될 수 있고 새로운 시행 스펙트럼이 성취될 수 있다. 이러한 단계는 시행 스펙트럼이 원하는 스펙트럼에 근접하게 일치할 때 까지 반복된다.

<50> 표 1은 3개의 구성 요소, 즉, LED, $SrGa_2S_4$: Eu 및 SrS:Eu의 스펙트럼을 파워 비율에 대응하는 각 계수에 부가함으로써 생성된다. 합성 스펙트럼이 얻어진다. 합성 스펙트럼은 CCT 및 CRI 값을 계산하는 CIE 추천 소프트웨어(예컨대, CIE 13.3-1995)를 이용하여 평가된다, 이러한 절차에 의해서, 원하는 CCT/CRI가 소정의 스펙트럼으

로 변환된다. CCT 및 Ra가 허용 공차 내에서의 기대치와 일치하지 않으면, 제 2 반복이 수행되어 체계적인 방법으로 파워 비율을 수정한다. 후속하는 반복은 수치적 최적화에 의해 성취될 수 있고, 예컨대, Simplex or Variable Metric 방법은 상기 절차를 자동화하는데 이용될 수 있다.

<51> 표 1은 예1의 형광물질 혼합물에 대한 파워 비율을 도시한다.

표 1

<52>

색 온도(K)	$SrGa_2S_4$: Eu(녹색)	SrS:Eu(적색)	LED(청색)
2700	28	61	11
3000	32	55	13
4000	34	45	21
5000	35	39	26
6400	37	31	32
8000	34	29	37

<53> 상기 결과로 방출된 광의 발광 등가는 약 310(±4)Im/W이다.

<54> 예 3: 5㎜ LED 램프

<55> 본 발명의 램프에 대한 일예는 여기에 기술된다. $SrGa_2S_4$: Eu의 7.6 wt% 및 SrS:Eu의 10.4 wt%의 형광물질 혼합물을 포함하는 Hysol ST 슬러리는 휴렛 패커드의 5㎜ 램프 고안의 반사기 컵에 배치된다. $SrGa_2S_4$: Eu의 평균 입자 크기는 약 9㎛이고, SrS:Eu의 평균 입자 크기는 약 11.5㎛ 이다. 460㎚의 여기 복사선, 4000K의 CCT 및 91의 CRT를 갖는 청색(In, Ga)N LED를 이용하여 성취되었다.

<56> 당업자라면 본 명세서에 목록된 모든 파라메타가 예시적인 것이며, 실제 파라메타는 본 발명의 방법 및 장치가 이용되는 특정 응용에 좌우됨을 알 것이다. 따라서, 상술한 실시예가 예시적으로 나타내고, 첨부한 청구 범위 및 그의 등가물의 범주내에서, 본 발명이 특정적으로 기술된 것과 다른 방법으로 실시될 수 있다는 것을 이해할 것이다.

도면의 간단한 설명

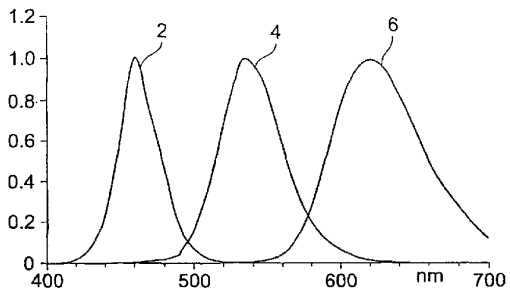
<15> 도 1은 460㎚의 청색 LED에 의해 여기될 시에 $SrGa_2S_4$: Eu 및 SrS:Eu의 정규화 스펙트럼의 오버레이를 도시한 도면.

<16> 도 2는 다른 색 온도에서 460㎚의 청색 LED에 의해 여기될 때 $SrGa_2S_4$: Eu 및 SrS:Eu의 혼합물의 스펙트럼의 모의 실험도.

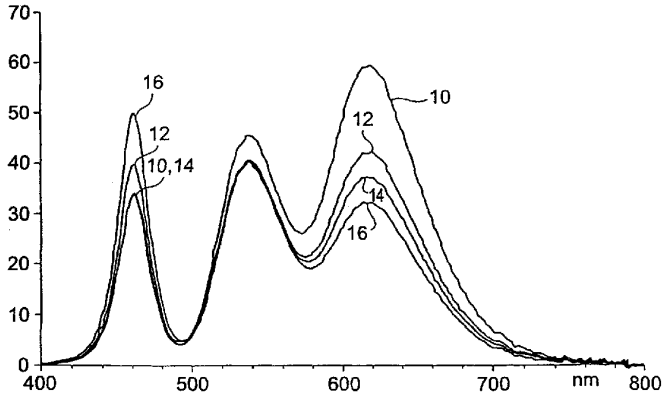
<17> 도 3은 LED에 의해 방출된 광 경로에 위치한 2 형광물질 혼합물을 포함하는 3색 램프의 개략도.

도면

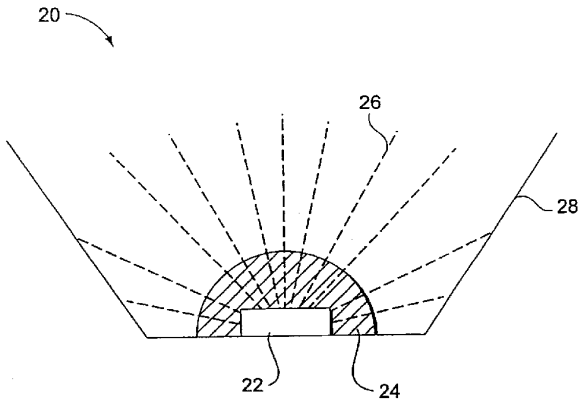
도면1



도면2


70
60
50
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600
700
800
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16
12
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12
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16

도면3


20
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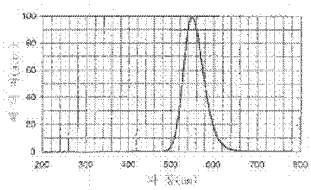
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(54) HIGHLY EFFICIENT FLUORESCENT MATERIAL

(57) Abstract:

The invention relates to a fluorescent material from the class of thiometallates, preferably thiogallates. The thiometallate is composed according to the formula (AS)*w(B2S3), A being at least one divalent cation from the group Mg, Ca, Sr and B being at least one trivalent cation from the group Al, Ga, Y. The factor W can lie in the range 0.8 <= w <= 0.98 or in the range 1.02 <= w <= 1.2.



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요약

본 발명은 티오철산염류의 형광물질, 바람직하게는 티오갈산염류의 형광물질에 관한 것이다. 상기 티오철산염은 (AS)•w(B_2S_3)의 공식에 일치하도록 구성되는데, 상기 공식에서 A는 Mg, Ca 및 Sr 그룹에서 선택된 하나 이상의 2가의 양이온이며, 상기 B는 Al, Ga 및 Y 그룹에서 선택된 하나 이상의 3가의 양이온이며, 상기 인수 w는 $0.8 \leq w \leq 0.98$의 범위내에 있거나 또는 $1.02 \leq w \leq 1.2$의 범위내에 있을 수 있다.

대표도
도 1

명세서

기술분야

본 발명은, 청구항 제 1 항의 서문에 따른, 티오철산염류의 형광물질에 관한 것으로써, 상기 티오철산염은 일반식 $AB_2S_4:D^{2+}$ 에 근거하며,상기 일반식에서 A는 Mg, Ca 및 Sr로 구성된 그룹에서 선택된 하나 이상의 2가(二價)의 양이온이며, 상기 B는 Al, Ga 및 Y로 구성된 그룹에서 선택된 하나 이상의 3가의 양이온이며, 상기 도핑제/활성제 D는 유로퓸 및/또는 세륨이다. 2가의 양이온 A의 함량은 첨가되는 활성제 D의 함량 t만큼 감소한다. 특별히 여기서는 녹색의 스펙트럼영역에서 빛을 방사하는 티오갈산염이 해당된다. 이 경우에 상기 형광물질의 조성은, 2가의 이온 A 대 3가의 이온 B의 몰비가 일반 실험식 AB_2S_4와 정확하게는 일치하지 않도록, 즉 A:B = 1:2의 비율에 일치하지 않도록 구성된다.

배경기술

US 3 639 254호 및 US 5 834 053호에 이미 공지되어 있는 티오갈산염의 방사 스펙트럼은 청색의 스펙트럼영역 또는 녹색의 스펙트럼영역에 있다. 상기 형광물질은 AGa_2S_4 의 공식을 따르며, 상기 공식에서 A는 특히 Ca, Ba, Sr 또는 Zn인 알칼리토류금속으로된 하나 이상의 원소를 나타낸다. 활성제는 유로퓸, 납 또는 세륨이다. 그러나 높은 광 효율을 필요로 하는 적용예(예를 들면 조명공학)에 있어서는 상기 형광물질의 방사효율이 너무 낮다. 상기 방사효율은 소위 양자효율 QE(흡수된 들뜸 양자 수량에 대한 방사된 양자 수량의 비율)로 표시된다. 상기 형광물질에 대한 전형적인 양자효율 값은 60% 내지 70% 사이에 있다.

WO 98/18721호에는, Sr을 가지거나, 또는 Ga, Al 또는 In이 3가의 양이온 역할을 하는 가운데 2가의 양이온으로서 다른 알칼리토류금속을 가진 티오갈산염 그룹에서 선택된 전기발광 형광물질이 공지되어 있다. 특히 상기 간행물에서는 일정량의 잔여산소를 유지하는 가운데 이루어지는 제조 공정이 설명된다.

발명의 상세한 설명

본 발명의 목적은, 청구항 제 1 항의 서문에 따른, 설정된 방사 파장에 최대한 높은 양자효율을 가진 형광물질을 제공하는데 있다.

상기 목적은 청구항 제 1 항에 있는 특징에 의해서 달성된다. 특히 바람직한 구성은 종속항에서 찾을 수 있다.

본 발명에 따른 형광물질의 조성은, 일반 실험식 AB_2S_4를 기반으로 하여, 2가의 이온 A 대 3가의 이온 B의 함량 비율이 A:B = 1:2의 비율과는 상이하게 선택된다. 또한 본 발명에 따른 구상은, 본래의 실험식 AB_2S_4에 의한 티오철산염이 AS•B_2S_3의 형태로된 AS 성분 및 B_2S_3 성분의 곱으로서 표기된다면, 다른 표기 방식으로도 표현될 수 있다. B_2S_3 성분에 대한 AS 성분의 비율은 다음과 같이 인수 $w = B_2S_3/AS$로 표기된다. 종합적인 결과로서 상기 티오철산염은 (AS)•w(B_2S_3)로 표기된다. 바로 (AS)•w(B_2S_3)의 조성을 갖는 형광물질은 $0.8 \leq w \leq 0.98$의 범위뿐만 아니라 $1.02 \leq w \leq 1.2$의 범위내에서도 w = 1의 조성을 갖는 형광물질에 비해서 보다 향상된 양자효율을 제공하는 것으로 판명되었다.

A타입 및 B타입의 다양한 양이온의 조합에 의하여 상이한 방사 파장 및 색도 좌표가 달성되고, 개개의 적용에 적합하게 할 수가 있다. 또한 효율적인(" 밝은") 형광물질을 위해서는 들뜬 영역에서의 근소한 반사 및 높은 양자효율이 전제되어야 한다.

개별적으로 또는 바람직하게 조합된 Mg, Ca, Sr이 양이온 A로서 적합하다. 특히 이 3가지 금속을 함께 사용하는 것이 적절한 것으로 증명되었다. 부분적으로 A를 대체하는 활성제로서는 유로퓸 또는 세륨이 적합하다. 양이온 B로서는 Ga, 또는 Al 및 Y가 적합하다. 이 경우에 특히 갈륨은 부분적으로 (10 mol%까지) 알루미늄으로 대체될 수 있다. 도핑제 D(D = 유로퓸 및/또는 세륨)는 완벽하게 보조성분 AS에 가산되며, 전체 공식은 $A_{1-t}D_tS$로 나타낸다.

a+b+c+t = 1인 경우에 $A = Mg_aCa_bSr_cEu_t$인 가운데, (AS) ◀ $w(B_2S_3)$의 조성을 갖는 형광물질은 특히 하기의 범위에서 높은 양자효율을 나타낸다: $0.4 \le a \le 0.7$; $0.1 \le b \le 0.4$; $0 \le c \le 0.4$; $0.01 \le t \le 0.1$이며, x+y+z = 1인 경우에 $B = (Ga_xAl_yY_z)_2$이고 $0.9 \le x \le 1$ 및 $0 \le y \le 0.1$ 및 $0 \le z \le 0.1$ 및 $0.8 \le w \le 0.98$ 또는 $1.02 \le w < 1.25$이며, 바람직하게 $w \le 1.2$이다. 바람직하게 $c \ge 0.01$이다.

제조 공정은 하기의 단계를 적용한다:

a) 원하는 조성에 일치하는 질산염 현탁액 제조 단계;

b) 미세하게 분산된 질산염 혼합물을 제조하기 위하여, 잔여 수분 함량이 전 중량의 <1%가 될 때까지 T ≤ 300℃의 온도로 상기 현탁액을 건조시키는 단계;

c) 실온에서 10분 내지 60분 동안, 바람직하게는 15분 내지 25분 동안 상기 질산염 혼합물을 모르타르 분쇄기(mortar mill)로 분쇄하는 단계.

d) 원하는 조성을 갖는 미세하게 분산된 금속 산화물 혼합물을 생성하기 위하여, Ar- 또는 N_2 -분위기에서 500℃ 내지 700℃의 온도로, 바람직하게는 600℃의 온도로 상기 분쇄된 질산염 혼합물을 열분해하는 단계.

e) 유동하는 H_2S- 혹은 CS_2 - 분위기 또는 상기 물질의 조합물내에서 800℃ 내지 1000℃의 온도로, 바람직하게는 900℃ 내지 950℃의 온도로 1시간 내지 6시간 동안, 바람직하게는 4시간동안 상기 금속 산화물 혼합물을 제 1 반응시키는 단계.

f) 상기 반응 생성물을 c)단계에서와 같이 분쇄하는 단계;

g) 유동하는 H_2S- 혹은 CS_2 - 분위기 또는 상기 물질의 조합물내에서 800℃ 내지 1000℃의 온도로, 바람직하게는 900℃ 내지 950℃의 온도로 1시간 내지 6시간 동안, 바람직하게는 2시간 동안 제 2 반응시키는 단계.

상기 e) 및 g)단계에서 정량적인 유량(flow rate)은 50 내지 500 ml/min이며, 바람직하게는 120 ml/min에 달하며, 가스 분위기는 H_2S 또는 CS_2 및 Ar 또는 N_2로 구성되는데, 상기 기체는 10% 내지 50%의 H_2S 및 CS_2 및 혼합물을 갖는, 바람직하게는 30%의 H_2S 또는 CS_2 또는 혼합물을 갖는 운반 기체로서 작용한다.

상기 e) 및 g)단계에서는, 반응 온도에 이를 때까지 0.5 내지 20 K/min의 비율로, 바람직하게는 10 K/min의 비율로 점진적인 가열이 이루어진다.

또한 상기 e) 및 g)단계에서는, 반응후에는 5 내지 20 K/min의 비율로, 바람직하게는 10 K/min의 비율로 점진적인 냉각이 이루어진다.

본 발명에 따른 형광물질은 컬러 변환(color conversion)을 위해서 자외선을 방사하는 LED 또는 청색을 방사하는 L

ED에 사용하기에 적합하다. 본 발명에 따른 형광물질은 단독으로 이용될 수 있으며 또는 다른 형광물질과 조합하여, 특히 본 발명에 따른 다른 형광물질과 조합하여 이용될 수 있다. 또 다른 가능한 적용으로서 플라즈마 표시장치(plasma display)를 들 수 있다. 또한 이 경우에도, 단파 플라즈마 방전 광선을 가시 광선으로 변환시키기 위하여, 상기 형광물질은 단독으로 이용될 수 있거나 또는 다른 형광물질과 조합하여, 특히 본 발명에 따른 다른 형광물질과 조합하여 이용될 수 있다.

도면의 간단한 설명

본 발명은 하기의 실시예에 의하여 보다 상세하게 설명된다.

도 1은 실시예에 기술된 방법에 따라 제조된 형광물질

$(Sr_{0.105}\ Ca_{0.210}\ Mg_{0.630}\ Eu_{0.055})S \cdot 1.1Ga_2S_3$에 대한 방사 스펙트럼이며,

도 2는 도 1의 형광물질에 대한 반사 스펙트럼이다.

실시예

$(Sr_{0.105}\ Ca_{0.210}\ Mg_{0.630}\ Eu_{0.055})S \cdot 1.1Ga_2S_3$의 조성을 갖는 형광물질을 제조하기 위하여 그 시발 재료로서 상기 공식에 부합하는 량의 고순도 산화물 및/또는 탄산염의 무게가 측정되며, 동질의 미세하게 분쇄된 산화물의 혼합물이 제조된다. 이 원료 혼합물은 약 30%의 질산과 동일한 몰량으로 혼합되고, 비등될 때까지 서서히 가열되어, 질산염으로 변환된다. 하기의 반응 방정식이 해당된다:

0.210 mol $CaCO_3$ + 0.105 mol $SrCO_3$ + 0.630 mol MgO + 0.0275 mol Eu_2O_3 + 1.100 mol Ga_2O_3 + 8.6 mol HNO_3 → 0.210 mol Ca2++ 0.105 mol Sr2++ 0.630 mol Mg2++ 0.055 mol Eu3++ 2.200 mol Ga3++ 8.6 mol NO3+ 4.3 mol H2O + 0.315 mol CO2↑

이제 침전된 질산염의 흰색 현탁액이 생성된다. 상기 현탁액은 고점성의 상태가 될 때까지 응축된다. 이렇게 얻어진 질산염 현탁액은 석영 보우트(quartz boat)로 옮겨지고, 300℃의 질소기체 흐름내에서 건조된다.

건조된 질산염 혼합물은 모르타르 분쇄기내에서 20분간 분쇄된 다음에, 다음과 같은 반응 방정식에 따라, 질소하에서 600℃의 온도로 4시간동안 열분해된다:

0.210 mol $Ca(NO_3)_2$ + 0.105 mol $Sr(NO_3)_2$ + 0.630 mol $Mg(NO_3)_2$ + 0.055 mol $Eu(NO_3)_3$ + 2.200 mol $Ga(NO_3)_3$

1 mol [0.210 CaO · 0.105 SrO · 0.630 MgO · 0.055 Eu_2O_3 · 1.100Ga_2O_3] + 8.6 mol NO_2 + 2.15 mol O_2.

이렇게 생성된 산화물 혼합물은 석영 보우트에 주입되고, 비활성 기체(아르곤)하에 관형로(tubular furnace)내에서 900℃까지 가열된다. 반응 온도에 도달하게 되면, 질소기체내에 30%의 H_2S가 사용되는 가운데, 120 ml/min의 황화수소가 도입되고, 상기 산화물 혼합물은 4시간 이내에, 다음과 같은 반응 방정식에 따라 티오갈산염으로 변환된다:

1 mol[0.210 CaO • 0.105 SrO • 0.630 MgO • 0.055 Eu_2O_3 • 1.100 Ga_2O_3] + 4.3275 mol H_2S → 1 mol[($Sr_{0.105}$ $Ca_{0.21}$ $Mg_{0.63}$ $Eu_{0.0275}$)S • 1.1Ga_2S_3] + 4.3275 mol H_2O + 0.0275 mol S.

870℃ 내지 930℃의 온도가 고효율 형광물질을 위한 최적의 반응 온도인 것으로 증명되었다.

상기 반응 생성물은 모르타르 분쇄기내에서 10분간 분쇄되고, 다시 3시간동안 900℃에서 20% 강도의 황화수소 기체 흐름내에서 반응한다.

상기 형광물질은, 공식 ($Sr_{0.105}$ $Ca_{0.210}$ $Mg_{0.630}$ $Eu_{0.055}$)S • 1.0Ga_2S_3 (w = 1)에 따른 형광물질에 비해서, 방사 스펙트럼이 변하지 않고 유지되는 가운데, 17%의 개선된 양자효율을 가지며, 최대 548㎚ ± 1㎚의 세기를 갖는다.

전술한 방법에 의해서 상기 조성에 따른 고효율 형광물질을 재생적으로 제조할 수 있다.

또 다른 실시예는 표 1에 기술된 형광물질에 대한 조성으로 나타난다. 본 표에서, 상기 실시예와 유사하게 제조된 형광물질의 양자효율 검출에 대한 결과가 A 양이온 혼합물 $Sr_{0.105}$ $Ca_{0.210}$ $Mg_{0.630}$ $Eu_{0.055}$ 로, 그러나 각각 별개의 비율 w = B_2S_3/AS로 요약된다. w가 1보다 낮거나 또는 높게 선택된 경우에, 방사 파장이 최대의 방사 세기 548㎚ 내지 549㎚에서 변동없이 유지되는 가운데, 양자효율은 분명하게 향상된다. w = 1.25일때 < 10 %의 분명히 낮은 양자효율이 확인되는데, 이것은 관련 형광물질 형성이 존재범위를 초과한 것을 가리킨다. 특히 615㎚의 대역을 뜻하는 방사 파장은, 활성제 Eu^{2+} 의 격자 형성이 더이상 원하는 방식으로 이루어지지 않는다는 것을 가리킨다. 상기 한계 값은 양이온 혼합물 A에 대한 정확한 조성에 따라 약간씩 변화된다.

본 실시예에서 명시된 형광물질 조성의 형성에 관련한 복합 반응 메카니즘(reaction mechanism) 및 이 조성내에서의 변화에 따른 원자 결정 구조 변동의 형성으로 인하여, 다수의 효과가 양이온 비율 A:B에 대한 관찰된 양자효율의 의존성에 기여한다는 사실을 추측하게 한다. 한편으로, A:B 비율을 바꾸는 것은 한층 개선된 반응 생성물의 변환에 기여할 수 있다. 이로 인하여 단점적인 2차 생성물, 그 밖의 전구체 생성물 및 중간 생성물이 회피된다. 다른 한편으로, 티오철산염 결정 격자를 보다 완벽하고 분열이 적게 구성한다는 관점에서, 활성제 Eu^{2+} 의 구성도 또한 유리할 수 있다. 또한 올바른 균형을 이루며, 코어-쉘(core shell) 형성 모델에 따라 국소적인 원자 양이온 조성에 보다 적합한 황 화학량론에 더 성공적으로 달성할 수 있다. 전체적으로, 변화된 형광물질 조성은 완벽한 형광물질의 생성을 향상시키며 또한 QE를 감소시키는 비방사성(non-radiating) 재조합 중심을 감소시킨다.

도 1은 상기 실시예(w = 1.1)에 있는 형광물질 ($Sr_{0.105}$ $Ca_{0.210}$ $Mg_{0.630}$ $Eu_{0.055}$)S • 1.1(Ga_2S_3)에 대한 방사 스펙트럼이 도시된다.비교에 있어서: 과거 방식으로 상기 형광물질은 대략 ($Mg_{0.63}$ $Ca_{0.21}$ $Sr_{0.105}$ $Eu_{0.055}$)$_{0.9}$ $Ga_2S_{3.9}$ 으로 표기된다. 방사 대역은 약 500㎚ 내지 620㎚사이의 녹색 스펙트럼영역내에 있다. 방사 최대는 548㎚에 있으며, 평균 파장은 557㎚에 있다. 색도 좌표 성분 x = 0.366; y = 0.618이다. 양자효율은 400㎚의 협소 밴드(narrow-band) 여기시에 81%에 이른다. 비교 해보면, w = 1.1 대신에 w = 1.1을 가진 화학량론적인 형광물질의 양자효율은 70% 보다 적다.

본 발명에 따른 형광물질은 300㎚ 내지 500㎚의 단파 광선에 의해서 우수하게 된다. 특히, 바람직하게는 컬러 변환용 LED, 소위 LED-컨버어터(LED converter)에서 사용하기에 적합하다. 이 경우에, 자외선을 방사하는 LED의 방사선 광선은 단일 또는 다수의 형광물질에 의해서 가시 광선으로 변환(이 경우에는 녹색 또는 청록색으로)되거나 또는 (적색, 녹색 및 청색을 방사하는 형광물질의 혼합인) 백색광으로 변환된다. 청색의 LED를 사용할 경우에는 제 2 변형예가 1개 또는 2개의 형광물질(예컨대 황색 또는 녹색 및 적색을 방사하는 형광물질)을 사용함으로써 이 경우에도 백색광이 나타난다. 이에 관한 기술적인 세부사항은 예컨대 US-A 5 998 925호에서 찾을 수 있다.

상기 형광물질을 LED-컨버어터로서의 적용은, 예컨대 에폭시 수지를 고형주입성형(solid casting)하는 가운데 성공적으로 이루어진다. 이를 위해서 형광물질 분말이 에폭시 수지에 분산되고, 방울 형태로 칩위에 놓이게 되고, 가황(加黃)된다. 여기서 중요한 점은, 상기 티오철산염이 습윤(濕潤)이 잘되는 비극성 수지의 것과 유사한 비극성 표면을 갖는 것이다. 그 밖의 장점으로는, YAG:Ce 또는 YAG:Ce에 기반을 둔 형광물질과 같은, 다른 형광물질과 혼합이 잘 이루어진다는 사실이며, 그 이유는 상기 양쪽 형광물질류의 비중량이 유사하기 때문에, 유사한 입자크기에서는 침강 효과에 의한 분리가 일어나지 않게된다. 일반적인 티오철산염의 상대 밀도는 약 4.4 내지 4.5 g/㎤에 달하며, 반면에 YAG:Ce에 기반을 둔 형광물질의 비중량은 일반적으로 4.6 내지 4.7 g/㎤에 달한다. 수지내에서의 침강은 < 5 ㎛의 평균 입자크기에 의해서, 특히 2 ± 1 ㎛만큼 극소화된다. 입자크기는 볼 분쇄기(ball mill)의 분쇄에 의하여 조정된다.

표 1:

A 양이온 혼합물 $Sr_{0.105}$ $Ca_{0.21}$ $Mg_{0.63}$ $Eu_{0.055}$ 및 변동 비율 w(w = B_2S_3/AS)를 갖는 형광물질에 대한 양자효율 검출 결과.

[표 1]

w	Sr몰비	Ca몰비	Mg몰비	Eu몰비	QE%	방사 파장nm
0.9	0.105	0.21	0.63	0.055	72	549
1	0.105	0.21	0.63	0.055	64	548
1.1	0.105	0.21	0.63	0.055	81	548
1.2	0.105	0.21	0.63	0.055	76	549
1.25	0.105	0.21	0.63	0.055	< 10	549-615

(57) 청구의 범위

청구항 1.

일반식 $AB_2S_4:D^{2+}$ 에 근거하며,상기 일반식에서 A는 Mg, Ca 및 Sr로 구성된 그룹에서 선택된 하나 이상의 2가의 양이온이며, 상기 B는 Al, Ga 및 Y로 구성된 그룹에서 선택된 하나 이상의 3가의 양이온이며, 상기 D는 활성제로서 유로퓸 및/또는 세륨이 선택되는, 티오철산염류의 고효율 형광물질에 있어서,

상기 형광물질의 조성은 일반식 (AS) • $w(B_2S_3)$에 일치하도록 구성되며, 상기 인수 w는 $0.8 \leq w \leq 0.98$의 범위내에 있거나 또는 $1.02 \leq w \leq 1.2$의 범위내에 있는 것을 특징으로 하는 고효율 형광물질.

청구항 2.

제 1 항에 있어서,

상기 양이온 B로서는, 부분적으로 알루미늄으로 대체될 수 있는 갈륨이 선택되는 것을 특징으로 하는 티오철산염 형광물질.

청구항 3.

제 1 항에 있어서,

상기 양이온 A로서는, Mg, Ca, Sr으로 구성된 그룹에서 선택된 하나의 금속이 개별적으로 또는 조합하여 선택되는 것을 특징으로 하는 티오철산염 형광물질.

청구항 4.

제 1 항에 있어서,

상기 (A를 치환하는)활성제로서는 유로퓸이 선택되는 것을 특징으로 하는 티오철산염 형광물질.

청구항 5.

제 1 항에 있어서,

$1.05 \leq w \leq 1.15$이고 $a+b+c+t = 1$인 경우에 $A = Mg_{a}Ca_{b}Sr_{c}Eu_{t}$: $0.4 \leq a \leq 0.7$; $0.1 \leq b \leq 0.4$; $0 \leq c \leq 0.4$; $0.01 \leq t \leq 0.1$인 공식 (AS) ▮ $w(Ga_2S_3)$이 적용되는 것을 특징으로 하는 티오철산염 형광물질.

청구항 6.

제 1 항 내지 제 5 항 중 어느 한 항에 따른 상기 티오철산염류의 고효율 형광물질에 대한 제조 방법에 있어서,

a) 제 1 항 내지 제 5 항에 있어서, 원하는 조성에 일치하는 질산염 현탁액 제조 단계;

b) 미세하게 분산된 질산염 혼합물을 제조하기 위하여, 잔여 수분 함량이 전 중량의 <1%가 될 때까지 T ≤ 300℃의 온도로 상기 현탁액을 건조시키는 단계;

c) 실온에서 10분 내지 60분 동안, 바람직하게는 15분 내지 25분 동안 상기 질산염 혼합물을 모르타르 분쇄기로 분쇄하는 단계.

d) 원하는 조성을 갖는 미세하게 분산된 금속 산화물 혼합을 생성하기 위하여, Ar- 또는 N_2 -분위기에서 500℃ 내지 700℃의 온도로, 바람직하게는 600℃의 온도로 상기 분쇄된 질산염 혼합물을 열분해하는 단계.

e) 유동하는 H_2S- 또는 CS_2 -분위기 또는 상기 물질의 조합물내에서 800℃ 내지 1000℃의 온도로, 바람직하게는 900℃ 내지 950℃의 온도로 1시간 내지 6시간 동안, 바람직하게는 4시간동안 상기 금속 산화물 혼합물을 제 1 반응시키는 단계.

f) 상기 반응 생성물을 c)단계에서와 같이 분쇄하는 단계;

g) 유동하는 H_2S- 또는 CS_2 -분위기 또는 상기 물질의 조합물내에서 800℃ 내지 1000℃의 온도로, 바람직하게는 900℃ 내지 950℃의 온도로 1시간 내지 6시간 동안, 바람직하게는 2시간동안 제 2 반응시키는 단계를 포함하는 것을 특징으로 하는 방법.

청구항 7.

제 6 항에 있어서,

상기 e) 및 g)단계에서 정량적인 유량은 50 내지 500 ml/min이며, 바람직하게는 120 ml/min에 달하며, 가스 분위기는 H_2S 또는 CS_2 및 Ar 또는 N_2로 구성되는데, 상기 기체는 10% 내지 50%의 H_2S 및 CS_2 및 혼합물을 갖는, 바람직하게는 30%의 H_2S 또는 CS_2 또는 혼합물을 갖는 운반 기체로서 작용하는 것을 특징으로 하는 방법.

청구항 8.

제 6 항에 있어서,

상기 e) 및 g)단계에서 반응 온도에 이를 때까지의 가열은 0.5 내지 20 K/min, 바람직하게는 10 K/min에 달하는 것을 특징으로 하는 방법.

청구항 9.

제 6 항에 있어서,

상기 e) 및 g)단계에서 냉각은 5 내지 20 K/min, 바람직하게는 10 K/min에 달하는 것을 특징으로 하는 방법.

청구항 10.

제 1 항 내지 제 5 항에 있어서,

자외선을 방사하는 LED 또는 청색을 방사하는 LED에서는 컬러 변환을 위하여, 단독으로 또는 다른 형광물질과 조합하여, 특히 제 1 항 내지 제 5 항에 따른 다른 형광물질과 조합하여 사용되는 상기 형광물질의 용도.

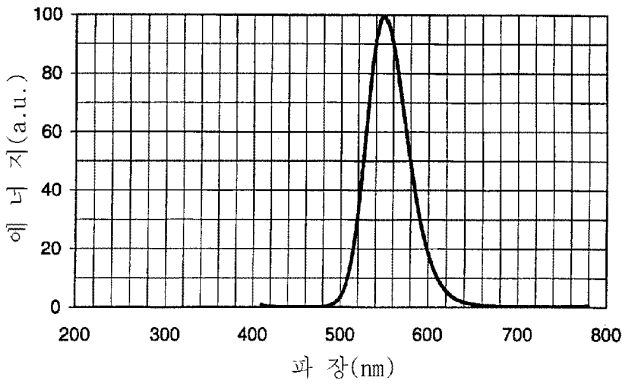
청구항 11.

제 1 항 내지 제 5 항에 있어서,

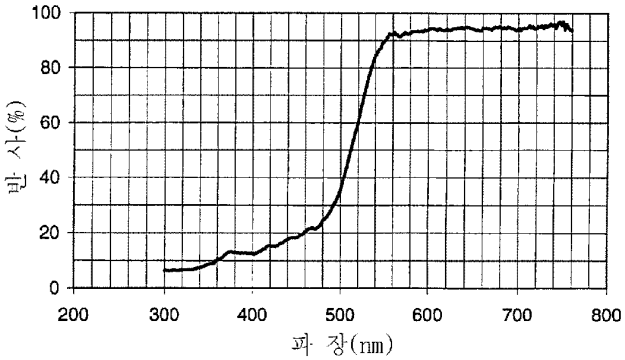
플라즈마 표시장치에서는 단파 플라즈마 방전 광선을 가시 광선으로 변환시키기 위하여, 단독으로 또는 다른 형광물질과 조합하여, 특히 제 1 항 내지 제 5 항에 따른 다른 형광물질과 조합하여 사용되는 상기 형광물질의 용도.

도면

도면 1



도면 2



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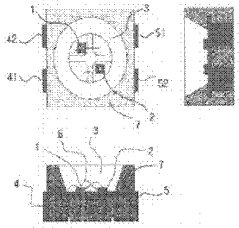
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(54) THREE-WAVELENGTH WHITE LED TO IMPROVE LUMINANCE AND COLOR REPRODUCTION

(57) Abstract:

PURPOSE: A three-wavelength white LED is provided to improve luminance and color reproduction by generating three-wavelength light of blue light, green light, and red light. CONSTITUTION: A three-wavelength white LED includes a green phosphor and a phosphor coating layer including a transparent resin. The green phosphor is used for absorbing the light radiated by a red semiconductor LED(2) and an InGaN-based blue semiconductor LED(1) in order to radiate the light of the different wavelength from the wavelength of the absorbing light. The green phosphor is formed with (Sr1-x-y,Mx)Ga2S4:Euy.



