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

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See application file for complete search history.

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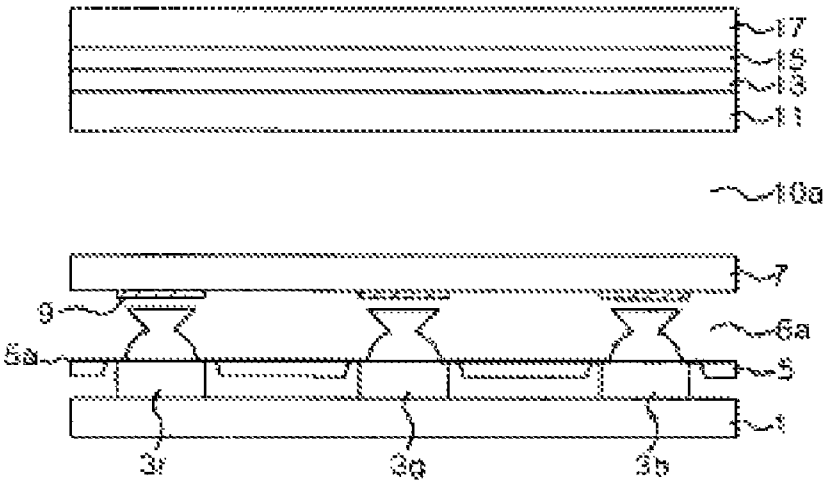
(57) **ABSTRACT**

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.

8 Claims, 2 Drawing Sheets



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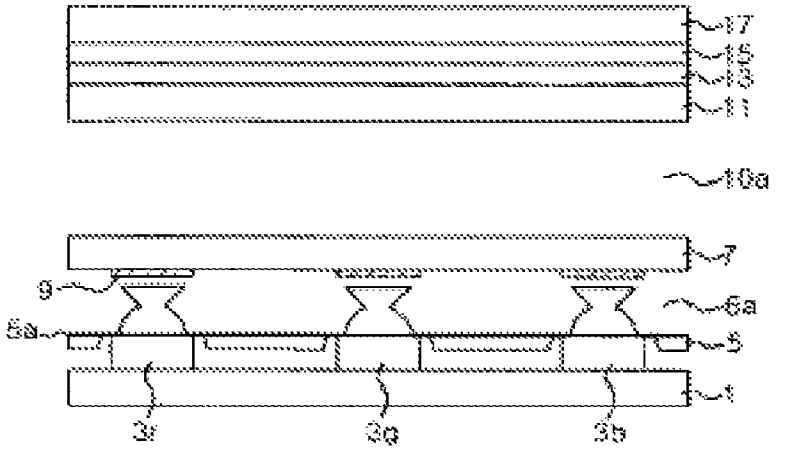
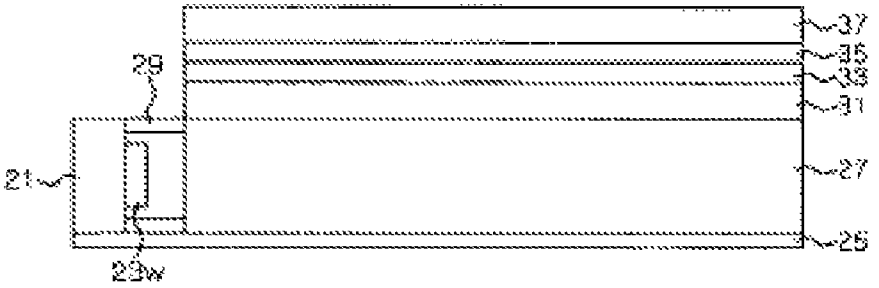
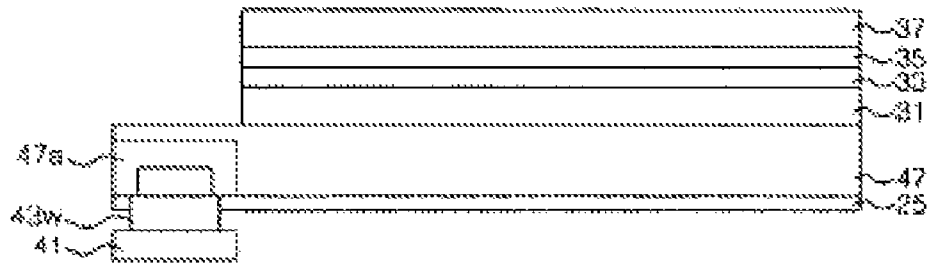
[Fig. 1]



