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(54) PHOTO-LUMINESCENCE LIQUID CRYSTAL DISPLAY

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(57) **ABSTRACT**

A photo-luminescence (PL) liquid crystal display (LCD) is provided. The PL LCD includes a blue backlight, red and green phosphor layers, and blue photo-luminescent nano-dot (ND) layer. The PL LCD improves conventional problems of a narrow viewing angle and orientation. The PL LCD further includes an ultraviolet (UV) filter blocking UV contained in ambient light, thus preventing excitation of light-emitting layer due to external light and degradation in the contrast ratio due to unnecessary light emission.

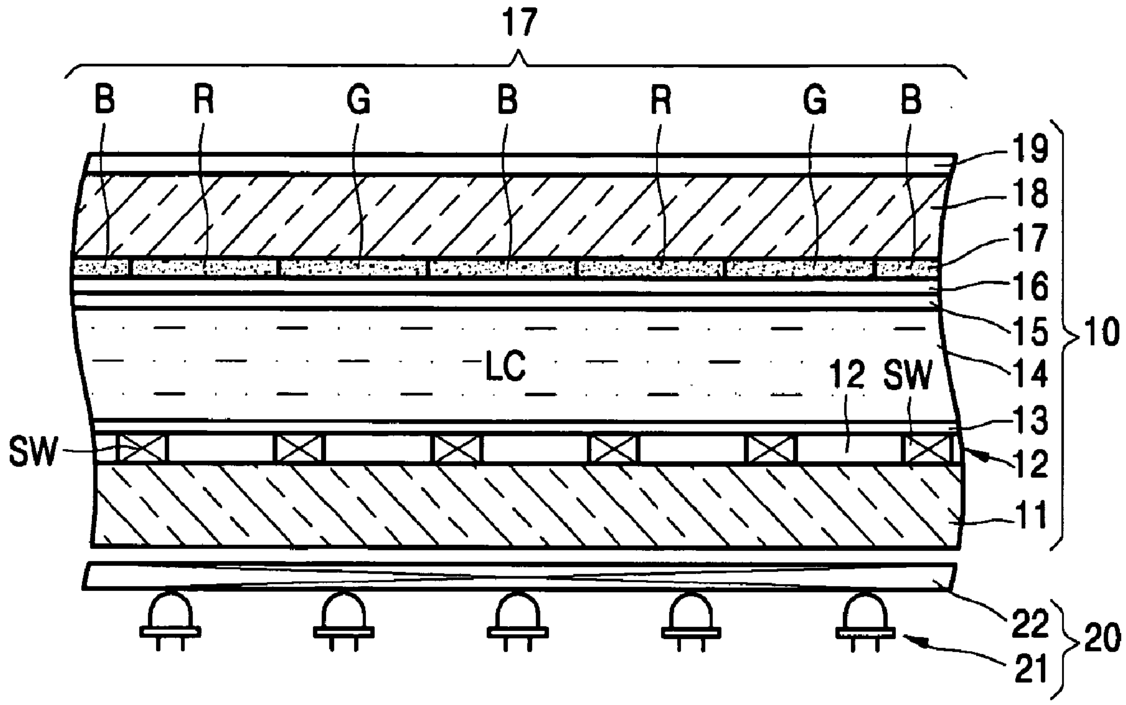

FIG. 1

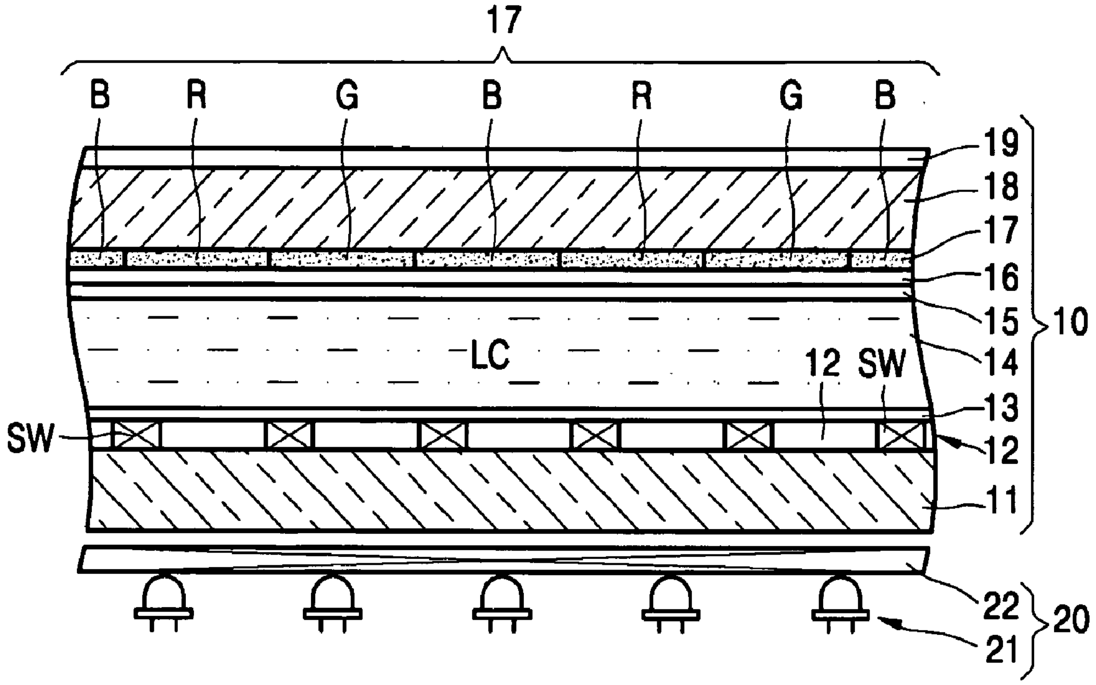
17
B
R
G
B
R
G
B
19
18
17
16
15
10
LC
14
12 SW
13
SW
12
11
22
20
21