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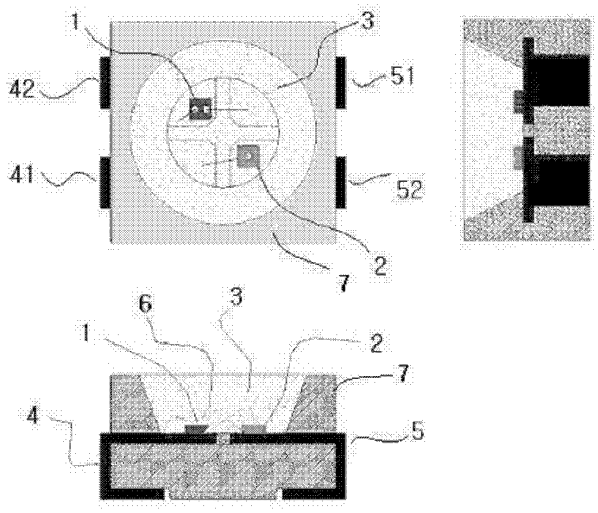
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요약

본 발명은 형광체를 이용한 삼파장 백색 반도체 발광장치에 관한 것으로서, 더욱 상세하게는 청색 및 적색의 발광 칩을 갖는 발광다이오드에 청색광의 일부는 투과하고, 청색의 일부를 흡수하여 녹색의 광을 발광하는 녹색형광체를 이용하여 청색, 녹색 및 적색 광의 혼색에 의한 백색을 구현하는 삼파장 백색 반도체 발광장치이다.

대표도



색인어

삼파장 백색발광다이오드, 황화스트론튬갈륨계 녹색형광체

명세서

도면의 간단한 설명

도 1은 본 발명의 황화스트론튬갈륨계 녹색형광체의 흡수스펙트럼을 나타낸 그래프이고,

도 2는 본 발명의 황화스트론튬갈륨계 녹색형광체의 발광스펙트럼을 나타낸 그래프이고,

도 3은 본 발명의 실시예로서 1개의 청색발광다이오드 와 1개의 적색발광다이오드에 녹색형광체가 코팅된 형태로 제작된 표면실장형 삼파장 백색 발광다이오드의 개략적인 구성도이고,

도 4는 본 발명의 또 다른 실시예로서 2개의 청색발광다이오드 와 1개의 적색발광다이오드에 녹색형광체가 코팅된 형태로 제작된 표면실장형 삼파장 백색 발광다이오드의 개략적인 구성도이고,

도 5는 본 발명의 또다른 실시예로서 1개의 청색발광다이오드 와 1개의 적색발광다이오드 가 직렬 연결된 구조로 녹색형광체가 코팅된 형태로서 제작된 표면실장형 삼파장 백색 발광다이오드의 개략적인 구성도이고,

도 6는 본 발명의 황화스트론튬계 녹색형광체, 적색 발광다이오드 및 청색 발광다이오드를 조합한 백색 발광다이오드의 발광스펙트럼을 나타낸 그래프이고,

도 7는 본 발명의 청색 발광다이오드, 녹색 형광체와 적색발광다이오드를 조합한 발광다이오드 소자에 의해 구현할 수 있는 색 재현 범위를 나타낸 색 좌표이다.

* 도면의 주요 부분에 대한 부호의 설명

1, 11, 12 : 청색 발광다이오드 칩

2 : 적색 발광다이오드 칩

3 : 에폭시 + 녹색형광체 몰드 층

4, 41, 42, 43 : 애노드 리드

5, 51, 52 : 캐소드 리드

6 : 골드 와이어

7 : 플라스틱계열의 사출 프레임

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 형광체를 이용한 삼파장 백색 반도체 발광장치에 관한 것으로서, 사파이어기판위에 형성된 InGaN 계열의 청색발광다이오드, 또는 SiC 기판위에 형성된 InGaN 계열의 청색 발광다이오드의 활성층으로부터 방출된 청색광과, 방출된 청색광의 일부를 흡수하여 녹색의 광을 발광하는 형광체 및 GaAs, AlAs계열, 또는 AlInGaP계열의 적색 발광다이오드가 하나의 패키지에 구성되어 청색광, 녹색 광, 적색광의 혼색에 의한 삼파장 백색 반도체 발광장치에 관한 것이다.

반도체인 발광다이오드(Light Emitting Diode)는 기본적으로 PN 접합 다이오드이며, 전압을 가하면 전자와 정공의 결합으로 반도체의 밴드갭에 해당하는 에너지를 빛의 형태로 방출하는 광전자소자 이다. 실리콘 PN 접합이 전자정보혁명의 주역이었다면 Ⅲ-Ⅴ족 화합물 반도체의 PN 접합은 빛 혁명의 주역이다.

현재 InGaN 계열의 발광다이오드를 이용하여 백색을 구현하는 기술은 전 세계적으로 활발하게 진행되고 있는데 그 방법은 크게 두 가지로 구분하여 요약할 수 있다. 그 예로 단일 칩 형태의 청색이나 혹은 UV 발광다이오드 칩 위에 형

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광 물질을 결합하여 백색을 구현하는 기술과 멀티 칩 형태로 두 개나 혹은 세 개의 발광다이오드 칩을 서로 조합하여 백색을 얻는 방법으로 백색을 구현하는 기술이 주류를 이루고 있다.

하나의 칩에 형광체를 접목시키는 방법은 1990년대 후반에 들어 고휘도 청색 발광다이오드의 상용화가 이뤄짐에 따라 청색 발광다이오드를 기준 광원으로 사용하여 노란색의 YAG (Yttrium Aluminum Garnet)형광체에 투사되면 입사된 빛이 여기되어 발광되는 빛은 500nm에서부터 780nm 까지 발광하게 되며 이 빛들의 혼색에 의하여 백색 발광다이오드가 처음으로 등장하게 되었다. 백색 발광다이오드는 청색과 노란색의 파장 간격이 넓어서 색 분리로 인한 섬광효과를 일으키기 쉽다.

따라서 색 좌표가 동일한 백색 발광다이오드의 양산이 어려우며, 조명 광원에서 중요한 변수인 색온도와 연색성 평가지수(Color Rendering Index: CRI)의 조절도 어렵다. 또한 동작 환경 온도에 따라 색 변환 현상이 치명적인 단점으로 되어 있다. 이에 따라 적색을 내는 형광물질을 첨가하여 발광 스펙트럼을 넓혀서 이러한 단점을 보완하고자 하는 시도도 있다.

UV 발광다이오드가 여기 광원으로 개발됨에 따라 단일 칩 방법으로 조명용 백색 발광다이오드 구현에 있어서 새로운 전기를 맞이하게 되었다.

이와 같은 방법은 전극 방전에 의해 254㎚ 혹은 185㎚의 자외선으로 형광등 램프의 구현하는 방법과 매우 비슷한 것으로서 UV 발광다이오드 위에 청색, 녹색, 적색의 다층 형광물질을 도포하면, 백열전구와 같은 아주 넓은 파장 스펙트럼을 갖게 된다. 따라서 우수한 색 안정성을 확보할 수 있으며 색 온도와 연색성 평가지수를 어느 정도 마음대로 조절할 수 있어 조명용 발광다이오드 광원 구현을 위한 가장 우수한 방법으로 대두되고 있으나 휘도가 낮아 상용화되지 못하고 있다.

멀티 칩으로 백색 발광다이오드를 구현하는 방법으로 처음 시도된 것은 RGB의 3개 칩을 조합하여 제작하는 것이다. 그러나 각각 칩마다 동작 전압의 불균일성, 주변 온도에 따라 각각의 칩의 출력이 변해 색 좌표가 달라지는 현상 및 구동회로 추가 등의 문제점을 가지고 있다. 따라서 백색 발광다이오드의 구현보다는 회로 구성을 통해 각각의 발광다이오드 밝기를 조절하여 다양한 색상의 연출을 필요로 하는 특수 조명 목적에 적합한 것으로 판단된다. 색 좌표란 1931년 국제조명위원회(CIE)에서 정한 등색함수에 따른 3색을 표시한 좌표로서 색광 혼합량으로 시료의 색을 표시할 수 있으므로 산업계에 광범위하게 보급되어 색을 표시하는 기준으로 사용하고 있다. CIE에서 표시된 백색 영역은 때로 사용 목적에 따라 좁게 표시되는 경우가 있다. 한 예로 미국 자동차 엔지니어협회(SAE)에서는 규정서 J578에서 자동차에 쓰이는 백색의 범위를 좁게 정의하고 있다.

최근에는 보색 관계를 갖는 2개의 발광다이오드를 결합하여 만드는 BCW(Binary Complementary) 발광다이오드가 출현했다. 주황색과 청녹색을 4대 1의 비율로 섞으면 백색광이 되는데 주황색에서 적색까지의 발광색을 조절할 수 있는 InGaAlP 발광다이오드의 경우 성능 지수가 100㏐/W를 초과함에 따라 현재 조합된 백색 발광다이오드의 조명 효율이 형광등과 가까운 정도이다. 그러나 현재 발광다이오드의 적용분야가 연색성을 중요시하는 모니터등의 디스플레이 백라이트에 집중됨에 따라 상용화에는 어려움이 있다.

발명이 이루고자 하는 기술적 과제

따라서 본 발명의 과제는 반도체 제조 공정중 와이어 본딩이 완료된 적색 발광다이오드와 청색 발광다이오드에 가시광선 전영역에 걸쳐 투광성이 좋은 액상 에폭시 또는 실리콘 계열의 물질에 녹색의 형광체를 혼합하여 발광다이오드 위에 도포하여 몰드하므로서 동작시 백색을 구현하며, 주 발광피크가 인체시감에서 가장 감도가 좋은 녹색대역이 발광하므로 광도를 향상시킬 수 있고, 연색성을 향상시킬 수 있는 삼파장 백색 반도체 발광장치를 제공하는데 있다.

발명의 구성 및 작용

상기 목적을 달성하기 위하여, 본 발명에서는 청색 발광다이오드 소자와 적색 발광다이오드에 하기 화학식 1로 표시되는 청색 발광다이오드용 황화스트론튬갈륨계 녹색형광체를 도포하여 기준광인 청색, 적색과 청색발광다이오드의 빛을 흡수하여 발광되는 녹색의 삼색을 이용한 삼파장 백색 반도체 발광 장치를 제공 한다:

<패키지>

본 실시형태에 있어서, 패키지의 금속 베이스는 양극의 단자를 구성하는 금속 박판과 음극의 단자를 구성하는 금속 박판이 절연성 수지에 의해 접합되어 이루어지고, 각각 발광다이오드 칩의 정(+)전극과 부(-)전극에 와이어에 의해 접속된다.

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여기서, 발광다이오드 칩은 한쪽의 금속 박판상에 다이 본딩용 접착제에 의해 다이본딩되어 있다. 그러나 본 발명에서는, 발광다이오드칩 은 다른쪽 금속 박판상에 다이본딩되어 있어도 되고, 금속 박판과 금속 박판에 걸쳐 다이본딩되어 있어도 된다.

< 발광다이오드 칩 >

본 실시형태의 청색 발광 다이오드는, 발광다이오드 칩에서의 광의 일부 또는 전부를 형광 물질에 의해 파장 변환하도록 구성하고 있기 때문에, 청색 발광다이오드 칩으로서는, 그 형광 물질을 여기 가능한 발광 파장의 광을 발광하는 것을 사용한다. 본 발명에 있어서는 형광 물질을 효율적으로 여기할 수 있는 단파장의 광이 발광 가능한 질화물 반도체(InAlGa)를 이용한 발광다이오드 칩을 사용하는 것이 바람직하다. 상기 청색 발광다이오드 칩은 InGaN을 발광층으로 갖고 있고, 그 혼합결정 조성에 의해 발광 파장을 약 430nm에서 480nm까지 임의로 바꿀 수 있다. 발광다이오드 칩의 구조로서는 MIS 접합, PIN 접합이나 PN 접합 등을 갖는 호모 구조, 헤테로 구조 혹은 더블 헤테로 구성의 것을 들 수 있고, 본 발명에서는 어느 것이나 사용할 수 있으나, 보다 고휘도의 것을 얻을 수 있는 더블 헤테로 구조를 채용하는 것이 바람직하다. 또한, 발광층(활성층)을 구성하는 반도체의 조성이나 그 혼합 정도에 따라 발광 파장을 여러 가지 선택할 수 있다. 또한, 활성층을 양자 효과가 생기는 박막을 포함하여 구성한 단일 양자 우물 구조나 다중 양자 우물구조로 할 수도 있다.

질화물 반도체를 사용하는 발광다이오드칩의 경우, 기판에는 사파이어, 스핀넬, SIC, Si, ZnO 등의 재료를 사용할 수 있으나, 결정성이 좋은 질화물 반도체를 양산성 좋게 형성시키기 위해서는 사파이어 기판을 사용하는 것이 바람직하다.

적색발광용도의 발광다이오드칩의 경우 AlInGaP 의 4원소 화합물을 구성원소로 하는 고휘도 칩을 사용하는 것이 바람직하다.

<형광체>

상기 본 발명의 발광다이오드에 사용되는 형광체는 반도체 발광층에서 발광된 가시광 영역대의 에너지원에의해 여기되고, 여기된 광과 다른 파장을 발광하는 발광다이오드에 적용할 수 있는 화학식1의 황화스트론튬갈륨계 녹색형광체 대해 더욱 상세하게 설명하면 아래와 같다.

화학식 1

$(Sr_{1-x-y},M_x)Ga_2S_4:Eu_y$

구체적으로 황화 스트론튬 갈륨계 녹색형광체는 일반적인 화학식 1로 표시되고, M는 Sr, Ca, Mg, K, Na, Ba에서 선택된 적어도 하나의 원소로서 $0 \leq x \leq 0.5$이고, $0 < y \leq 0.5$이다.

바람직하기로는 $0 < x+y \leq 1$이며, 더욱 바람직하기로는 $0 < x+y \leq 0.5$이다. 또한, $0.05 \leq x \leq 0.3$, $0.0005 \leq y \leq 0.1$인 것이 바람직하다.

상기 일반식에서, x와 y이 상기 수치범위인 경우에 바람직한 발광효율을 얻을 수 있다. 또한, y가 상기 수치 범위인 경우에, Eu이 활성제로서 적절한 기능을 발휘할 수 있으며, 그 상한선을 벗어나는 경우에는 농도소광효과(quenching effect)에 따른 휘도저하가 발생될 수 있다. 상기 녹색 형광체는 약 400 nm 내지 500 nm 범위에서 흡수피크를 나타내고, 약 500 nm 내지 600nm에서 발광피크를 나타낸다.

이하, 첨부된 도면을 참조하여 본 발명의 바람직한 실시 예에 대해 설명한다.

도 1 및 도 2는 본 발명의 황화스트론튬갈륨계 녹색 형광체의 흡수 및 발광스펙트럼을 나타낸다.

본 발명에서 사용하고자하는 $SrGa_2S_4:Eu$ 형광체의 정확한 구조식의 표현은$Sr_{0.95}Ga_2S_4:Eu_{0.05}$ 이다. Eu^{2+} 이온이 Sr^{2+} 위치에 최환되므로 합성에는 스트론튬 황화물, 갈륨 질화물, 황 및 유로퓸 황화물을 양론비 만큼 사용한다.

도 1에 도시된 흡수스펙트럼에서 $SrGa_2S_4:Eu$은 청색 발광다이오드의 발광 영역인 440nm에서 470nm의 좋은 흡수특성을 가짐을 알 수 있다. 또, 도 2에 표시된 발광스펙트럼에서 $SrGa_2S_4:Eu$은 500nm에서 600nm의 좋은 발광특성을 보임을 알 수 있다.

도 3과 도 4, 그리고 도 5는 본 발명의 실시 예로서 청색 발광다이오드에 의해 발광된 일부 광은 투과하고 일부광은 흡수되어 녹색을 발광하는 황화스트론튬갈륨계 녹색형광체를 투광성 몰드수지인 액상의 에폭시 또는 실리콘에 적량 혼합하여 발광다이오드의 칩 위에 도포하여 기준광원인 청색광과 제2여기광인 녹색광, 그리고 적색발광다이오드로 칩으로부터 발광되는 적색광이 혼색되어 백색 발광특성을 나타내는 삼파장 백색 발광다이오드의 개략적인 구성도를 나타낸 것이다.

도 6은 도 3과 도 4의 발명의 실시 예로서 제작된 삼파장 백색 발광다이오드의 발광스펙트럼을 나타낸 것이다.

도 7은 본 발명의 실시 예로서 청색 발광다이오드에 의해 발광된 일부 광을 흡수하여 녹색 및 적색의 발광을 하는 황화스트론튬갈륨계 녹색형광체와 적색 발광다이오드를 조합한 삼파장 백색 발광다이오드의 색 재현 범위를 나타낸 색좌표이다. 도 7에 도시된 바와 같이, 적색 발광다이오드 칩과 청색 발광다이오드 칩의 일부 광을 흡수하는 황화스트론튬갈륨계 녹색형광체의 함유량을 조정함으로써, 선택되어진 영역의 색좌표 구현이 가능하다.

발명의 효과

상술한 바와 같이, 본 발명에서 청색 발광다이오드에 의해 발광된 청색광의 일부는 투과하여 청색을 나타내고, 일부 광은 황화스트론튬갈륨계 녹색형광체에 흡수하여 녹색의 광을 발광하며 적색발광다이오드에서 발광되는 적색의 세 가지 색의 혼색에 의한 삼파장 백색 발광다이오드는 휘도 및 색재현성이 우수하여 휴대폰을 비롯한 소형 LCD 백라이트용 광원뿐만 아니라 노트북 및 LCD TV 모니터등에 백라이트 광원으로 사용될 수 있다. 본 발명은 상술한 실시 예에 한정되지 않으며, 본 발명의 기술적 사상 내에서 당 분야의 통상의 지식을 가진 자에 의하여 많은 변형이 가능함은 명백할 것이다.

(57) 청구의 범위

청구항 1.
적색반도체 발광다이오드와 InGaN 계열의 청색 반도체 발광다이오드에 의해 방출된 광의 일부를 흡수하여 흡수한 광의 파장과는 다른 파장을 가진 광을 방출하는 녹색 형광체와 투명수지를 함유하는 형광체 코팅층을 포함하며,

상기 녹색 형광체는 2가의 유로퓸으로 활성화된 황화스트론튬갈륨계이고;

$(Sr_{1-x-y},M_x)Ga_2S_4:Eu_y$

구체적으로 황화 스트론튬 갈륨계 녹색형광체는 일반적인 화학식으로 표시되고, M는 Sr, Ca, Mg, K, Na, Ba에서 선택된 적어도 하나의 원소로 이루어진 군으로부터 선택된 것임을 특징으로 하는 삼파장 반도체 발광장치.

청구항 2.
제 1항에 있어서, 상기 녹색 형광체는 하기 일반식으로 표시되는 것임을 특징으로 하는 삼파장 백색 반도체 발광장치:

$(Sr_{1-x-y},M_x)Ga_2S_4:Eu_y$

식에서, M는 전형원소의 금속원소로서 Sr, Ca, Mg, K, Na, Ba에서 선택된 적어도 하나의 원소로서 $0 \leq x \leq 0.5$이고, $0 < y < 0.5$이고,

바람직하기로는 $0 < x+y < 1$이며, 더욱 바람직하기로는 $0 < x+y < 0.5$이다. 또한, $0.05 \leq x \leq 0.3$, $0.0005 \leq y \leq 0.1$인 것이 바람직하다.

청구항 3.
제 1항에 있어서, 상기 녹색 형광체가 약 420nm에서 480nm 범위 내에서 흡수피크를 나타내고, 약 500nm에서 600nm 내에서 발광피크를 나타내는 것을 특징으로 하는 삼파장 백색 반도체 발광장치.

청구항 4.
제 1항에 있어서, 상기 반도체 발광다이오드가 플라스틱사출물로 형성된 반사컵내에 위치한 캐소드패드와 캐소드패드에 위치하는 질화물계 반도체층, 상기 패드상에 2항의 형광체와 투명수지를 함유하는 형광체 코팅층을 포함하는 것을 특징으로 하는 백색 반도체 발광장치.

청구항 5.
제 1항에 있어서, 상기 형광체 코팅층의 투명수지는 투명 에폭시 수지 또는 실리콘 수지인 것을 특징으로 하는 삼파장 백색 반도체 발광장치.

청구항 6.
제 2항과 3항에 있어서, 용적 분배의 평균 입자 크기(d_{50})가 1μm 내지 30μm인 것을 특징으로 하는 삼파장 백색 반도체 발광장치.

청구항 7.
적색 반도체 발광다이오드와 청색 반도체 발광다이오드에 의해 방출된 광의 일부를 흡수하여 흡수한 광의 파장과는 다른 파장을 가진 광을 방출하는 녹색 형광체와 투명수지를 함유하는 형광체 코팅층을 포함하며,

상기 녹색 형광체는 2가의 유로퓸으로 활성화된 황화스트론튬갈륨계이고;

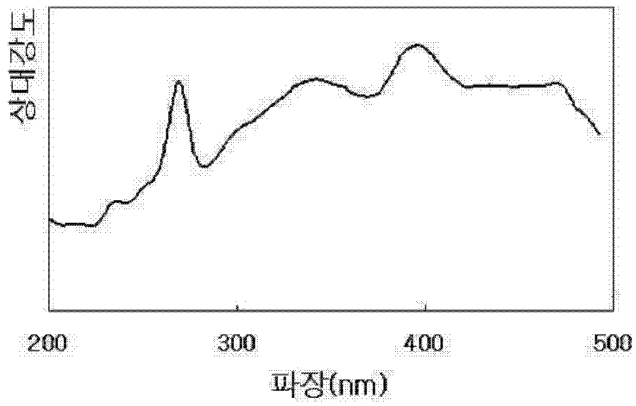
$(Sr_{1-x-y},M_x)Ga_2S_4:Eu_y$

구체적으로 황화 스트론튬 갈륨계 녹색형광체는 일반적인 화학식으로 표시되고, M는 Sr, Ca, Mg, K, Na, Ba에서 선택된 적어도 하나의 원소로 이루어진 군으로부터 선택된 것임을 특징으로 하는 삼파장 반도체 발광장치.

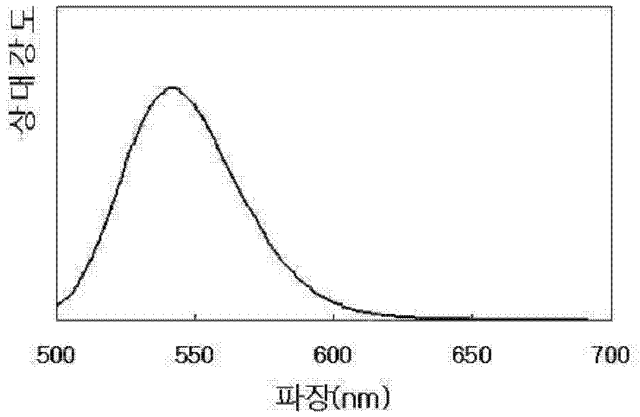
청구항 8.
제 1항 내지 7항 중 어느 한 항에 따른 삼파장 백색 반도체 발광장치를 배면광원으로 채용한 디스플레이 모듈 및 기구 장치.

도면

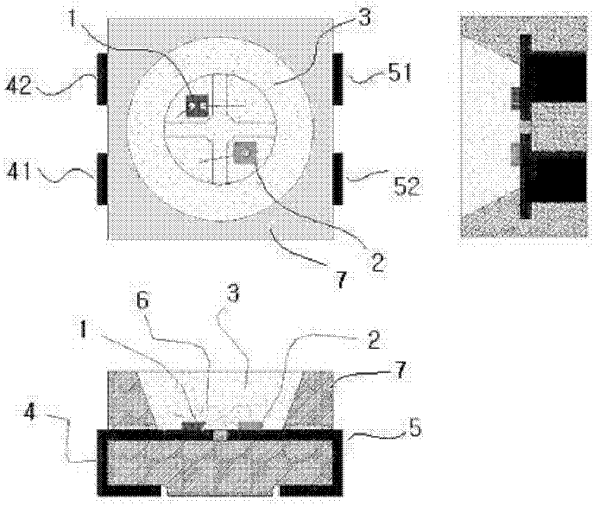
도면1



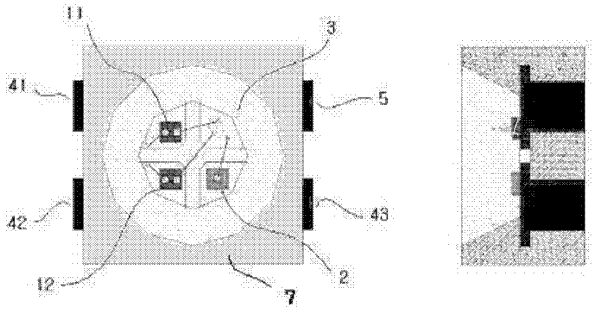
도면2


상대강도
500
550
600
650
700
파장(nm)

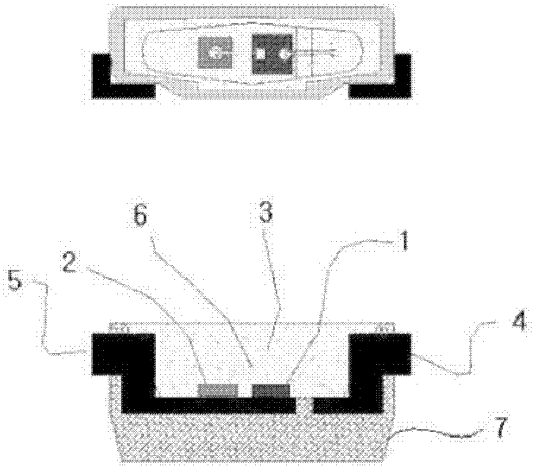
도면3


1
3
42
51
41
52
2
7
6
3
1
2
7
4
5

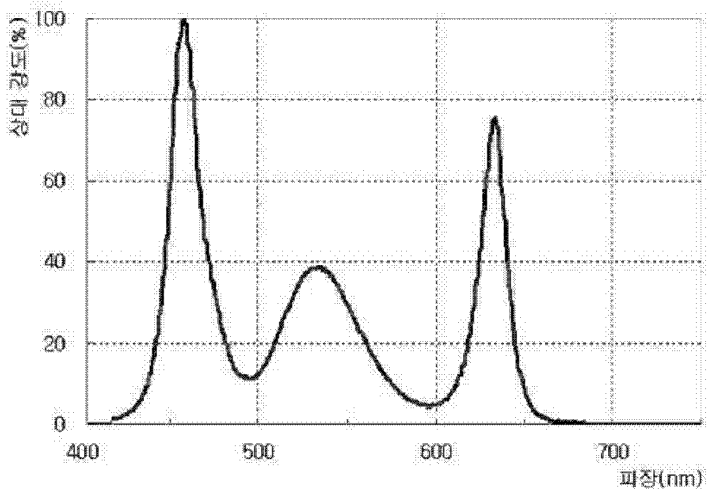
도면4


11
3
41
5
42
43
12
2
7

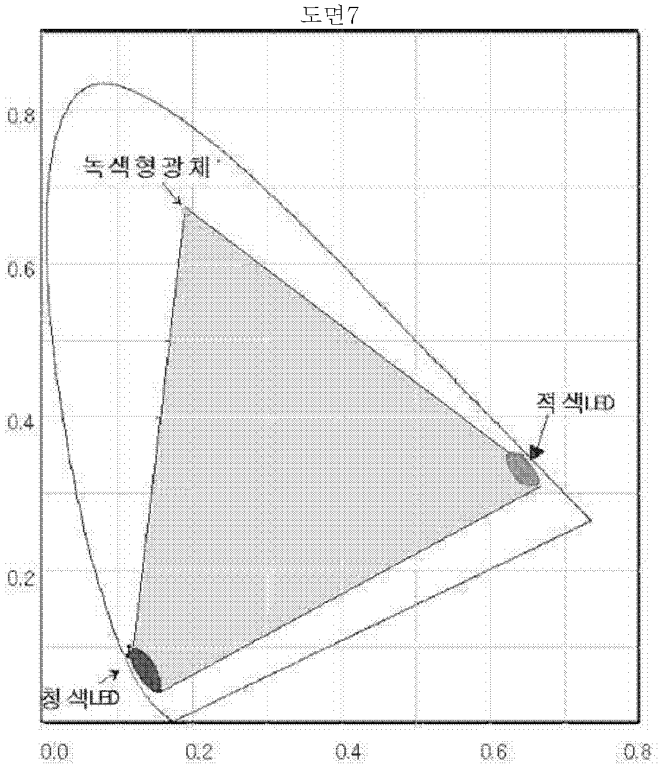
도면5



도면6



도면7



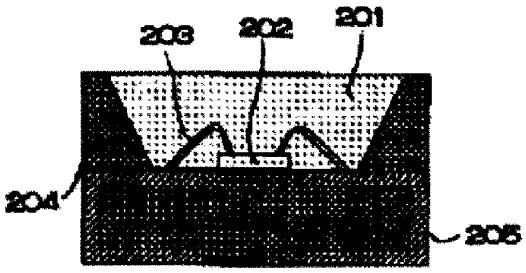
LIGHT EMITTING DIODE AND DISPLAY DEVICE USING THE SAME

Publication number: JP10242513
Publication date: 1998-09-11
Inventor(s): SHIMIZU YOSHINORI; SAKANO AKIMASA
Applicant(s): NICHIA KAGAKU KOGYO KK
Classification:
- International: ***H04N5/66; G09F9/00; H01L33/00;*** H04N5/66; G09F9/00; H01L33/00; (IPC1-7): H01L33/00; G09F9/00; H04N5/66
- European:
Application number: JP19970218149 19970728
Priority number(s): JP19970218149 19970728; JP19960198585 19960729; JP19960245381 19960918; JP19960350004 19961227

Report a data error here

Abstract of **JP10242513**

PROBLEM TO BE SOLVED: To reduce the luminous efficiency deterioration and color slurring of a light emitting diode even when the diode is used for a long time under a high-luminance condition, by respectively constituting the LED chip and photoluminescent phosphor of the diode of a nitride compound semiconductor and cerium-reactivated yttrium aluminum garnet phosphor. SOLUTION: An LED chip 202 using a gallium nitride semiconductor is fixed in an enclosure 204 of a chip type LED with an epoxy resin, etc. An epoxy resin in which a (RE1-x Smx)3 (Aly Ga1-y)5 O12 : Ce phosphor is scattered is uniformly cured as a molded member 201 which protects the LED chip 202, conductive wires, etc., from the external stresses. The cerium-reactivated yttrium aluminum garnet phosphor is scattered in the epoxy resin as a photoluminescent phosphor.



