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(54) **ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE**

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Sep. 17, 2018 (KR) 10-2018-0110904

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H01L 27/32 (2006.01)
H01L 51/52 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 27/3213*** (2013.01); ***H01L 27/322*** (2013.01); ***H01L 27/3244*** (2013.01); ***H01L 51/5284*** (2013.01)

(58) **Field of Classification Search**
CPC H01L 27/3213; H01L 27/322; H01L 27/3244; H01L 51/5284
See application file for complete search history.

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(57) **ABSTRACT**

An organic light emitting diode (OLED) display device includes an OLED with a plurality of sub-pixels. A first portion of light-absorption filter layer is between the OLED and an emission surface at locations corresponding to selected sub-pixel locations. The first portion of light-absorption filter layer includes a first light-absorption dye and a second light-absorption dye such that the first portion has a light transmittance curve that has a first valley between 470 nm and 550 nm and has a second valley between 570 nm and 620 nm. At the selected sub-pixel locations, there is a color filter between the OLED and the light-absorption filter.

18 Claims, 10 Drawing Sheets

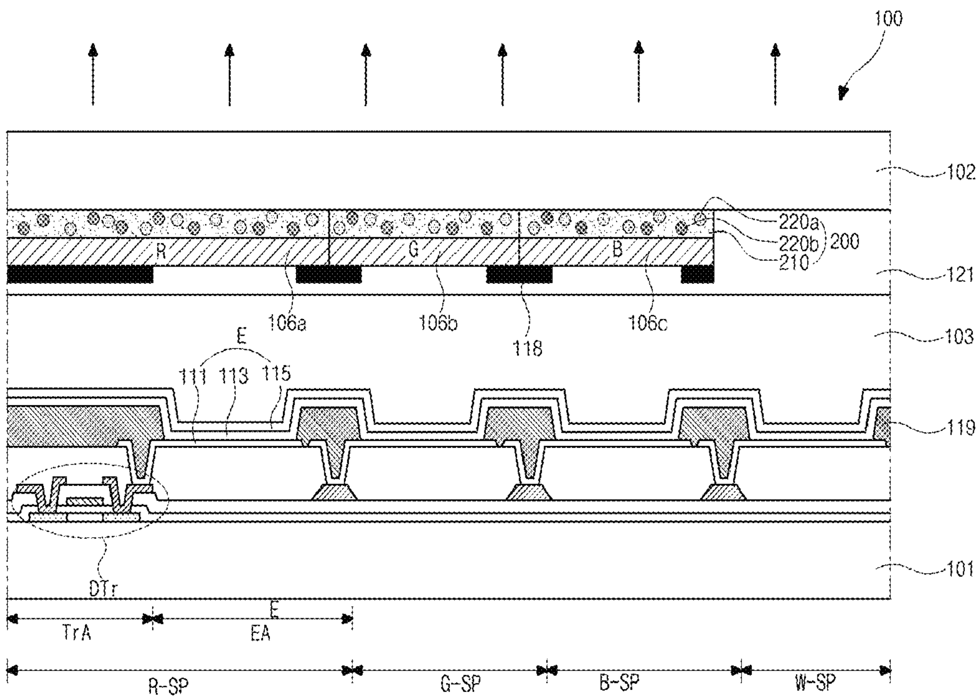
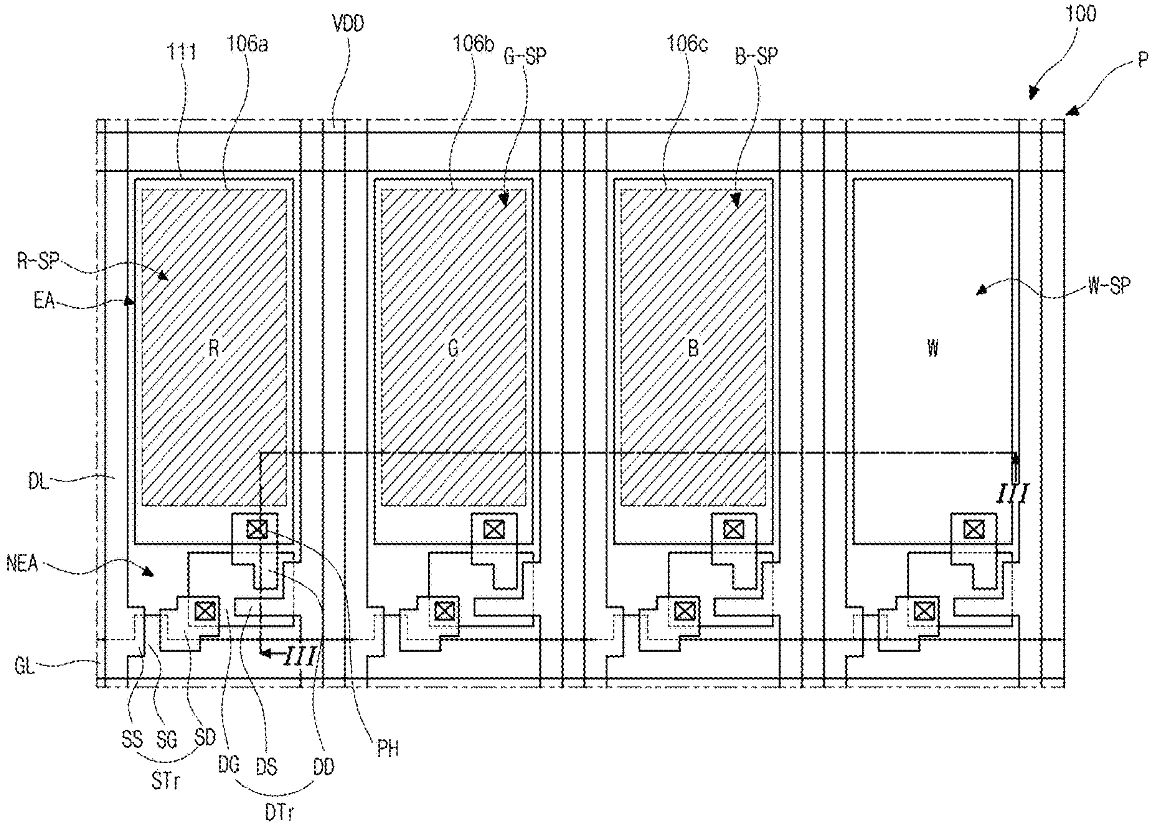