FIG. 2

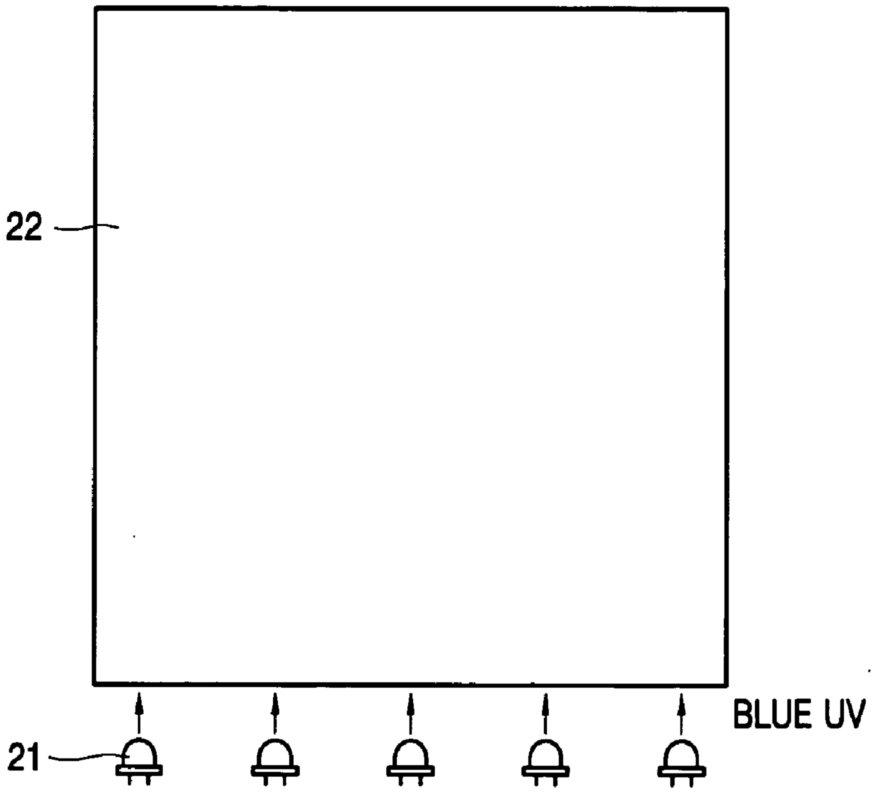
22
BLUE UV
21

FIG. 3

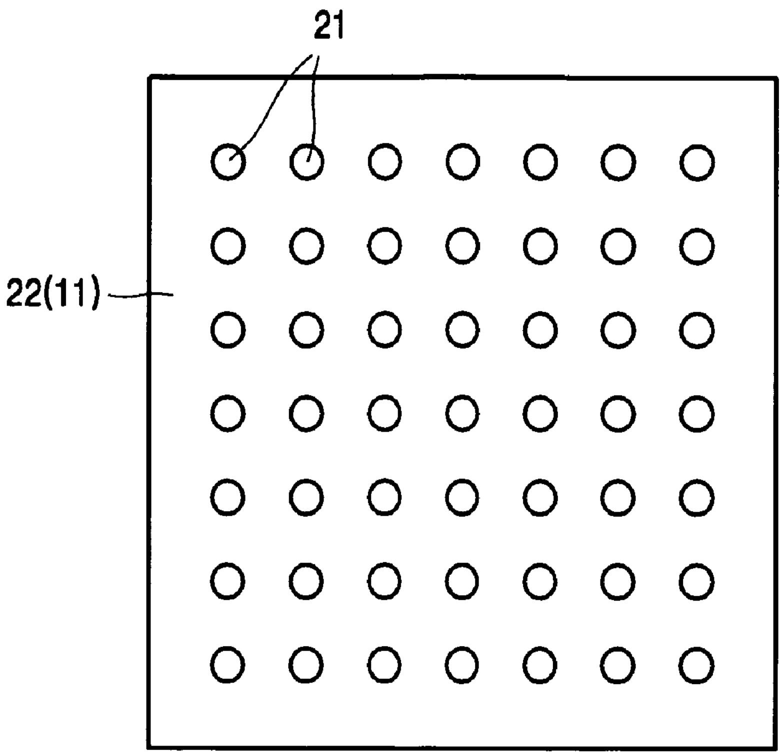

FIG. 4