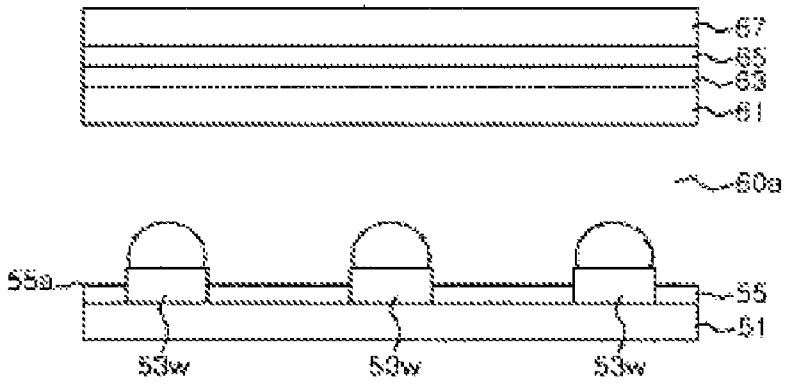
[Fig. 2]



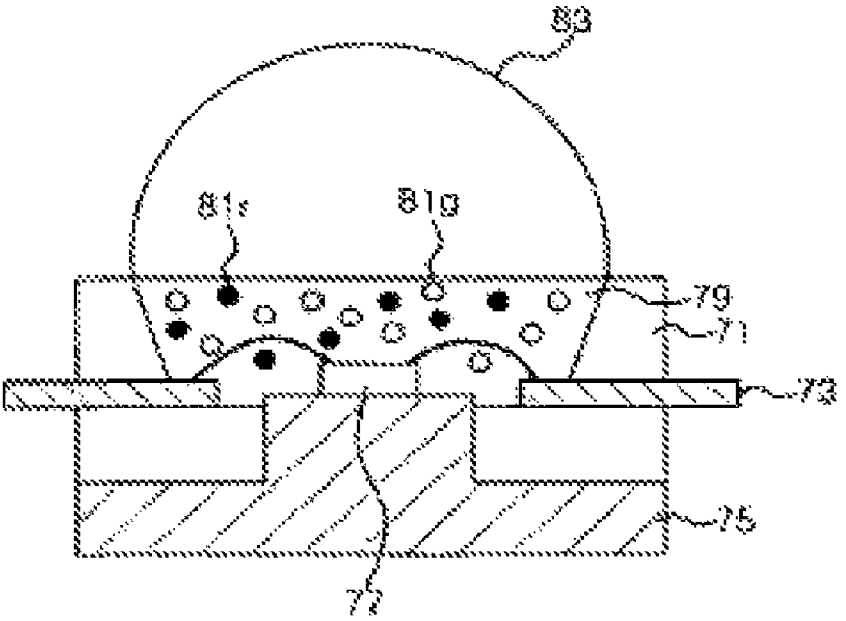
[Fig. 3]



[Fig. 4]



[Fig. 5]



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

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 11/909,700, filed on Sep. 25, 2007, which is the National Stage of International Application No. PCT/KR2006/000885, filed on Mar. 13, 2006, and claims priority from and the benefit of Korean Patent Application No. 10-2005-0027133, filed on Mar. 31, 2005, which are both hereby incorporated by reference for all purposes as if fully set forth herein.