FIG. 1


111
106a
VDD
106b
G-SP
106c
B-SP
100
P
R-SP
EA
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G
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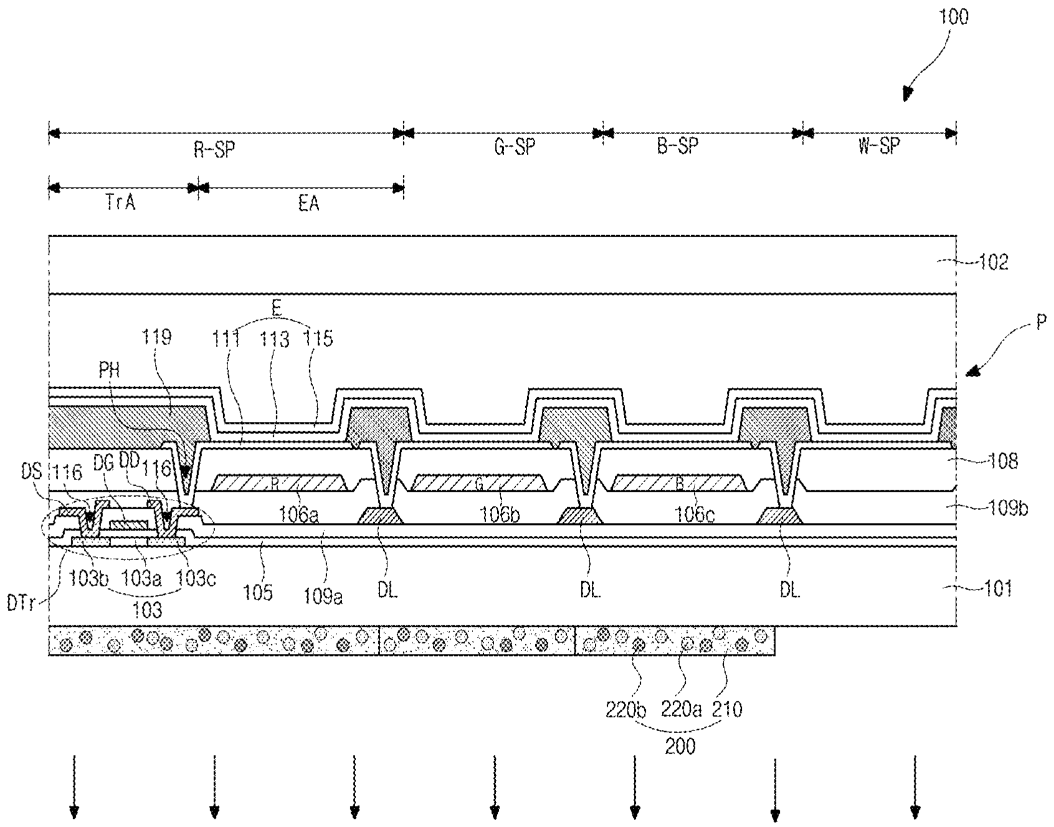
W
W-SP
DL
III
NEA
III
GL
SS
SG
SD
STr
DG
DS
DD
DTr
PH