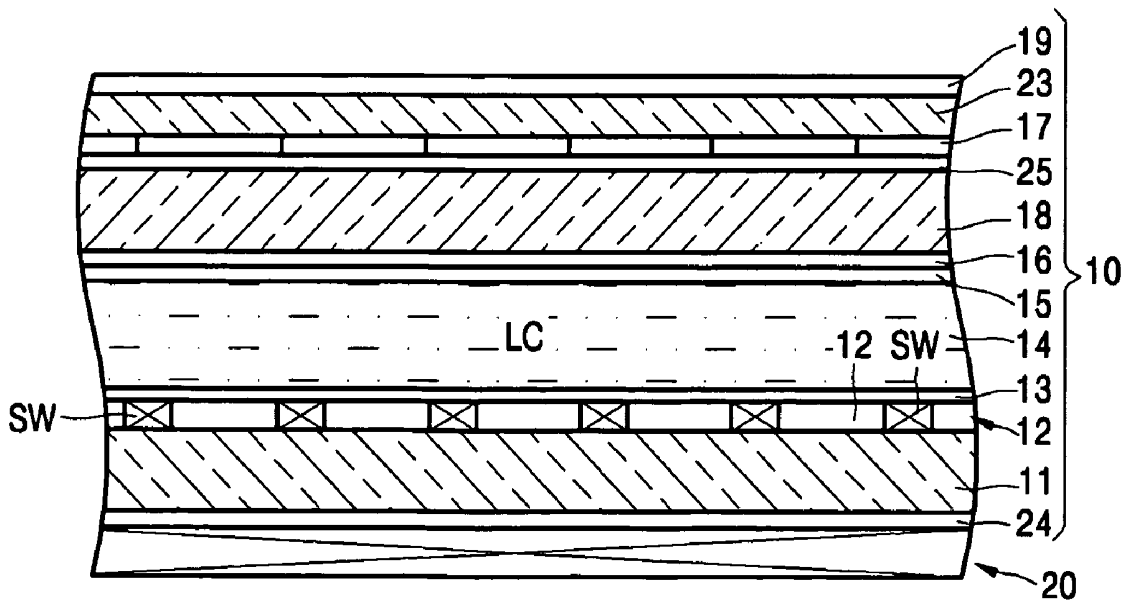

FIG. 5

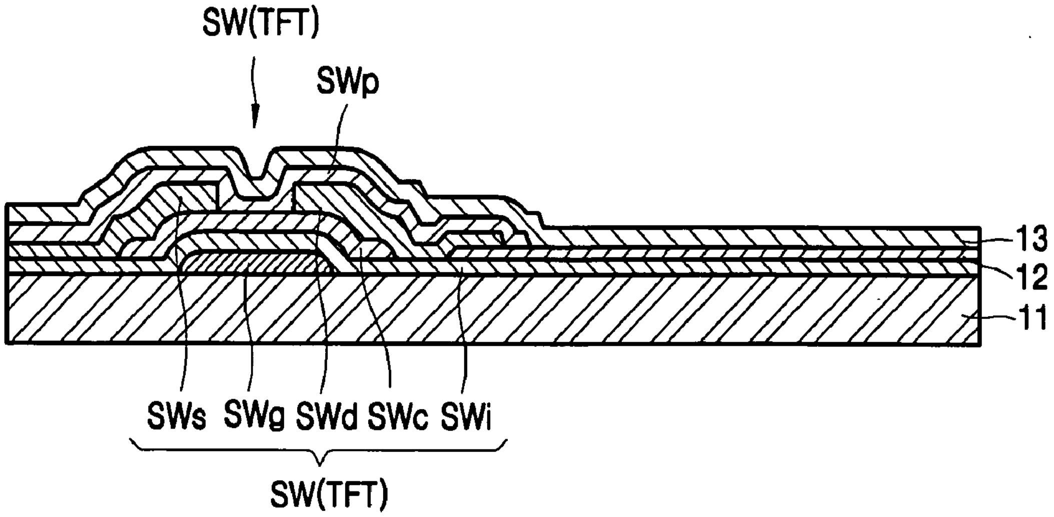
SW(TFT)
SWp
13
12
11
SWs SWg SWd SWc SWi
SW(TFT)