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(56)参考文献　特開　昭50－43913（ＪＰ，Ａ）
特開　昭62－20237（ＪＰ，Ａ）
実開　昭50－79379（ＪＰ，Ｕ）
実開　平７－42152（ＪＰ，Ｕ）

最終頁に続く

(54)【発明の名称】　発光ダイオード

(57)【特許請求の範囲】

【請求項１】　マウント・リードのカップ内に配置させた発光層が窒化ガリウム系化合物半導体であるＬＥＤチップと、該ＬＥＤチップと導電性ワイヤーを用いて電気的に接続させたインナー・リードと、前記ＬＥＤチップが発光した光によって励起され発光する蛍光体を含有する透明樹脂を前記カップ内に充填させたコーティング部材と、該コーティング部材、ＬＥＤチップ、導電性ワイヤー及びマウント・リードとインナーリードの先端を被覆するモールド部材とを有する発光ダイオードであって、前記ＬＥＤチップは、発光スペクトルが４００ｎｍから５３０ｎｍの単色性ピーク波長を発光し、前記蛍光体は（$RE_{1-x}Sm_x)_3(Al_yGa_{1-y})_5O_{12}$：Ｃｅであり、且つＬＥＤチップからの光及び蛍光体からの光はモールド部材を透過することによって白色

系が発光可能なことを特徴とする発光ダイオード。ただし、$0 \leq x < 1$、$0 \leq y \leq 1$、ＲＥは、Ｙ、Ｇｄから選択される少なくとも１種である。

【請求項２】　前記モールド部材が、レンズ効果を有する形状であると共に拡散材を含有する請求項１に記載の発光ダイオード。

【請求項３】　前記透明樹脂が、エポキシ樹脂、ユリア樹脂、シリコーンから選択される一種である請求項１に記載の発光ダイオード。

【請求項４】　前記モールド部材は、前記コーティング部材を構成する透明樹脂と同じ部材を用いている請求項１に記載の発光ダイオード。

【請求項５】　前記コーティング部の表面側からＬＥＤチップ側に蛍光体を徐々に多くする請求項１に記載の発光ダイオード。

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【請求項６】　チップタイプＬＥＤの筐体内に配置させた発光層が窒化ガリウム系化合物半導体であるＬＥＤチップと、該ＬＥＤチップが発光した光によって励起されて発光する蛍光体を含有する透明樹脂を前記ＬＥＤチップが配設された筐体内に充填させたモールド部材とを有する発光ダイオードであって、前記ＬＥＤチップは、発光スペクトルが４００ｎｍから５３０ｎｍの単色性ピーク波長を発光し、前記蛍光体は（$RE_{1-x}Sm_x$）$_3$（Al_yGa_{1-y}）$_5O_{12}$：Ｃｅであり、且つＬＥＤチップからの光及び蛍光体からの光は、前記モールド部材を透過することによって白色系が発光可能なことを特徴とする発光ダイオード。ただし、$0 \leqq x < 1$、$0 \leqq y \leqq 1$、ＲＥは、Ｙ、Ｇｄから選択される少なくとも１種である。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本願発明は、ＬＥＤディスプレイ、バックライト光源、信号機、照光式スイッチ及び各種インジケータなどに利用される発光ダイオードに係わり、特に発光素子であるＬＥＤチップからの発光を変換して発光させるフォトルミネセンス蛍光体を有し使用環境によらず高輝度、高効率な発光装置である白色系が発光可能な発光ダイオードに関する。

【０００２】

【従来の技術】発光ダイオード（以下、ＬＥＤともいう）は、小型で効率が良く鮮やかな色の発光をする。また、半導体素子であるため球切れなどの心配がない。駆動特性が優れ、振動やON／OFF点灯の繰り返しに強いという特長を有する。そのため各種インジケータや種々の光源として利用されている。最近、超高輝度高効率な発光ダイオードとしてＲＧＢ（赤、緑、青色）などの発光ダイオードがそれぞれ開発された。これに伴いＲＧＢの三原色を利用したＬＥＤディスプレイが省電力、長寿命、軽量などの特長を生かして飛躍的に発展を遂げつつある。

【０００３】発光ダイオードは使用される発光層の半導体材料、形成条件などによって紫外から赤外まで種々の発光波長を放出させることが可能である。また、優れた単色性ピーク波長を有する。

【０００４】しかしながら、発光ダイオードは優れた単色性ピーク波長を有するが故に白色系発光光源などとさせるためには、ＲＧＢなどが発光可能な各ＬＥＤチップをそれぞれ近接して発光させ拡散混色させる必要がある。このような発光ダイオードは、種々の色を自由に発光させる発光装置としては有効であるが、白色系などの色のみを発光させる場合においても赤色系、緑色系及び青色系の発光ダイオード、あるいは青緑色系及び黄色系の発光ダイオードをそれぞれ使用せざるを得ない。ＬＥＤチップは、半導体であり色調や輝度のバラツキもまだ相当ある。また、半導体発光素子であるＬＥＤチップがそれぞれ異なる材料を用いて形成されている場合、各ＬＥＤチップの駆動電力などが異なり個々に電源を確保する必要がある。そのため、各半導体ごとに電流などを調節して白色系を発光させなければならない。同様に、半導体発光素子であるため個々の温度特性の差や経時変化が異なり、色調が種々変化してしまう。さらに、ＬＥＤチップからの発光を均一に混色させなければ色むらを生ずる場合がある。

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【０００５】そこで、本出願人は先にＬＥＤチップの発光色を蛍光体で色変換させた発光ダイオードとして特開平５－１５２６０９号公報、特開平７－９９３４５号公報などに記載された発光ダイオードを開発した。これらの発光ダイオードによって、１種類のＬＥＤチップを用いて白色系など他の発光色を発光させることができる。

【０００６】具体的には、発光層のエネルギーバンドギャップが大きいＬＥＤチップをリードフレームの先端に設けられたカップ上などに配置する。ＬＥＤチップは、ＬＥＤチップが設けられたメタルステムやメタルポストとそれぞれ電気的に接続させる。そして、ＬＥＤチップを被覆する樹脂モールド部材中などにＬＥＤチップからの光を吸収し波長変換する蛍光体を含有させて形成させてある。

【０００７】ＬＥＤチップからの発光を波長変換した発光ダイオードとして、青色系の発光ダイオードの発光と、その発光を吸収し黄色系を発光する蛍光体からの発光との混色により白色系が発光可能な発光ダイオードなどとすることができる。これらの発光ダイオードは、白色系を発光する発光ダイオードとして利用した場合においても十分な輝度を発光する発光ダイオードとすることができる。

【０００８】

【発明が解決する課題】発光ダイオードによって励起される蛍光体は、蛍光染料、蛍光顔料さらには有機、無機化合物などから様々なものが挙げられる。また、蛍光体は、発光素子からの発光波長を波長の短いものから長い波長へと変換する、あるいは発光素子からの発光波長を波長の長いものから短い波長へと変換するものとがある。

【０００９】しかしながら、波長の長いものから短い波長へと変換する場合、変換効率が極めて悪く実用に向かない。また、ＬＥＤチップ周辺に近接して配置された蛍光体は、太陽光よりも約３０倍から４０倍にも及ぶ強照射強度の光線にさらされる。特に、発光素子であるＬＥＤチップを高エネルギーバンドギャップを有する半導体を用い蛍光体の変換効率向上や蛍光体の使用量を減らした場合においては、ＬＥＤチップから発光した光が可視光域にあるといっても光エネルギーが必然的に高くなる。この場合、発光強度を更に高め長期にわたって使用すると、蛍光体自体が劣化しやすい。蛍光体が劣化すると色調がずれる、あるいは蛍光体が黒ずみ光の外部取り

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出し効率が低下する場合がある。同様にＬＥＤチップの近傍に設けられた蛍光体は、ＬＥＤチップの昇温や外部環境からの加熱など高温にもさらされる。さらに、発光ダイオードは、一般的に樹脂モールドに被覆されてはいるものの外部環境からの水分の進入などを完全に防ぐことや製造時に付着した水分を完全に除去することはできない。蛍光体によっては、このような水分が発光素子からの高エネルギー光や熱によって蛍光体物質の劣化を促進する場合もある。また、イオン性の有機染料に至って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。したがって、本願発明は上記課題を解決し、より高輝度、長時間の使用環境下においても発光光率の低下や色ずれの極めて少ない発光ダイオードを提供することを目的とする。

【００１０】

【課題を解決するための手段】本願発明の請求項１の発光ダイオードは、マウント・リードのカップ内に配置させた発光層を窒化ガリウム系化合物半導体とするＬＥＤチップと、このＬＥＤチップに導電性ワイヤーを用いて電気的に接続されるインナー・リードと、ＬＥＤチップの発光によって励起されて発光する発光体を含有する透明樹脂であってカップ内に充填されているコーティング部材と、コーティング部材、ＬＥＤチップ、導電性ワイヤー及びマウント・リードとインナー・リードの少なくとも一部を被覆するモールド部材とを有する。ＬＥＤチップの発光スペクトルは、４００ｎｍから５３０ｎｍに発光ピークのある、単色性ピーク波長のものである。蛍光体は（$RE_{1-x}Sm_x$）$_3$（Al_yGa_{1-y}）$_5O_{12}$：Ｃｅである。ただし、０≦ｘ＜１、０≦ｙ≦１、ＲＥは、Ｙ、Ｇｄから選択される少なくとも１種である。ＬＥＤチップからの光及び蛍光体からの光は、モールド部材を透過して、白色系に発光可能な状態となっている。

【００１１】また、本発明の請求項２の発光ダイオードは、モールド部材に、レンズ効果のある形状のものを使用し、さらに、請求項３の発光ダイオードは、透明樹脂に、エポキシ樹脂、ユリア樹脂、シリコーンから選択される一種のものを使用する。

【００１２】さらにまた、本願発明の請求項４に記載する発光ダイオードは、モールド部材に、コーティング部材を構成している透明樹脂と同じ部材を用いている。

【００１３】また、本発明の請求項５の発光ダイオードは、コーティング部に、表面側からＬＥＤチップ側に、蛍光体を徐々に多くしている。

【００１４】さらに、本発明の請求項６に記載する発光ダイオードは、ＬＥＤチップとモールド部材とを有する。ＬＥＤチップは、チップタイプＬＥＤの筐体内に配置させている発光層を窒化ガリウム系化合物半導体とする。モールド部材は、透明樹脂をＬＥＤチップを配設している筐体内に充填させたもので、ＬＥＤチップの発光

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に励起されて発光する蛍光体を含有している。ＬＥＤチップの発光スペクトルは、４００ｎｍから５３０ｎｍに発光ピークのある単色性ピーク波長を示す。蛍光体は（$RE_{1-x}Sm_x$）$_3$（Al_yGa_{1-y}）$_5O_{12}$：Ｃｅである。ただし、０≦ｘ＜１、０≦ｙ≦１、ＲＥは、Ｙ、Ｇｄから選択される少なくとも１種である。ＬＥＤチップからの光及び蛍光体からの光は、モールド部材を透過して、白色系が発光可能である。

【００１５】

【発明の実施の形態】本願発明者は、種々の実験の結果、可視光域における光エネルギーが比較的高いＬＥＤチップからの発光光をフォトルミネセンス蛍光体によって色変換させる発光ダイオードにおいて、特定の半導体及び蛍光体を選択することにより高輝度、長時間の使用時における光効率低下や色ずれを防止できることを見出し本願発明を成すに至った。

【００１６】すなわち、発光ダイオードに用いられるＬＥＤチップとしては、

１．ＬＥＤチップの発光特性が長期間の使用に対して安定していること。

２．蛍光体を励起させ二次的な放出を行うのに十分な高輝度、高エネルギーの単色性ピーク波長を効率よく発光可能であることが求められる。また、発光ダイオードに用いられるフォトルミネセンス蛍光体としては、

１．耐光性に優れていることが要求される。特に、半導体発光素子などの微小領域から強放射されるために太陽光の約３０倍から４０倍にもおよぶ強照射強度にも十分耐える必要がある。

２．発光素子との混色を利用するため紫外線ではなく青色系発光で効率よく発光すること。

３．混色を考慮して緑色系から赤色系の光が発光可能なこと。

４．発光素子近傍に配置されるため温度特性が良好であること。

５．色調が組成比あるいは複数の蛍光体の混合比で連続的に変えられること。

６．発光ダイオードの利用環境に応じて耐候性があることなどの特長を有することが求められる。

【００１７】これらの条件を満たすものとして本願発明の発光ダイオードは、発光層に高エネルギーバンドギャップを有する窒化ガリウム系化合物半導体素子と、フォトルミネセンス蛍光体であるセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体とを組み合わせる。これにより発光素子から放出された可視光域における高エネルギー光を長時間その近傍で高輝度に照射した場合であっても発光色の色ずれや発光輝度の低下が極めて少ない発光ダイオードとすることができるものである。特に、窒化物系化合物半導体としてＩｎＧａＮの青色発光と、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体の吸収スペクトルとは

非常に良く一致している。また、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体の発する蛍光とＩｎＧａＮの青色光の混色は、演色性の良い良質の白色を得るという点において他の組み合わせにはない極めて特異な性能を有する。

【００１８】具体的な発光ダイオードの一例を図１に示し、さらに、チップタイプＬＥＤのの断面図を図２に示す。チップタイプＬＥＤの筐体２０４内に窒化ガリウム系半導体を用いたＬＥＤチップ２０２をエポキシ樹脂などを用いて固定させてある。導電性ワイヤー２０３として金線をＬＥＤチップ２０２の各電極と筐体に設けられた各電極２０５とにそれぞれ電気的に接続させてある。（$RE_{1-x}Sm_x$）$_3$（Al_yGa_{1-y}）$_5O_{12}$：Ｃｅ蛍光体をエポキシ樹脂中に混合分散させたものをＬＥＤチップ、導電性ワイヤーなどを外部応力などから保護するモールド部材２０１として均一に硬化形成させる。このような発光ダイオードに電力を供給させることによってＬＥＤチップ２０２を発光させる。ＬＥＤチップ２０２からの発光と、その発光によって励起されたフォトルミネセンス蛍光体からの発光光との混色により白色系などが発光可能な発光ダイオードとすることができる。以下、本願発明の構成部材について詳述する。

【００１９】

（蛍光体）

本願発明の発光ダイオードに用いられるフォトルミネセンス蛍光体は、半導体発光層から発光された可視光や紫外線で励起されて発光するフォトルミネセンス蛍光体である。フォトルミネセンス蛍光体は、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体である。

【００２０】本明細書においてイットリウム・アルミニウム・ガーネット系蛍光体は特に広義に解釈するものとし、イットリウムの一部あるいは全体を、Ｌｕ、Ｓｃ、Ｌａ、Ｇｄ及びＳｍからなる群から選ばれる少なくとも１つの元素に置換し、あるいは、アルミニウムの一部あるいは全体を、ＧａとＩｎの何れかまたは両方で置換する蛍光体を含む広い意味に使用する。

【００２１】更に詳しくは、（$RE_{1-x}Sm_x$）$_3$（Al_yGa_{1-y}）$_5O_{12}$：Ｃｅ（但し、$0 \leq x < 1$、$0 \leq y \leq 1$、ＲＥは、Ｙ、Ｇｄから選択される少なくとも一種）である。窒化ガリウム系化合物半導体を用いたＬＥＤチップから発光した光と、ボディーカラーが黄色であるフォトルミネセンス蛍光体から発光する光が補色関係にある場合、ＬＥＤチップからの発光と、フォトルミネセンス蛍光体からの発光とを混色表示させると、白色系の発光色表示を行うことができる。そのため発光ダイオード外部には、ＬＥＤチップからの発光とフォトルミネセンス蛍光体からの発光とがモールド部材を透過する必要がある。したがって、フォトルミネセンス蛍光体をスパッタリング法などにより形成させた蛍光体の層などにＬＥＤチップを閉じこめ、フォトルミネセンス蛍光体層にＬＥＤチップからの光が透過する開口部を１ないし２以上有する或いはＬＥＤチップからの光が透過可能な如き薄膜とした構成の発光ダイオードとしても良い。なお、スパッタリング法などにより形成させた蛍光体は、コーティング部のバインダーを省略することもできる。その膜厚で発光色を調整することもできる。また、フォトルミネセンス蛍光体の粉体を樹脂や硝子中に含有させＬＥＤチップからの光が透過する程度に薄く形成させても良い。同様に、フォトルミネセンス蛍光体の粉体を樹脂や硝子中に含有させＬＥＤチップからの光が透過する程度に薄く形成させても良い。フォトルミネセンス蛍光体と樹脂などとの比率や塗布、充填量を種々調整すること及び発光素子の発光波長を選択することにより白色を含め電球色など任意の色調を提供させることができる。

【００２２】さらに、フォトルミネセンス蛍光体の含有分布は、混色性や耐久性にも影響する。すなわち、フォトルミネセンス蛍光体が含有されたコーティング部やモールド部材の表面側からＬＥＤチップに向かってフォトルミネセンス蛍光体の分布濃度が高い場合は、外部環境からの水分などの影響をより受けにくく水分による劣化を抑制しやすい。他方、フォトルミネセンス蛍光体の含有分布をＬＥＤチップからモールド部材表面側に向かって分布濃度が高くなると外部環境からの水分の影響を受けやすいがＬＥＤチップからの発熱、照射強度などの影響がより少なくフォトルミネセンス蛍光体の劣化を抑制することができる。このような、フォトルミネセンス蛍光体の分布は、フォトルミネセンス蛍光体を含有する部材、形成温度、粘度やフォトルミネセンス蛍光体の形状、粒度分布などを調整させることによって種々形成させることができる。したがって、使用条件などにより蛍光体の分布濃度を、種々選択することができる。

【００２３】本願発明の発光ダイオードのフォトルミネセンス蛍光体は、特にＬＥＤチップと接する、あるいは近接して配置され照射強度として（Ｅｅ）＝３Ｗ・ｃｍ$^{-2}$以上１０Ｗ・ｃｍ$^{-2}$以下においても高効率に十分な耐光性を有し、優れた発光特性の発光ダイオードとすることができる。

【００２４】本願発明に用いられるフォトルミネセンス蛍光体は、ガーネット構造のため、熱、光及び水分に強く、図４に示すように、励起スペクトルのピークを４５０ｎｍ付近にさせることができる。また、発光ピークも図４に示すように、５８０ｎｍ付近にあり７００ｎｍまで裾を引くブロードな発光スペクトルを持つ。

【００２５】また、本願発明の発光ダイオードのフォトルミネセンス蛍光体は、結晶中にＧｄ（ガドリニウム）を含有することにより、４６０ｎｍ以上の長波長域の励起発光効率を高くすることができる。Ｇｄの含有量の増

加により、発光ピーク波長が長波長に移動し全体の発光波長も長波長側にシフトする。すなわち、赤みの強い発光色が必要な場合、Ｇｄの置換量を多くすることで達成できる。一方、Ｇｄが増加すると共に、青色光によるフォトルミネセンスの発光輝度は低下する傾向にある。

【００２６】しかも、ガーネット構造を持ったイットリウム・アルミニウム・ガーネット系蛍光体の組成の内、Ａｌの一部をＧａで置換することで発光波長が短波長側にシフトする。また、組成のＹの一部をＧｄで置換することで、発光波長が長波長側にシフトする。

【００２７】ＡｌをＧａに置換させる場合、発光効率と発光波長を考慮してＡｌ：Ｇａ＝６：４から１：１の間の比率に設定することが好ましい。同様に、Ｙの一部をＧｄで置換することはＹ：Ｇｄ＝９：１から１：９の範囲の比率に設定することが好ましく、４：１から２：３の範囲に設定することがより好ましい。Ｇｄへの置換が２割未満では、緑色成分が大きく赤色成分が少なくなる。また、Ｇｄへの置換が６割以上では、赤み成分が増えるものの輝度が急激に低下する傾向にある。特に、ＬＥＤチップの発光波長によるがイットリウム・アルミニウム・ガーネット系蛍光体の組成の内Ｙ：Ｇｄ＝４：１から２：３の範囲とすることにより１種類のイットリウム・アルミニウム・ガーネット系蛍光体を用いて黒体放射軌跡におおよそ沿って白色光が発光可能な発光ダイオードとすることができる。なお、Ｙ：Ｇｄ＝２：３より多く１：４では輝度は低くなるものの電球色が発光可能＊な発光ダイオードとすることができる。また、Ｃｅの含有（置換）は、０．００３から０．２含有させることにより相対発光輝度が７０％以上となる。（なお、相対発光輝度は、ｑ＝０．０３の蛍光体の発光輝度を１００％とした場合における発光輝度である。）０．００３未満では、Ｃｅによるフォトルミネセンスの励起発光中心の数が減少することで輝度が低下し、逆に、０．２より大きくなると濃度消光が生ずる。（濃度消光とは、蛍光体の輝度を高めるため付活材の濃度を増加していくと、ある最適値以上の濃度では発光強度が低下することをいう。）

【００２８】本願発明の発光ダイオードのフォトルミネセンス蛍光体は、このように組成を変化することで発光色を連続的に調節することが可能である。また、２５４ｎｍや３６５ｎｍなどのＨｇ輝線ではほとんど励起されず４５０ｎｍ付近などの青色系ＬＥＤチップからの光による励起効率が高い。したがって、長波長側の強度がＧｄの組成比で連続的に変えられるなど窒化物半導体の青色系発光を白色系発光に変換するための理想条件を備えている。

【００２９】表１は、本願発明に用いられるフォトルミネセンス蛍光体の組成と発光特性の一例を示す。（なお、測定条件は、４６０ｎｍの青色光で励起して観測してある。また、輝度と効率は、相対値で表してある。）

【００３０】

【表１】

フォトルミネッセンス蛍光体の組成	ＣＩＥ色度座標		輝度	エネルギー効率
	x	y	Y	ENG
$Y_3Al_5O_{12}:Ce$	0.41	0.56	100	100
$Y_3(Al_{0.6}Ga_{0.4})_5O_{12}:Ce$	0.32	0.56	61	63
$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}:Ce$	0.29	0.54	55	67
$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}:Ce$	0.45	0.53	102	108
$(Y_{0.6}Gd_{0.4})_3Al_5O_{12}:Ce$	0.47	0.52	102	113
$(Y_{0.4}Gd_{0.6})_3Al_5O_{12}:Ce$	0.49	0.51	97	113
$(Y_{0.2}Gd_{0.8})_3Al_5O_{12}:Ce$	0.50	0.50	72	86

【００３１】また、窒化ガリウム系半導体を用いたＬＥＤチップと、セリウムで付活されたイットリウム・アルミニウム・ガーネット蛍光体（ＹＡＧ）に希土類元素のサマリウム（Ｓｍ）を含有させたフォトルミネセンス蛍光体と、を有する発光ダイオードとすることによりさらに光効率を向上させることができる。

【００３２】このようなフォトルミネセンス蛍光体は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍ、Ａｌ及びＧａの原料として酸化物、又は高温で容易に酸化物になる化合物を使用し、それらを化学量論比で十分に混合して原料を得る。又は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈したものを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムとを混合して混合原料を得る。これにフラックスとしてフッ化アンモニウム等のフッ化物を適量混合して坩堝に詰め、空気中１３５０～１４５０°Ｃの温度範囲で２～５時間焼成して焼成品を得、次に焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通すことで得る

ことができる。

【００３３】Ｓｍを含有する（$Y_{1-p-q-r}Gd_pCe_qSm_r$）$_3Al_5O_{12}$蛍光体は、Ｇｄの含有量の増加に関わらず温度特性の低下が少ない。このようにＳｍを含有させることにより、高温度におけるフォトルミネセンス蛍光体の発光輝度は大幅に改善される。その改善される程度はＧｄの含有量が高くなるほど大きくなる。すなわち、Ｇｄを増加してフォトルミネセンス蛍光体の発光色調に赤みを付与した組成ほどＳｍの含有による温度特性改善に効果的であることが分かった。（なお、ここでの温度特性とは、４５０ｎｍの青色光による常温（２５°Ｃ）における励起発光輝度に対する、同蛍光体の高温（２００°Ｃ）における発光輝度の相対値（％）で表している。）

【００３４】Ｓｍの含有量は０．０００３≦ｒ≦０．０８の範囲で温度特性が６０％以上となり好ましい。この範囲よりｒが小さいと、温度特性改良の効果が小さくなる。また、この範囲よりｒが大きくなると温度特性は逆に低下してくる。０．０００７≦ｒ≦０．０２の範囲では温度特性は８０％以上となり最も好ましい。

【００３５】本願発明の発光ダイオードにおいてこのようなフォトルミネセンス蛍光体は、２種類以上の$(RE_{1-x}Sm_x)_3(Al_yGa_{1-y})_5O_{12}$：Ceフォトルミネセンス蛍光体を混合させてもよい。すなわち、Ａｌ、Ｇａ、Ｙ及びＧｄやＳｍの含有量が異なる２種類以上の$(RE_{1-x}Sm_x)_3(Al_yGa_{1-y})_5O_{12}$：Ceフォトルミネセンス蛍光体を混合させてＲＧＢの波長成分を増やすことができる。これに、カラーフィルターを用いることによりフルカラー液晶表示装置用としても利用できる。

【００３６】

（ＬＥＤチップ１０２、２０２、７０２）

ＬＥＤチップは、図１に示すように、モールド部材１０４に埋設される。本願発明の発光ダイオードに用いられるＬＥＤチップとは、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を効率良く励起できる窒化物系化合物半導体である。ここで、窒化物系化合物半導体（一般式$In_iGa_jAl_kN$、但し、０≦ｉ、０≦ｊ、０≦ｋ、ｉ＋ｊ＋ｋ＝１）としては、ＩｎＧａＮや各種不純物がドープされたＧａＮを始め、種々のものが含まれる。発光素子であるＬＥＤチップは、ＭＯＣＶＤ法等により基板上にＩｎＧａＮ等の半導体を発光層として形成させる。半導体の構造としては、ＭＩＳ接合、ＰＩＮ接合やＰＮ接合などを有するホモ構造、ヘテロ構造あるいはダブルヘテロ構成のものが挙げられる。半導体層の材料やその混晶度によって発光波長を種々選択することができる。また、半導体活性層を量子効果が生ずる薄膜に形成させた単一量子井戸構造や多重量子井戸構造とすることもできる。特に、本願発明においては、ＬＥＤチップの活性層をＩｎＧａＮの単一量子井戸構造とすることにより、フォトルミネセンス蛍光体の劣化がなく、より高輝度に発光する発光ダイオードとして利用することができる。

【００３７】窒化ガリウム系化合物半導体を使用した場合、半導体基板にはサファイヤ、スピネル、ＳｉＣ、Ｓｉ、ＺｎＯ等の材料が用いられる。結晶性の良い窒化ガリウムを形成させるためにはサファイヤ基板を用いることが好ましい。このサファイヤ基板上にＧａＮ、ＡｌＮ等のバッファー層を形成しその上にＰＮ接合を有する窒化ガリウム半導体を形成させる。窒化ガリウム系半導体は、不純物をドープしない状態でＮ型導電性を示す。発光効率を向上させるなど所望のＮ型窒化ガリウム半導体を形成させる場合は、Ｎ型ドーパントとしてＳｉ、Ｇｅ、Ｓｅ、Ｔｅ、Ｃ等を適宜導入することが好ましい。一方、Ｐ型窒化ガリウム半導体を形成させる場合は、Ｐ型ドーパンドであるＺｎ、Ｍｇ、Ｂｅ、Ｃａ、Ｓｒ、Ｂａ等をドープさせる。窒化ガリウム系化合物半導体は、Ｐ型ドーパントをドープしただけではＰ型化しにくいためＰ型ドーパント導入後に、炉による加熱、低速電子線照射やプラズマ照射等によりＰ型化させることが好ましい。エッチングなどによりＰ型半導体及びＮ型半導体の露出面を形成させた後、半導体層上にスパッタリング法や真空蒸着法などを用いて所望の形状の各電極を形成させる。

【００３８】次に、形成された半導体ウエハー等をダイヤモンド製の刃先を有するブレードが回転するダイシングソーにより直接フルカットするか、又は刃先幅よりも広い幅の溝を切り込んだ後（ハーフカット）、外力によって半導体ウエハーを割る。あるいは、先端のダイヤモンド針が往復直線運動するスクライバーにより半導体ウエハーに極めて細いスクライブライン（経線）を例えば碁盤目状に引いた後、外力によってウエハーを割り半導体ウエハーからチップ状にカットする。このようにして窒化ガリウム系化合物半導体であるＬＥＤチップを形成させることができる。

【００３９】本願発明の発光ダイオードにおいて白色系を発光させる場合は、フォトルミネセンス蛍光体との補色関係や樹脂劣化等を考慮して発光素子の発光波長は４００ｎｍ以上５３０ｎｍ以下が好ましく、４２０ｎｍ以上４９０ｎｍ以下がより好ましい。ＬＥＤチップとフォトルミネセンス蛍光体との効率をそれぞれより向上させるためには、４５０ｎｍ以上４７５ｎｍ以下がさらに好ましい。本願発明の白色系発光ダイオードの発光スペクトルを図３に示す。４５０ｎｍ付近にピークを持つ発光がＬＥＤチップからの発光であり、５７０ｎｍ付近にピークを持つ発光がＬＥＤチップによって励起されたフォトルミネセンスの発光である。なお、本願発明のＬＥＤチップに加えて、蛍光体を励起しないＬＥＤチップを一緒に用いることもできる。

【００４０】具体的には、フォトルミネセンス蛍光体が

励起可能な窒化物系化合物半導体であるＬＥＤチップに加えて、フォトルミネセンス蛍光体を実質的に励起しない発光層がガリウム燐、ガリウムアルミニウム砒素、ガリウム砒素燐やインジュウムガリウムアルミニウム燐などであるＬＥＤチップを配置させる。フォトルミネセンス蛍光体を励起しないＬＥＤチップからの光は、蛍光体自体に吸収されることなく外部に放出される。そのため、効率よく紅白が発光可能な発光ダイオードなどとすることができる。

【００４１】

（導電性ワイヤー１０３、２０３）

導電性ワイヤー１０３、２０３としては、ＬＥＤチップ１０２、２０２の電極とのオーミック性、機械的接続性、電気伝導性及び熱伝導性がよいものが求められる。熱伝導度としては０．０１ｃａｌ／（ｓ）（ｃｍ²）（℃／ｃｍ）以上が好ましく、より好ましくは０．５ｃａｌ／（ｓ）（ｃｍ²）（℃／ｃｍ）以上である。また、作業性などを考慮して導電性ワイヤーの直径は、好ましくは、Φ１０μｍ以上、Φ４５μｍ以下である。特に、蛍光体が含有されたコーティング部と蛍光体が含有されていないモールド部材との界面で導電性ワイヤーが断線しやすい。それぞれ同一材料を用いたとしても蛍光体が入ることにより実質的な熱膨張量が異なるため断線しやすいと考えられる。そのため、導電性ワイヤーの直径は、２５μｍ以上がより好ましく、発光面積や扱い易さの観点から３５μｍ以下がより好ましい。このような導電性ワイヤーとして具体的には、金、銅、白金、アルミニウム等の金属及びそれらの合金を用いた導電性ワイヤーが挙げられる。このような導電性ワイヤーは、各ＬＥＤチップの電極と、インナー・リード及びマウント・リードなどと、をワイヤーボンディング機器によって容易に接続させることができる。

【００４２】

（マウント・リード１０５）

マウント・リード１０５としては、ＬＥＤチップ１０２を配置させるものであり、ダイボンド機器などで積載するのに十分な大きさがあれば良い。また、ＬＥＤチップを複数設置しマウント・リードをＬＥＤチップの共通電極として利用する場合においては、十分な電気伝導性とボンディングワイヤー等との接続性が求められる。また、マウント・リード上のカップ内にＬＥＤチップを配置すると共に蛍光体を内部に充填させる場合は、近接して配置させた別の発光ダイオードからの光により疑似点灯することを防止することができる。

【００４３】ＬＥＤチップ１０２とマウント・リード１０５のカップとの接着は熱硬化性樹脂などによって行うことができる。具体的には、エポキシ樹脂、アクリル樹脂やイミド樹脂などが挙げられる。また、フェースダウンＬＥＤチップなどによりマウント・リードと接着させると共に電気的に接続させるためにはＡｇペースト、カーボンペースト、金属バンプ等を用いることができる。さらに、発光ダイオードの光利用効率を向上させるためにＬＥＤチップが配置されるマウント・リードの表面を鏡面状とし、表面に反射機能を持たせても良い。この場合の表面粗さは、０．１Ｓ以上０．８Ｓ以下が好ましい。また、マウント・リードの具体的な電気抵抗としては３００μΩ－ｃｍ以下が好ましく、より好ましくは、３μΩ－ｃｍ以下である。また、マウント・リード上に複数のＬＥＤチップを積置する場合は、ＬＥＤチップからの発熱量が多くなるため熱伝導度がよいことが求められる。具体的には、０．０１ｃａｌ／（ｓ）（ｃｍ²）（℃／ｃｍ）以上が好ましくより好ましくは ０．５ｃａｌ／（ｓ）（ｃｍ²）（℃／ｃｍ）以上である。これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅、メタライズパターン付きセラミック等が挙げられる。

【００４４】

（インナー・リード１０６）

インナー・リード１０６としては、マウント・リード１０５上に配置されたＬＥＤチップ１０２と接続された導電性ワイヤー１０３との接続を図るものである。マウント・リード上に複数のＬＥＤチップを設けた場合は、各導電性ワイヤー同士が接触しないよう配置できる構成とする必要がある。具体的には、マウント・リードから離れるに従って、インナー・リードのワイヤーボンディングさせる端面の面積を大きくすることなどによってマウント・リードからより離れたインナー・リードと接続させる導電性ワイヤーの接触を防ぐことができる。導電性ワイヤーとの接続端面の粗さは、密着性を考慮して１．６Ｓ以上１０Ｓ以下が好ましい。インナー・リードの先端部を種々の形状に形成させるためには、あらかじめリードフレームの形状を型枠で決めて打ち抜き形成させてもよく、あるいは全てのインナー・リードを形成させた後にインナー・リード上部の一部を削ることによって形成させても良い。さらには、インナー・リードを打ち抜き形成後、端面方向から加圧することにより所望の端面の面積と端面高さを同時に形成させることもできる。

【００４５】インナー・リードは、導電性ワイヤーであるボンディングワイヤー等との接続性及び電気伝導性が良いことが求められる。具体的な電気抵抗としては、３００μΩ－ｃｍ以下が好ましく、より好ましくは３μΩ－ｃｍ以下である。これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅及び銅、金、銀をメッキしたアルミニウム、鉄、銅等が挙げられる。

【００４６】

（コーティング部１０１）

本願発明に用いられるコーティング部１０１とは、モールド部材１０４とは別にマウント・リードのカップに設けられるものでありＬＥＤチップの発光を変換するフォトルミネセンス蛍光体が含有されるものである。コーテ

ィング部の具体的材料としては、エポキシ樹脂、ユリア樹脂、シリコーンなどの耐候性に優れた透明樹脂や硝子などが好適に用いられる。また、フォトルミネセンス蛍光体と共に拡散剤を含有させても良い。具体的な拡散剤としては、チタン酸バリウム、酸化チタン、酸化アルミニウム、酸化珪素等が好適に用いられる。

【００４７】

（モールド部材１０４）

モールド部材１０４は、発光ダイオードの使用用途に応じてＬＥＤチップ１０２、導電性ワイヤー１０３、フォトルミネセンス蛍光体が含有されたコーティング部１０１などを外部から保護するために設けることができる。モールド部材は、一般には樹脂を用いて形成させることができる。また、フォトルミネセンス蛍光体を含有させることによって視野角を増やすことができるが、樹脂モールドに拡散剤を含有させることによってＬＥＤチップ１０２からの指向性を緩和させ視野角をさらに増やすことができる。更にまた、モールド部材１０４を所望の形状にすることによってＬＥＤチップからの発光を集束させたり拡散させたりするレンズ効果を持たせることができる。従って、モールド部材１０４は複数積層した構造でもよい。具体的には、凸レンズ形状、凹レンズ形状さらには、発光観測面から見て楕円形状やそれらを複数組み合わせた物である。モールド部材１０４の具体的材料としては、主としてエポキシ樹脂、ユリア樹脂、シリコーン樹脂などの耐候性に優れた透明樹脂や硝子などが好適に用いられる。また、拡散剤としては、チタン酸バリウム、酸化チタン、酸化アルミニウム、酸化珪素等が好適に用いられる。さらに、拡散剤に加えてモールド部材中にもフォトルミネセンス蛍光体を含有させることもできる。したがって、フォトルミネセンス蛍光体はモールド部材中に含有させてもそれ以外のコーティング部などに含有させて用いてもよい。また、コーティング部をフォトルミネセンス蛍光体が含有された樹脂、モールド部材を硝子などとした異なる部材を用いて形成させても良い。この場合、生産性良くより水分などの影響が少ない発光ダイオードとすることができる。また、屈折率を考慮してモールド部材とコーティング部とを同じ部材を用いて形成させても良い。本願発明においてモールド部材に拡散剤や着色剤を含有させることは、発光観測面側から見た蛍光体の着色を隠すことができる。なお、蛍光体の着色とは、本願発明のフォトルミネセンス蛍光体が強い外光からの光のうち、青色成分を吸収し発光する。そのため黄色に着色しているように見えることである。特に、凸レンズ形状などモールド部材の形状によっては、着色部が拡大されて見えることがある。このような着色は、意匠上など好ましくない場合がある。モールド部材に含有された拡散剤は、モールド部材を乳白色に着色剤は所望の色に着色することで着色を見えなくさせることができる。したがって、このような発光観測面側からフォトルミネセンス蛍光体の色が観測されることはない。また、ＬＥＤチップから放出される光の主発光波長が４３０ｎｍ以上では、光安定化剤である紫外線吸収剤をモールド部材中に含有させた方が耐候性上より好ましい。

【００４８】

（表示装置）

本願発明の発光ダイオードをＬＥＤ表示器に利用した場合、ＲＧＢをそれぞれ発光する発光ダイオードの組み合わせだけによるＬＥＤ表示器よりも、より高精細に白色系表示させることができる。従来の装置が、３個の発光ダイオードで白色表示するのに対して、本発明の発光ダイオードを使用する装置は１個の発光ダイオードで白色表示できるからである。すなわち、従来の表示装置は、発光ダイオードを組み合わせて白色系などを混色表示させるためには、ＲＧＢの各発光ダイオードをそれぞれ同時に発光せざるを得ない。そのため赤色系、緑色系、青色系のそれぞれ単色表示した場合に比べて、一画素あたりの表示領域が大きくなる。したがって、白色系の表示の場合においては、ＲＧＢ単色のモノクローム表示に比較して、高精細に表示させることができない。また、白色系の表示は各発光ダイオードの発光出力を調節して表示させるため、各半導体の温度特性などを考慮し種々調整しなければならない。さらに、混色による表示であるが故にＬＥＤ表示器の視認する方向や角度によって、ＲＧＢの発光ダイオードが部分的に遮光され表示色が変わる場合もある。本願発明の発光ダイオードをＲＧＢの発光ダイオードに代えて使用する表示装置は、より高精細化が可能となると共に、安定して白色系に発光でき、さらに、色むらを少なくできる特長がある。また、本発明の発光ダイオードは、ＲＧＢの各発光ダイオードとともに使用することもできる。この表示装置は、輝度を向上させることができる。