FIG. 2


100
R-SP
G-SP
B-SP
W-SP
TrA
EA
102
P
E
119
111
113
115
PH
108
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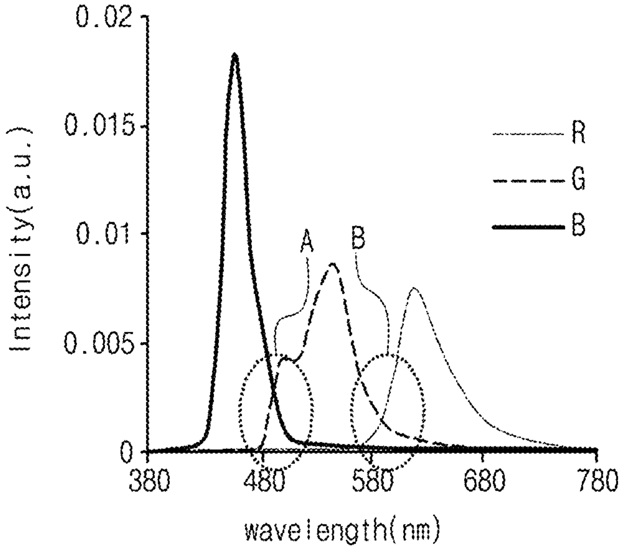
116
DG
DD
116
106a
106b
106c
109b
103b
103a
103c
103
DTr
105
109a
DL
DL
DL
101
220b
220a
210
200