FIG. 6

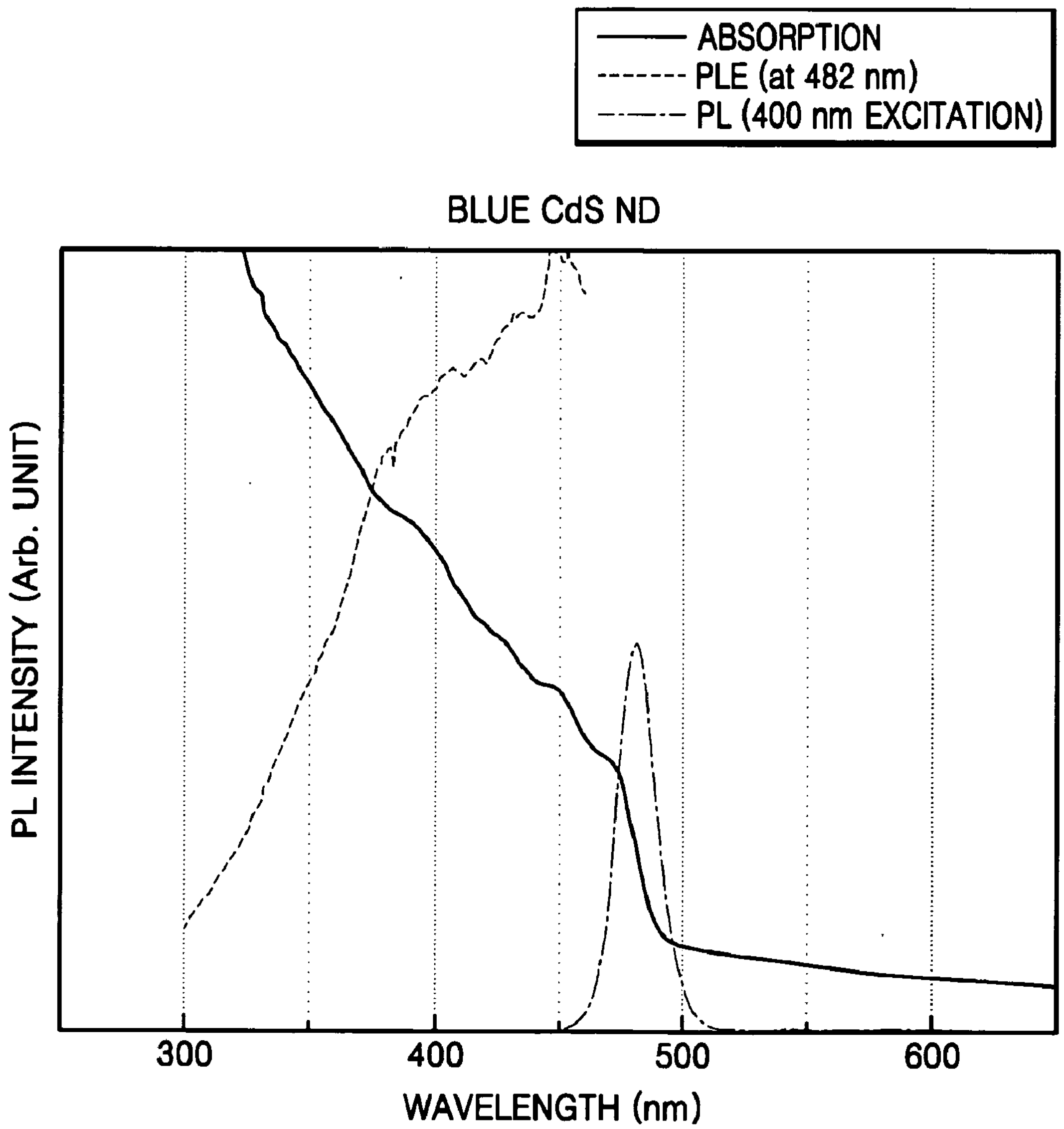
ABSORPTION
PLE (at 482 nm)
PL (400 nm EXCITATION)
BLUE CdS ND
PL INTENSITY (Arb. UNIT)
300
400
500
600
WAVELENGTH (nm)

FIG. 7

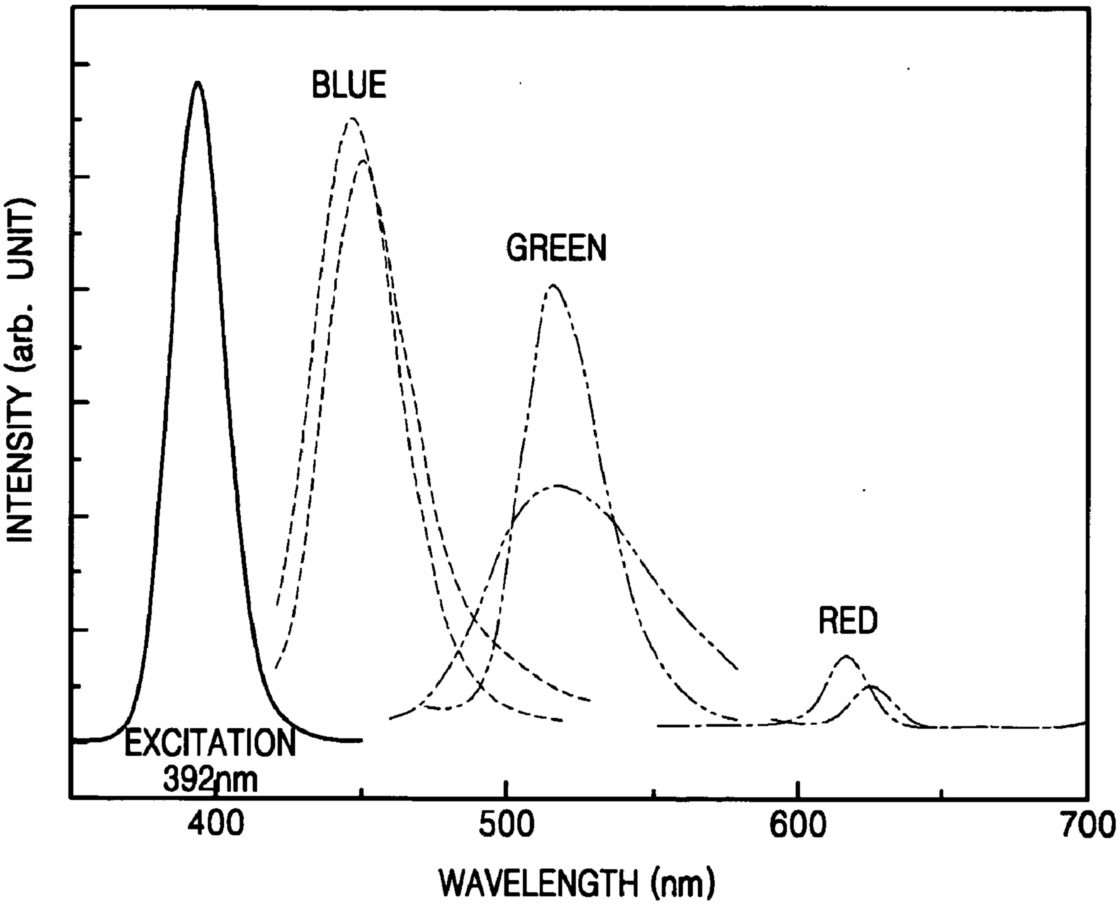
BLUE
GREEN
RED
EXCITATION
392nm
INTENSITY (arb. UNIT)
400
500
600
700
WAVELENGTH (nm)