【００４９】また、本願発明の発光ダイオードを用いたＬＥＤ表示器を図５に示す。この図のＬＥＤ表示器は、本願発明の白色系発光ダイオードのみを用いて、白黒用のＬＥＤ表示装置に使用される。白黒用のＬＥＤ表示器は、本願発明の発光ダイオード５０１のみをマトリックス状などに配置している。この図のＬＥＤ表示器を備える表示装置は、ＲＧＢの発光ダイオードを備えない。このため、ＲＧＢ発光ダイオード用の複数の駆動回路を必要としない。複数の駆動回路に代わって、白色系発光ダイオード用の駆動回路で、ＬＥＤ表示器を駆動できる。

【００５０】ＬＥＤ表示器は、駆動回路である点灯回路などと電気的に接続させる。駆動回路からの出力パルスによって種々の画像が表示可能なデイスプレイ等とすることができる。駆動回路を図６に示す。駆動回路は、入力される表示データを一時的に記憶させる画像データー記憶手段であるＲＡＭ（Ｒａｎｄｏｍ、Ａｃｃｅｓｓ、Ｍｅｍｏｒｙ）６０３と、ＲＡＭ６０３に記憶されるデータから、ＬＥＤ表示器６０１のそれぞれの発光ダイオ

ードを所定の明るさに点灯させるための階調信号を演算する階調制御回路６０４と、階調制御回路６０４の出力信号でスイッチングされて、発光ダイオードを点灯させるドライバー６０２とを備える。階調制御回路６０４は、ＲＡＭ６０３に記憶されるデータからＬＥＤ表示器６０１の発光ダイオード点灯時間を演算して点滅させるパルス信号を出力する。

【００５１】したがって、白黒用のＬＥＤ表示器は、ＲＧＢのフルカラー表示器と異なり、回路構成を簡略化できると共に高精細化できる。そのため、安価にＲＧＢの発光ダイオードの特性に伴う色むらなどのないディスプレイとすることができるものである。また、従来の赤色、緑色のみを用いたＬＥＤ表示器に比べ人間の目に対する刺激が少なく長時間の使用に適している。

【００５２】本願発明の発光ダイオードは、白色発光ダイオード（Ｗ）として図９の如く、ＲＧＢにそれぞれ発光する発光ダイオードに加えて使用することもできる。図中９００は、ＬＥＤ表示器の一部を表し９００が一絵素を構成する。このＬＥＤ表示器は、駆動回路である点灯回路などと電気的に接続させる。駆動回路からの出力パルスによって種々の画像が表示可能なデイスプレイ等とすることができる。駆動回路は、モノクロームの表示装置と同じように、入力される表示データを一時的に記憶させる、画像データー記憶手段であるＲＡＭ（Ｒａｎｄｏｍ、Ａｃｃｅｓｓ、Ｍｅｍｏｒｙ）と、ＲＡＭに記憶されるデータから各発光ダイオードを所定の明るさに点灯させるための階調信号を演算する階調制御回路と、階調制御回路の出力信号でスイッチングされて、各発光ダイオードを点灯させるドライバーとを備える。ただし、この駆動回路は、ＲＧＢと白色系に発光する発光ダイオードに専用の回路を必要とする。階調制御回路は、ＲＡＭに記憶されるデータから、それぞれの発光ダイオードの点灯時間を演算して、点滅させるパルス信号を出力する。ここで、白色系の表示を行う場合は、ＲＧＢ各発光ダイオードを点灯するパルス信号のパルス幅を短く、あるいは、パルス信号のピーク値を低く、あるいは全くパルス信号を出力しない。他方、それを補償するように白色系発光ダイオードにパルス信号を出力する。これにより、ＬＥＤ表示器の白色を表示する。

【００５３】したがって、白色系発光ダイオードを所望の輝度で点灯させるためのパルス信号を演算する階調制御回路としてＣＰＵを別途備えることが好ましい。階調制御回路から出力されるパルス信号は、白色系発光ダイオードのドライバーに入力されてドライバーをスイッチングさせる。ドライバーがオンになると白色系発光ダイオードが点灯され、オフになると消灯される。

【００５４】

（信号機）

本願発明の発光ダイオードを表示装置の１種である信号機として利用した場合、長時間安定して発光させることが可能であると共に発光ダイオードの一部が消灯しても色むらなどが生じないという特長がある。本願発明の発光ダイオードを用いた信号機の概略構成として、導電性パターンが形成された基板上に白色系発光ダイオードを配置させる。このような発光ダイオードを直列又は直並列に接続された発光ダイオードの回路を発光ダイオード群として扱う。発光ダイオード群を２つ以上用いそれぞれ渦巻き状に発光ダイオードを配置させる。全ての発光ダイオードが配置されると円状に全面に配置される。各発光ダイオード及び基板から外部電力と接続させる電源コードをそれぞれ、ハンダにより接続させた後、鉄道用信号用の筐体内に固定させる。ＬＥＤ表示器は、遮光部材が付いたアルミダイキャストの筐体内に配置され表面にシリコーンゴムの充填材で封止されている。筐体の表示面は、白色レンズを設けてある。また、ＬＥＤ表示器の電気的配線は、筐体の裏面からゴムパッキンを通し筐体内を密閉する。これにより白色系信号機を形成することができる。本願発明の発光ダイオードを、複数の群に分け中心部から外側に向け輪を描く渦巻き状などに配置し、並列接続させることでより信頼性が高い信号機とさせることができる。中心部から外側に向け輪を描くとは連続的に輪を描くものも断続的に配置するものをも含む。したがって、ＬＥＤ表示器の表示面積などにより配置される発光ダイオードの数や発光ダイオード群の数を種々選択することができる。この信号機により、一方の発光ダイオード群や一部の発光ダイオードが何らかのトラブルにより消灯したとしても他方の発光ダイオード群や残った発光ダイオードにより信号機を円形状に均一に発光させることが可能となるものである。また、色ずれが生ずることもない。渦巻き状に配置してあることから中心部を密に配置することができ電球発光の信号と何ら違和感なく駆動させることができる。

【００５５】

（面状発光光源）

本願発明の発光ダイオードは、図７に示すように、面状発光光源とすることもできる。図に示す面状発光光源の発光ダイオードは、フォトルミネセンス蛍光体をコーティング部や導光板上の散乱シート７０６に含有させる。あるいはバインダー樹脂と共に散乱シート７０６に塗布などさせシート状７０１に形成しモールド部材を省略しても良い。具体的には、絶縁層及び導電性パターンが形成されたコの字形状の金属基板７０３内にＬＥＤチップ７０２を固定する。ＬＥＤチップと導電性パターンとの電気的導通を取った後、フォトルミネセンス蛍光体をエポキシ樹脂と混合攪拌しＬＥＤチップ７０２が積載された金属基板７０３上に充填させる。こうして固定されたＬＥＤチップは、アクリル性導光板７０４の端面にエポキシ樹脂などで固定される。導光板７０４の一方の主面上には、蛍現象防止のため白色散乱剤が含有されたフィルム状の反射部材７０７を配置させてある。同様に、導

光板の裏面側全面やＬＥＤチップが配置されていない端面上にも反射部材７０５を設け発光効率を向上させてある。これにより、ＬＣＤのバックライトとして十分な明るさを得られる面状発光光源の発光ダイオードとすることができる。液晶表示装置として利用する場合は、導光板７０４の主面上に不示図の透光性導電性パターンが形成された硝子基板間に注入された液晶装置を介して配された偏光板により構成させることができる。以下、本願発明の実施例について説明するが、本願発明は具体的実施例のみに限定されるものではないことは言うまでもない。

【００５６】

【実施例】

（実施例１）

発光素子として発光ピークが４５０ｎｍ、半値幅３０ｎｍのＩｎＧａＮ半導体を発光層に用いた。ＬＥＤチップは、洗浄させたサファイア基板上にＴＭＧ（トリメチルガリウム）ガス、ＴＭＩ（トリメチルインジュウム）ガス、窒素ガス及びドーパントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化物系化合物半導体を成膜させることにより形成させた。成膜時に、ドーパントガスとしてＳｉH_4とＣp_2Ｍｇと、を切り換えることによってＮ型導電性やＰ型導電性を有する窒化ガリウム半導体を形成させる。半導体発光素子としては、Ｎ型導電性を有する窒化ガリウム半導体であるコンタクト層と、Ｐ型導電性を有する窒化ガリウムアルミニウム半導体であるクラッド層、Ｐ型導電性を有する窒化ガリウム半導体であるコンタクト層を形成させた。Ｎ型導電性を有するコンタクト層と、Ｐ型導電性を有するクラッド層との間に厚さ約３ｎｍであり、単一量子井戸構造とされるノンドープＩｎＧａＮの活性層を形成した。（なお、サファイア基板上には低温で窒化ガリウム半導体を形成させバッファ層としてある。また、Ｐ型半導体は、成膜後４００℃以上でアニールさせてある。）

【００５７】エッチングによりＰＮ各半導体表面を露出させた後、スパッタリングにより各電極をそれぞれ形成させた。こうして出来上がった半導体ウエハーをスクライブラインを引いた後、外力により分割させ発光素子としてＬＥＤチップを形成させた。

【００５８】銀メッキした銅製リードフレームの先端にカップを有するマウント・リードにＬＥＤチップをエポキシ樹脂でダイボンディングした。ＬＥＤチップの各電極とマウント・リード及びインナー・リードと、をそれぞれ直径が３０μｍの金線でワイヤーボンディングし電気的導通を取った。

【００５９】一方、フォトルミネセンス蛍光体は、Ｙ、Ｇｄ、Ｃｅの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウムを混合して混合原料を得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中１４００°Ｃの温度で３時間焼成して焼成品を得た。焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通して形成させた。フォトルミネセンス蛍光体は、Ｙ（イットリウム）がＧｄ（ガドリニウム）で約２割置換されたイットリウム・アルミニウム酸化物として（$Y_{0.8}Gd_{0.2}$）$_3Al_5O_{12}$：Ｃｅが形成された。なお、Ｃｅの置換は、０．０３であった。

【００６０】形成された（$Y_{0.8}Gd_{0.2}$）$_3Al_5O_{12}$：Ｃｅ蛍光体８０重量部、エポキシ樹脂１００重量部をよく混合してスラリーとさせた。このスラリーをＬＥＤチップが配置されたマウント・リード上のカップ内に注入させた。注入後、フォトルミネセンス蛍光体が含有された樹脂を１３０℃１時間で硬化させた。こうしてＬＥＤチップ上に厚さ１２０μのフォトルミネセンス蛍光体が含有されたコーティング部が形成された。なお、コーティング部には、ＬＥＤチップに向かってフォトルミネセンス蛍光体が徐々に多くしてある。照射強度は、約３．５Ｗ／ｃm^2であった。その後、さらにＬＥＤチップやフォトルミネセンス蛍光体を外部応力、水分及び塵芥などから保護する目的でモールド部材として透光性エポキシ樹脂を形成させた。モールド部材は、砲弾型の型枠の中にフォトルミネセンス蛍光体のコーティング部が形成されたリードフレームを挿入し透光性エポシキ樹脂を混入後、１５０℃５時間にて硬化させた。こうして形成された発光ダイオードは、発光観測正面から視認するとフォトルミネセンス蛍光体のボディーカラーにより中央部が黄色っぽく着色していた。

【００６１】こうして得られた白色系が発光可能な発光ダイオードの色度点、色温度、演色性指数を測定した。それぞれ、色度点（ｘ＝０．３０２、ｙ＝０．２８０）、色温度８０８０Ｋ、Ｒａ（演色性指数）＝８７．５と三波長型蛍光灯に近い性能を示した。また、発光効率は９．５１ｍ／ｗと白色電球並であった。さらに寿命試験として温度２５℃６０ｍＡ通電、温度２５℃２０ｍＡ通電、温度６０℃９０％ＲＨ下で２０ｍＡ通電の各試験においても蛍光体に起因する変化は観測されず通常の青色発光ダイオードと寿命特性に差がないことが確認できた。

【００６２】

（比較例１）

フォトルミネセンス蛍光体を（$Y_{0.8}Gd_{0.2}$）$_3Al_5O_{12}$：Ｃｅから（ＺｎＣｄ）Ｓ：Ｃｕ、Ａｌとした以外は、実施例１と同様にして発光ダイオードの形成及び寿命試験を行った。形成された発光ダイオードは通電直後、実施例１と同様白色系の発光が確認されたが輝度が低かった。また、寿命試験においては、約１００時間で出力がゼロになった。劣化原因を解析した結果、蛍光体が黒化していた。

【００６３】これは、発光素子の発光光と蛍光体に付着

していた水分あるいは外部環境から進入した水分により光分解し蛍光体結晶表面にコロイド状亜鉛金属を析出し外観が黒色に変色したものと考えられる。温度２５℃２０ｍＡ通電、温度６０℃９０％ＲＨ下で２０ｍＡ通電の寿命試験結果を実施例１と共に図８に示す。輝度は初期値を基準にしそれぞれの相対値を示す。また、実線が実施例１であり破線が比較例１を示す。

【００６４】

（実施例２）

ＬＥＤチップの窒化物系化合物半導体を実施例１よりもＩｎの含有量を増やし発光ピークを４６０ｎｍとした。同様にフォトルミネセンス蛍光体として実施例１よりもＧｄの含有量を増やし（$Y_{0.8}Gd_{0.4})_3Al_5O_{12}$：Ｃｅとした以外は実施例１と同様にして発光ダイオードを１００個形成し寿命試験を行った。

【００６５】こうして得られた白色系が発光可能な発光ダイオードの色度点、色温度、演色性指数を測定した。それぞれ、色度点（ｘ＝０．３７５、ｙ＝０．３７０）、色温度４４００Ｋ、Ｒａ（演色性指数）＝８６．０であった。さらに寿命試験においては、形成させた発光ダイオード１００個平均で行った。寿命試験前の光度を１００％とし１０００時間経過後における平均光度を調べた。寿命試験後も９８．８％であり特性に差がないことが確認できた。この実施例のフォトルミネッセンス蛍光体と、ＬＥＤチップ及び発光ダイオードの各発光スペクトルを、図１０（Ａ）、（Ｂ）、（Ｃ）にそれぞれ示している。

【００６６】

（実施例３）

フォトルミネセンス蛍光体をＹ、Ｇｄ、Ｃｅの希土類元素に加えＳｍを含有させ（$Y_{0.39}Gd_{0.57}Ce_{0.03}Sm_{0.01})_3Al_5O_{12}$蛍光体とした以外は、実施例１と同様にして発光ダイオードを１００個形成した。この発光ダイオードを１３０℃の高温下において点灯させても実施例１の発光ダイオードと比較して平均温度特性が８％ほど良好であった。

【００６７】

（実施例４）

本願発明の発光ダイオードを図５のごとくＬＥＤ表示器の１つであるディスプレイに利用した。実施例１と同様にして形成させた発光ダイオードを銅パターンを形成させたセラミックス基板上に、１６×１６のマトリックス状に配置させた。基板と発光ダイオードとは自動ハンダ実装装置を用いてハンダ付けを行った。次にフェノール樹脂によって形成された筐体５０４内部に配置し固定させた。遮光部材５０５は、筐体と一体成形させてある。発光ダイオードの先端部を除いて筐体、発光ダイオード、基板及び遮光部材の一部をピグメントにより黒色に着色したシリコンゴム４０６によって充填させた。その後、常温、７２時間でシリコンゴムを硬化させＬＥＤ表示器を形成させた。このＬＥＤ表示器と、入力される表示データを一時的に記憶させるＲＡＭ（Ｒａｎｄｏｍ、Ａｃｃｅｓｓ、Ｍｅｍｏｒｙ）及びＲＡＭに記憶されるデータから発光ダイオードを所定の明るさに点灯させるための階調信号を演算する階調制御回路と階調制御回路の出力信号でスイッチングされて発光ダイオードを点灯させるドライバーとを備えたＣＰＵの駆動手段と、を電気的に接続させてＬＥＤ表示装置を構成した。ＬＥＤ表示器を駆動させ白黒ＬＥＤ表示装置として駆動できることを確認した。

【００６８】

（実施例５）

実施例５の発光ダイオードは、フォトルミネセンス蛍光体として一般式$(Y_{0.2}Gd_{0.8})_3Al_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個形成させた。こうして得られた発光ダイオードの色度点（平均値）は（ｘ＝０．４５０、ｙ＝０．４２０）であり電球色を発光することができた。また、実施例５の発光ダイオードは、実施例１の発光ダイオードと比較して輝度が約４０％低くかった。しかし、寿命試験においては実施例１と同様に優れた耐候性を示していた。この実施例のフォトルミネッセンス蛍光体、ＬＥＤチップ及び発光ダイオードの各発光スペクトルを、図１１（Ａ）、（Ｂ）、（Ｃ）にそれぞれ示している。

【００６９】

（実施例６）

実施例６の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Y_3Al_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個形成させた。実施例６の発光ダイオードは、実施例１の発光ダイオードと比較してやや黄緑色がかった白色であった。しかし、寿命試験においては実施例１と同様に優れた耐候性を示していた。この実施例のフォトルミネッセンス蛍光体、ＬＥＤチップ及び発光ダイオードの各発光スペクトルを、図１２（Ａ）、（Ｂ）、（Ｃ）に示している。

【００７０】

（実施例７）

実施例７の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表される蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個形成させた。実施例７の発光ダイオードは、緑色がかっており輝度が低かった。しかし、寿命試験においては実施例１と同様に優れた耐候性を示していた。この実施例のフォトルミネッセンス蛍光体、ＬＥＤチップ及び発光ダイオードの各発光スペクトルを、順番に図１３（Ａ）、（Ｂ）、（Ｃ）に示している。

【００７１】

（実施例８）
実施例８の発光ダイオードは、フォトルミネセンス蛍光体として一般式$Gd_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表されるＹを含まない蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個形成させた。実施例８の発光ダイオードは、輝度が低いが、寿命試験において実施例１と同様に優れた耐候性を示していた。

【００７２】
（実施例９）
実施例９の発光ダイオードは、フォトルミネッセンス蛍光体として一般式$Y_3In_3O_{12}$：Ｃｅで表されるＡｌを含まない蛍光体を用いた以外は、実施例１と同様にして発光ダイオードを１００個形成させた。実施例９の発光ダイオードは、輝度が低いが寿命試験において実施例１と同様に優れた耐候性を示していた。

【００７３】
【発明の効果】本願発明の発光ダイオードは、窒化ガリウム系化合物半導体の発光素子と、特定の蛍光体を組み合わせることにより長時間高輝度時の使用においても発光効率が高い発光ダイオードを実現する。さらに、本願発明の発光ダイオードは、信頼性や省電力化、小型化さらには色温度の可変性など車載や航空産業、一般電気機器に表示の他に照明として新たな用途を開くことができる。特に、本願発明に用いられるフォトルミネセンス蛍光体は、短残光であり１２０ｎsecという応答速度を有する光源などとして利用することもできる。また、発光色を白色にして、人間の目で長時間視認する場合には刺激が少なく目に優しい発光ダイオードとすることができる。さらに、ＬＥＤチップは単色性ピーク波長を有するといってもある程度のスペクトル幅を持つため演色性が高い。広く光源として使用する場合には欠かせない長所となる。即ち、発光ダイオードを用いてスペクトル幅の広いスキャナー用の光源などとすることもできる。

【００７４】特に、本願発明の発光ダイオードは、高輝度、長時間の使用においても色ずれ、発光効率の低下が極めて少ない白色系が発光可能な発光ダイオードとすることができる。また、樹脂劣化に伴う輝度の低下も抑制させることができる。

【００７５】本発明の発光ダイオードは、効率よく発光することができる。すなわち、一般に、蛍光体は短波長側から長波長側に変換させる方が効率がよい。また、発光ダイオードにおいては紫外光が樹脂（モールド部材やコーティング部材に樹脂を用いた場合）を劣化させるために可視光の方が好ましい。本願発明は、可視光のうち短波長側の青色光を利用し、フォトルミネセンス蛍光体によってそれよりも長波長側の光に効率よく変換させることができる。さらに、変換された光はＬＥＤチップから放出される光よりも長波長側（すなわち、蛍光体からの光エネルギーは、ＬＥＤチップのバンドギャプよりも小さい）になっている。そのため、フォトルミネセンス蛍光体などによって非発光観測面側であるマウント・リード側などに反射散乱されてもＬＥＤチップに吸収されにくい。そのためにフォトルミネセンス蛍光体により変換された光が、ＬＥＤチップ側に向かったとしてもＬＥＤチップに吸収されずマウント・リードのカップなどで反射され効率よく発光することが可能となる。

【００７６】本願発明の発光ダイオードは、高輝度、長時間の使用においても色ずれ、発光効率の低下が極めて少ない発光ダイオードなど種々の発光ダイオードとすることができることに加えて、発光ダイオードを複数近接して配置した場合においても他方の発光ダイオードからの光により蛍光体が励起され疑似点灯されることを防止させることができる。また、ＬＥＤチップ自体の発光むらを蛍光体により分散することができるためより均一な発光光を有する発光ダイオードとすることができる。通常、ＬＥＤチップから放出される光は、ＬＥＤに電力を供給する電極を介して光が放出される。放出された光は、ＬＥＤチップに形成された電極の陰となる。電極により一定の不要な発光パターンをとる。そのため全方位的に均等に光を放出することができない。本願発明は、フォトルミネセンス蛍光体によってＬＥＤチップからの光を散乱させるため発光ダイオードから均一な発光をさせることができ不要な発光パターンをとることはない。

【図面の簡単な説明】
【図１】図１は、本願発明の発光ダイオードの模式的断面図である。
【図２】図２は、本願発明の他の発光ダイオードの模式的断面図である。
【図３】図３は、本願発明の発光ダイオードの発光スペクトルの一例を示した図である。
【図４】図４（Ａ）は、本願発明に使用されるフォトルミネセンス蛍光体の吸収スペクトルの一例を示し、図４（Ｂ）は、本願発明に使用されるフォトルミネセンス蛍光体の発光スペクトルの一例を示した図である。
【図５】図５は、本願発明の発光ダイオードを用いたＬＥＤ表示装置の模式図である。
【図６】図６は、図５に用いられるＬＥＤ表示装置のブロック図である。
【図７】図７は、本願発明の発光ダイオードを用いた別のＬＥＤ表示装置の模式図である。
【図８】図８（Ａ）は、本願発明の実施例１と比較のために示した比較例１の発光ダイオードとの温度２５℃２０ｍＡ通電における寿命試験を示し、図８（Ｂ）は、本願発明の実施例１と比較のために示した比較例１の発光ダイオードとの温度６０℃９０％ＲＨ下で２０ｍＡ通電における寿命試験を示したグラフである。
【図９】図９は、本願発明の発光ダイオードに加えＲＧＢがそれぞれ発光可能な発光ダイオードを一絵素として配置させた表示装置の部分正面図である。

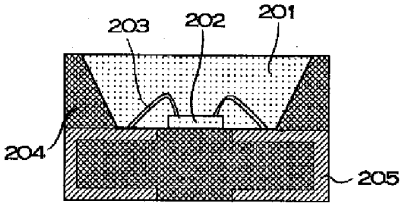
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【図１０】
図１０（Ａ）は、（$Y_{0.8}Gd_{0.4}$）$_3Al_5O_{12}$：Ｃｅで表される実施例２のフォトルミネッセンス蛍光体の発光スペクトルを示す。
図１０（Ｂ）は、主ピーク波長が４６０ｎｍを有する実施例２のＬＥＤチップの発光スペクトルを示す。
図１０（Ｃ）は、実施例２の発光ダイオードの発光スペクトルを示す。
【図１１】
図１１（Ａ）は、（$Y_{0.2}Gd_{0.8}$）$_3Al_5O_{12}$：Ｃｅで表される実施例５のフォトルミネッセンス蛍光体の発光スペクトルを示す。
図１１（Ｂ）は、主ピーク波長が４５０ｎｍを有する実施例５のＬＥＤチップの発光スペクトルを示す。
図１１（Ｃ）は、実施例５の発光ダイオードの発光スペクトルを示す。
【図１２】
図１２（Ａ）は、$Y_3Al_5O_{12}$：Ｃｅで表される実施例６のフォトルミネッセンス蛍光体の発光スペクトルを示す。
図１２（Ｂ）は、主ピーク波長が４５０ｎｍを有する実施例６のＬＥＤチップの発光スペクトルを示す。
図１２（Ｃ）は、実施例６の発光ダイオードの発光スペクトルを示す。
【図１３】
図１３（Ａ）は、$Y_3(Al_{0.5}Ga_{0.5})_5O_{12}$：Ｃｅで表される実施例７のフォトルミネッセンス蛍光体の発光スペクトルを示す。

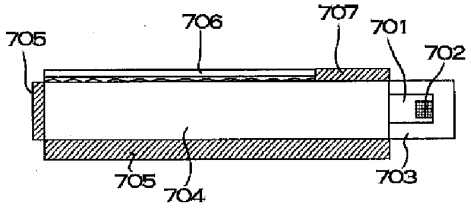
26

＊図１３（Ｂ）は、主ピーク波長が４５０ｎｍを有する実施例７のＬＥＤチップの発光スペクトルを示す。
図１３（Ｃ）は、実施例７の発光ダイオードの発光スペクトルを示す。
【符号の説明】
１０１、７０１・・・フォトルミネセンスが含有されたコーティング部
１０２、２０２、７０２・・・ＬＥＤチップ
１０３、２０３・・・導電性ワイヤー
１０４・・・モールド部材
１０５・・・マウント・リード
１０６・・・インナー・リード
２０１・・・フォトルミネセンスが含有されたモールド部材
２０４・・・筐体
２０５・・・筐体に設けられた電極
５０１・・・発光ダイオード
５０４・・・筐体
５０５・・・遮光部材
５０６・・・充填材
６０１・・・ＬＥＤ表示器
６０２・・・ドライバー
６０３・・・ＲＡＭ
６０４・・・階調制御手段
７０３・・・金属製基板
７０４・・・導光板
７０５、７０７・・・反射部材
７０６・・・散乱シート

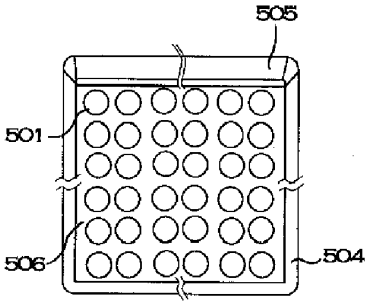
【図２】



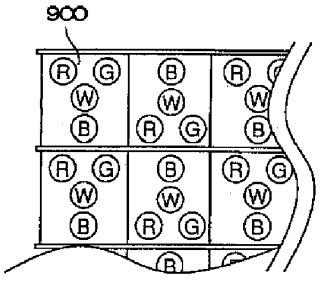
【図７】



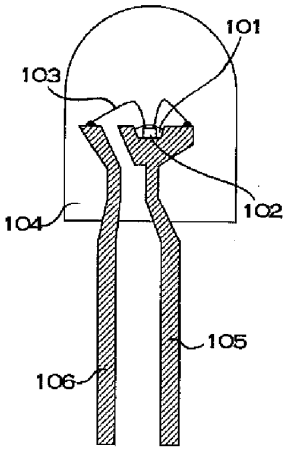
【図５】



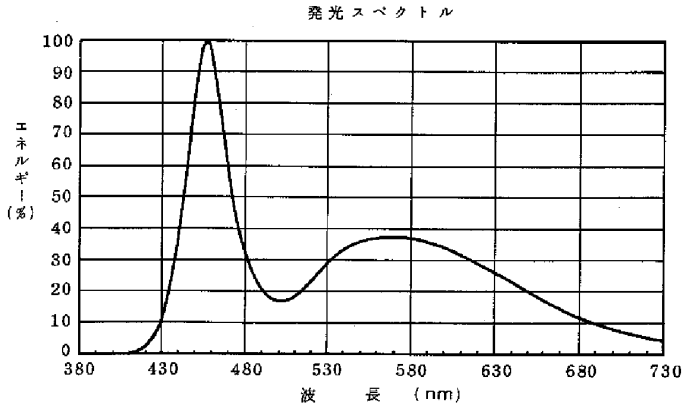
【図９】



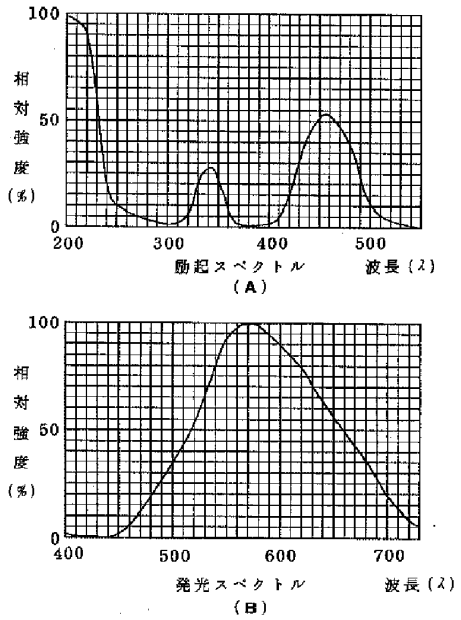
【図１】


101
103
102
104
105
106

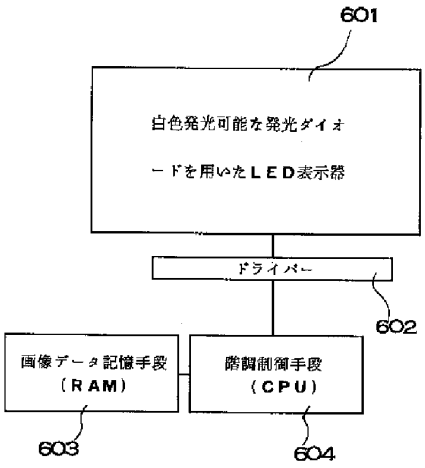
【図３】


発光スペクトル
エネルギー（%）
100
90
80
70
60
50
40
30
20
10
0
380
430
480
530
580
630
680
730
波　長（nm）

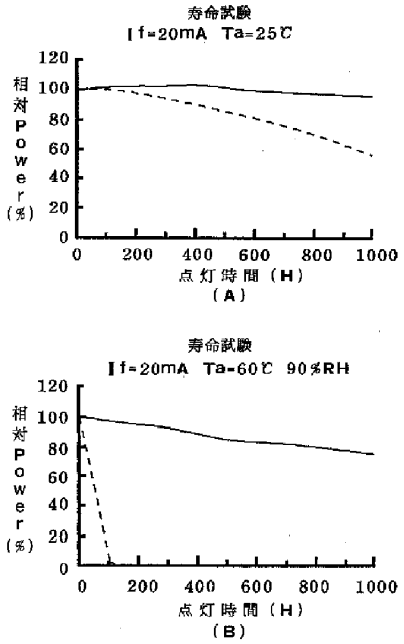
【図４】


100
相対強度（%）
50
0
200
300
400
500
励起スペクトル　波長（λ）
（A）
100
相対強度（%）
50
0
400
500
600
700
発光スペクトル　波長（λ）
（B）

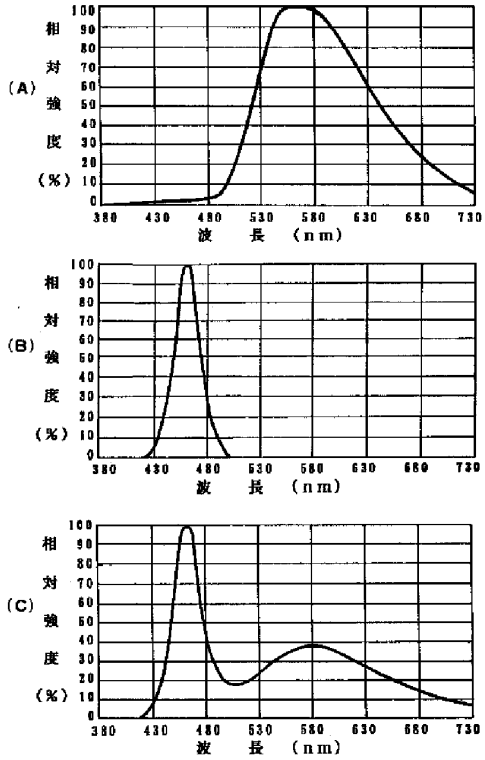
【図６】


601
白色発光可能な発光ダイオードを用いたＬＥＤ表示器
ドライバー
602
画像データ記憶手段（ＲＡＭ）
階調制御手段（ＣＰＵ）
603
604

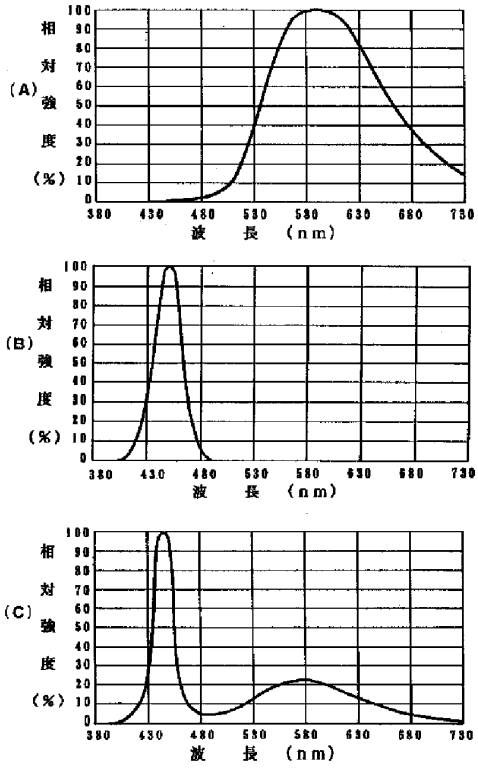
【図８】


寿命試験
If=20mA Ta=25℃
相対Power(%)
120
100
80
60
40
20
0
0 200 400 600 800 1000
点灯時間（H）
(A)
寿命試験
If=20mA Ta=60℃ 90%RH
相対Power(%)
120
100
80
60
40
20
0
0 200 400 600 800 1000
点灯時間（H）
(B)

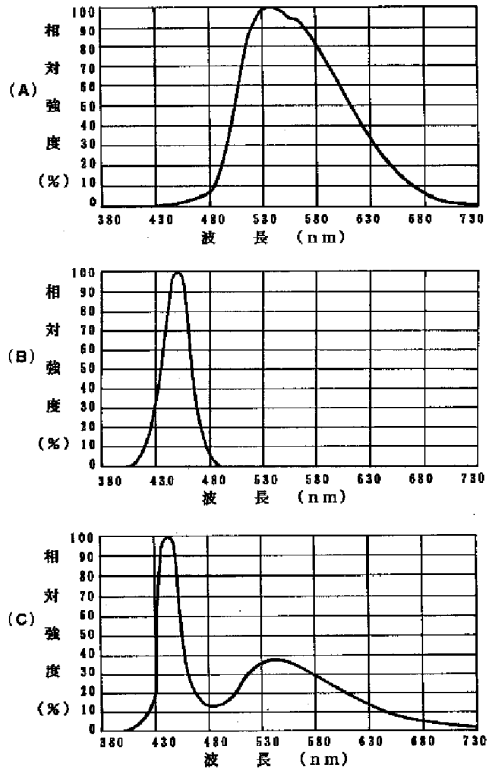
【図１０】


(A)
(B)
(C)
相対強度（%）
100
90
80
70
60
50
40
30
20
10
0
380 430 480 530 580 630 680 730
波長（nm）

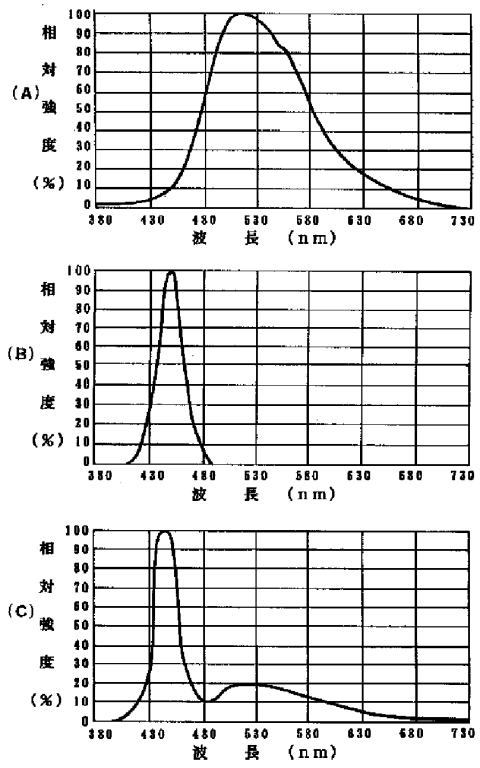
【図１１】


(A)
(B)
(C)
相対強度（%）
100
90
80
70
60
50
40
30
20
10
0
380
430
480
530
580
630
680
730
波長（nm）

【図１２】


(A)
(B)
(C)
相対強度（%）
100
90
80
70
60
50
40
30
20
10
0
380
430
480
530
580
630
680
730
波長（nm）

【図１３】



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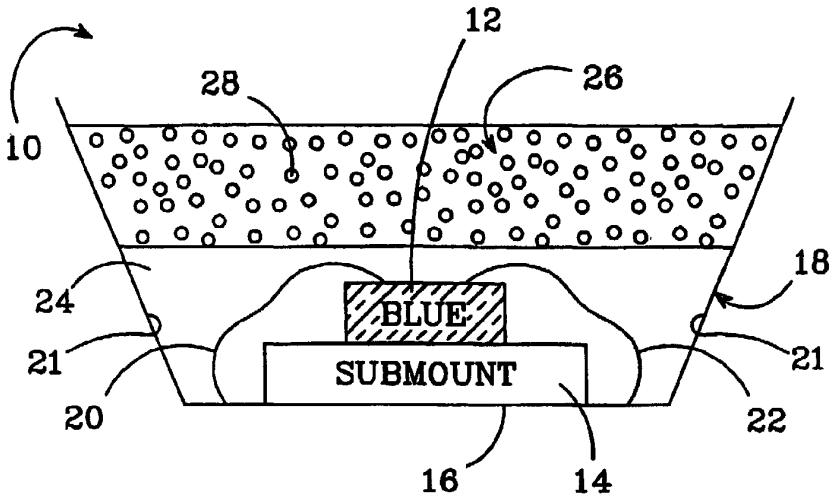
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[Continued on next page]

(54) Title: SATURATED PHOSPHOR SOLID STATE EMITTER



(57) Abstract: A high efficiency, high yield emitter package is disclosed exhibiting limited wavelength variations between batches and consistent wavelength and emission characteristics with operation. One embodiment of an emitter package according to the present invention comprises a semiconductor emitter and a conversion material. The conversion material is arranged to absorb substantially all of the light emitting from the semiconductor emitter and re-emit light at one or more different wavelength spectrums of light. The conversion material is also arranged so that there is not an excess of conversion material to block said re-emitted light as it emits from said emitter package, said emitter package emitting light at said one or more wavelength spectrums from said conversion material. The semiconductor emitter is preferably a light emitting diode (LED) or laser diode.

