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(54) BLACKLIGHT UNIT, LIQUID CRYSTAL DISPLAY DEVICE HAVING THE SAME, AND METHOD FOR PROVIDING SUBSTANTIALLY WHITE LIGHT FOR LIQUID CRYSTAL DISPLAY DEVICE

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(57) **ABSTRACT**

A backlight unit as embodied includes a plurality of unit groups, each unit group having a plurality of light emitting diodes (LEDs); and a light mixing layer formed over the unit groups, for mixing lights emitted from the LEDs to provide substantially white light.

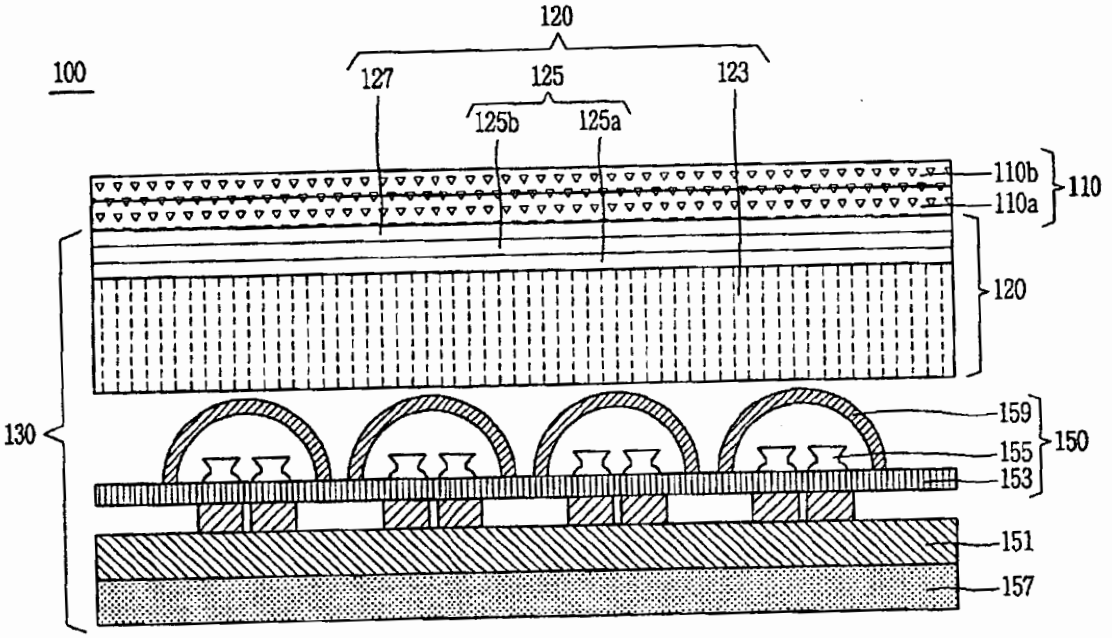


FIG. 1

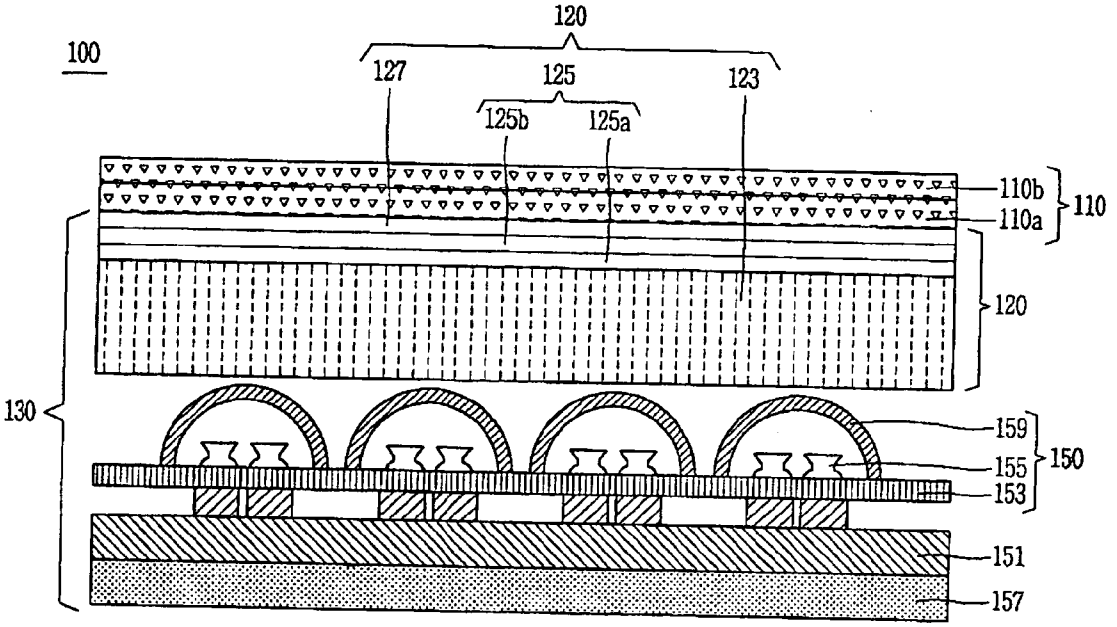

100
120
127
125
123
125b
125a
110b
110a
110
120
130
159
155
150
153
151
157

FIG. 2

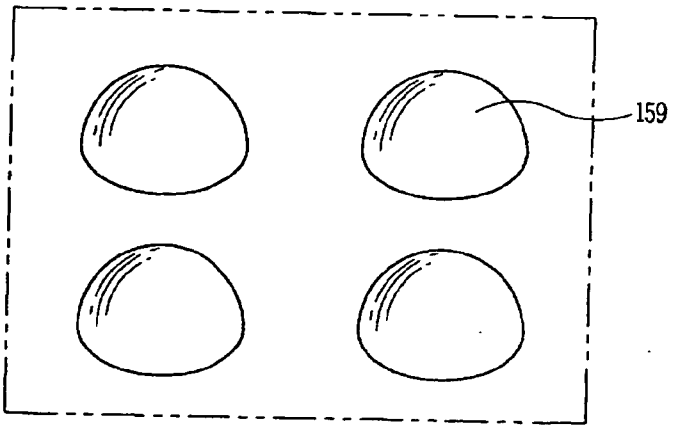

159

FIG. 3

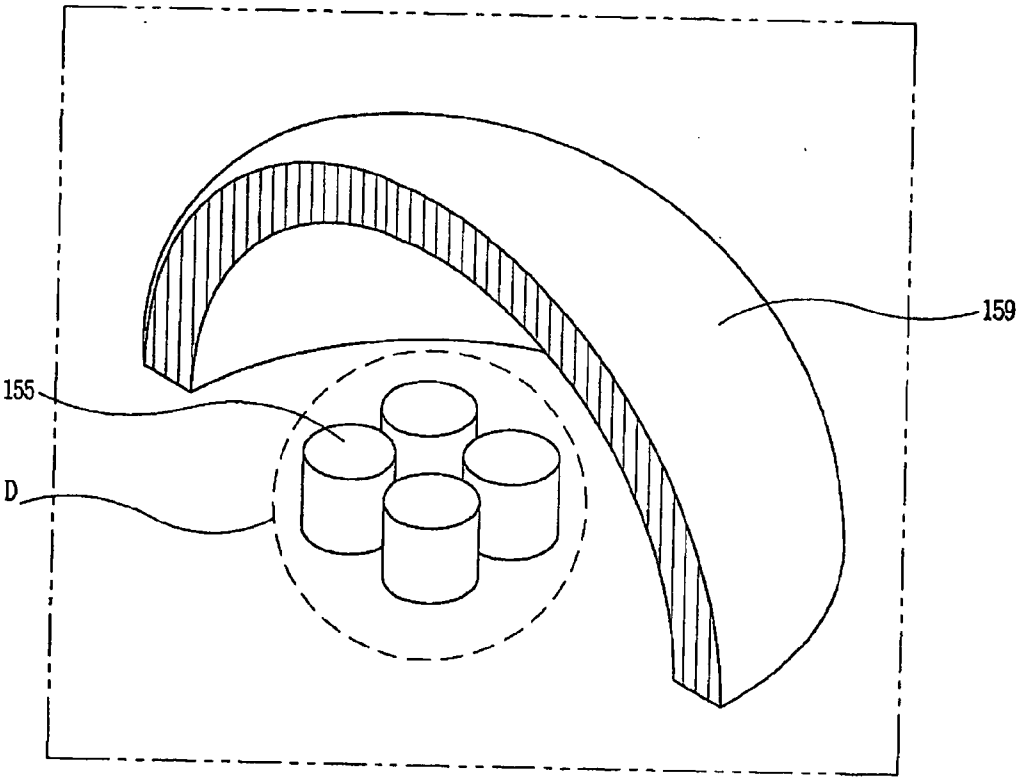


FIG. 4

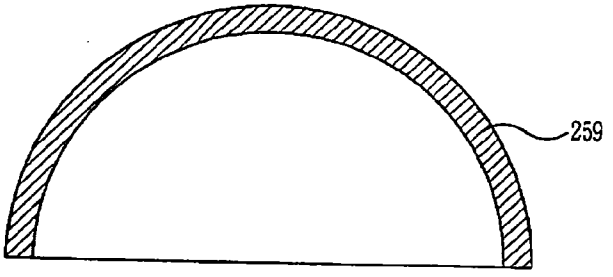


FIG. 5

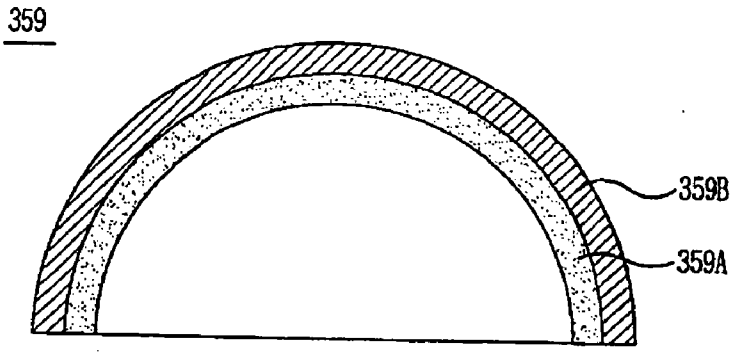


FIG. 6

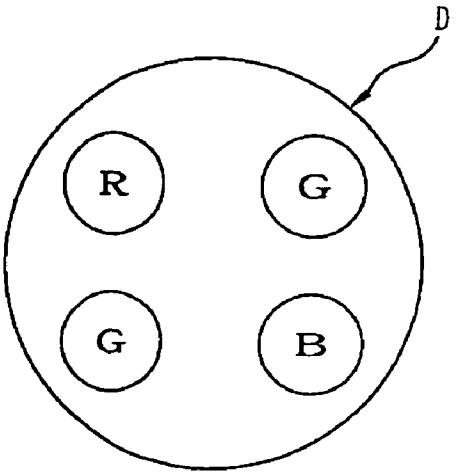


FIG. 7

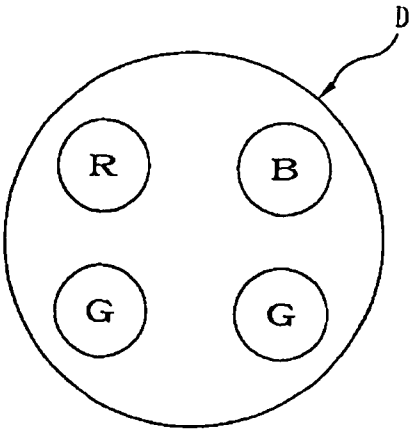
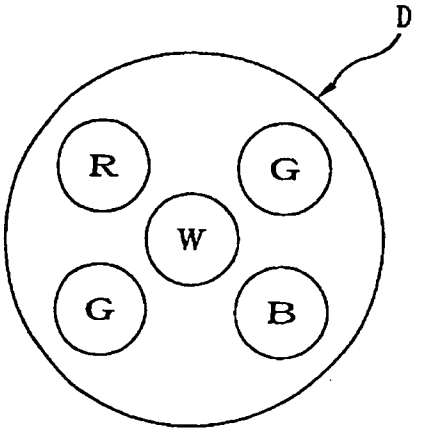


FIG. 8



BLACKLIGHT UNIT, LIQUID CRYSTAL DISPLAY DEVICE HAVING THE SAME, AND METHOD FOR PROVIDING SUBSTANTIALLY WHITE LIGHT FOR LIQUID CRYSTAL DISPLAY DEVICE

[0001] This Nonprovisional Application claims priority under 35 U.S.C. §119(a) on Patent Application No. 10-2005-0129995 filed in Korea on Dec. 26, 2005, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a backlight unit and a liquid crystal display (LCD) device, and more particularly, to a backlight unit capable of enhancing color uniformity, an LCD device having the same, and a method for providing substantially white light for a liquid crystal display device.