PHOTO-LUMINESCENCE LIQUID CRYSTAL DISPLAY

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2005-0032738, filed on Apr. 20, 2005, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE DISCLOSURE

[0002] 1. Field of the Disclosure

[0003] The present disclosure relates to a liquid crystal display (LCD) and a photo-luminescence (PL)-LCD with high light utilization efficiency.

[0004] 2. Description of the Related Art

[0005] LCDs are non-emissive displays and need a separate backlight device to display an image on a screen. LCDs also require Red (R), Green (G), and Blue (B) color filters for their respective pixels to display a color image.

[0006] The R, G, and B color filters respectively separate white light emitted from a backlight device into red, green, and blue. The R, G, and B color filters each transmit only light of a specific wavelength that is one third of white light, resulting in significant optical loss. Thus, a high brightness backlight device is needed to produce an image with sufficient brightness.

[0007] With high light utilization efficiency, PL-LCDs using phosphors excited by ultraviolet (UV) light instead of color filters have been disclosed in U.S. Pat. Nos. 4,822,144 and 4,830,469.

[0008] In U.S. Patent Publication No. 2002/0145,685, Regina et al. propose a PL-LCD using a blue backlight and red and green phosphors. The blue backlight simply switches a light path using liquid crystal instead of a color filter or phosphors. The red and green phosphors are excited by blue light from the blue backlight switched by the liquid crystal.

[0009] The drawback of the proposed PL-LCD is that it has a narrow viewing angle and orientation because light emitted from a blue pixel has a polarization component. The blue pixel with a polarization component and a narrow viewing angle has different optical characteristics than red and green pixels with no polarization component and a wide viewing angle.

[0010] The phosphors for the red and green pixels are excited by the blue backlight as well as ambient light incident from an external light source since the ambient light also contains blue UV as well. The UV contained in the ambient light unnecessarily excites the phosphors without contributing to displaying an image on the LCD, thereby degrading a contrast ratio.

SUMMARY OF THE DISCLOSURE

[0011] The present disclosure provides a simple photo-luminescence (PL)-liquid crystal display (LCD) designed to reduce difference in optical characteristics between pixels.

[0012] The present invention also may provide a PL-LCD that is capable of displaying a high quality image by suppressing a reduction in contrast ratio due to ambient light.

[0013] According to an aspect of the present invention, there may be provided a PL LCD including: a backlight generating blue light; liquid crystals defining a plurality of red, green, and blue pixels and switching blue light from the backlight to control the passage of the blue light through the pixels defined for each color and a liquid crystal driving unit driving the liquid crystals; a red phosphor layer corresponding to the red pixel, the red phosphor layer being excited by the blue light to emit red light; a green phosphor layer corresponding to the green pixel, the green phosphor layer being excited by the blue light to emit green light; and a blue photo-luminescent nano-dot (ND) layer corresponding to the blue pixel, the blue photo-luminescent ND layer being excited by the blue light to emit blue light.

[0014] The blue light may have a wavelength of 430 to 480 nm. The backlight includes a blue light-emitting diode (LED) light source. The blue photo-luminescent ND layer may be formed of cadmium sulfide (CdS).