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P0254US-7 PATENT

SATURATED PHOSPHOR SOLID STATE EMITTER

This application claims the benefit of provisional application Serial Number 60/388,327 to Keller et al., which was filed on June 13, 2002.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to solid state emitters and more particularly to light emitting diodes (LEDs) laser diodes whose wavelength of emitted light is converted by a conversion material.

Description of the Related Art

Light emitting diodes (LEDs) are solid-state devices that convert electric energy to light, and generally comprise an active layer of semiconductor material sandwiched between two oppositely doped semiconductor layers. When a bias is applied across the doped layers, holes and electrons are injected into the active layer where they recombine to generate light. Light is emitted omnidirectionally from the active layer and from all surfaces of the LED. Recent advances in LEDs (such as Group III nitride based LEDs) have resulted in highly efficient light sources that surpass the efficiency of filament-based light sources, providing light with equal or greater brightness in relation to input power.

Solid-state semiconductor laser diodes convert electrical energy to light in much the same way as LEDs.

They are structurally similar to LEDs but include mirrors on two opposing surfaces, one of which is partially transmissive. In the case of edge emitting lasers, the mirrors are on the side surfaces; the mirrors provide optical feedback so that stimulated emission can occur. This stimulated emission provides a highly collimated/coherent light source. A vertical cavity laser works much the same as an edge emitting laser but the mirrors are on the top and the bottom. It provides a similar collimated output from its top surface. Some types of solid-state lasers can be more efficient than LEDs at converting electrical current to light.

Green emitting LEDs can be fabricated from different material systems including the Group III nitride based material system. Conventional green emitting LEDs, however, are typically subject to low yield and are considered difficult to fabricate with uniform emission characteristics from batch to batch. The LEDs can also exhibit large wavelength variations across the wafer within a single batch, and can exhibit strong wavelength and emission variations with operation conditions such as drive current and temperature.

Phosphors, polymers and dyes have been used to surround LEDs to downconvert the LED's light to a different wavelength, thereby modifying the light emitted by the LED. For example, a single blue emitting LED has been surrounded with a yellow phosphor, polymer or dye, with a typical phosphor being cerium-doped yttrium aluminum garnet (Ce:YAG). [See Nichia Corp. white LED, Part No. NSPW300BS, NSPW312BS, etc.; See also U.S. Patent No. 5,959,316 to Lowery, "Multiple Encapsulation of Phosphor-LED Devices"]. The surrounding phosphor material "downconverts" the wavelength of some of the LED light and re-emits it as a

different wavelength such that the overall "LED package" emits two wavelengths of light. In the case of a blue emitting LED surrounded by a yellow phosphor, some of the blue light passes through the phosphor without being converted, while the remaining light is downconverted to yellow. The blue light passing through the phosphor plays a major role in the overall color of light emitted by the LED package, which emits both blue and yellow light that combine to provide a white light.

In these types of LED packages, it can be difficult to apply the downconverting material in such a way that the light source (LED) emits homogeneous light. Replicability and mass production also presents problems because even slight fluctuations in the layer thickness of the conversion material can change the color of emitted light. U.S. Patent No. 6,066,861 to Hohn et al. discloses a casting composition that surrounds an LED and contains conversion material in stable dispersion such that the light from the LED appears more homogeneous. In one embodiment, the conversion material (luminous substance) is a phosphor group of the general formula $A_3B_5X_{12}:M$ having particles sizes <20 μm and a mean grain diameter d_{50}<5 μm. Similar to the LED package having a yellow conversion material surrounding a blue LED, the casting composition is arranged so that a substantial portion of the LED light passes through, while the remaining LED light is downconverted.

Another disadvantage of the typical blue LED surrounded by a yellow downconverting material is that the resulting white light can have an unacceptable color temperature and poor color rendering such that the LED is not suitable for standard room lighting. U.S. Patent No. 6,252,254 to Soules et al. discloses a blue LED (or a laser

diode) covered with a green and red downconverting phosphor. Similar the blue LED surrounded by yellow downconverting material, the green/red phosphor absorbs some of the blue LED light and reemits red and green light, such that the LED and phosphor both emit light that combines as a white light. Soules et al. discloses that the resulting white light has an improved color temperature and improved color rendering.

Another disadvantage of a typical blue LED with yellow downconverting material is that the material can deteriorate, leading to color tone deviation and darkening of the fluorescent material. U.S. Patent No. 5,998,925 to Shimuzu et al. discloses a LED to address this disadvantage by providing a light emitting component (e.g. LED or laser diode) and a phosphor capable of absorbing part of the light emitted by the light emitting component and emitting light of a wavelength different from that of the absorbed light. The light emitting component comprises a nitride based semiconductor and the phosphor contains a particular garnet fluorescent material. Shimuzu et al. discloses that the phosphor has excellent resistance to light so that the fluorescent properties experience little deterioration when used over an extended period of time.

Light extraction is another recognized problem with conventional LEDs, which typically have an active layer and doped layers with a refractive index n of about 3.5. The LEDs are then encapsulated in an epoxy having a refractive index n of about 1.5. Application of Snell's law shows that only light emitted from the active region within an angle theta of about 0.443 radians to normal of the interface with the epoxy can exit from the top of the LED. For larger angles, the light is trapped within the LED by total internal reflection, such that only a fraction of the light

(approximately 9.6% in some cases) contributes to light emission. U.S. Patent No. 5,813,753 to Vriens et al. discloses a UV/blue LED phosphor device with enhanced conversion and extraction of light. The device utilizes most of the LED's edge emitted light by the appropriate positioning of reflectors and phosphor. The device also affects angular emission and color of the visible light emitted by the UV/blue LED-phosphor device by the use of one or more dielectric filters on the device. In one embodiment, a light emitting device is placed in a cup-shaped header with a reflector that is then filled with a transparent material having a homogeneously mixed phosphor. The device anticipates that not all of the light will be absorbed by the phosphor and includes a glass plate that is placed on the device that prevents UV/blue light which is not absorbed by the phosphor grains from exiting into air. In another embodiment a long wave pass filter (LPW) is added adjacent to the glass plate to reflect UV/blue light back to the phosphor and to transmit visible light emitted by the phosphor

All of the LED, packages described above have a common characteristic. Each relies on or contemplates that a portion of the light from the LED (or laser diode) passes through the conversion material without being absorbed and in most cases the light passing through plays an important role in the overall color emitted by the package.

SUMMARY OF THE INVENTION

The present invention seeks to provide solid state emitter packages that are easy to manufacture and provide a high yield, while at the same time providing emitter packages exhibiting limited wavelength variations between batches of packages and exhibit consistent wavelength and

emission characteristics with operation over time. One embodiment of a saturated conversion material emitter package according to the present invention comprises a semiconductor emitter and a conversion material. The conversion material is arranged to absorb substantially all of the light emitting from the semiconductor emitter and re-emit light at one or more different wavelength spectrums of light. The conversion material is also arranged so that there is not an excess of conversion material to block the re-emitted light as it emits from the emitter package. The emitter package emits light at the one or more wavelength spectrums from the conversion material.

Another embodiment of a saturated conversion material emitter package according to the present invention comprises one or more semiconductor emitters, each of which emits light in response to a bias. A metal cup is included with the semiconductor emitters arranged at the base of the cup. A plurality of conductive paths are coupled to the semiconductor emitters for applying a bias to the emitters to cause them to emit light. A conversion material is arranged so that light from the emitters passes through the conversion material, with the conversion material absorbing substantially all light from the emitters and re-emitting light at one or more different wavelengths of light. The conversion material is also arranged so that it does not substantially block the re-emitted light as it emits from the emitter package. The emitter package emits light at the one or more wavelength spectrums from the conversion material.

In one embodiment of an emitter package according to the present invention, the semiconductor emitter comprises a blue of UV emitting LED, with the LED light passing through a green phosphor. The phosphor is saturated by the

light such that the package emits in the green portion of the spectrum. This arrangement offers a number of advantages over convention nitride-based green LEDs. Unlike green LEDs, the emission spectrum of green phosphor is essentially fixed by the specific material and is accordingly less subject to wavelength variation. Phosphors in general can also have a spectrally broader emission spectrum, which may be desirable in some applications.

The light from an LED passing through a saturated conversion material according to the present invention can be subject to losses due to non-unity conversion efficiency of the phosphor and the Stokes shift. This loss, however, is acceptable because the preferred embodiments of LED packages according to the present invention comprise high efficiency, high yield LEDs, such as UV and blue emitting Group III nitride-based LEDs, which compensate for the losses and result in a LED package with higher emission efficiency compared to typical LEDs.

This technology is well suited for manufacturing and the development of a wide variety of flexible products for solid-state lighting. The possible applications of LED packages according to the present invention include, but are not limited to, traffic lights, displays, specialty illumination, signals, etc. The invention also can be used in combination with blue and red emitters to fabricate a white light emitting LED package, which would be suited for nearly any application requiring high efficiency, high color rendering solid-state lighting. This includes indoor and outdoor commercial and residential architectural lighting, auto taillights, displays, flashbulbs and general lighting. This will result in cumulative energy saving and reduction of environmental impacts.

These and other further features and advantages of

the invention will be apparent to those skilled in the art from the following detailed description, taken together with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of one embodiment of a saturated conversion material LED package according to the present invention;

FIG. 2 is a graph showing the output intensity verses peak emission wavelength of a saturated conversion material LED according to the present invention;

FIG. 3 is a graph showing the wavelength spectrum of saturated conversion material LED according to the present invention;

FIG. 4 is a graph showing the output loss verses operating hours for saturated conversion material LEDs according to the present invention.

FIG. 5 is a sectional view of another embodiment of a saturated conversion material LED package according to the present invention;

FIG. 6 is a sectional view of one embodiment of a saturated conversion material semiconductor laser package according to the present invention;

FIG. 7 is a sectional view of an embodiment of a saturated conversion material emitter package according to the present invention having different concentration layers of conversion material; and

FIG. 8 is a sectional view of an embodiment of a saturated conversion material emitter package according to the present invention having homogeneous concentration of conversion material.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows one embodiment of a saturated conversion material LED package 10 according to the present invention. It comprises an LED 12 (although more than one LED can be used) which generally includes an active layer sandwiched between two oppositely doped layers. The layers have standard thicknesses and the active layer emits light omnidirectionally when a bias is applied across the oppositely doped layers. The layers of the LED 12 can be made of many different semiconductor material systems and the LED 12 can emit many different colors of light. The LED 12 preferably emits blue light and can be formed of a semiconductor material from the Group III nitride based material system, which provides for high efficiency radiation of blue light. Group III nitrides refer to those semiconductor compounds formed between nitrogen and the elements in Group III of the periodic table, usually aluminum (Al), gallium (Ga), and indium (In). The term also refers to ternary and tertiary compounds such as AlGaN and AlInGaN.

The LED 12 can also comprise a substrate with the LED's active and oppositely doped layers formed in a stack on the substrate. The substrate can be formed of many different materials such as sapphire (Al_2O_3), silicon (Si) or silicon carbide (SiC), with the preferred substrate being a 4H polytype of SiC. Other SiC polytypes can also be used including 3C, 6H and 15R polytypes. A buffer layer can also be included between the substrate and other LED layers to provide an appropriate crystal structure transition. Silicon carbide has a much closer crystal lattice match to Group III nitrides than sapphire and results in Group III nitride films of higher quality. Silicon carbide also has a very high thermal conductivity so that the total output

power of Group III nitride devices on silicon carbide is not limited by the thermal dissipation of the substrate (as is the case with some devices formed on sapphire). The availability of silicon carbide substrates also provides the capacity for device isolation and reduced parasitic capacitance that make commercial devices possible. SiC substrates are available from Cree Research, Inc., of Durham, North Carolina and methods for producing them are set forth in the scientific literature as well as in a U.S. Pat. Nos. Re. 34,861; 4,946,547; and 5,200,022.

The LED's active layer and oppositely doped layers are formed on the substrate using known semiconductor fabrication processes, such as metal-organic chemical vapor deposition (MOCVD). Similarly, techniques for epitaxial growth of Group III nitrides have been reported in scientific literature, and in U.S. Pat. Nos. 5,210,051; 5,393,993; 5,523,589; and 5,292,501.

The LED 12 can also comprise first and second contacts, each of which are arranged in ohmic contact with a respective oppositely doped layer. A bias applied to the contacts is conducted to the oppositely doped layers, resulting in electrons and holes being injected into the LED's active region where they recombine to cause the active layer to emit light.

The LED 12 can also be mounted on a submount 14 for mechanical stability. The submount 14 can contain electrical circuitry for controlling the amount of current or power applied to the LED 12 or to otherwise modify the electric signal applied to the LED 12. The submount 14 can also contain components and circuitry to make the LED package 10 resistant to electrostatic shock. The submount 14 is mounted at the horizontal base 16 of "metal cup" 18 that typically has first and second conductive paths 20, 22

for applying a bias across the LED's contacts to cause the LED 12 to emit light. Alternatively, the bias can be applied to the LED (or its contacts) fully or partially through the submount 16 and its electronic circuitry. The cup 18 can have a reflective surface 20 that reflects light emitted from the LED 12 so that it contributes to the overall light emitted from the package 10.

The LED 12, submount 14 and conductive paths 20, 22 are encased in a protective layer 24 that is made of a radiation hard and transparent material such as a silicon, resin, or epoxy, with the preferred material being an epoxy. During manufacturing of the package 10 the epoxy is injected into and fills the bottom portion of the cup 18 such that the LED 12, the submount 16, and conductive paths 20, 22 are covered by the epoxy, and the epoxy is then cured.

The LED 12 further comprises a conversion material layer 26 on top of the transparent material 24, with the layer 26 also being made of a radiation hard and transparent material similar to layer 24, and also has a conversion material 28 distributed throughout. The material 28 can be one or more fluorescent or phosphorescent material such as a phosphor, fluorescent dye or photoluminescent semiconductor. The following list phosphors that can be used as the conversion material 28, grouped by the re-emitted color following excitation:

RED

$Y_2O_2S:Eu^{3+},Bi^{3+}$
$YVO4:Eu3^{+},Bi^{3+}$
$SrS:Eu^{2+}$
$SrY_2S_4:Eu^{2+}$
$CaLa2S_4:Ce3^{+}$
$(Ca,Sr)S:Eu^{2+}$

$Y_2O_3:Eu^{3+},Bi^{3+}$
$Lu_2O_3:Eu^{3+}$
$(Sr_{2-x}La_x)(Ce_{1-x}Eu_x)O_4$
$Sr_2Ce_{1-x}Eu_xO_4$
$Sr_{2-x}Eu_xCeO_4$
Sr_2CeO_4
$SrTiO_3:Pr^{3+},Ga^{3+}$

ORANGE

$SrSiO_3:Eu,Bi$

YELLOW/GREEN

$YBO_3:Ce^{3+},Tb^{3+}$
$BaMgAl_{10}O_{17}:Eu^{2+},Mn^{2+}$
$(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$
$ZnS:Cu^{+},Al^{3+}$
$LaPO_4:Ce,Tb$
$Ca_8Mg(SiO_4)_4Cl_2:Eu^{2+},Mn^{2+}$
$((Gd,Y,Lu,Se,La,Sm)_3(Al,Ga,In)5O_{12}:Ce3^{+}$
$((Gd,Y)_{1-x}Sm_x)_3(Al_{1-y}Ga_y)_5O_{12}:Ce^{3+}$
$(Y_{1-p-q-r}Gd_pCe_qSm_r)_3(Al_{1-y}Ga_y)_5O_{12}$
$Y_3(Al_{1-s}Ga_s)_5O_{12}:Ce^{3+}$
$(Y,Ga,La)_3Al_5O_{12}:Ce^{3+}$
$Gd_3In_5O_{12}:Ce^{3+}$
$(Gd,Y)_3Al_5O_{12}:Ce^{3+},Pr^{3+}$
$Ba_2(Mg,Zn)Si_2O_7:Eu^{2+}$
$(Y,Ca,Sr)_3(Al,Ga,Si)_5(O,S)_{12}$
$Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{2+0.06}$
$(Ba_{1-x-y}Sr_xCa_y)SiO_4:Eu$
$Ba_2SiO_4:Eu^{2+}$

BLUE

$ZnS:Ag,Al$

COMBINED YELLOW/RED

$Y_3Al_5O_{12}:Ce^{3+},Pr^{3+}$

WHITE

$SrS:Eu^{2+},Ce^{3+},K^{+}$

From the list above, the following phosphors are most suitable for use as the conversion material 28 in LED

package 10 by having excitation in the blue and/or UV emission spectrum, providing a desirable peak emission, having efficient light conversion, and acceptable Stokes shift:

RED

$Lu_2O_3:Eu^{3+}$
$(Sr_{2-x}La_x)(Ce_{1-x}Eu_x)O_4$
$Sr_2Ce_{1-x}Eu_xO_4$
$Sr_{2-x}Eu_xCeO_4$
$SrTiO_3:Pr^{3+},Ga^{3+}$

YELLOW/GREEN

$(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$
$Ba_2(Mg,Zn)Si_2O_7:Eu^{2+}$
$Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{2+}{}_{0.06}$
$(Ba_{1-x-y}Sr_xCa_y)SiO_4:Eu$
$Ba_2SiO_4:Eu^{2+}$

During manufacturing, the conversion material layer 26 is injected on top of the layer 24 to fill most, or all, of the cup 18, and is cured. The particles in material 28 absorb light emitted by the UV LED 12 and re-emit the absorbed light at one or more wavelength spectrums that are different from the absorbed wavelength. The conversion material 28 can comprise more than one type of material, each of which re-emits light at a different wavelength so that the conversion material layer 26 re-emits more than one wavelength of light. The conversion material 28 can also be in different concentrations throughout the conversion material layer 26.

The amount of LED light absorbed and re-emitted by the conversion material is generally proportional to the amount of conversion material that the LED light passes through. However, if the LED light passes through too much conversion material 28, part of the conversion material's

re-emitted light can be blocked from emitting from the LED package 10, by excess conversion material 28. This can reduce the overall light emitting efficiency of the package 10. The amount of conversion material that the LED light passes through can be varied by varying the concentration of conversion material 28 or varying the thickness of the layer 26, or both.

In LED package 10, light from the LED 12 passes through a sufficient amount of conversion material 28 so that substantially all of the LED light is absorbed and re-emitted at a different wavelength of light. At the same time, the re-emitted light does not pass through an excess conversion material 28 so that the re-emitted light is not blocked from emitting from the package 10. By providing a sufficient amount of conversion material 28 to provide full conversion without blocking, the conversion material 28 is in a "saturation" condition. The amount of conversion material for conversion material saturation depends on the size and luminous flux of the LED 12 (or laser). The greater the size and luminous flux, the greater the amount of conversion material 28 needed.

In conversion material saturation, the emitted light from the package 10 is composed primarily of photons produced by the conversion material 28. However, in some embodiments it may be desirable to allow a small portion of the LED light to be transmitted through the conversion material 28 without absorption for the purpose of modifying slightly the chromaticity of the resulting package radiation. For the LED 10, most embodiments of the package 10 emit less than 10% of the emission power of primary radiation in the absence of the conversion material 28; i.e. the conversion material 28 absorbs 90% or more of the light from the LED 12.

As described above, the LED 12 is blue emitting and a suitable conversion material is a green phosphor such as $SrGa_2S_4:Eu^{2+}$ (Sr:Thiogallate) or $Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{+2}{}_{0.06}$. Sr:Thiogallate has a peak excitation wavelength ranging from 400 to 450nm and the percent of blue light (or UV light) that is absorbed by Sr:Thiogallate and then re-emitted as green light is estimated to be 74% +/-5%, which makes this phosphor one of the more efficient for excitation in the blue (or UV) range. The use of a high efficiency blue emitter in combination with a phosphor that is efficient for excitation in the blue range, results in a saturation conversion material LED package that efficiently emits green.

FIGs. 2-4 show results of performance studies completed by applicants on LED packages 10 according to the present invention having a blue LED with green conversion material in, or near, saturation. FIG. 2 shows a graph 40 plotting the emission performance in Lumens of four different LED packages according to the present invention at their peak emission wavelength in nanometers (nm), with 350mA applied across the LED in each package. Using a green Sr:Thiogallate phosphor as the conversion material, the LED package emitted up to 58 Lumens at its peak wavelength of approximately 530nm, which is a significant improvement over the performance of typical green emitting LEDs.

FIG. 3 shows a graph 50 plotting the emission spectrum as Intensity in a.u. verses wavelength in nm, of the light re-emitted from green Sr:Thiogallate phosphor from the LED packages. Each package exhibited a similar spectrum having a peak (~70nm full width at half maximum (FWHM) centered at ~530-550nm, which is close to the peak of the general photopic human eye response curve. This results in an emission of green light having high efficacy. Applicants

also maintained the operation of each of the LED packages under test and each maintained this emission spectrum without change for approximately 168 hours, showing that the LED packages are stable over time.

FIG. 4 shows a graph 60 that plots the light output loss over operating hours for three of the four LED packages 10 under test. The graph 60 illustrates that for each, the light output loss is minimal over time. This also shows that the LED packages 10 are stable over time and this performance is consistent with the performance of standard green emitting LEDs.

FIG. 5 shows another embodiment of an LED package 70 according to the present invention, having many similar features as the package 10 in FIG. 1. It comprises an LED 72 mounted to a submount 74, which is then mounted to the horizontal base 76 of a metal cup 78. First and second conductors 80, 82 are provided to apply a bias across the LED 72, although a bias can be applied in other ways as described above. A protective layer 84 is included over the LED 72, submount 74 and conductive paths 80, 82, and a conversion material layer 86 is included on top of the protective layer 84 and includes a conversion material 88.

The LED 72 is UV emitting and can be made of many different material systems, with a preferred material system being the Group III nitride material system. The conversion material 88 can be any of the materials listed above, but is preferably a green phosphor such as Sr:Thiogallate. The thickness of layer 86 and the concentration of Sr:Thiogallate is such that the conversion material 88 is in saturation, i.e. all of the UV light is absorbed without an excess of conversion material 88 blocking emission of the re-emitted green light. Sr:Thiogallate is efficient at absorbing UV light and re-

emitting green light, and using this phosphor in combination with a high efficiency UV LED 72 results in a saturated conversion material LED package 70 that efficiently emits green light.

FIG. 6 shows an embodiment of laser diode package 90 according to the present invention having similar features to the packages 10, 70 described above, but instead of having a LED as a light source, the package 90 has a solid-state semiconductor laser diode 92. Mirrors 94, 96 are included on two opposing surfaces of the laser diode 92, with mirror 94 being partially transmissive. The mirrors 94, 96 provide optical feedback so that stimulated emission can occur, which provides a highly collimated/coherent light source. The laser diode 92 can be mounted to a submount 98 that is then mounted to the horizontal base 100 of a metal cup 102 having conductors paths 104, 106 to apply a bias to the laser diode 92. The laser diode 92, submount 98 and conductive paths 104, 106 are covered in a protective layer 108. A conversion layer 110 is included on the protective layer 108 and comprises a conversion material 112, which can be any of the conversion materials discussed above.

Different laser diodes emitting different colors of light can be used for diode 92 and the conversion material 112 is arranged so that the light from the laser diode 92 passes through it and the LED package 90 operates in saturation of the conversion material 112. All (or most) of the light from diode 92 is absorbed by the conversion material 112 and re-emitted as a different wavelength of light, while minimizing the amount of re-emitted light blocked by excess conversion material 112.

To improve the uniformity of light emitting from the package 90, it can be desirable to scatter the light as it

passes through the layers 108, 110, particularly in the case of collimated/coherent light from the laser diode 92. One way to scatter light is by using scattering particles 114 that randomly refract light. To effectively scatter light, the diameter of the particles 114 should be approximately one half of the wavelength of the light being scattered. In package 90 the scattering particles 114 are shown in layer 110, although they can also be included in layer 108 or formed in another layer arranged on the layer 110. Light from the diode 92 passes through the particles 114 and is refracted to mix and spread the light as it passes through the conversion material.

The scattering particles 114 are shown evenly distributed throughout layer 100 but they can also be distributed in varying concentrations throughout the layer 114 to most effectively scatter the light by matching the pattern of LED light passing through the layer 114. The preferred scattering particles would not substantially absorb laser diode light and would have a substantially different index of refraction than the material in which it is embedded (for example, epoxy). The scattering particles 114 should have as high of an index of refraction as possible. Suitable scattering particles can be made of titanium oxide (TiO_2) which has a high index of refraction (n=2.6 to 2.9) and is effective at scattering light. Since the primary requirement for the scattering "particles" is that they have a different index of refraction from their surrounding material and that they have a particular size range, other elements such as small voids or pores could also be used as "scattering particles".

FIG. 7 shows another embodiment of an emitter package 120 having a semiconductor emitter 122 that is either a LED or a laser diode. Like the packages 10, 70 and 90 above,

the package 120 has a submount 124, reflective cup 126, first and second conductors 128, 130, a protective layer 132 and a conversion material layer 134. However, in the package 120 the protective layer 132 contains a concentration of conversion particles 136 that is different from the concentration of conversion particles 138 in layer 134. The particles 136 can also be a different type from the particles 138, such that layer 132, 134 each re-emits a different color of light. In both embodiments, the package 120 is arranged to operate in conversion material saturation.

FIG. 8 shows another embodiment of an emitter package 150 according to the invention that is the same as the package 120 in FIG. 4, but instead of having a protective layer 132 and a conversion material layer 134 as shown in FIG. 4, the cup 152 in package 150 is filled with a single conversion layer 156 that serves to protect the packages emitter 158, submount 160, and conductive paths 162, 164 and contains a the conversion material 166 distributed throughout. The conversion material can be homogeneously distributed or distributed in different concentrations. Like above, the package 150 operates in conversion material saturation such that all (or most) of the light from the emitter 158 is absorbed and re-emitted without the conversion material 166 significantly blocking the re-emitted light.

Although the present invention has been described in considerable detail with reference to certain preferred configurations thereof, other versions are possible. Each of the LED package embodiments described above can have different components having different features. Each of the LED packages above can have emitters made of different material systems and each can include scattering particles.

Other conversion materials beyond those listed above can be used. Therefore, the spirit and scope of the invention should not be limited to the preferred versions of the invention described above.

WE CLAIM:

1. An emitter package, comprising:

a semiconductor emitter;

a conversion material arranged to absorb substantially all of the light emitting from said semiconductor emitter and re-emit light at one or more different wavelength spectrums of light, said conversion material also arranged so that there is not an excess of conversion material to block said re-emitted light as it emits from said emitter package, said emitter package emitting light primarily at said one or more wavelength spectrums from said conversion material.

2. The emitter package of claim 1, wherein said semiconductor emitter is made of semiconductor materials from the Group III nitride based material system.

3. The emitter package of claim 1, wherein said semiconductor emitter is a light emitting diode (LED) or a laser diode.

4. The emitter package of claim 1, wherein said conversion material is one or more materials from the group consisting of phosphors, fluorescent dyes and photoluminescent semiconductors.

5. The emitter package of claim 1, wherein said conversion material has peak excitation wavelength in the range if 400 to 450nm.

6. The emitter package of claim 1, wherein said semiconductor emitter is a blue light emitting and said conversion material is $SrGa_2S_4:Eu^{2+}$ or $Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{+2}{}_{0.06}$, said emitter package emitting green light from said conversion material.

7. The emitter package of claim 1, wherein said semiconductor emitter is a ultra violet (UV) light emitting and said conversion material is Sr:Thiogallate ($SrGa_2S_4:Eu$) or $(Gd_{0.46}Sr_{0.31})Al_{1.23}O_xF_{1.38}:Eu^{+2}{}_{0.06}$, said emitter package emitting green light from said conversion material.

8. The emitter package of claim 1, wherein said conversion material absorbs at least 90% of light emitted from said semiconductor emitter.

9. The emitter package of claim 1, wherein said conversion material comprises a material from the group consisting of $Lu_2O_3:Eu^{3+}$, $(Sr_{2-x}La_x)(Ce_{1-x}Eu_x)O_4$, $Sr_2Ce_{1-x}Eu_xO_4$, $Sr_{2-x}Eu_xCeO_4$, $SrTiO_3:Pr^{3+},Ga^{3+}$, $(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$, $Ba_2(Mg,Zn)Si_2O_7:Eu^{2+}$, $Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{2+}{}_{0.06}$, $(Ba_{1-x-y}Sr_xCa_y)SiO_4:Eu$, and $Ba_2SiO_4:Eu^{2+}$.

10. A saturated conversion material emitter package, comprising:

one or more semiconductor emitters, each of which emits light in response to a bias;

a metal cup, said semiconductor emitters arranged at the base of said cup;

a plurality of conductive paths coupled to said semiconductor emitters for applying a bias to said emitters; and

a conversion material arranged so that light from said

emitters passes through said conversion material, said conversion material absorbing substantially all light from said emitters and re-emitting light at one or more different wavelengths of light, said conversion material also arranged so that it does not substantially block said re-emitted light as it emits from said emitter package, said emitter package emitting light at said one or more wavelength spectrums from said conversion material.

11. The emitter package of claim 10, wherein said emitter is a light emitting diode (LED) or laser diode made of semiconductor materials from the Group III nitride based material system.

12. The emitter package of claim 10, wherein said conversion material is one or more materials from the group consisting of phosphors, fluorescent dyes and photoluminescent semiconductors.

13. The emitter package of claim 10, wherein said conversion material has peak excitation wavelength in the range if 400 to 450nm.

14. The emitter package of claim 10, wherein said semiconductor emitter is a blue light emitting and said conversion material is Sr:Thiogallate ($SrGa_2S_4$:Eu) or $(Gd_{0.46}Sr_{0.31})Al_{1.23}O_xF_{1.38}:Eu^{+2}_{0.06}$, said emitter package emitting green light from said conversion material.

15. The emitter package of claim 10, wherein said semiconductor emitter is an ultra violet (UV) light emitting and said conversion material is Sr:Thiogallate ($SrGa_2S_4$:Eu) or $(Gd_{0.46}Sr_{0.31})Al_{1.23}O_xF_{1.38}:Eu^{+2}_{0.06}$, said emitter

package emitting green light from said conversion material.

16. The emitter package of claim 10, further comprising a submount, said LED mounted to said submount and said submount being arranged between said LED and said base of said metal cup.

17. The emitter package of claim 10, further comprising a layer of protective material in said metal cup and covering said LED and conductive paths, said layer of protective material being radiation hard and transparent.

18. The emitter package of claim 17, further comprising a conversion material layer on said protective layer, said conversion material distributed throughout said conversion material layer.

19. The emitter package of claim 18, wherein said protective layer contains conversion material at a different concentration than said conversion material in said conversion material layer.

20. The emitter package of claim 10, further comprising a conversion layer filling said cup and covering said emitter and conductive paths, said conversion layer made of protective radiation hard and transparent material with a conversion material spread throughout.

21. The emitter package of claim 10, wherein said conversion material absorbs at least 90% of light emitted from said semiconductor emitter.

22. The emitter package of claim 10, further comprising

scattering particles to disperse light from said semiconductor emitters.

23. A saturated conversion material emitter package, comprising:

a semiconductor emitter;

a conversion material arranged to absorb all of the light emitting from semiconductor emitter and re-emit light at one or more different wavelength spectrums of light.