[0004] 2. Description of the Background Art

[0005] Generally, a liquid crystal display (LCD) device comprises a liquid crystal display (LCD) panel having a thin film transistor (TFT) array substrate, a color filter substrate facing the TFT array substrate, and a liquid crystal layer interposed between the two substrates; a driving unit for driving the LCD panel; and a backlight unit for supplying light to the LCD panel.

[0006] On the TFT array substrate, a plurality of data lines and a plurality of gate lines arranged in a horizontal direction cross each other to define pixels. The pixels are arranged as a matrix form.

[0007] On the color filter substrate, R, G, and B color filter layers are arranged at positions corresponding to the pixels. A black matrix for preventing light from being leaked between the color filter layers and for preventing color interference of light that passes through the pixels is formed on the color filter substrate.

[0008] A common electrode and a pixel electrode are respectively formed at inner surfaces of the color filter substrate and the TFT array substrate facing each other, thereby applying an electric field to the liquid crystal layer. The pixel electrode is formed on the TFT array substrate at a position corresponding to each pixel. The common electrode is integrally formed on an entire surface of the color filter substrate. Therefore, a voltage to be applied to the pixel electrode is controlled under a state that a voltage has been applied to the common electrode, thereby changing an alignment state of liquid crystal molecules of the liquid crystal layer and thus individually controlling an optical transmittance of each of the pixels.

[0009] The backlight unit supplies light to the LCD device that does not spontaneously emit light. When the light emitted from the backlight unit passes through the liquid crystal layer, an optical transmittance is determined by the alignment state of the liquid crystal molecules and thus an image is displayed.

[0010] The backlight unit is divided into an edge type and a direct type according to a position of a lamp to be used as an optical source.

[0011] In the edge type backlight unit, a lamp is positioned at one side surface or two side surfaces of an LCD panel, and the light emitted from the lamp is transmitted to an entire surface of the LCD panel by a light guiding plate.

[0012] The direct type backlight unit has been developed since a size of the LCD panel is increased to be more than 20 inches. In the direct type backlight unit, a plurality of fluorescent lamps are arranged at a lower surface of a diffusion plate in series thereby to directly irradiate the light to an entire surface of the LCD panel. The direct type backlight unit provides higher optical efficiency than the edge type backlight unit, thereby being mainly used to an LCD device of a large screen requiring higher brightness.

[0013] A cold cathode fluorescent lamp (CCFL), a hot cathode fluorescent lamp (HCFL), an electro-luminescence (EL) lamp, a light emitting diode (LED), etc. are used as an optical source. Among the optical sources, the CCFL and the LED are mainly used.

[0014] The CCFL provides high brightness and enhances brightness uniformity. However, the CCFL cannot provide a partial brightness control and an original color reproduction.

[0015] In the LED, R, G, and B LEDs are arranged in a stripe form thereby to provide a partial brightness control and an original color reproduction. However, the LED has inferior color uniformity to the CCFL. That is, since the LED emits white light by mixing R, G, and B light emitted from the R, G, and B LEDs, a pure white image can not be displayed and uneven brightness is caused when the R, G, B colors are not uniformly mixed together.

BRIEF DESCRIPTION OF THE INVENTION

[0016] Therefore, an object of the present invention is to provide a backlight unit capable of enhancing color uniformity, a liquid crystal display (LCD) device having the same, and a method for providing substantially white light for a liquid crystal display device.

[0017] Another object of the present invention is to provide a backlight unit capable of enhancing brightness uniformity, a liquid crystal display (LCD) device having the same, and a method for providing substantially white light for a liquid crystal display device.

[0018] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a backlight unit, comprising: an optical source including a plurality of unit groups, each unit group having a plurality of light emitting diodes (LEDs); and a light mixing layer formed over the unit groups, for mixing lights emitted from the LEDs to provide substantially white light.

[0019] In another aspect of the present invention, as embodied, there is also provided a liquid crystal display (LCD) device, comprising: an LCD panel; an optical source having a plurality of unit groups for emitting lights toward the LCD panel, each unit group having a plurality of light emitting diodes (LEDs); and a light mixing layer formed over the unit groups, for mixing the lights emitted from the LEDs to provide substantially white light to the LCD panel.