[0015] The PL LCD may further include an ultraviolet (UV) filter blocking external UV and preventing absorption of UV into the red and green phosphor layers and the blue ND layer. The UV filter may use a chemical blocking agent for absorbing UV, such as para-aminobenzoic acid (PABA) precursor, cinnamate precursor, salicylic acid precursor, benzophenone and its precursor or antharanilate and its precursor, or a physical blocking agent for reflecting and scattering incident UV, such as zinc oxide, titanium dioxide, iron oxide or magnesium oxide.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above and other features and advantages of the present invention are described in detailed exemplary embodiments thereof with reference to the attached drawings in which:

[0017] **FIG. 1** is a cross-sectional view of a liquid crystal display (LCD) according to a first embodiment of the present invention;

[0018] **FIG. 2** shows an example of the backlight of the LCD of **FIG. 1**;

[0019] **FIG. 3** shows another example of the backlight of the LCD of **FIG. 1**;

[0020] **FIG. 4** is a cross-sectional view of a LCD according to a second embodiment of the present invention;

[0021] **FIG. 5** is a cross-sectional view showing the structure of a switching element and a pixel electrode in a LCD according to the present invention;

[0022] **FIG. 6** is a graph showing a change in photo-luminescence (PL) intensity in CdS nano-dot (ND); and

[0023] **FIG. 7** is a graph showing emission intensity for phosphors excited by ultraviolet (UV) contained in ambient light in a conventional PL-LCD.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0024] The present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown.

[0025] Referring to **FIG. 1**, a liquid crystal display (LCD) according to a first embodiment of the present invention includes a display panel **10** and a blue backlight **20**. For example, the blue backlight **20** may use a blue light-emitting diode (LED) generating blue visible light having 460 nm wavelength. The display panel **10** includes a front substrate **18** and a rear substrate **11** spaced from each other by a predetermined distance and a liquid crystal (LC) layer **14** sandwiched between the front and rear substrates **18** and **11**.

[0026] A light-emitting layer **17** containing red phosphor layers R, green phosphor layers G, and blue nano-dot (ND) layers B is disposed on an inner surface of the front substrate **18**. A common electrode **16** and an upper alignment layer **15** are sequentially formed on the light-emitting layer **17**. A liquid crystal driving circuit including a plurality of thin-film transistor (TFT) switching elements SW and a plurality of pixel electrodes **12** and a lower alignment layer **13** are sequentially disposed on the rear substrate **11**. Here, the phosphor layers R and G and the blue ND layer B are excited by 460 nm blue light from the backlight **20** and emit light. For example, the ND layer B is excited by 460 nm blue light from the backlight **20** and generates light near 460 nm. Light passing through the LC layer **14** and incident on the ND layer B has a polarization component and light generated by the ND layer B has an elliptical or circular polarization component. Because the light generated by the ND layer B has no linear polarization component, the ND layer B for the blue pixel provides a wide viewing angle and the generated light has non-directional light or non-orientative light.

[0027] The blue ND (or quantum dot) refers to a semiconductor particle of a predetermined size showing a quantum confinement effect. The quantum dots have a diameter of 1 to 10 nm and may be synthesized by a wet chemistry method. Here, the wet chemistry method is a commonly known technique that allows particles to grow by mixing a precursor material in an organic solvent.

[0028] For example, the quantum dots may be formed of a II-VI compound such as cadmium selenide (CdSe), cadmium telluride (CdTe), cadmium sulfide (CdS), zinc selenide (ZnSe), zinc telluride (ZnTe), zinc sulfide (ZnS), mercury telluride (HgTe), or mercury sulfide (HgS). The quantum dots may have a core-shell structure in which the core includes one compound selected from the group consisting of CdSe, CdTe, CdS, ZnSe, ZnTe, ZnS, HgTe, and HgS and the shell includes one compound selected from the group consisting of CdSe, CdTe, CdS, ZnSe, ZnTe, ZnS, HgTe, and HgS. The quantum dots may also be formed of a III-V compound such as indium phosphide (InP).

[0029] An ultraviolet (UV) filter **19** is disposed on an outer surface of the front substrate **18**. The UV filter **19**, may use a chemical blocking agent absorbing UV, such as para-aminobenzoic acid (PABA) precursor, cinnamate precursor, salicylic acid precursor, benzophenone and its precursor or antharanilate and its precursor, or a physical blocking agent reflecting and scattering incident UV, such as zinc oxide, titanium dioxide, iron oxide or magnesium oxide. The UV filter **19** prevents UV light that causes unnecessary light emission from the light-emitting layer **17** from entering the light-emitting layer **17**. The UV light to be blocked is in the near-blue region shorter than 460 nm light emitted by the blue ND. For example, the UV light may have a wavelength of less than 400 nm.

[0030] The blue backlight **20** located near the bottom surface of the rear substrate **11** has a blue lamp **21** and a light guide/diffusion element **22**. As described above, the lamp **21** may be a blue LED. The light guide/diffusion element **22** guides and uniformly diffuses blue light from the lamp **21** toward the rear substrate **11**.

[0031] The light guide/diffusion element **22** is optional and the lamp **21** has a size corresponding to the entire surface of the rear substrate **11**. For example, when the LEDs are used as the lamp **21**, a plurality of LEDs may be densely arranged in a two-dimensional array. A light source supplying light over the entire surface of the LCD in this way is needed to achieve a large-screen LCD.