24. The emitter package of claim 23, wherein said conversion material is also arranged so that there is not an excess of conversion material to block said re-emitted light as it emits from said emitter package.

25. The emitter package of claim 23, wherein said semiconductor emitter is a light emitting diode (LED) or laser diode made of semiconductor materials from the Group III nitride based material system.

26. The emitter package of claim 23, wherein said conversion material is one or more materials from the group consisting of phosphors, fluorescent dyes and photoluminescent semiconductors.

27. The emitter package of claim 23, wherein said conversion material has peak excitation wavelength in the range if 400 to 450nm.

28. The emitter package of claim 23, wherein said conversion material is Sr:Thiogallate ($SrGa_2S_4$:Eu) or $(Gd_{0.46}Sr_{0.31})Al_{1.23}O_xF_{1.38}:Eu^{+2}_{0.06}$, said emitter package emitting green light from said conversion material.

29. The emitter package of claim 23, wherein said conversion material comprises a material from the group consisting of $Lu_2O_3:Eu^{3+}$, $(Sr_{2-x}La_x)(Ce_{1-x}Eu_x)O_4$, $Sr_2Ce_{1-x}Eu_xO_4$, $Sr_{2-x}Eu_xCeO_4$, $SrTiO_3:Pr^{3+},Ga^{3+}$, $(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$, $Ba_2(Mg,Zn)Si_2O_7:Eu^{2+}$, $Gd_{0.46}Sr_{0.31}Al_{1.23}O_xF_{1.38}:Eu^{2+}_{0.06}$, $(Ba_{1-x-y}Sr_xCa_y)SiO_4:Eu$, and $Ba_2SiO_4:Eu^{2+}$.

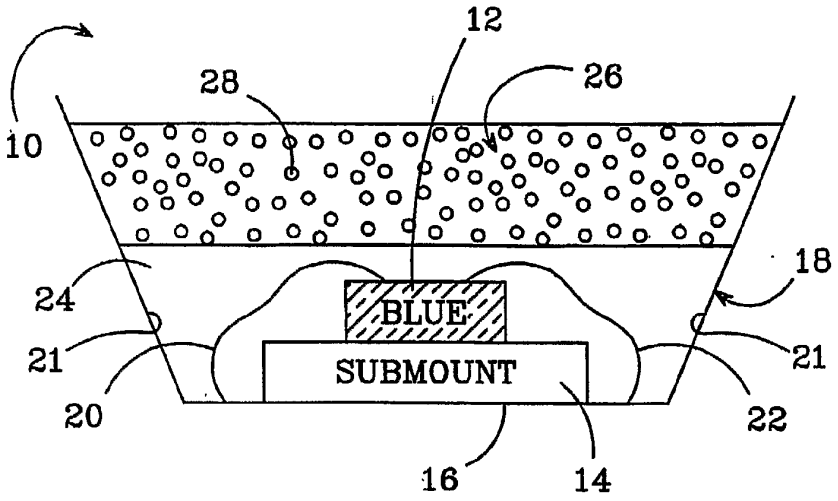

12
28
26
10
18
24
BLUE
21
SUBMOUNT
21
20
22
16
14

FIG.1

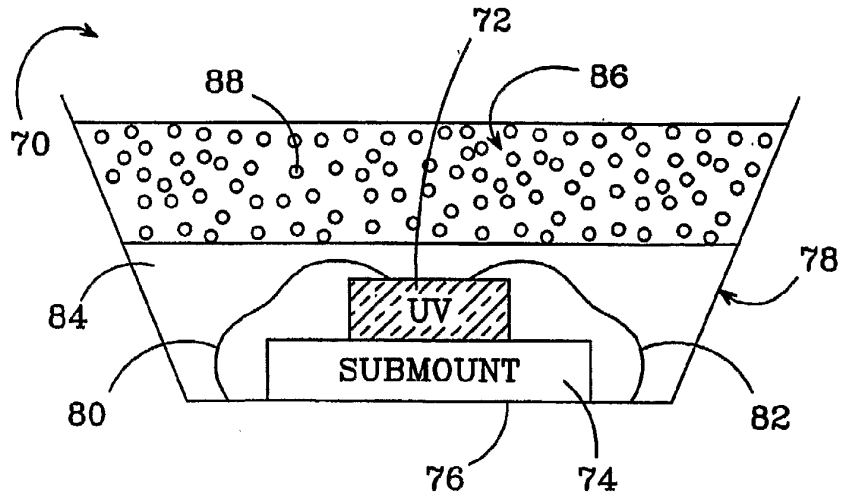

72
88
86
70
78
84
UV
SUBMOUNT
80
82
76
74

FIG.5

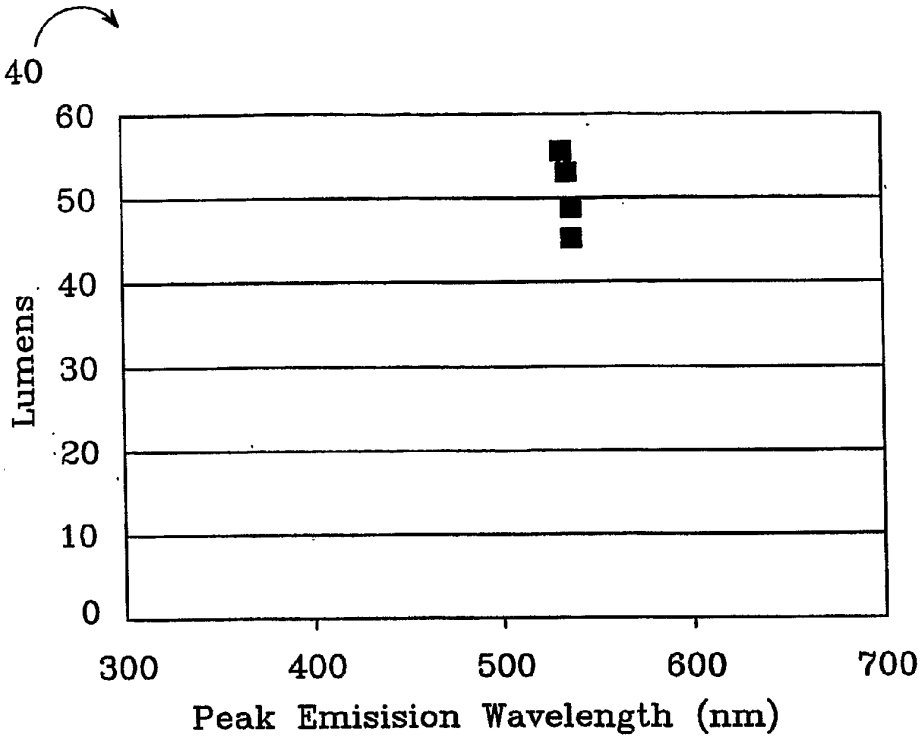

40
60
50
40
30
20
10
0
Lumens
300
400
500
600
700
Peak Emisision Wavelength (nm)

FIG.2

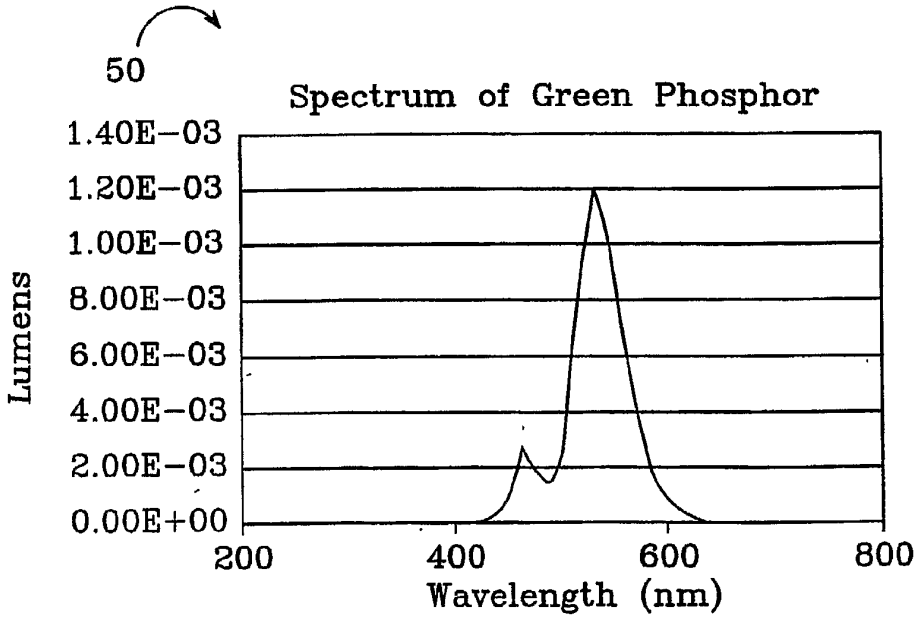

50
Spectrum of Green Phosphor
1.40E−03
1.20E−03
1.00E−03
8.00E−03
6.00E−03
4.00E−03
2.00E−03
0.00E+00
Lumens
200
400
600
800
Wavelength (nm)

FIG.3

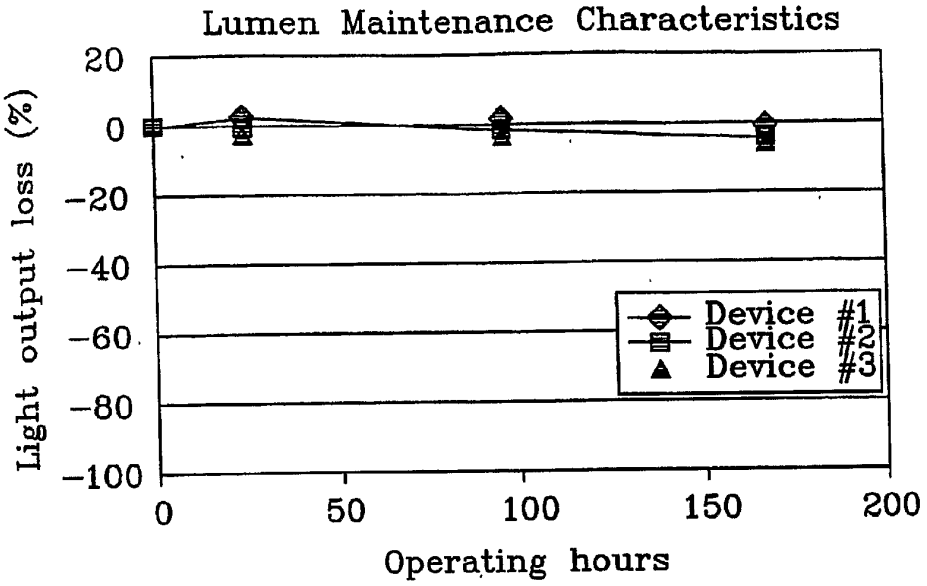

Lumen Maintenance Characteristics
Light output loss (%)
20
0
-20
-40
-60
-80
-100
0
50
100
150
200
Operating hours
Device #1
Device #2
Device #3

FIG.4

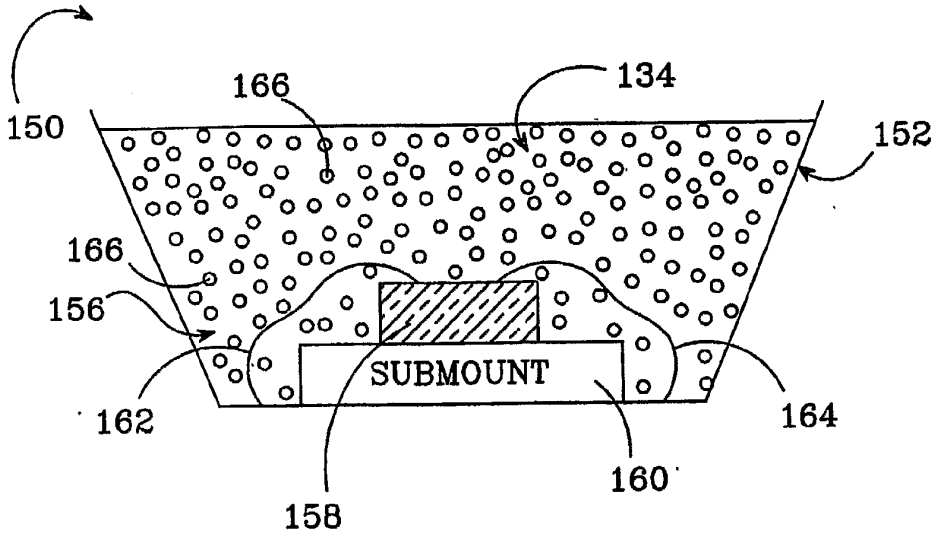

150
166
134
152
166
156
SUBMOUNT
162
164
160
158

FIG.8

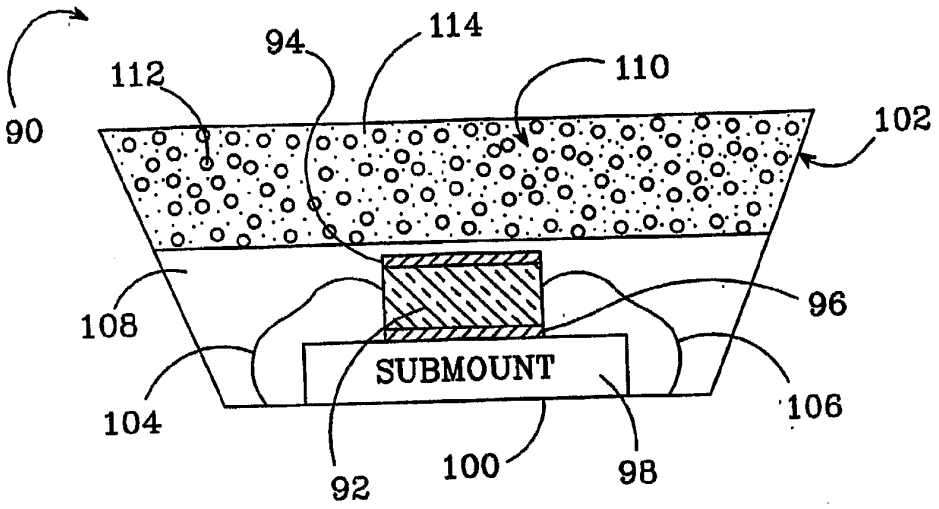

90
94
114
112
110
102
108
96
SUBMOUNT
104
106
92
100
98

FIG.6

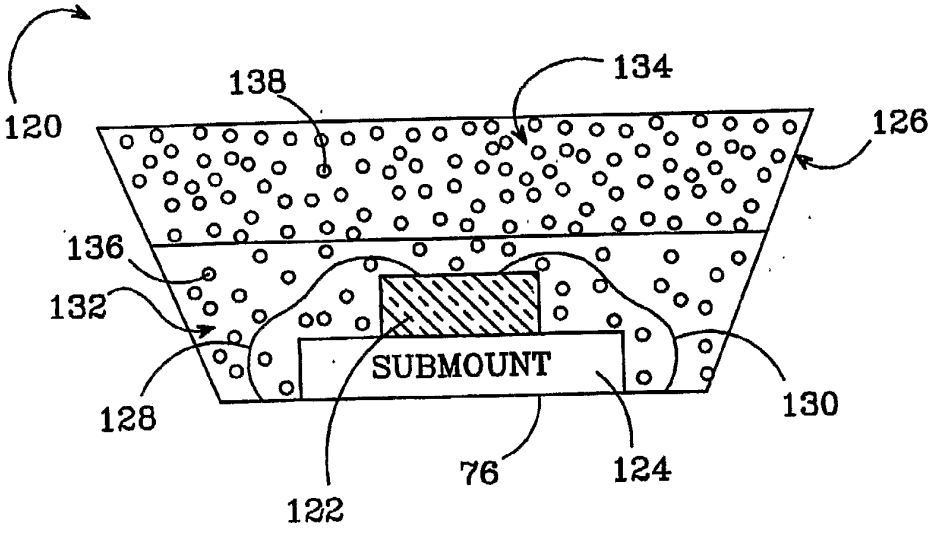

120
138
134
126
136
132
SUBMOUNT
128
130
76
124
122

FIG.7

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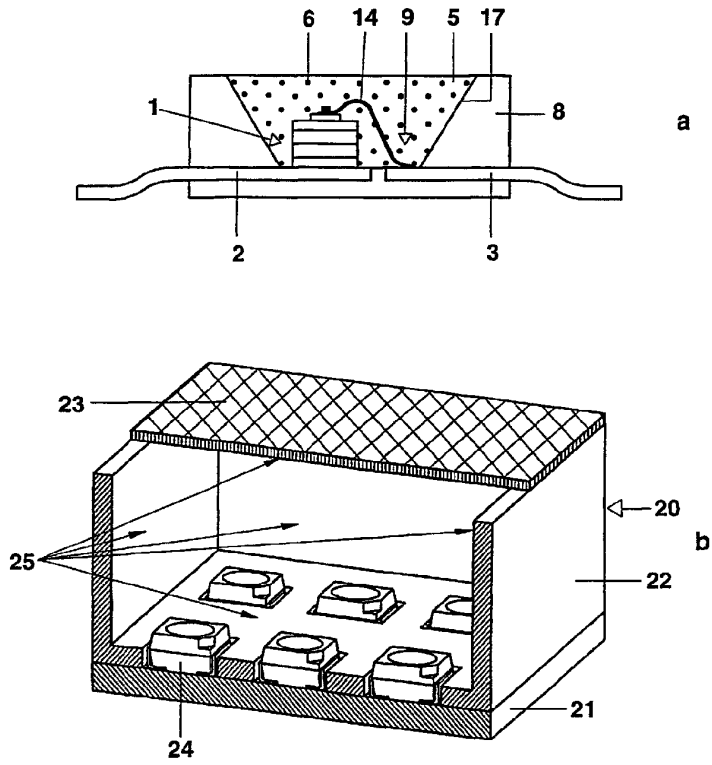
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(54) Title: LUMINESCENCE CONVERSION BASED LIGHT EMITTING DIODE AND PHOSPHORS FOR WAVELENGTH CONVERSION



(57) Abstract: A device for the generation of specific colored light including white light by luminescent down conversion and additive color mixing based on a light-emitting diode "LED"(1) comprising a semiconductor light-emitting layer emitting near UV light about 370-420 nm or blue light about 420-480 nm and phosphors (6) which absorb completely or partly the light emitted by the light-emitting component and emit light of wavelengths longer than that of the absorbed primary light, wherein the light emitting layer of the light emitting component is preferably a Ga(In)N-based semiconductor; and at least one of the phosphors (6) contains a metal sulfide fluorescent material activated with europium containing at least one element selected from the group consisting of Ba, Sr, Ca, Mg and Zn; and/or at least another phosphor (6) which contains a complex thiometalate fluorescent material activated with either europium, cerium or both europium and cerium containing at least one element selected from the group consisting of Ba, Sr, Ca, Mg and Zn; and at least one element selected from the group consisting of Al, Ga, In, Y, La and Gd.

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AMENDED CLAIMS

[received by the International Bureau on 18 January 2001 (18.01.02);
Claims 16 – 23, replaced by new claims 16 – 23; claims 1-15 and 24-29, unchanged
(1 page)]

16. A phosphor which absorbs radiation having a first spectrum and emits radiation having a second spectrum, the phosphor comprising:
a photoluminescent metal sulfide MS (Type I phosphor) of the formula $(Sr_{1-x-y} M_x Eu_y)S$ with M is at least one of Ba, Mg, Zn alone or in combination with Ca and $0< x \leq 0.5$ and $0< y \leq 0.10$,
or a photoluminescent phosphor comprising a complex metal thiometallate photoluminescent material $M^*N^*_2S_4$ (type II phosphor) comprising of at least one element selected from the group M* = Mg, Zn, alone or in combination with at least one of Ba, Sr, Ca, and at least one element selected from the group N* = Al, Ga, alone or in combination with In, Y, La, Gd, N* being activated with at least one of europium (Eu) and cerium (Ce).

17. A phosphor composition comprising at least one of the phosphors of type I and one of the phosphors of type II in accordance with claim 16.

18. A phosphor in accordance with claim 16 wherein M is one of Ba, Mg or Zn.

19. A phosphor in accordance with claim 16 wherein the phosphor is the type I according to $(Sr_{1-x-y} M_x Eu_y)S$ with M is at least one of Ba, Mg, Zn alone or in combination with Ca and $0< x \leq 0.5$ and $0< y \leq 0.10$.

20. A phosphor in accordance with claim 19 wherein the phosphor is according to $(Sr_{1-x-y}Ba_xEu_y)S$ with $x \leq 0.25$.

21. A phosphor in accordance with claim 19 wherein the phosphor is according to $(Sr_{1-x-z-y}Ca_xBa_zEu_y)S$ with $x+y+z \leq 0.35$.

22. A phosphor in accordance with claim 16, wherein the phosphor composition is according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor) with M* is at least one of M* = Mg, Zn alone or together with at least one of Ba, Sr, Ca, and N* is at least one of N* = Al, Ga, alone or together with small proportions (below 20%) of In, Y, La, Gd.

23. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor containing Mg as one of the host lattice elements

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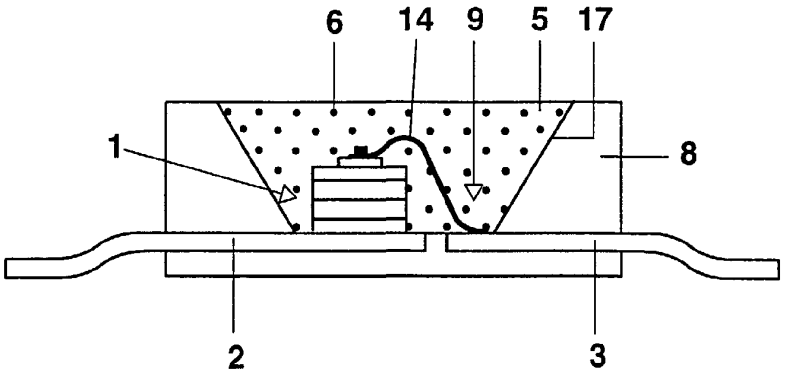
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Luminescence Conversion Based Light Emitting Diode and Phosphors for Wavelength Conversion

FIELD OF INVENTION

The invention relates to a light emitting device and phosphors for the generation of specific, colored light, including white light, by luminescent down conversion and additive color mixing based on a light-emitting diode (LED) comprising a light-emitting semiconductor component which emits a primary light in the range of 370 to 480 nm and especially in the UV spectral range from about 370 to 415 nm, or in the blue spectral range from about 420 to 480 nm. The chip or a plurality of chips in a lighting unit is covered directly or indirectly by a phosphor or a combination of various phosphors, described as phosphor blends, which absorb completely or partly the primary light emitted by the light-emitting semiconductor component and emit a secondary light of wavelengths higher than that one of the primary light. The light-emitting semiconductor component is preferably a Ga(In)N-based semiconductor. The phosphors comprise at least a metal sulfide photoluminescent material MS activated with europium containing at least one element selected from the group M = Ba, Sr, Ca, Mg, Zn , and/or a complex thiometalate photoluminescent material $M^*N^*_2S_4$ activated with either europium, cerium or both, europium and cerium, containing at least one element selected from the group M* = Ba, Sr, Ca, Mg, Zn, and at least one element selected from the group N* = Al, Ga, In, Y, La, Gd.

In this disclosure, a phosphor blend is defined as any combination of two or more photoluminescent materials the output of which, in combination with the emission of the semiconductor, is capable of producing colored emission including white emission with a high color rendering index value or specific broad band or multi-band emission with defined color coordinates. Photophysical data regarding all of the above requirements have been investigated, and as a result a device may be fabricated in which the excitation/emission profiles of phosphors are optimally selected as required for a specific purpose.

DESCRIPTION OF RELATED ART

Solid state light sources based on light-emitting semiconductor components have been available for many years. Special interest is dedicated to light emitting diodes (LEDs) and to phosphors for converting primary light of a light emitting semiconductor component to longer wavelength, for example, for general purpose illumination as described, for example, in US 5 998 925, WO 00/33390 and WO 00/33389.

US 5 998 925 discloses a white light emitting LED device. It uses yttrium aluminum garnet doped with cerium, $Y_3Al_5O_{12}$:Ce, to convert blue emission of an InGaN-diode into yellow to produce white light of suitable color temperature. Another approach (WO 00/33390) uses a combination of a blue emitting LED together with a green and red phosphor. The phosphors are at least one of a first phosphor , among others thiogallates $(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$, and at least one of a second phosphor, among others metal sulfide $SrS:Eu^{2+}$, or $(Ca,Sr)S:Eu^{2+}$, or thiogallate $CaLa_2S_4:Ce^{3+}$, to produce white light of distinct color temperature. The thiogallate $(Sr,Ca,Ba)(Al,Ga)_2S_4:Eu^{2+}$ can be used to generate specific colors together with light emitting elements such as blue LEDs, see WO 00/33389.

The above mentioned phosphors can be used to produce white light with various color temperatures and suitable index of color rendering by luminescent down conversion of primary LED emission, but they exhibit several drawbacks related to total conversion efficiency, absorption strength, emission wavelength tunability, thermal quenching characteristics and life time which are of high importance for using these phosphors in LEDs.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a light emitting device having a light-emitting semiconductor component and a phosphor or a phosphor blend whereby the phosphors are capable of absorbing, with high efficiency, the primary light emitted by the light-emitting semiconductor component and emitting secondary light of wavelengths higher than that one of the primary light whereby secondary light emitted by the phosphors and primary light of the light-emitting semiconductor component may combine to generate light of any color, including white light.

Thus, the present invention provides a light-emitting device, comprising a light-emitting semiconductor component, emitting in the UV to blue spectral range between 370 and 480 nm, preferably between 370 and 415 nm or 420 to 480 nm, in combination with a phosphor or phosphor blend comprising at least one, preferably at least two, phosphors capable of absorbing at least a part of the primary light emitted by the light-emitting semiconductor component and emitting secondary light of wavelengths higher tan that one of the primary light. Said light-emitting semiconductor component comprises preferably a Ga(In,Al)N-based semiconductor. Said at least one phosphor comprises a photoluminescent metal sulfide MS (Type I phosphor) comprising at least one element selected from the group M = Ba, Mg, and Zn alone or in combination with at least one of Sr, Ca; the sulfide being activated with europium, or it comprises at least one phosphor comprising a complex metal thiometallate photoluminescent material $M^*N^*_2S_4$ (type II phosphor) comprised of at least one element selected from the group M* = Mg, Zn, alone or in combination with at least one of Ba, Sr, Ca, and at least one element selected from the group N* = Al, Ga, alone or in combination with In, Y, La, Gd, the thiogallate being activated with at least one of europium (Eu) and cerium (Ce).

Preferably at least one of type I and one of type II phosphor, possibly with addition of other well-known phosphors, can be combined to achieve a specific color (for example magenta) or even white light when irradiated by a LED emitting primary UV or blue light as specified above.

Beside the main characteristics, like spectral range of emission and absorption, and total conversion efficiency, additional important characteristics of the phosphors include 1) resistance to thermal quenching of luminescence at typical device operating temperatures (*e.g.* 80°C); 2) lack of interfering reactivity with the encapsulating resins used in the device fabrication; 3) suitable absorptive profiles to minimize dead absorption within the visible spectrum; 4) a temporally stable luminous output over the operating lifetime of the device and; 5) compositionally controlled tuning of the phosphors excitation and emission properties.

In addition, the chemical compositions of the phosphors play a decisive role due to the composition dependent crystal field dependence of absorption, emission and conversion behavior of the optical 4f-5d transition of the emitting centers, Eu^{2+} and Ce^{3+} applied herein.

The invention also relates to phosphor compositions according to MS:Eu (type I phosphor) with M is at least one of M = Ba, Mg, Zn alone or in combination with Sr, Ca. This type of phosphor emits in the red spectral range of the visible spectrum and thus provides the red component in LEDs emitting specific colors or even white light.

In particular, the invention relates to specific phosphor compositions (type I phosphor) according to $(Sr_{1-x-y}M_xEu_y)S$ with M is at least one of = Ba, Mg, Zn alone or in combination with Ca and $0< x \leq 0.5$ and $0< y \leq 0.10$. Preferred are the binary compositions according to $(Sr_{1-x-y}Ba_xEu_y)S$ with $x \leq 0.25$ and the ternary compositions according to $(Sr_{1-x-z-y}Ca_xBa_zEu_y)S$ with $x + y + z \leq 0.35$ which exhibit a high quantum efficiency of 65-80 %, high absorbance in the range from 370 nm to 470 nm of 60-80% and low loss, below 10%, of the luminescent lumen output from room temperature to 100 °C due to thermal quenching.

The invention also relates to phosphor compositions according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor) with M* is at least one of M* = Mg, Zn alone or together with at least one of Ba, Sr, Ca, and N* is at least one of N* = Al, Ga, alone or together with small amounts (below 20%) of In, Y, La, Gd, which emits in the blue, green or green-yellow spectral range of the visible spectrum and thus can provide the blue, green or green-yellow component in LEDs emitting specific colors or even white light.

In particular, the invention relates to specific compositions (type II phosphor) containing Mg as one of the host lattice elements according to $(M^{**}_{1-u}Mg_u)(Ga_{1-v}N^*_v)_2S_4$:Ce with $u \leq 0.75$ and $v \leq 0.10$, and M** is at least one of M** = Ba, Sr, Ca, Zn.

In particular, the invention relates to specific compositions (type II phosphor) according to $(M^{**}_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with M** is at least one of = Mg, Zn alone or in combination with Sr, Ba, Ca, and N* = Al, In, Y, La, Gd and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$ with $v \leq 0.10$, which emit in green to green-yellow spectral range of the visible spectrum from 500 nm to 555 nm.

In particular, the invention relates to specific binary compositions (type II phosphor) according to $((Ba_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$ which emit in green spectral range of the visible spectrum from 500 nm to 540 nm and may exhibit a quantum efficiency above 75%, preferably above 80%, absorbance in the range from 320 nm to 460 nm of about 60%

and low loss of the luminescent lumen output from room temperature to 100 °C below 7% due to thermal quenching.

In particular, the invention relates to specific ternary compositions (type II phosphor) according $(((Ba_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$, which emit in green-yellow spectral range of the visible spectrum from 525 nm to 535 nm and preferably exhibit a quantum efficiency above 80%, absorbance in the range from 320 nm to 410 nm above 60%, and low loss of the luminescent lumen output from room temperature to 100 °C below 15% due to thermal quenching.

In particular, the invention relates to specific ternary compositions (type II phosphor) according $(((Ba_{1-r}Sr_r)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u< 0.75$ and $r \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$, which emit in green-yellow spectral range of the visible spectrum from 525 nm to 535 nm and preferably exhibit a quantum efficiency above 60 %, absorbance in the range from 320 nm to 410 nm above 60 % and low loss of the luminescent lumen output from room temperature to 100 °C below 15 % due to thermal quenching.

In particular, the invention relates to specific ternary compositions (type II phosphor) $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $t:s < 0.2$ which emit in yellow-green spectral range of the visible spectrum from 535 nm to 555 nm and exhibit a quantum efficiency above 60 %, absorbance in the range from 320 nm to 410 nm above 60% and low loss of the luminescent lumen output from room temperature to 100 °C below 15 % due to thermal quenching.

In particular, the invention relates to specific ternary compositions (type II phosphor) $(((Sr_{1-p}Zn_p)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u < 0.75$ and $p \leq 0.35$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$, which emit in green spectral range of the visible spectrum from 525 nm to 540 nm and exhibit a quantum efficiency of at least 60 %, absorbance in the range from 370 nm to 420 nm above 60 % and low efficiency reduction from room temperature to 100 °C below 15 % due to thermal quenching.

The phosphors described and phosphor blends thereof which may comprise further additional phosphors well-known in the present state of the art can be used together with a light emitting semiconductor component, preferably a GaN-based

LED, to achieve white light when excited by UV radiation or blue light of the LED. The achievable color temperatures cover a broad range of from 3000 to 6000° K with a device luminous efficacy of up to 20 lumens per watt of input electrical powder and a color rendering index of typically more than 75, preferably more than 80.

The phosphors described and phosphor blends thereof which may comprise additional phosphors well-known in the present state of the art can be used together with a light emitting semiconductor component, preferably a GaN-based LED, are able to achieve colored light when excited by UV light or blue light covering a wide space of color coordinates ranging from x = 0.15 – 0.68 and y = 0.05 – 0.82.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will be apparent from the following detailed description and the accompanying drawings.

Figure 1 discloses the photoluminescent emission spectrum of $(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$ (Fig. 1a) and of $((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$(Fig. 1b);

Figure 2 discloses the reflection spectra of $(Sr_{0.82-x}Ba_{0.03}Ca_{0.15}Eu_x)S$ with various Eu content (Fig. 2a) and of $((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$ (Fig. 2b);

Figure 3 discloses the thermal quenching of the photoluminescence of $(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$ and $Sr_{0.98}Eu_{0.02}S$ (Fig. 3a) and of $((Sr_{0.25}Ca_{0.75})_{0.45}Mg_{0.55}Eu_{0.05}Ga_2S_4$; $((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$ and $((Sr_{0.85}Zn_{0.15})_{0.65}Mg_{0.30}Eu_{0.05})Ga_2S_4$(Fig. 3b);

Figure 4 discloses a light emitting device using one of said phosphors, with a first embodiment (Fig. 4a) and a second embodiment (Fig. 4b);

Figure 5 to 10 discloses the emission and reflectance spectra of various further phosphors in accordance with the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The detailed construction of luminescence conversion based light emitting devices are shown for example in the prior art discussed above. Those or similar constructions, see for example US 6 066 861, may be used. Emphasis is given in more detail to the phosphors and phosphor blends to be used in this invention.

The values of the quantum efficiency of luminescent down conversion are the ratio of the number of emitted photons to the number of absorbed photons. The quantum efficiency given in percent is determined by measuring the relative absorbance and the relative radiance compared to standard phosphors with known quantum efficiency. The used standard phosphors were $SrAl_2O_4$:Eu for 400 nm excitation and $Y_3Al_5O_{12}$:Ce for 460 nm excitation. The relative reflectance is measured in relation to a commercial $BaSO_4$-standard. The relative values given in percent for the optical absorbance of described phosphors corresponds directly to the mentioned values in percent for the optical reflectance, measured versus reflectance grade $BaSO_4$, by the relationship reflectance = 100 % – reflectance. The term high chromaticity used herein comprises features such as narrow lines and high color saturation. The content of the chemical elements in the described phosphor compositions are given in molar parts.

A first group of embodiments is directed to light emitting devices based on a light emitting semiconductor component which emits primary light in the near UV spectral range from 370-415 nm.