[0020] In another aspect of the present invention, as embodied, there is also provided a method for providing substantially white light for a liquid crystal display device, comprising: providing a plurality of unit groups, each unit group having a plurality of light emitting diodes (LEDs);

emitting lights from the LEDs toward a LCD panel; and mixing the lights emitted from the LEDs by a light mixing layer to provide substantially white light to the LCD panel.

[0021] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0023] In the drawings:

[0024] FIG. **1** is a schematic view showing a construction of a liquid crystal display (LCD) device according to an embodiment of the present invention;

[0025] FIG. **2** is a schematic view showing an optical source according to an embodiment of the present invention;

[0026] FIG. **3** is an enlarged view showing a unit group of the optical source according to an embodiment of the present invention;

[0027] FIG. **4** shows a light mixing layer of a single-layer structure according to an embodiment of the present invention;

[0028] FIG. **5** shows a light mixing layer of a double-layer structure according to an embodiment of the present invention; and

[0029] FIGS. **6-8** respectively show different arrangements of an LED according to different embodiments of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0030] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0031] Hereinafter, a backlight unit and a liquid crystal display (LCD) device having the same according to an embodiment of the present invention will be explained in more detail with reference to the attached drawings.

[0032] FIG. **1** is a schematic view showing a construction of a liquid crystal display (LCD) device according to an embodiment of the present invention. As shown in FIG. **1**, an LCD device **100** comprises an LCD panel having a thin film transistor (TFT) array substrate **110***a*, a color filter substrate **110***b*, and a liquid crystal layer (not shown) interposed therebetween; and a backlight unit **130** for supplying light to the LCD panel **110**.

[0033] Although not shown, the TFT array substrate **110***a* comprises a plurality of gate lines, a plurality of data lines crossing the gate lines thereby implementing pixel regions in a matrix form, and a switching device for switching each of the pixels.

[0034] On the color filter substrate **110***b*, R, G, and B color filter layers are formed at positions corresponding to the pixels. A black matrix for preventing light from being leaked between the color filter layers and for preventing color interference of light that passes through the pixels is formed on the color filter substrate **110***b*.

[0035] A common electrode and a pixel electrode are respectively formed at inner surfaces of the color filter substrate and the TFT array substrate facing each other, thereby applying an electric field to the liquid crystal layer. A voltage applied between the common electrode and the pixel electrode is controlled to change an alignment state of liquid crystal molecules of the liquid crystal layer, thereby individually controlling an optical transmittance of each of the pixels.

[0036] The backlight unit **130** comprises a light emitting portion **150** for supplying light to the LCD panel **110**, and an optical sheet **120** disposed between the LCD panel **110** and the light emitting portion **150** for enhancing the optical efficiency.

[0037] The optical sheet **120** comprises a diffusion plate **123**, first and second prism sheets **125***a* and **125***b* formed on the diffusion plate **123**, and a protection sheet **127** formed on the first and second prism sheets **125***a* and **125***b*. The diffusion plate **123** formed on the light emitting portion **150** disperses light incident from the light emitting portion **150**, thereby preventing generating bright spots due to a partial light concentration. The diffusion plate **123** also converts a propagating direction of the light that is moving towards the first prism sheet **125***a* to a vertical direction. The first prism sheet **125***a* has a flat lower surface and wrinkled surfaces in the front and rear directions, whereas the second prism sheet **125***b* has a flat lower surface and wrinkled surfaces in the right and left directions. The first prism sheet **125***a* collects the light moving towards the second prism sheet **125***b* in the front and rear directions, and the second prism sheet **125***b* collects the light moving towards the protection sheet **127** in the right and left directions. Therefore, the light moving towards the protection sheet **127** from the diffusion plate **123** is vertical. Accordingly, the light that passes through the first prism sheet **125***a* and the second prism sheet **125***b* moves in the vertical direction to be uniformly distributed on an entire surface of the protection sheet **127**, thereby increasing the brightness.

[0038] The light emitting portion **150** comprises an optical source **155** for generating light, and a light mixing layer **159** for effectively dispersing R, G, and B light emitted from the optical source **155** and thereby mixing the dispersed R, G, and B light together due to the refraction of the light mixing layer **159**. The optical source **155** is formed on a metal core printed circuit board (MCPCB), and a reflector **153** for upwardly reflecting light that is downwardly dispersed is provided between the light emitting portion **150** and the MCPCB **151**. The reflector **153** is formed of an AI material having excellent reflection characteristics.