[0032] When the lamp **21** is an array of LEDs, the LEDs **21** may be arranged along a line parallel to one edge of the light guide/diffusion element **22** as in an edge light type backlight shown in **FIG. 2**. Alternatively, as shown in **FIG. 3**, the LEDs **21** may be arranged on the entire surface of the light guide/diffusion element **22** corresponding to the entire surface of the rear substrate **11**.

[0033] **FIG. 4** is a cross-sectional view of a LCD according to a second embodiment of the present invention. The difference between the LCDs of the first and second embodiments lies in the position of a light-emitting layer **17** and a UV filter **19**. Referring to **FIG. 4**, the LCD includes a display panel **10** and a blue backlight **20**. The display panel **10** includes a front substrate **18** and a rear substrate **11** spaced from each other by a predetermined distance and a LC layer **14** sandwiched between the front and rear substrates **18** and **11**. A common electrode **16** and an upper alignment layer **15** are sequentially formed on a bottom surface of the front substrate **18**. Polarization plates **25** and **24** are respectively disposed on a top surface of the front substrate **18** and a bottom surface of the rear substrate **11**. A light-emitting layer **17** overlies the polarization plate **25** and emits color light when irradiated with UV light. The light-emitting layer **17** includes red and green phosphor layers and a blue ND layer, which are commonly known to emit color light by absorbing 460 nm blue light as described above.

[0034] The light-emitting layer **17** is covered by a protective substrate **23** and the UV filter **19** is disposed on the protective substrate **23** and blocks UV light of a wavelength shorter than light generated by the ND layer B as described above. The UV filter **19** may be a chemical blocking agent for absorbing UV, such as PABA precursor, cinnamate precursor, salicylic acid precursor, benzophenone and its precursor or antharanilate and its precursor, or a physical blocking agent for reflecting and scattering incident UV, such as zinc oxide, titanium dioxide, iron oxide or magnesium oxide. The UV filter **19** prevents UV light that causes unnecessary light emission from the light-emitting layer **17** from entering the light-emitting layer **17**.

[0035] **FIG. 5** is a cross-sectional view showing a vertical structure of a switching element SW that is a thin film transistor (TFT) and a pixel electrode **12** connected to the switching element SW in a LCD according to the present invention. Referring to **FIG. 5**, the TFT has a bottom gate structure in which a gate SWg is disposed below a silicon channel SWc. More specifically, the gate SWg is formed on one side of a substrate **11** and a gate insulating layer SWi is formed over the substrate **11** on which the gate SWg has been formed. The silicon channel SWc is formed on the gate insulating layer SWi immediately above the gate SWg and a transparent indium tin oxide (ITO) pixel electrode **12** is located on the gate insulating layer SWi and adjacent to the silicon channel SWc. A source SWs and a drain SWd are formed on either side of the silicon channel SWc and a passivation layer SWp is formed on the source SWs and drain SWd. The drain SWd extends onto and is electrically connected to the pixel electrode **12**. A lower alignment layer **13** is formed on the TFT switching element SW and the pixel electrode **12** and is in contact with LC and aligns the LC to a specific orientation.

[0036] As described above, in a LCD according to the present invention, the red phosphor is selected from the group consisting of (Sr,CaS):Eu2+, (Sr,Ca)2Si5N8:Eu2+, and Mg4GeO 5.5 F:Mn 4+ and the green phosphor is selected from the group consisting of SrGa2S4:Eu2+, (Ba, Sr)SiO4:Eu2+, MgSi2O7, SrAl2O4:Eu2+, Ca8Mg(SiO4)$_4$Cl2:Eu 2+, and (Cr,Ca)(Al,Si)$_2$:Eu 2+.

[0037] **FIG. 6** is a graph showing a change in photo-luminescence (PL) intensity in CdS that is a photo-luminescent material. Referring to **FIG. 6**, the CdS ND shows maximum PL intensity at a wavelength near 480 nm by absorbing up to light having a wavelength near 480 nm. Thus, by using the property of the ND, polarized blue light can be converted into unpolarized light having a similar wavelength.

[0038] **FIG. 7** is a graph showing emission intensity for phosphors excited by 392 nm UV contained in ambient light such as bright illumination or sunlight. To obtain the result shown in **FIG. 7**, two phosphors available from two different manufacturers were used as conventional UV-excited phosphor for each color and a 392 nm LED was used as a light source.

[0039] As evident from **FIG. 7**, when ambient UV light having a wavelength of about 392 nm is excited, red, green, and blue phosphors, are excited with two different kinds of blue phosphors emitting the shortest wavelength blue light having similar intensities. The two green phosphors available from different manufacturers respectively generated green light with high and low intensities. The red phosphors emitted light having very low intensities.

[0040] When PL-LCD is exposed to an environment in which ambient light intensity is very high, light emission not contributing to displaying an image on a screen occurs across the entire surface of the display, thus degrading the contrast for each color. In particular, blue and green have a significantly lower contrast ratio than red.