In this connection a preferred embodiment is related to a device for the generation of specific, colored light including white light by luminescent conversion and additive color mixing based on a light-emitting diode comprising a light-emitting component using a semiconductor as a light-emitting layer emitting a primary light in the range of 370 – 415 nm and phosphors which absorb at least a part of the primary light and emit light of longer wavelengths than the primary light, including red light, wherein the light-emitting layer of the light-emitting component is an Ga(In)N-based semiconductor and the red-emitting phosphor according to $(Sr_{1-x-y}M_xEu_y)S$ (type I phosphor) with M at least one of M = Ba, Mg, Zn alone or in combination with Ca, and $0< x \leq 0.5$ and $0< y \leq 0.10$ preferably the binary compositions according to $(Sr_{1-x-}$

$_yMg_xEu_y)S$ or $(Sr_{1-x-y}Ba_xEu_y)S$ with $x \leq 0.25$ and the ternary compositions according to $(Sr_{1-x-z-y}Ca_xBa_zEu_y)S$ with

$x + y + z \leq 0.35$. The red-emitting phosphor may be combined with a near UV (~400 nm) LED and a blue-emitting phosphor, a green emitting phosphor, both of the appropriate color, and when appropriate, a yellow-emitting phosphor for the production of specific colored light and more preferably for production of white light with a high color-rendering index of >80%.

Europium activated strontium sulfide, is a high chromaticity red phosphor excitable from the near UV (400 nm) to the blue-green (500 nm) with high quantum efficiency. For an optimized use of this phosphor for luminescent conversion of primary LED light it is necessary to modify the photophysical characteristics to achieve, for example, efficacy, color specifications and life time of related light emitting devices. The chromaticity and quantum efficiency of the europium activated strontium sulfide can be modified through the substitution of divalent metal ions for strontium from the list including Ba, Ca, Mg, and Zn.

The red emitting phosphor $(Sr_{1-x-y}\ M_x\ Eu_y\ )S$ is prepared by mixing stoichiometric amounts of SrO, $Ba(OH)_2x8H_2O$, CaO and Eu_2O_3. The mixture is then heated in an alumina crucible an nitrogen atmosphere up to 1000 - 1200 °C, preferably to1100 °C. When the maximum temperature is achieved the mixture is reacted in a H_2S flowing atmosphere for 1-4 hours, preferably for 2 hours. Another method for synthesis of $(Sr_{1-x-y}\ M_x\ Eu_y\ )S$ uses commercially available sulfide precursors such as SrS and EuS. Stoichiometric amounts of binary sulfide were well ground using an agate mortar and pestle under either an ambient atmosphere or in an argon-filled glove box. After grinding, the powders were transferred to graphite crucibles and placed into a tube furnace under flowing Ar. The furnace was then purged at room temperature in flowing Ar for 6-12 hours. When the tube was fully purged, the furnace was ramped at 10°/minute to 150 °C where the temperature remained stable for 2 hours to more fully purge the furnace of water and oxygen. After the two hours was completed, the furnace was ramped at 5°/minute to 1250 °C where the temperature remained stable for 6 hours. After six hours the furnace was turned off and allowed to cool. When the furnace had reached room temperature, the sample was removed and finely ground. The sample was then returned to the furnace where the general procedure was repeated with the only alterations being that the

sample was heated to 1300°C for 12 hours. Samples were annealed for a total of 30-42 hours. Photophysical measurements were performed at the completion of each annealing step to monitor the progress of the reaction.

The photophysical characteristics of substituted europium activated strontium sulfide synthesized as described above are listed in the following Table I together with unsubstituted europium activated strontium sulfide. The photoluminescent emission spectrum for $(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$, excited at 400 nm, and reflectance spectra for $Sr_{0.82-x}Ba_{0.03}Ca_{0.15}Eu_x)S$ with various Eu content are shown in Fig 1a and Fig. 2a. SrS activated with 1% europium vs. 2% europium, for example, displays a dramatically different body color and consequently different absorption and reflectance characteristics. Loss in luminescent output due to thermal quenching is consistently less than 10% at temperatures of 100 °C and higher compared to room temperature, given arbitrarily as 100% (Fig. 3a). X-ray diffraction (Figure 4) displays the presence of only single phase materials crystallizing in the expected NaCl structure with the expected lattice parameter shifts for a given substitution. Loss in luminescent output due to thermal quenching is consistently less than 10% at temperatures of 100°C and higher compared to room temperature.

Table I: Photophysical characteristics for various $(Sr_{1-x-y-z}\ Ba_x\ Ca_z\ Eu_y)S$ phosphors excited at 400 nm			
Composition	Emission Wave-length (Peak) nm	Reflectance at 400 nm %	Quantum Efficiency %
$(Sr_{0.81}Ba_{0.03}Ca_{0.15}Eu_{0.01})S$	630	50	59
$(Sr_{0.805}Ba_{0.03}Ca_{0.15}Eu_{0.015})S$	632	44	72
$(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$	632	45	71
$(Sr_{0.795}Ba_{0.03}Ca_{0.15}Eu_{0.025})S$	632	37	67
$(Sr_{0.79}Ba_{0.03}Ca_{0.15}Eu_{0.03})S$	632	35	62
$(Sr_{0.98}Eu_{0.02})S$	618	52	69

Referring to the use of near UV radiation as a primary light source a preferred embodiment is related to a device for the generation of specific, colored light including white light as described above using phosphors which absorb at least a part of the primary light and emit light of longer wavelengths than the primary light, including green and yellow light, wherein the green to green-yellow-emitting complex metal sulfide photoluminescent materials are according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor) with M* = Mg, Zn alone or in combination with Ba, Sr, Ca, and N* = Al, Ga, alone or in combination with In, Y, La, Gd, preferably compositions according to $(M^*_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with N* = Al, In, Y, La, Gd and $0 < s \leq 0.10$ and t:s < 0.2 with $v \leq 0.10$, preferably binary compositions according to $((Ba_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 and ternary compositions according to $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 as well as $(((Ba_{1-r}Sr_r)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u < 0.75$ and $r \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 as well as $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 as well as $(((Sr_{1-p}Zn_p)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u < 0.75$ and $p \leq 0.35$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2. These green to green-yellow-emitting phosphor may be combined with a near UV (~400 nm) LED and a blue-emitting phosphor, a red emitting phosphor, both of

the appropriate color for the production of specific colored light and more preferably for production of white light with a high color-rendering index of >80.

Europium and/or cerium activated, substituted strontium thiogallate, is a high chromaticity green to yellow phosphor excitable from the near UV(400 nm) to the blue-green (480 nm), preferably 420 to 480 nm, with high efficiency. For an optimized use of these phosphors for luminescent conversion of primary LED light it is necessary to modify the photophysical characteristics to meet, for example, efficacy, color specifications and life time of related light emitting devices. The chromaticity and quantum efficiency of the substituted strontium thiometalate may be modified through the substitution of divalent metal ions for strontium from the list including Ba, Ca, Mg, and Zn and/or the substitution of trivalent metal ions for gallium from the list including Al, In, Y, La, and Gd.

These green to green-yellow emitting phosphors are prepared by the following technique: High purity nitrates, oxalates and acetates were dissolved with stirring in 25-30 ml deionized water. The solutions are stirred with heating on a hot-plate until the water has evaporated resulting in a white or yellow paste, depending on composition. The solids are dried overnight (~12 hours) at 120 °C followed by 12 hours at 550°C. The resulting solid is finely ground and placed into a high purity alumina crucible. The crucibles are loaded into a tube furnace and purged with flowing Ar for several hours. The furnace parameters are 10 °C/min to 900 °C, followed by a 6 hour dwell at 900 °C after which the furnace is turned off and allowed to cool to room temperature. H_2S is introduced to the furnace only after the temperature has reached 800°C and is turned off when the furnace has cooled to 800 °C. The samples are once again finely ground before analysis. Additional time at temperature and in H_2S may be required after the initial reaction, however this is dependent on composition. Luminous output may be improved through an additional anneal at slightly lower temperatures in flowing argon.

Examples of the photophysical characteristics of substituted europium activated thiogallates are listed in Table II. The photoluminescent emission spectrum for $((Sr_{0.77}Zn_{0.23})_{0.85}MgO_{0.10}Eu_{0.05})Ga_2S_4$, excited at 400 nm, and related reflectance spectrum are shown in Fig 1b and Fig. 2b. X-ray diffraction is consistent with the structure of $SrGa_2S_4$ with certain small deviations of position and intensity due to the substitution of smaller divalent metal ions for strontium. Loss in luminescent output

due to thermal quenching is consistently less than 15% at temperatures of 100 °C and higher compared to room temperature (Fig. 3a).

Table II: Photophysical characteristics for various $(M^*_{1-s}Eu_s)Ga_2S_4$ phosphors excited at 400 nm with M* = Ba, Mg, Sr, Ca, Zn

Composition	Emission Wave-length (Peak) nm	Reflectance at 400 nm %	Quantum Efficiency %
$(Ba_{0.80}Mg_{0.15}Eu_{0.05})Ga_2S_4$	509	29	63
$(Ba_{0.38}Mg_{0.57}Eu_{0.05})Ga_2S_4$	533	28	69
$((Sr_{0.25}Ca_{0.75})_{0.40}Mg_{0.55}Eu_{0.05})Ga_2S_4$	533	20	80
$((Ba_{0.57}Ca_{0.43})_{0.40}Mg_{0.55}Eu_{0.05})Ga_2S_4$	548	18	82
$((Sr_{0.25}Ba_{0.75})_{0.40}Mg_{0.55}Eu_{0.05})Ga_2S_4$	536	23	72
$((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$	538	27	73
$((Sr_{0.85}Zn_{0.15})_{0.65}Mg_{0.30}Eu_{0.05})Ga_2S_4$	535	14	68
$((Sr_{0.05}Mg_{0.05}Ba_{0.90})_{0.98}Ce_{0.02})Ga_2S_4$	455	36	69

Referring to the use of near UV radiation as primary light source a preferred embodiment is related to a device for the generation of specific, colored light including white light as described above using phosphors which absorb at least a part of the primary light and emit light of longer wavelengths than the primary light, including blue light, wherein the blue-emitting complex metal sulfide photoluminescent materials are according to according to $((Ba_{1-r} Sr_r)_{1-u}Mg_u)_{1-t}Ce_t)(Ga_{1-v}N_v)_2S_4$ with $0 < t \leq 0.10$ and $u \leq 0.25$ and $r \leq 0.95$ and $v = 0.10$ This blue-emitting phosphor may be combined with a near UV (~400 nm) LED and green-emitting phosphor, yellow-emitting phosphor and a red-emitting phosphor of the appropriate color and if appropriate for the production of specific colored light and more preferably for production of white light with a high color-rendering index of >80%.

This blue emitting phosphor is synthesized following the techniques described for complex metal sulfide photoluminescent materials according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor). An example for the photophysical characteristics is given in Table II.

Another embodiment with relation to the phosphors of the first group of embodiments is a light emitting device comprising the combination of a 400 nm emitting GaN-based LED together with a phosphor blend containing a blue emitting (MgSrBa)Ga_2S_4:Ce phosphor, a green emitting (CaSrBa)Ga_2S_4:Eu phosphor and a red emitting (CaBaSr)S:Eu phosphor with the corresponding spectral weight ratio blue:green:red =1.1:2.4:2.18 which emits white light with color coordinates x = 0.336 and y = 0.339 and index of color rendering of 83 and a lumen output of about 21 lumen/Watt.

A second group of embodiments is directed to light emitting devices based on a light emitting semiconductor component which emits primary light in the blue spectral range from 420 to 480 nm.

The preferred embodiments for the second group are the same as for the first group of embodiments in relation to the applied light emitting semiconductor component and phosphors except the blue emitting phosphor according to $((Ba_{1-r} Sr_r)_{1-u}Mg_u)_{1-t}Ce_t)(Ga_{1-v}N_v)_2S_4$. Due to the broad absorption band of the 4f-5d-transition of Eu^{2+} the described phosphors exhibit suitable absorption or low reflectance in the disclosed spectral range from 370 nm to 480 nm for the primary light emitted by the light emitting semiconductor component.

A preferred embodiment of the second group is a red-emitting phosphor according to $(Sr_{1-x-y} M_x Eu_y)S$ (type I phosphor) with M = Ba, Mg, Zn, alone or in combination with Ca, and $0 < x \leq 0.5$ and $0< y \leq 0.10$ preferably the binary compositions according to $(Sr_{1-x-y}Mg_xEu_y)S$ or $(Sr_{1-x-y},Ba_xEu_y)S$ with $x \leq 0.25$ and the ternary compositions according to $(Sr_{1-x-z-y}Ca_xBa_zEu_y)S$ with $x + y + z \leq 0.35$. The red-emitting phosphor may be combined with a blue 460 nm LED and at least a green emitting phosphor of the appropriate color, and when appropriate, a yellow-emitting phosphor for the production of specific colored light and more preferably for production of white light with a high color-rendering index of >80.

The synthesis of this red phosphor may follow the techniques as already described for the first group of embodiments and can be modified by similar compositional substitutions as described there for achieving optimized photophysical characteristics to meet the required device specifications.

Achieved values for the photophysical properties are listed in table III in relation to the conversion of primary light of 460 nm.

Table III: Photophysical characteristics for various $(Sr_{1-x-y-z}\ Ba_x\ Ca_z\ Eu_y\ )S$ phosphors excited at 460 nm

Composition	Emission Wave-length (Peak) nm	Reflectance at 460 nm %	Quantum Efficiency %
$(Sr_{0.81}Ba_{0.03}Ca_{0.15}Eu_{0.01})S$	630	21	76
$(Sr_{0.805}Ba_{0.03}Ca_{0.15}Eu_{0.015})S$	632	15	79
$(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$	632	13	77
$(Sr_{0.795}Ba_{0.03}Ca_{0.15}Eu_{0.025})S$	632	10	71
$(Sr_{0.79}Ba_{0.03}Ca_{0.15}Eu_{0.03})S$	632	10	65
$(Sr_{0.98}Eu_{0.02})S$	618	21	75

Another preferred embodiment of the second group are green to green-yellow emitting phosphors according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor) with M* = Mg, Zn alone or in combination with Ba, Sr, Ca, and N* = Al, Ga, In, Y, La, Gd, preferably compositions according to $(M^*_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with N*= Al, In, Y, La, Gd and $0 \leq s \leq 0.10$ and t:s < 0.2 with $v \leq 0.10$, preferably binary compositions according to $((Ba_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with $u \leq 0.75$ and $v \leq 0.10$ and $0.1 \leq s \leq 0.10$ and t:s < 0.2 and ternary compositions according to $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 as well as $(((Ba_{1-r}Sr_r)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with u< 0.75 and $r \geq 0.10$ and $v \leq 0.10$ and $0 \leq s \leq 0.10$ and t:s < 0.2 as well as $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2 as well as $(((Sr_{1-p}Zn_p)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N_v)_2S_4$ with $u < 0.75$ and $p \leq 0.35$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and t:s < 0.2. These green to green-yellow-emitting phosphor may be combined with a blue emitting (~460 nm) LED and at least a red emitting phosphor of the appropriate color for the production of specific colored light and more preferably for production of white light with a high color-rendering index of >80.

Table IV: Photophysical characteristics for various $(M^*_{1-s}Eu_s)Ga_2S_4$ phosphors excited at 460 nm with M* = Ba, Mg, Sr, Ca, Zn

Composition	Emission Wave-length (Peak) nm	Reflectance at 400 nm %	Quantum Efficiency %
$(Ba_{0.38}Mg_{0.57}Eu_{0.05})Ga_2S_4$	509	40	75
$((Sr_{0.25}Ca_{0.75})_{0.40}Mg_{0.55}Eu_{0.05})Ga_2S_4$	533	32	88
$((Ba_{0.57}Ca_{0.43})_{0.40}Mg_{0.55}Eu_{0.05})Ga_2S_4$	548	31	76
$((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$	538	32	72
$((Sr_{0.85}Zn_{0.15})_{0.65}Mg_{0.30}Eu_{0.05})Ga_2S_4$	535	25	65

Another embodiment with relation to the phosphors of the second group of embodiments is a light emitting device comprising the combination of a 460 nm emitting GaN-based LED together with a phosphor blend containing a green emitting $(Y,Lu)_3Al_5O_{12}$:Ce phosphor and a red emitting (CaBaSr)S:Eu phosphor with the corresponding spectral weight ratio blue:green:red = 1.95:1.0:0.9 which emits white light with color coordinates x = 0.333 and y = 0.337 and index of color rendering of 80 and a lumen output of about 27 lumen/Watt. As a specific example Figure 4a shows a light emitting device with a chip 1 of InGaN-type, with a peak emission of 460 nm with a first and second electrical lead 2,3, and with a housing 8 having a cavity 9. One of the leads is connected to the chip via a bond wire 14. A wall 17 serves as a reflecting contour for the emitted radiation. The cavity is filled with a translucent resin 5, comprising epoxy and phosphor pigments 6. The phosphor is a blend as outlined above.

Another embodiment with relation to the phosphors of the second group of embodiments is a light emitting device comprising the combination of a 460 nm emitting GaN-based LED together with a phosphor blend containing a green emitting $(SrMgZn)Ga_2S_4$:Eu phosphor and a red emitting (CaBaSr)S:Eu phosphor with the corresponding spectral weight ratio blue:green:red = 1.0:0.4:0.35 which emits white light with color coordinates x = 0.333 and y = 0.336 and index of color rendering of 84 and a lumen output of about 25 lumen/Watt.

In particular further phosphors were investigated under excitation of a 400 nm LED, as summarized in Table V. By way of example, figure 4b shows a light source

20 having a common carrier 21. an essentially block-shaped housing is secured on it by an adhesive. The upper side of the housing 22 is formed with recesses, in which individual semiconductor elements 24 are located, preferably UV-LEDs based on InGaN with peak emission around 400 nm. Conversion into visible light, for example white light, is effected by light conversion layers 25, which are attached to all (or main part of) surfaces subject to UV-radiation from the LEDs. This includes the inner surfaces of the sidewalls of the housing 22, the bottom of the housing 22, and the cover 23. the individual LEDs may form individual pixels. Another example is a compact lamp utilizing LEDs.

The emission and reflection spectra, related to the phosphors of table V, in arbitrary units and in percent resp. as a function of the wavelength are shown in Figures 5 to 10.

Table V

Phosphor	Peak Emission wavelength	QE	Color coordinate x	Color coordinate y	Related figure
$(Mg_{0.57}Ba_{0.38}Eu_{0.05})(Ga_{1..95}Al_{0.05})S_4$	533 nm	60 %	0.263	0.650	5
$(Ba_{0.8}Mg_{0.15}Eu_{0.05})(Ga_{1.95}In_{0.05})S_4$	507 nm	57 %	0.317	0.558	6
$(Ba_{0.2}Mg_{0.6}Ca_{0.15}Eu_{0.05})Ga_2S_4$	535 nm	62 %	0.297	0.638	7
$(Sr_{0.09}Mg_{0.57}Eu_{0..05}Ba_{0.29})\ (Ga_{1..95}Y_{0.05})S_4$	536 nm	63 %	0.280	0.679	8
$(Sr_{0.095}Mg_{0.57}Eu_{0.05}Ca_{0.285})Ga_2S_4$	548 nm	64 %	0.358	0.624	9
$(Sr_{0.57}Mg_{0.285}Zn_{0.095}Eu_{0.05})Ga_2S_4$	532 nm	56 %	0.274	0.682	10

Claims:

1. A light emitting device comprising at least one LED with primary emission (peak) from 370 to 480 nm covered directly or indirectly with a phosphor-containing covering, the phosphor–containing covering comprising at least one of the following phosphors: type I: a metal sulfide photoluminescent material activated with europium containing at least one element M selected from the group consisting of Ba, Mg, and Zn;

type II: a complex thiometalate photoluminescent material activated with at least one of europium and cerium, containing 1) at least one element M* selected from the group consisting of Mg, and Zn, and 2) at least one element N* selected from the group consisting of Al, Ga, In, Y, La, Gd.

2. A light emitting device according to claim 1 wherein the type I phosphor contains in addition at least one of Ca, Sr as part of the element M.

3. A light emitting device according to claim 1 wherein the type II phosphor contains in addition at least one of Ca, Sr, Ba as part of the element M*.

4. A light emitting device according to claim 1 wherein the emission peak of the LED is at 370 to 415 nm.

5. A light emitting device according to claim 1 wherein the emission peak of the LED is at 420 to 480 nm.

6. A light emitting device according to claim 1 wherein at least one phosphor of type I and II are combined.

7. A light emitting device according to claim 6 wherein one phosphor of type I and two phosphors of type II are combined to achieve white light.

8. A light emitting device comprising a blue emitting LED covered with a phosphor containing covering, the phosphor–containing covering containing at least one of the following phosphors:

type I: a metal sulfide photoluminescent material activated with europium containing at least one element M selected from the group consisting of Ba, Mg, and Zn;

type II: a complex thiometalate photoluminescent material activated with at least one of europium and cerium, containing 1) at least one element M* selected from the group consisting of Mg, and Zn, and 2) at least one element N* selected from the group consisting of Al, Ga, In, Y, La, Gd.

9. A light emitting device according to claim 8 wherein the emission peak of the LED is at 420 to 480 nm.

10. A light emitting device according to claim 8 wherein at least one phosphor of type I and II are combined.

11. A light emitting device according to claim 8 wherein one phosphor of type I and one phosphor of type II are combined to achieve white light.

12. A light emitting device comprising a UV emitting LED covered with a phosphor containing covering, the phosphor–containing covering containing at least one of the following phosphors: type I: a metal sulfide photoluminescent material activated with europium containing at least one element M selected from the group consisting of Ba, Mg, and Zn;

type II: a complex thiometalate photoluminescent material activated with at least one of europium and cerium, containing 1) at least one element M* selected from the group consisting of Mg, and Zn, and 2) at least one element N* selected from the group consisting of Al, Ga, In, Y, La, Gd.

13. A light emitting device according to claim 8 wherein the emission peak of the LED is at 370 to 415 nm.

14. A light emitting device according to claim 8 wherein at least one phosphor of type I and II are combined.

15. A light emitting device according to claim 8 wherein one phosphor of type I and one phosphor of type II are combined to achieve white light.

16. A phosphor which absorbs radiation having a first spectrum and emits radiation having a second spectrum, the phosphor comprising: a photoluminescent metal sulfide MS (Type I phosphor) comprising at least one element selected from the group M = Ba, Mg, and Zn alone or in combination with at least one of Sr, Ca; M being activated with europium, or a photoluminescent phosphor comprising a complex metal thiometallate photoluminescent material $M^*N^*_2S_4$ (type II phosphor) comprising of at least one element selected from the group M* = Mg, Zn, alone or in combination with at least one of Ba, Sr, Ca, and at least one element selected from the group N* = Al, Ga, alone or in combination with In, Y, La, Gd, N* being activated with at least one of europium (Eu) and cerium (Ce).

17. A phosphor composition comprising at least one of the phosphors of type I and one of the phosphor of type II.

18. A phosphor in accordance with claim 16 wherein the phosphor is according to MS:Eu (type I phosphor) with M is at least one of M = Ba, Mg, Zn alone or in combination with Sr, Ca.

19. A phosphor in accordance with claim 16 wherein the phosphor of type I is according to $(Sr_{1-x-y} M_x Eu_y)S$ with M is at least one of = Ba, Mg, Zn alone or in combination with Ca and $0< x \leq 0.5$ and $0< y \leq 0.10$.

20. A phosphor in accordance with claim 19 wherein the phosphor is according to $(Sr_{1-x-y}Ba_xEu_y)S$ with $x \leq 0.25$.

21. A phosphor in accordance with claim 19 wherein the phosphor is according to $(Sr_{1-x-z-y}Ca_xBa_zEu_y)S$ with $x + y + z \leq 0.35$.

22. A phosphor in accordance with claim 16, wherein the phosphor composition is according to $M^*N^*_2S_4$:Eu,Ce (type II phosphor) with M* is at least one of M* = Mg, Zn alone or together with at least one of Ba, Sr, Ca, and N* is at least one of N* = Al, Ga, alone or together with small proportions (below 20%) of In, Y, La, Gd.

23. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor containing Mg as one of the host lattice elements

according to $(M^{**}_{1-u}M_{gu})(Ga_{1-v}N^*_v)2S4:Ce$ with $u \leq 0.75$ and $v \leq 0.10$, and M** is at least one of M** = Ba, Sr, Ca, Zn.

24. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $(M^{**}_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with M** is at least one of = Mg, Zn alone or in combination with Sr, Ba, Ca, and N* = Al, In, Y, La, Gd and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$ with $v \leq 0.10$.

25. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $((Ba_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$.

26. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $(((Ba_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$.

27. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $(((Ba_{1-r}Sr_r)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u< 0.75$ and $r \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \leq t:s < 0.2$.

28. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $(((Sr_{1-w}Ca_w)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u \leq 0.75$ and $w \geq 0.10$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $t:s < 0.2$.

29. A phosphor in accordance with claim 16, wherein the phosphor is of type II phosphor according to $(((Sr_{1-p}Zn_p)_{1-u}Mg_u)_{1-s-t}Eu_sCe_t)(Ga_{1-v}N^*_v)_2S_4$ with $u < 0.75$ and $p \leq 0.35$ and $v \leq 0.10$ and $0 < s \leq 0.10$ and $0 \geq t:s < 0.2$.

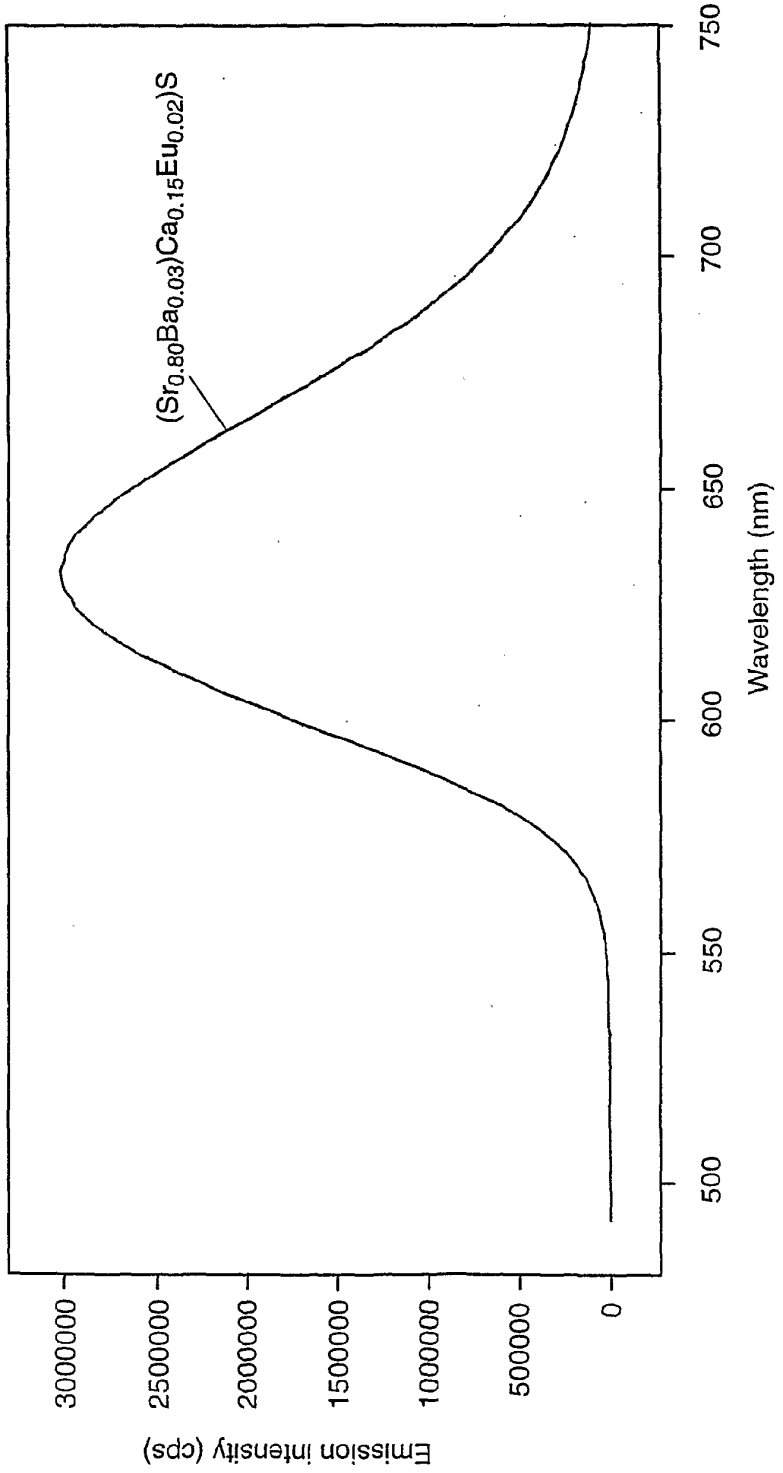

Emission intensity (cps)
3000000
2500000
2000000
1500000
1000000
500000
0
500
550
600
650
700
750
Wavelength (nm)
$(Sr_{0.80}Ba_{0.03})Ca_{0.15}Eu_{0.02})S$

FIG. 1a

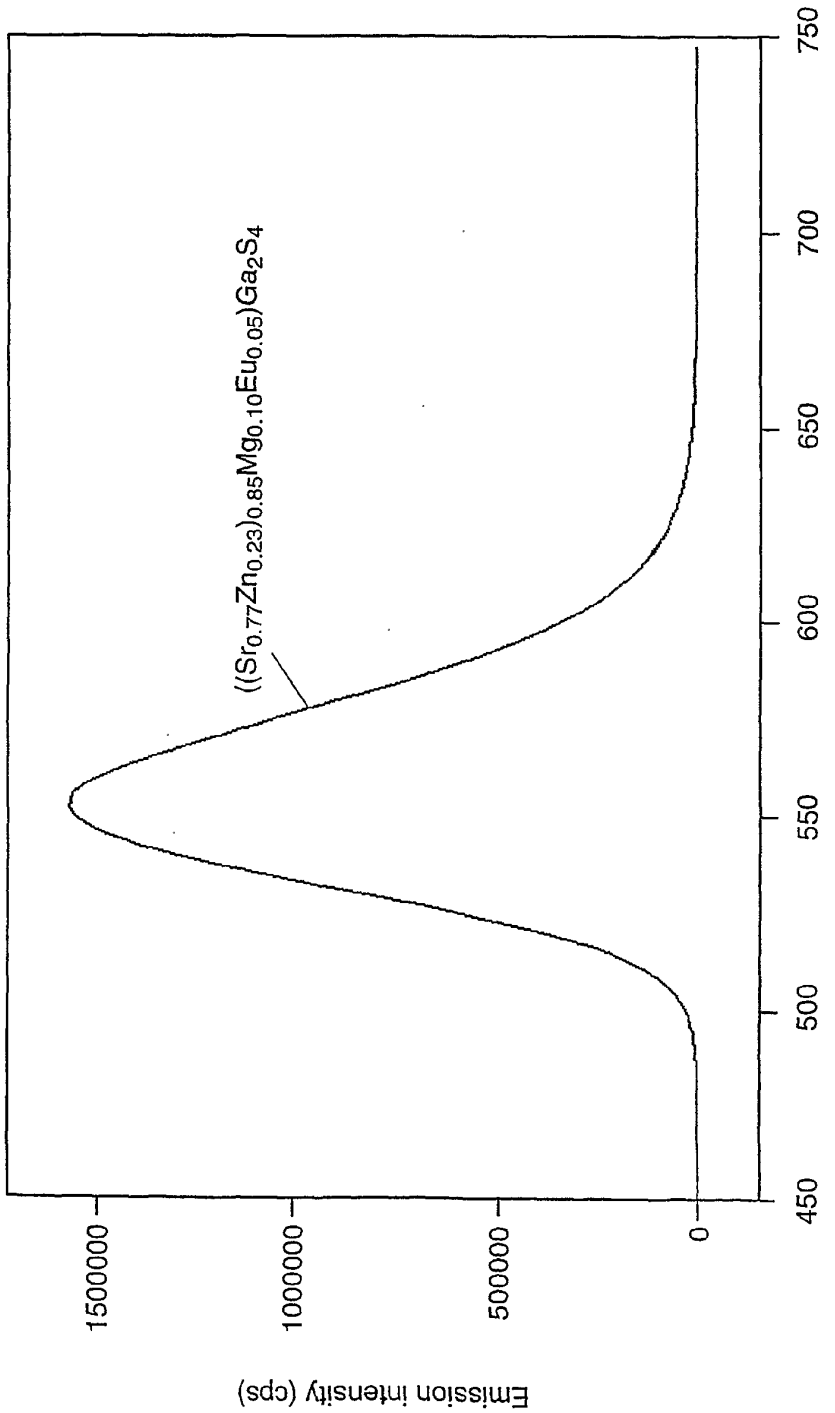

Emission intensity (cps)
1500000
1000000
500000
0
450
500
550
600
650
700
750
Wavelength (nm)
$((Sr_{0.77}Zn_{0.23})_{0.85}Mg_{0.10}Eu_{0.05})Ga_2S_4$

FIG. 1b

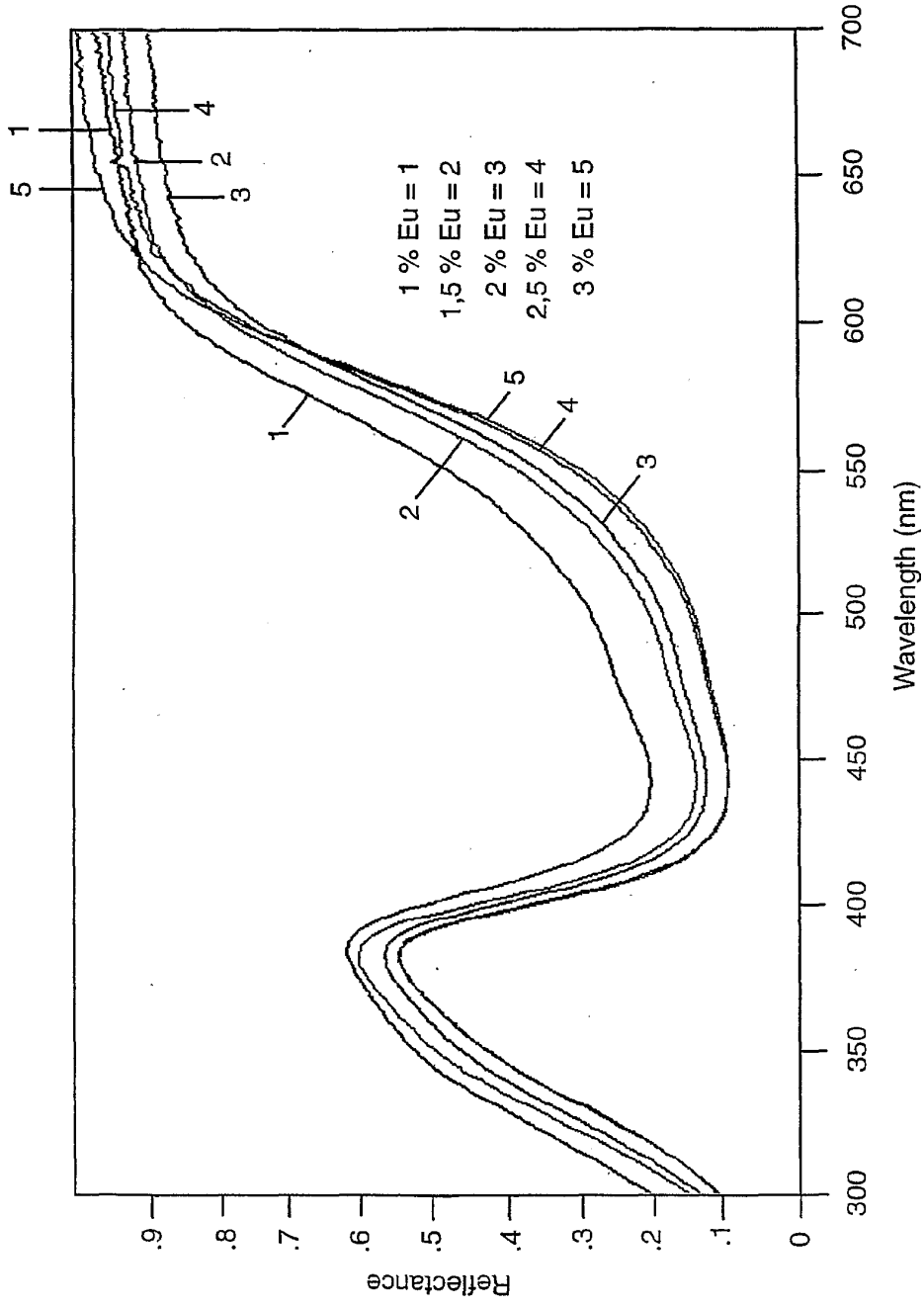

Reflectance
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
300
350
400
450
500
550
600
650
700
Wavelength (nm)
1 % Eu = 1
1,5 % Eu = 2
2 % Eu = 3
2,5 % Eu = 4
3 % Eu = 5
1
2
3
4
5