[0039] The optical source **155** is implemented as an LED, which has better excellent brightness and color reproduction than those of a fluorescent lamp. However, as the brightness of the LED is increased, an inner temperature of the LED is increased. Therefore, the output brightness of the optical source **155** is decreased.

[0040] Therefore, a heat emitting plate **157** is provided at the bottom surface of the MCPCB **151**. The heat emitting

plate **157** receives the heat from the LED and emits it outwardly, thereby preventing the inner temperature of the LED from being increased. That is, as the LED emits the light, the heat is generated in the LED. The generated heat is absorbed by the reflector **153** and then transmitted to the MCPCB **151**. Then, the heat is transmitted from the MCPCB **151** to the heat emitting plate **157**, and thereafter is outwardly emitted.

[**0041**] The optical source **155** is implemented as a plurality of LEDs for emitting R, G, and B light constituted as one unit group D (see FIG. **3**). A light mixing layer **159** for uniformly mixing R, G, and B light emitted from the corresponding unit group D to generate substantially white light is provided at the optical source **155**.

[**0042**] The light mixing layer **159** has a semi-spherical shape so as to disperse R, G, and B light and uniformly mix the dispersed R, G, and B light, thereby generating the white light. That is, the LEDs **155** for emitting R, G, and B light are provided in the light mixing layer **159** having a semi-spherical shape, and the light mixing layer **159** disperses light emitted from the LEDs **155** to outwardly emit it.

[**0043**] FIG. **2** shows a light mixing layer **159** having a semi-spherical shape, in which the LEDs (not shown) constituting each unit group are capsulated by the light mixing layer **159** and the reflector **153**. The light mixing layer **159** covers the LEDs **155** therein, and is fixed onto the MCPCB **151** and in contact with the reflector **153**.

[**0044**] FIG. **3** is an enlarged view showing a unit group D of the LEDs **155** inside the light emitting layer **159** according to an embodiment of the present invention. As shown, the LEDs are arranged in a rectangular/square two-by-two matrix form thus to constitute a unit group D inside the light mixing layer **159**, thereby effectively mixing R, G, and B light. In an embodiment, the LEDs in each unit group are arranged to be as close as possible to each other. It should be noted that the distance between the adjacent LEDs may vary in order to provide the desired effect of the lights.

[**0045**] The light mixing layer **159** disperses and mixs R, G, and B light emitted from the LEDs, and is formed of a dispersion material of a single-layer or a double-layer structure.

[**0046**] FIG. **4** shows a light mixing layer of a single-layer structure according to an embodiment of the present invention, and FIG. **5** shows a light mixing layer of a double-layer structure according to an embodiment of the present invention. As shown in FIG. **4**, when a light mixing layer **259** is a single-layer structure, it can be formed of one of poly methyl methcrylate (PMMA), SK_4, silica, epoxy, and MgF.

[**0047**] As shown in FIG. **5**, when a light mixing layer **359** is a double-layer structure composed of an inner layer **359**A and an outer layer **359**B, the inner layer **359**A can be formed of one of poly methyl methcrylate (PMMA), SK_4, silica, epoxy, and MgF, and the outer layer **359**B can be formed of one of SK_4, silica, and MgF. Herein, the materials of the inner layer **359**A and the outer layer **359**B are selected so that a refractive index of the inner layer **359**A is larger than a refractive index of the outer layer **359**B in order to provide excellent color mixture. That is, when the light is incident from the inner layer **359**A having a relatively large refractive index to the outer layer **359**B having a relatively small refractive index, a total reflection occurs in an incident angle more than a threshold value. When the total reflection occurs in the light mixing layer **359**, the color mixture is performed more effectively.

[**0048**] The following table 1 presents each refractive index of PMMA, SK_4, silica, epoxy, and MgF that can be a material of the outer layer and the inner layer. Herein, the inner layer and the outer layer can be respectively formed of any of the materials as long as the refractive index of the inner layer is larger than the refractive index of the outer layer.