[0041] Thus, the PL-LCD according to the present invention uses a UV filter to prevent external light to enter a light-emitting layer of the LCD. As described above, the UV filter uses a chemical or physical blocking agent to suppress degradation in the contrast ratio due to external light.

[0042] For example, a wavelength of light blocked by a UV filter is shorter than wavelengths in the visible blue band including a wavelength band near 400 nm necessary for excitation of a light-emitting layer and does not contain a visible light region used for displaying an image.

[0043] While the present invention has been described with reference to a TFT active matrix LCD, a simple matrix LCD without a switching element may be used.

[0044] The PL-LCD of the present invention improves the drawback of a conventional LCD without a phosphor for a blue pixel while preventing excitation of the light-emitting layer due to external light and the resulting degradation in the contrast ratio that are drawbacks of a typical PL-LCD. Thus, the PL-LCD provides a high quality image with high brightness and a high light utilization efficiency.

[0045] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, the invention should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art. It will be understood by those of ordinary skill in the art that various changes in structure and arrangement may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A photo-luminescence (PL) liquid crystal display (LCD), comprising:

a backlight generating blue light;

liquid crystals defining a plurality of red, green, and blue pixels and switching blue light emitted from the backlight to control the passage of the blue light through the pixels defined for each color and a liquid crystal driving unit driving the liquid crystals;

a red phosphor layer corresponding to the red pixel, the red phosphor layer being excited by the blue light to emit red light;

a green phosphor layer corresponding to the green pixel, the green phosphor layer being excited by the blue light to emit green light; and

a blue photo-luminescent nano-dot (ND) layer corresponding to the blue pixel, the blue photo-luminescent ND layer being excited by the blue light to emit blue light.

2. The PL LCD of claim 1, wherein the blue photo-luminescent ND layer is formed of one of II-IV and III-V compounds.

3. The PL LCD of claim 1, wherein the red phosphor layer is made of one selected from the group consisting of (Sr,CaS):Eu2+, (Sr,Ca)$_2$Si5N8:Eu2+, and Mg4GeO 5.5 F:Mn4+,

wherein the green phosphor layer is made of one selected from the group consisting of SrGa2S4:Eu2+, (Ba, Sr)SiO4:Eu2+, MgSi2O7, SrAl2O4:Eu2+, Ca8Mg(SiO4)$_4$Cl2:Eu2+, and (Cr,Ca)(Al,Si)$_2$:Eu2+, and

wherein the blue photo-luminescent ND layer is formed of one of II-IV and III-V compounds.

4. The PL LCD of claim 1, further comprising an ultra-violet (UV) filter blocking external UV and preventing absorption of UV into the red and green phosphor layers and the blue ND layer.

5. The PL LCD of claim 4, wherein the UV filter is formed of one selected among the group consisting of para-aminobenzoic acid (PABA) precursor, cinnamate precursor, salicylic acid precursor, benzophenone and its precursor, and antharanilate and its precursor.

6. The PL LCD of claim 4, wherein the UV filter is formed of one selected from the group consisting of zinc oxide, titanium dioxide, iron oxide, and magnesium oxide.

7. The PL LCD of claim 2, wherein the red phosphor layer is made of one selected from the group consisting of (Sr,CaS):Eu2+, $(Sr,Ca)_2$Si5N8:Eu2+, and Mg4GeO 5.5 F:Mn4+,

wherein the green phosphor layer is made of one selected from the group consisting of SrGa2S4:Eu2+, (Ba, Sr)SiO4:Eu2+, MgSi2O7, SrAl2O4:Eu2+, Ca8Mg$(SiO4)_4$Cl2:Eu2+, and $(Cr,Ca)(Al,Si)_2$:Eu2+, and

wherein the blue photo-luminescent ND layer is formed of one of II-IV and III-V compounds.

8. The PL LCD of claim 2, further comprising an ultraviolet (UV) filter blocking external UV and preventing absorption of UV into the red and green phosphor layers and the blue ND layer.

* * * * *

专利名称(译)	光致发光液晶显示器		
公开(公告)号	US20060238671A1	公开(公告)日	2006-10-26
申请号	US11/336815	申请日	2006-01-23
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
[标]发明人	KIM BYUNG KI IM SEUNG JAE CHOI JAE YOUNG KANG YOON SOK YOON SEON MI CHO JAE HEE		
发明人	KIM, BYUNG-KI IM, SEUNG-JAE CHOI, JAE-YOUNG KANG, YOON-SOK YOON, SEON-MI CHO, JAE-HEE		
IPC分类号	G02F1/1335		
CPC分类号	B82Y20/00 G02B6/0068 G02F1/133603 G02F2202/36 G02F2202/102 G02F2202/106 G02F2202/107 G02F1/133617		
优先权	1020050032738 2005-04-20 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供一种光致发光（PL）液晶显示器（LCD）。 PL LCD包括蓝色背光，红色和绿色磷光体层以及蓝色光致发光纳米点（ND）层。 PL LCD改善了窄视角和方向的传统问题。 PL LCD还包括阻挡环境光中包含的UV的紫外（UV）滤光器，从而防止由于外部光引起的发光层的激发和由于不必要的光发射导致的对比度的降低。