FIG. 2a


Reflectance
0
.2
.4
.6
.8
300
350
400
450
500
550
600
650
700
Wavelength (nm)

FIG. 2b

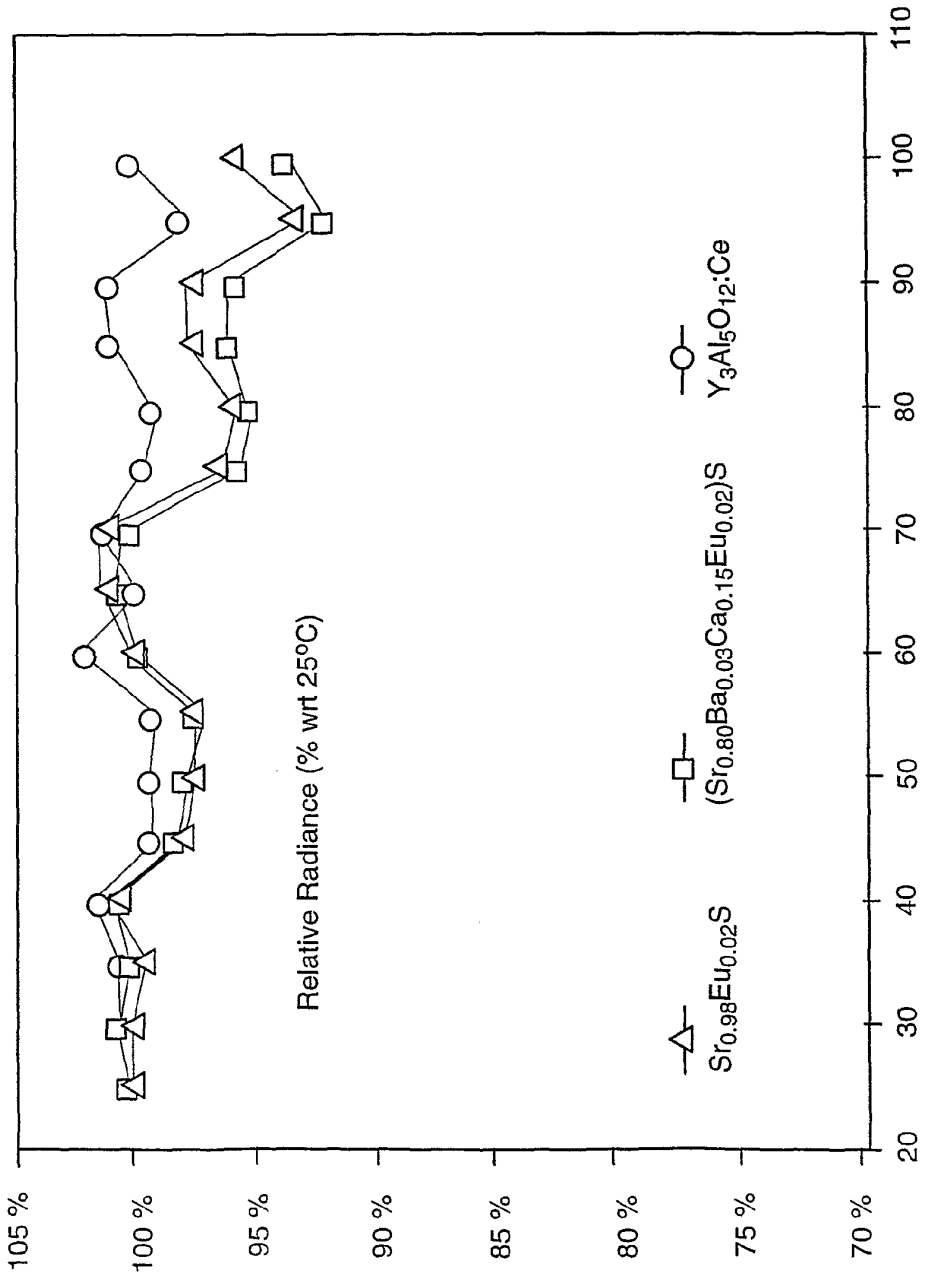

105 %
100 %
95 %
90 %
85 %
80 %
75 %
70 %
Relative Radiance (% wrt 25°C)
20
30
40
50
60
70
80
90
100
110
Temperature (°C)
$Sr_{0.98}Eu_{0.02}S$
$(Sr_{0.80}Ba_{0.03}Ca_{0.15}Eu_{0.02})S$
$Y_3Al_5O_{12}:Ce$

FIG. 3a

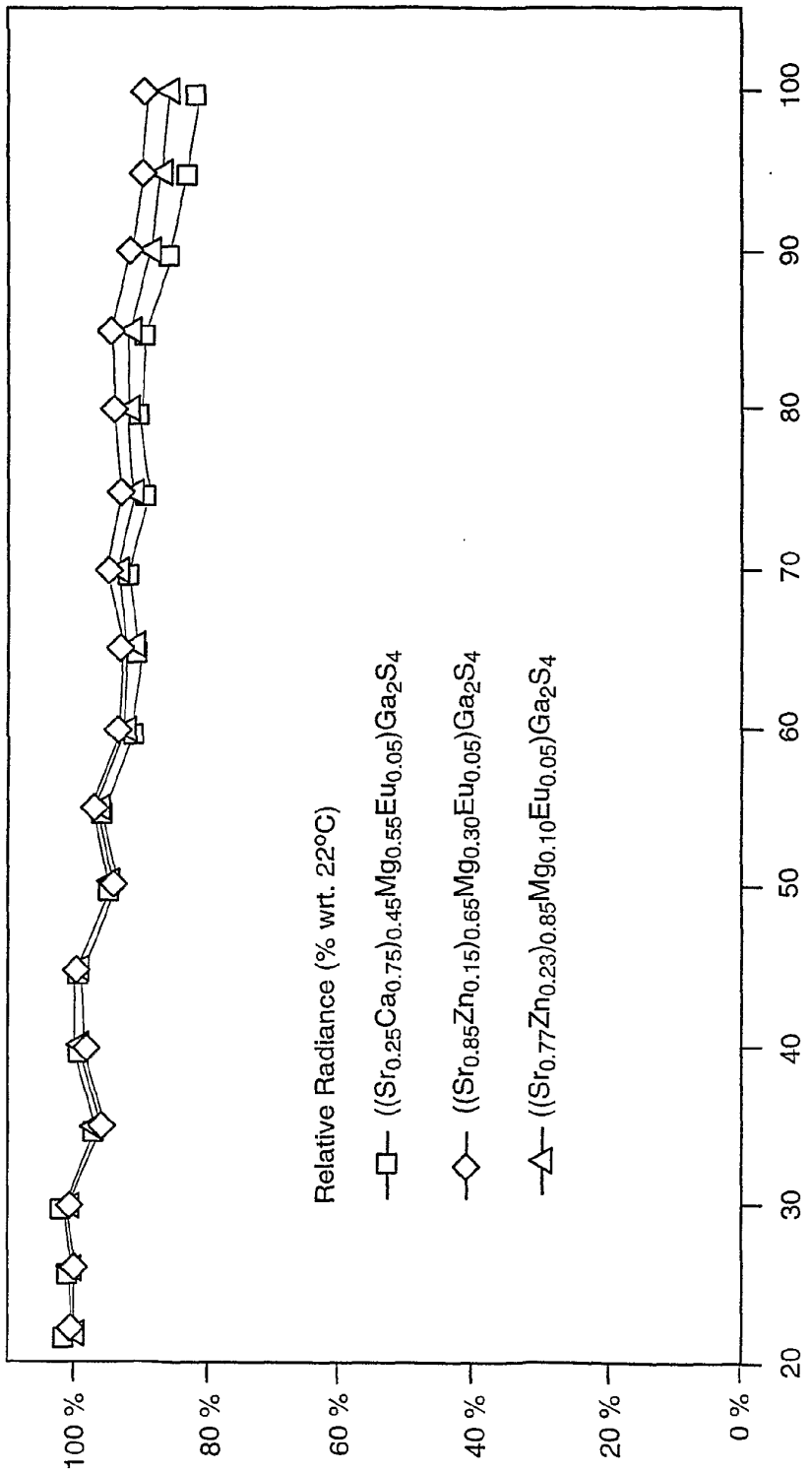

Relative Radiance (% wrt. 22°C)
100 %
80 %
60 %
40 %
20 %
0 %
20
30
40
50
60
70
80
90
100
Temperature (°C)
((Sr0.25Ca0.75)0.45Mg0.55Eu0.05)Ga2S4
((Sr0.85Zn0.15)0.65Mg0.30Eu0.05)Ga2S4
((Sr0.77Zn0.23)0.85Mg0.10Eu0.05)Ga2S4

FIG. 3b

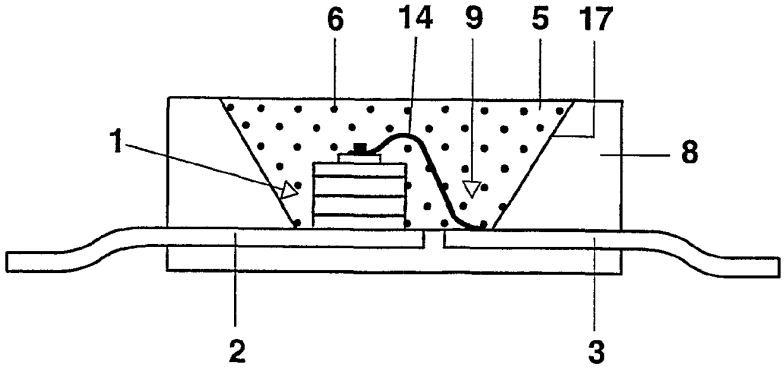


FIG. 4a

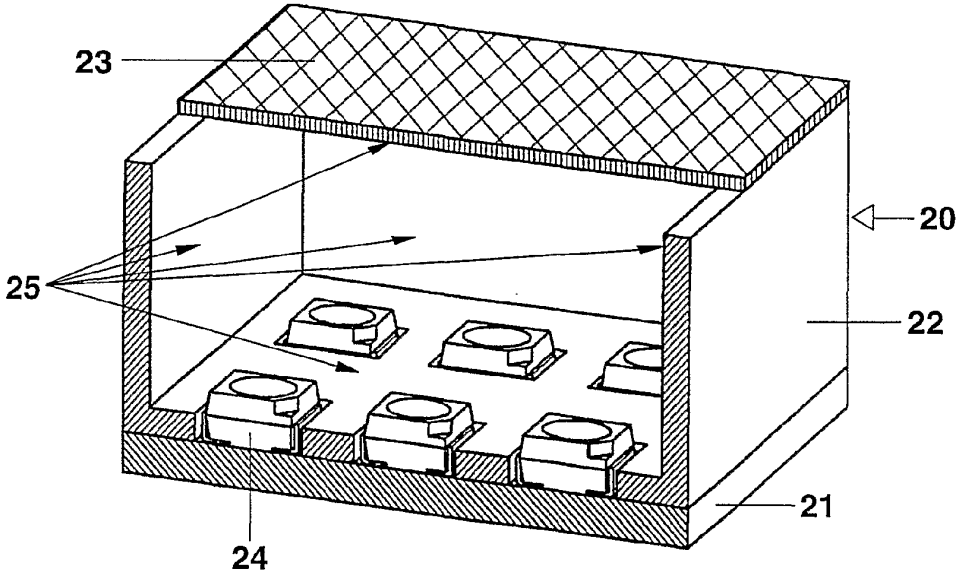


FIG. 4b

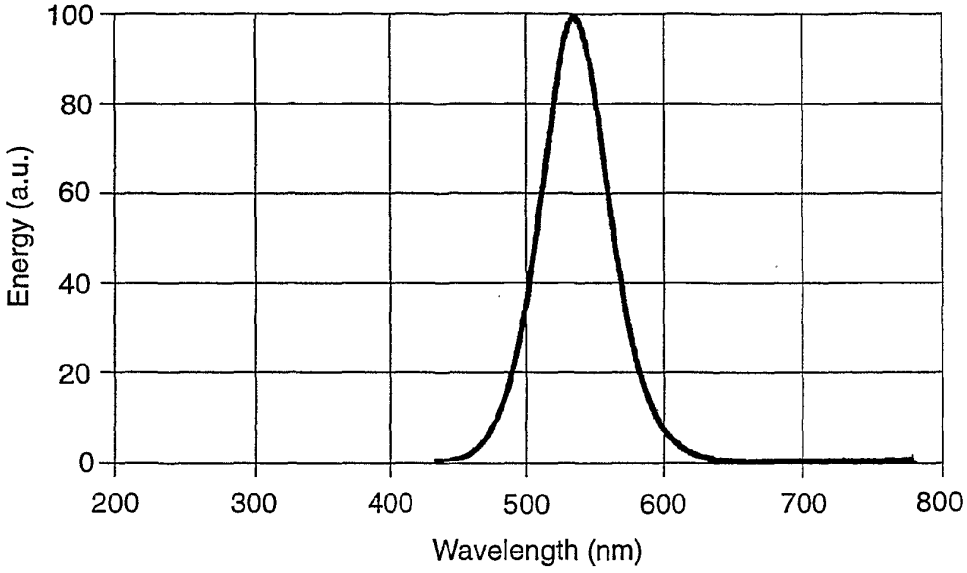

100
80
60
40
20
0
Energy (a.u.)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 5a

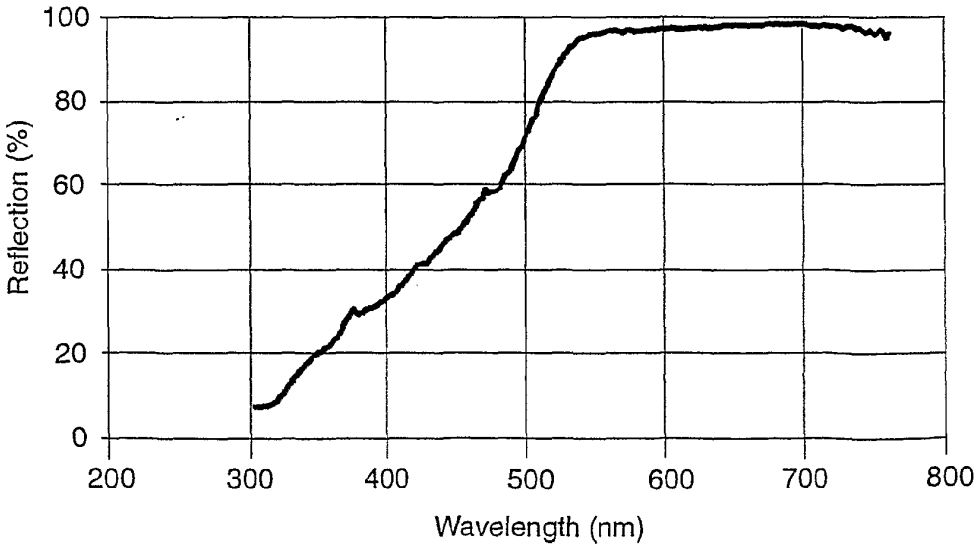

100
80
60
40
20
0
Reflection (%)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 5b

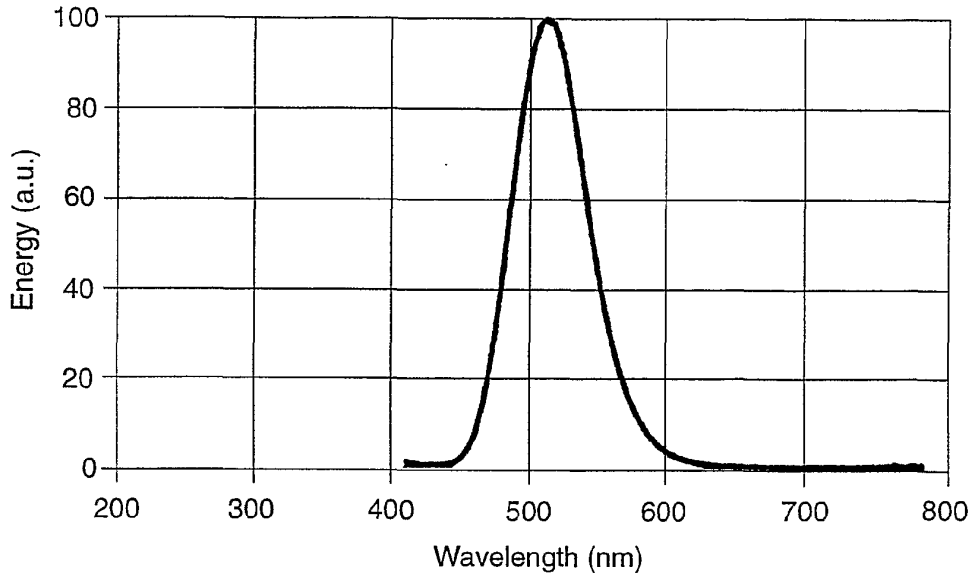

100
80
60
40
20
0
Energy (a.u.)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 6a

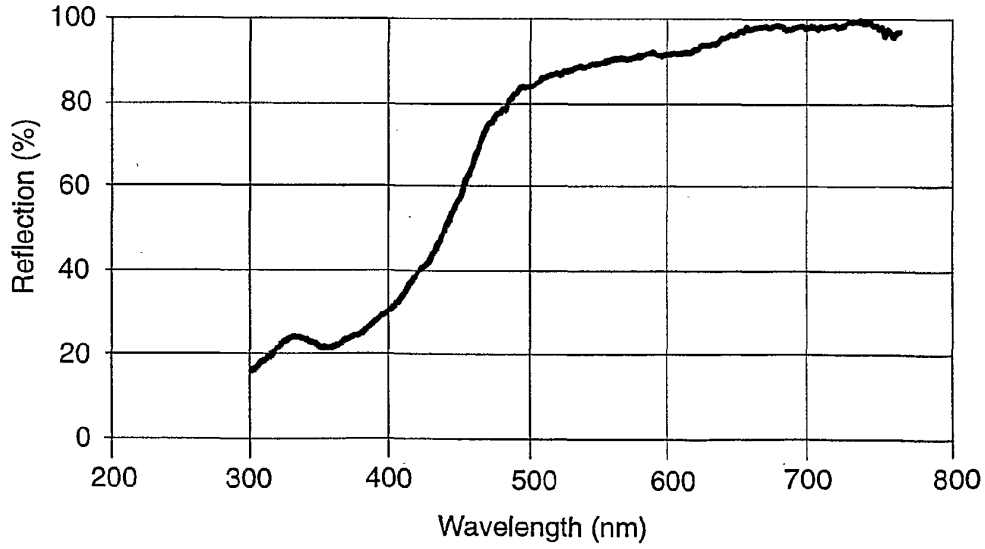

100
80
60
40
20
0
Reflection (%)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 6b

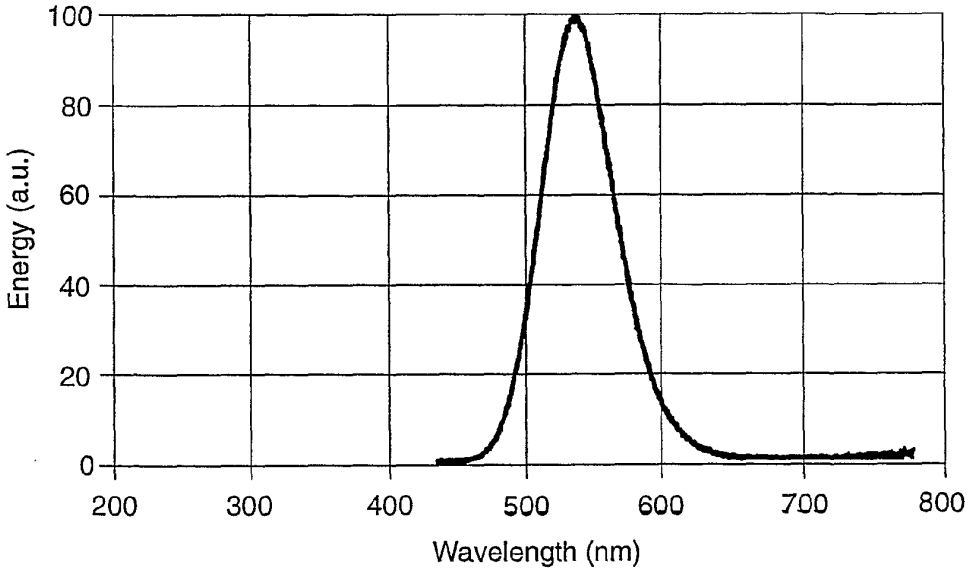

100
80
60
40
20
0
Energy (a.u.)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 7a

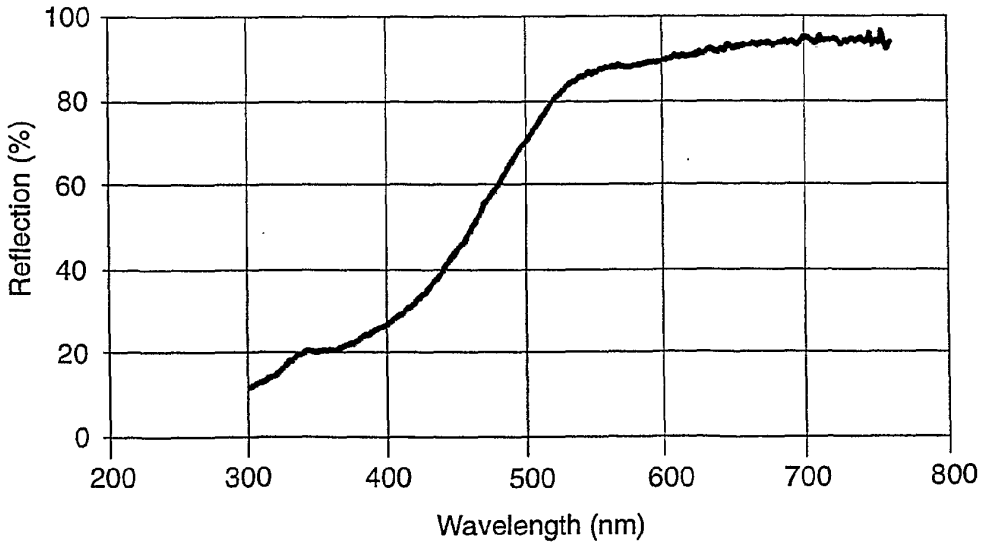

100
80
60
40
20
0
Reflection (%)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 7b

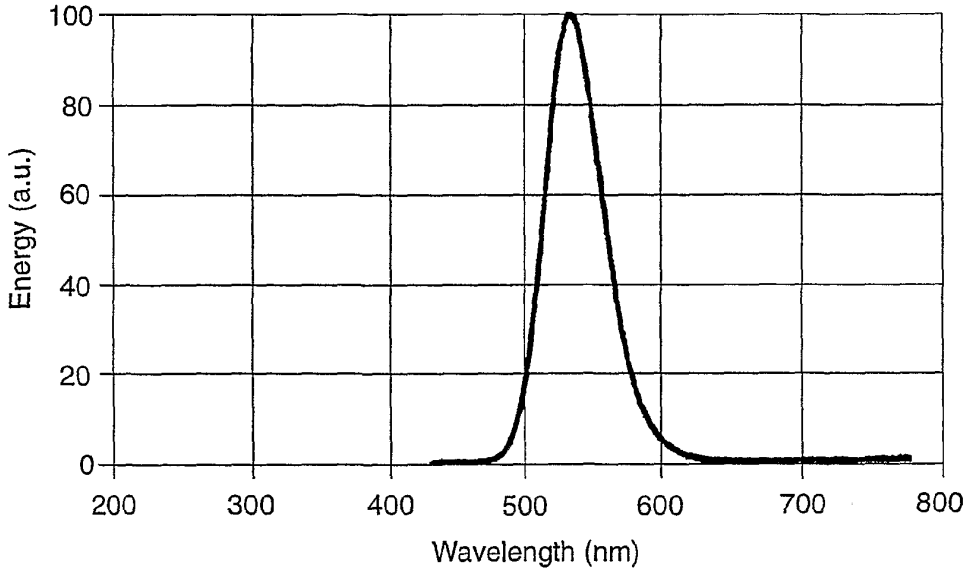

100
80
60
40
20
0
Energy (a.u.)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 8a

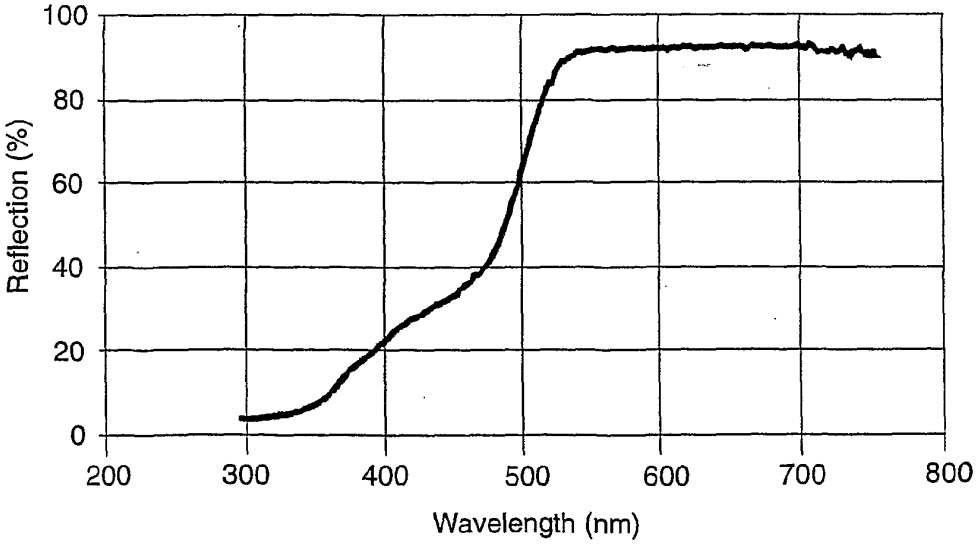

100
80
60
40
20
0
Reflection (%)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 8b

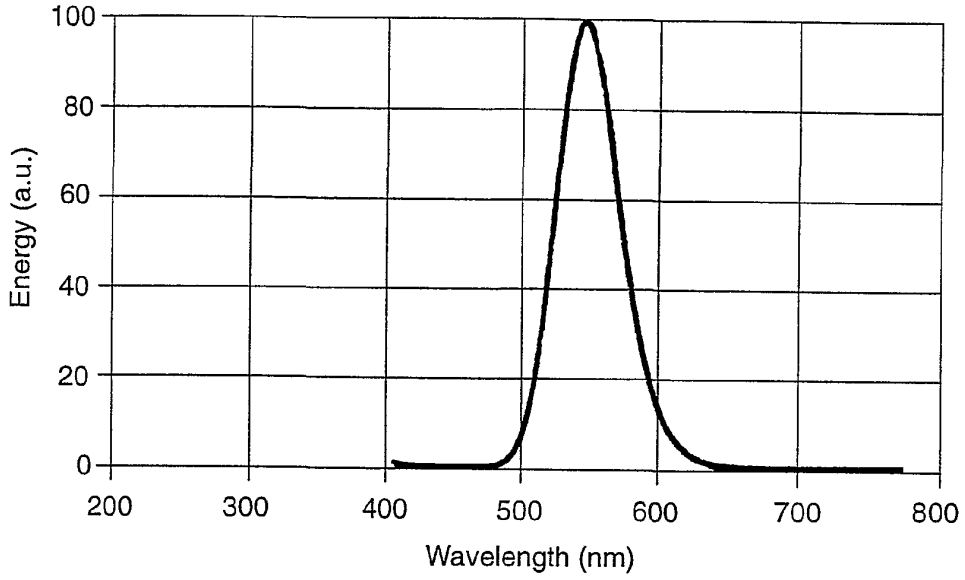

100
80
60
40
20
0
Energy (a.u.)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 9a

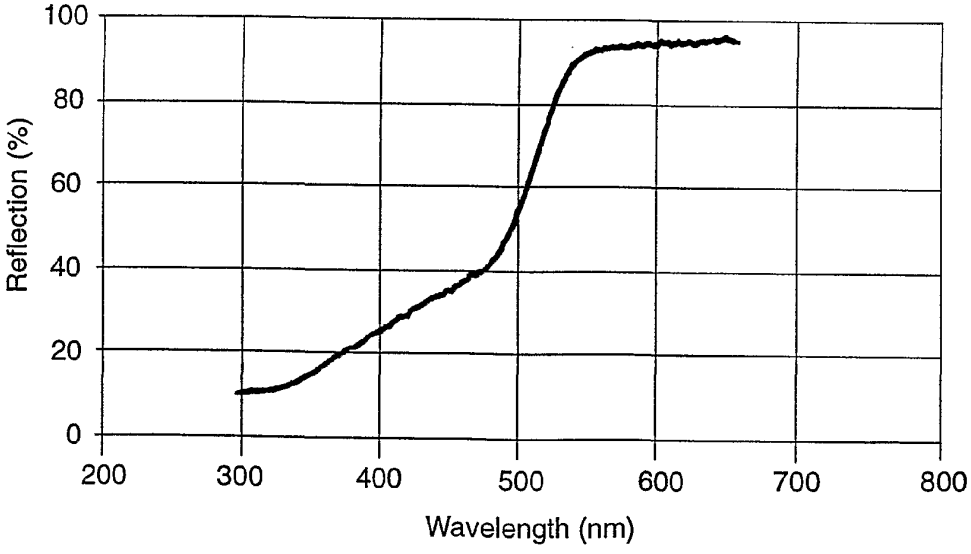

100
80
60
40
20
0
Reflection (%)
200
300
400
500
600
700
800
Wavelength (nm)

FIG. 9b

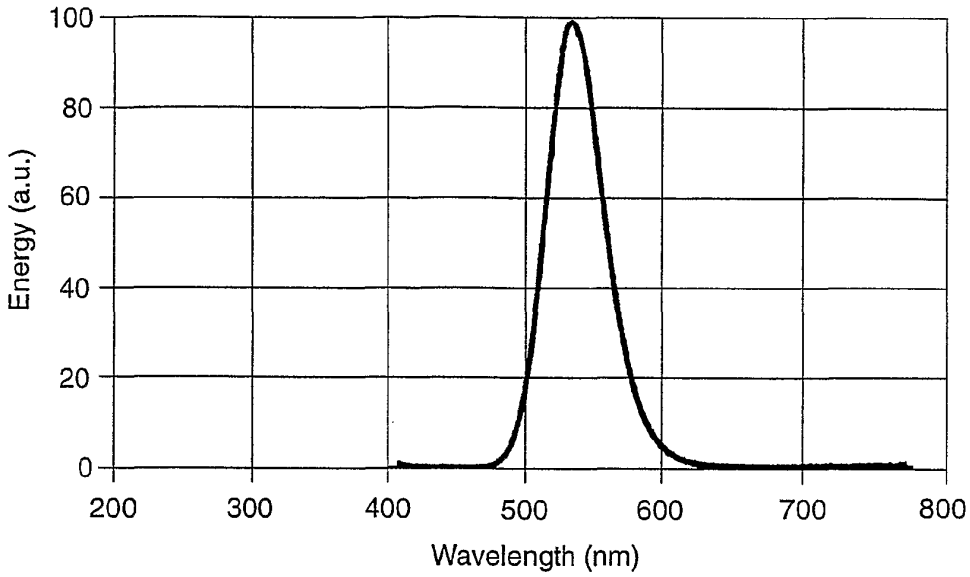


FIG. 10a

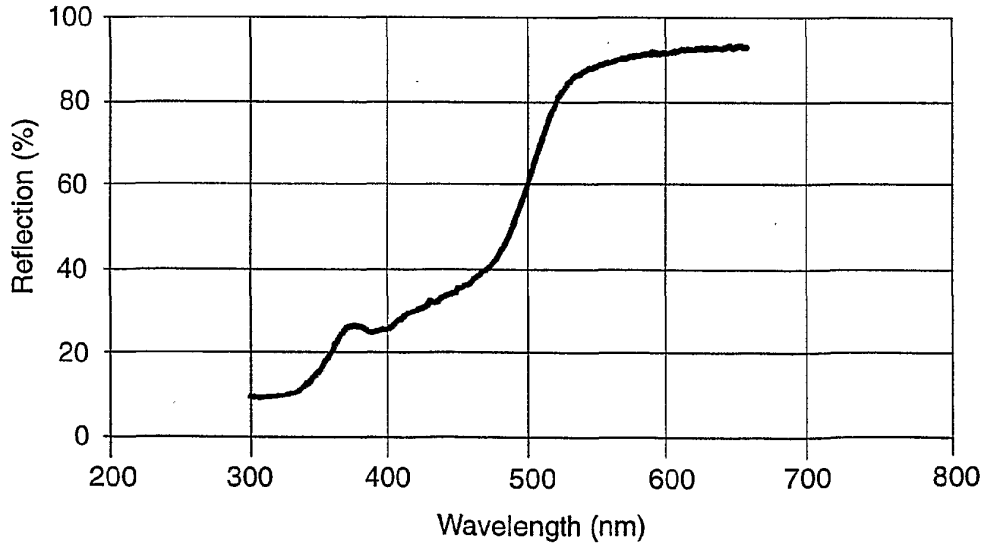


FIG. 10b