TABLE 1

Material	Refractive index
SK_4	1.613
Silica	1.51
PMMA	1.49
Epoxy	1.45
MgF	1.38

[**0049**] In the present invention, since the LEDs are arranged in a rectangular/square two-by-two matrix form rather than in a straight line form, the color uniformity can be more enhanced. Herein, the LEDs can be arranged regardless of the color of the LEDs, and a white LED can be further provided for enhancing the brightness.

[**0050**] FIGS. **6-8** respectively show different arrangements of the LEDs according to different embodiments of the present invention. As shown in FIGS. **6-8**, one unit group is composed of one red LED, one blue LED, and two green LEDs. Herein, the four LEDs (R, **2**G, and B) can be arranged in any order as long as they are arranged in a rectangular/square two-by-two matrix form. That is, two green LEDs (G) can be arranged in a diagonal direction as shown in FIG. **6**, or the two green LEDs (G) can be arranged to be immediately adjacent to each other as shown in FIG. **7**.

[**0051**] As shown in FIG. **8**, a white LED (W) can be further provided in the central portion of the rectangular/square two-by-two matrix formed by four LEDs. Using two green LEDs and/or one white LED (W) can enhance the brightness. It is also possible to implement a unit group composed of one red LED, one green LED, and one blue LED. Herein, the three LEDs are arranged in a triangular form, and one white LED can be further provided thereto.

[**0052**] Whereas the conventional LEDs are arranged in a straight line, the illustrated LEDs are arranged in a rectangular/square two-by-two matrix form, a triangular form, etc. in order to improve the color mixture. It should be noted that the LEDs are not limited into the illustrated positions.

[**0053**] Moreover, in the present invention, the light mixing layer for capsulating the LEDs is provided to effectively mix R, G, and B light. The light mixing layer can be formed of any material as long as it has a light dispersion function.

[**0054**] As aforementioned, in the illustrated embodiments, the LEDs for emitting R, G, and B light are implemented as one unit group, and the light mixing layer for covering the LEDs is provided. Accordingly, the color mixture is effectively performed, and the color uniformity and the brightness uniformity are enhanced, thereby providing an LCD device having better picture quality.

[0055] As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the metes and bounds of the claims, or equivalents of such metes and bounds are therefore intended to be embraced by the appended claims.

What is claimed is:

1. A backlight unit, comprising:

an optical source including a plurality of unit groups, each unit group having a plurality of light emitting diodes (LEDs); and

a light mixing layer formed over the unit groups, for mixing lights emitted from the LEDs to provide substantially white light.

2. The backlight unit of claim 1, wherein each of the unit groups comprises one red (R) LED, one blue (B) LED, and two green (G) LEDs.

3. The backlight unit of claim 2, wherein the R, B and G LEDs of each of the unit groups are arranged in a matrix form.

4. The backlight unit of claim 3, wherein each of the unit groups further comprises a white LED at a center thereof surrounded by the R, B and G LEDs.

5. The backlight unit of claim 1, wherein the light mixing layer includes a plurality of light mixing layers , each of the light mixing layers covering the LEDs in the corresponding unit group, the LEDs being arranged in a matrix form.

6. The backlight unit of claim 5, further comprising a reflector, the LEDs being enclosed by the reflector and the corresponding light mixing layer.

7. The backlight unit of claim 6, wherein each of the light mixing layers has a substantially semi-spherical shape and is in contact with the reflector.

8. The backlight unit of claim 6, further comprising a heat emitting plate below the reflector, a heat generated by the LEDs being absorbed by the reflector and being transmitted from the reflector to the heat emitting plate.

9. The backlight unit of claim 8, further comprising a printed circuit board for driving the LEDs, the printed circuit board being between the reflector and the heat emitting plate, the heat generated by the LEDs being transmitted from the reflector to the heat emitting plate via the printed circuit board.

10. The backlight unit of claim 1, wherein the light mixing layer is a single-layer structure.

11. The backlight unit of claim 10, wherein the light mixing layer is formed of a dispersion material.

12. The backlight unit of claim 11, wherein the light mixing layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, and MgF.

13. The backlight unit of claim 1, wherein the light mixing layer is a double-layer structure including an inner layer and an outer layer.

14. The backlight unit of claim 13, wherein a refractive index of the inner layer is larger than a refractive index of the outer layer.

15. The backlight unit of claim 14, wherein the inner layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF, and the outer layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF.