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 **3***r*, **3***g* and **3***b* 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 is be formed with a reflection layer **5***a* 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 **6***a* which is an air layer. The first gap is a region where red, green and blue light emitted respectively from the LEDs **3***r*, **3***g* and **3***b* 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 **10***a* which is an air layer. Thus, the light transmitted through the light transmission layer **7** is again mixed within the second gap **10***a* 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 **6***a* and **10***a* 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 conventional 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 fowls. 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 **23***w* 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 **23***w* 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 posi-

tioned at both sides of the light guide plate **27**. Accordingly, the luminance of the LCD panel **37** can be further enhanced.

The white LED **23***w* 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 **23***w* will be described in detail later with reference to FIG. **5**.

Meanwhile, light shielding walls **29** are positioned above and below the white LED **23***w*, respectively. The light shielding walls prevent light emitted from the white LED **23***w* 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 **47***a* 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 **47***a* of the light guide plate **47**.

A white LED **43***w* is accommodated in the receiving groove **47***a*. 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 **43***w* 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 **53***w* 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 **53***w* includes a blue LED chip, and green and red phosphors positioned over the blue LED chip. The white LEDs **53***w* will be described in detail later with reference to FIG. **5**.

Each of the white LEDs **53***w* 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 **53***w* 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 **53***w*. The reflection sheet **55** may be formed with a reflection layer **55***a* thereon. The reflection sheet may be made of an aluminum sheet and coated with the reflection layer **55***a* 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 **60***a* corresponding to an air layer. White light emitted from the white LEDs **53***w* are mixed with one another in the gap **60***a* 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 **53***w* 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 **53***w* 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 **23***w*, **43***w* or **53***w* 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 **81***r* and **81***g* 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 **81***r* may be an alkali earth metal sulfide-based red phosphor, while the green phosphor **81***g* 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 **81***r* and **81***g* 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 **81***r* and **81***g* 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.

What is claimed is:

1. A backlight panel, comprising:

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

a plurality of white light emitting diodes arranged below the bottom surface of the diffusion plate, the white light emitting diodes to emit light directly onto the bottom surface of the diffusion plate; and

a reflection sheet arranged below light exit surfaces of the white light emitting diodes, the reflection sheet to reflect light toward the diffusion plate,

wherein each white light emitting diode comprises a blue light emitting diode chip and a red phosphor and a green phosphor arranged on the blue light emitting diode chip.

2. The backlight panel of claim **1**, further comprising a brightness enhancement film and/or a dual brightness enhancement film arranged on the top surface of the diffusion plate.

3. The backlight panel of claim **1**, wherein the red phosphor comprises an alkaline earth metal sulfide-based phosphor expressed by the 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; $2 \leqq x \leqq 5$; and $0.0005 \leqq (a/x) \leqq 0.02$.

4. The backlight panel of claim **1**, further comprising an air gap arranged between the bottom surface of the diffusion plate and the reflection sheet.

5. The backlight panel of claim **4**, wherein light emitted from the white light emitting diodes is mixed together in the air gap before being emitted directly onto the bottom surface of the diffusion plate.

6. The backlight panel of claim 1, wherein the green phosphor comprises a thiogallate-based phosphor expressed by the 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; $0.01 \leqq x \leqq 0.1$; 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 $0.2 \leqq y \leqq 0.8$.

7. The backlight panel of claim 6, wherein the red phosphor comprises an alkaline earth metal sulfide-based phosphor expressed by the general formula: $A_{x-a}Eu_aGeS_z$, where A is at least one element selected from the group consisting of Ca and Sr; $z=x+2$; $2 \leqq x \leqq 5$; and $0.0005 \leqq (a/x) \leqq 0.02$.

8. The backlight panel of claim 3, wherein the green phosphor comprises a thiogallate-based phosphor expressed by the 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; $0.01 \leqq x \leqq 0.1$; 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 $0.2 \leqq y \leqq 0.8$.

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