16. The backlight unit of claim 1, further comprising an optical sheet over the light mixing layer, wherein the optical sheet comprises:

a diffusion plate for diffusing the substantially white light incident from the optical source;

a prism sheet above the diffusion plate for increasing frontal brightness of the substantially white light passing through the diffusion plate; and

a protection sheet attached onto the prism sheet.

17. A liquid crystal display (LCD) device, comprising:

an LCD panel;

an optical source having a plurality of unit groups for emitting lights toward the LCD panel, each unit group having a plurality of light emitting diodes (LEDs); and

a light mixing layer formed over the unit groups, for mixing the lights emitted from the LEDs to provide substantially white light to the LCD panel.

18. The LCD device of claim 17, wherein each of the unit groups comprises one red (R) LED, one blue (B) LED, and two green (G) LEDs.

19. The LCD device of claim 18, wherein the R, B and G LEDs of each of the unit groups are arranged in a matrix form.

20. The LCD device of claim 19, wherein each of the unit groups further comprises a white LED at a center thereof surrounded by the R, B and G LEDs.

21. The LCD device of claim 17, wherein the light mixing layer includes a plurality of light mixing layers , each of the light mixing layers covering the LEDs in the corresponding unit group, the LEDs being arranged in a matrix form.

22. The LCD device of claim 21, further comprising a reflector, the LEDs being enclosed by the reflector and the corresponding light mixing layer.

23. The LCD device of claim 22, wherein each of the light mixing layers has a substantially semi-spherical shape and is in contact with the reflector.

24. The LCD device of claim 22, further comprising a heat emitting plate below the reflector, a heat generated by the LEDs being absorbed by the reflector and being transmitted from the reflector to the heat emitting plate.

25. The LCD device of claim 24, further comprising a printed circuit board for driving the LEDs, the printed circuit board being between the reflector and the heat emitting plate, the heat generated by the LEDs being transmitted from the reflector to the heat emitting plate via the printed circuit board.

26. The LCD device of claim 17, wherein the light mixing layer is a single-layer structure formed of one of poly methyl methcrylate (PMMA), SK4, silica, and MgF.

27. The LCD device of claim 17, wherein the light mixing layer is a double-layer structure including an inner layer and an outer layer and a refractive index of the inner layer is larger than a refractive index of the outer layer.

28. The LCD device of claim 27, wherein the inner layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF, and the outer layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF.

29. The LCD device of claim 17, further comprising an optical sheet located between the LCD panel and the light mixing layer, wherein the optical sheet comprises:

a diffusion plate for diffusing the substantially white light incident from the optical source;

a prism sheet above the diffusion plate for increasing frontal brightness of the white light passing through the diffusion plate; and

a protection sheet attached onto the prism sheet.

30. A method for providing substantially white light for a liquid crystal display device, the method comprising:

providing a plurality of unit groups, each unit group having a plurality of light emitting diodes (LEDs);

emitting lights from the LEDs toward a LCD panel; and

mixing the lights emitted from the LEDs by a light mixing layer to provide substantially white light to the LCD panel.

31. The method of claim 30, wherein the step of providing the plurality of unit groups includes providing one red (R) LED, one blue (B) LED, and two green (G) LEDs in each of the unit groups and arranging the R, B, G LEDs in a matrix form.

32. The method of claim 31, further comprising providing a white LED at a center of the unit group to be surrounded by the R, B and G LEDs.

33. The method of claim 30, wherein the light mixing layer includes a plurality of light mixing layers, and the step of mixing the lights includes

covering the LEDs arranged in a matrix form in the corresponding unit group by the corresponding light mixing layer; and

mixing the lights emitted from the LEDs in the corresponding unit group by the corresponding light mixing layer.

34. The method of claim 33, further comprising:

absorbing a heat generating by the LEDs by a reflector that is in contact with the light mixing layers; and

dissipating the heat absorbed by the reflector from the reflector to a heat emitting plate below the reflector.

35. The method of claim 30, further comprising forming the light mixing layer to be a single-layer structure by one of poly methyl methcrylate (PMMA), SK4, silica, and MgF.

36. The method of claim 30, further comprising forming the light mixing layer to be a double-layer structure including an inner layer and an outer layer, and a refractive index of the inner layer being larger than a refractive index of the outer layer.

37. The method of claim 36, wherein the inner layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF, and the outer layer is formed of one of poly methyl methcrylate (PMMA), SK4, silica, epoxy, and MgF.

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