FIG. 3A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0.015
0.01
0.005
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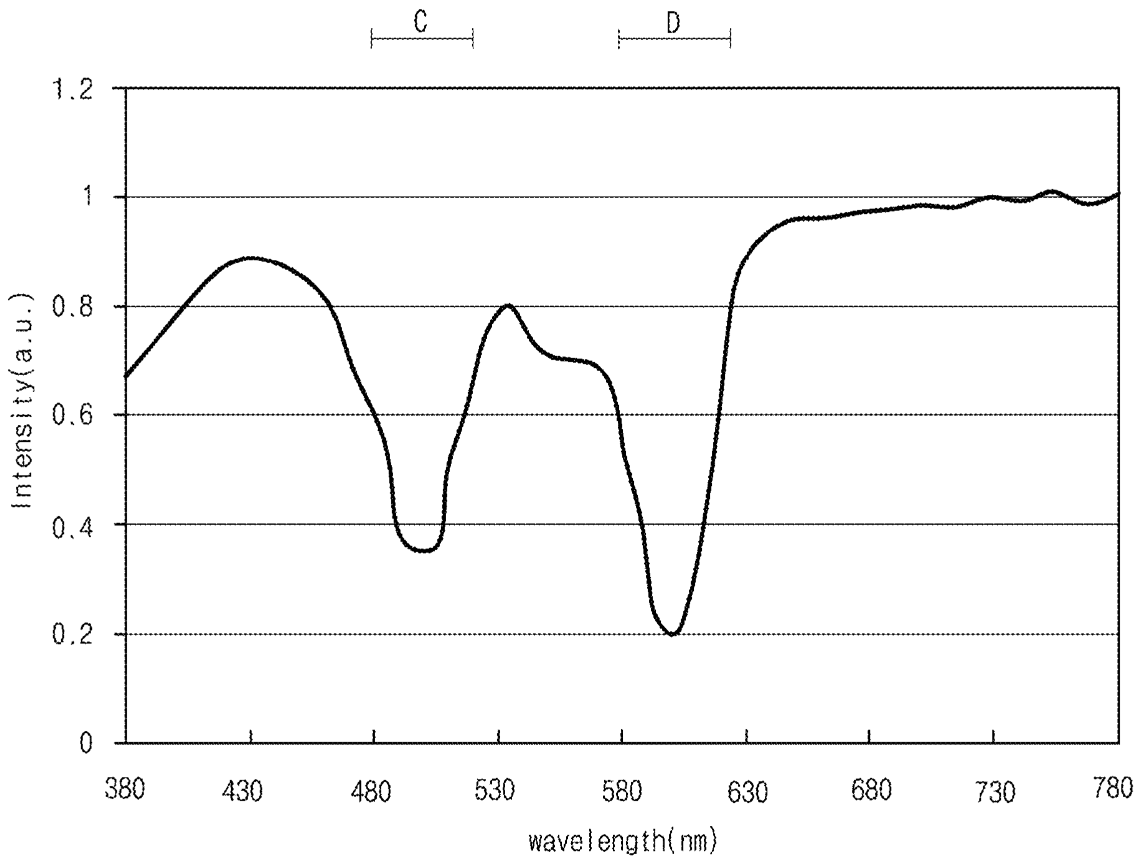
Intensity(a.u.)
R
G
B
A
B
380
480
580
680
780
wavelength(nm)

FIG. 3B


C
D
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530
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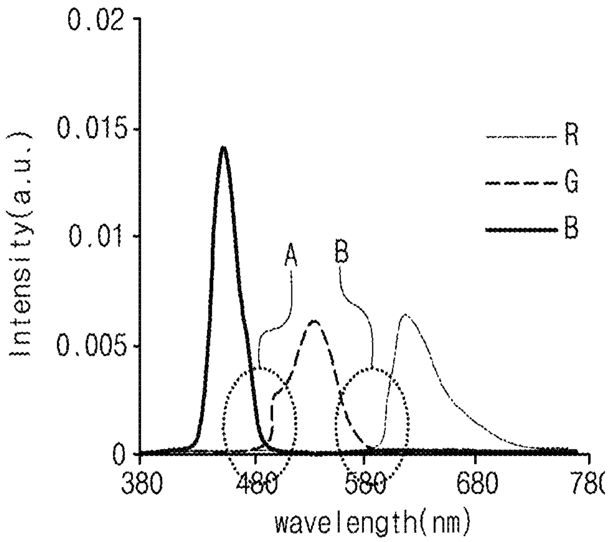
630
680
730
780
wavelength(nm)

FIG. 3C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0.01
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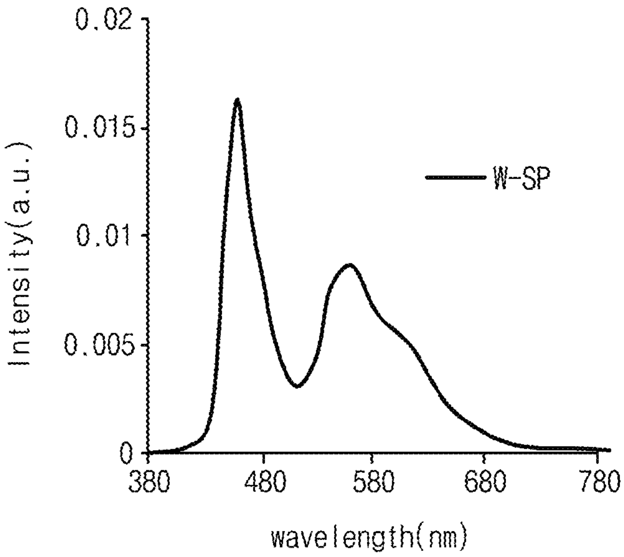
Intensity(a.u.)
R
G
B
A
B
380
480
580
680
780
wavelength(nm)

FIG. 4A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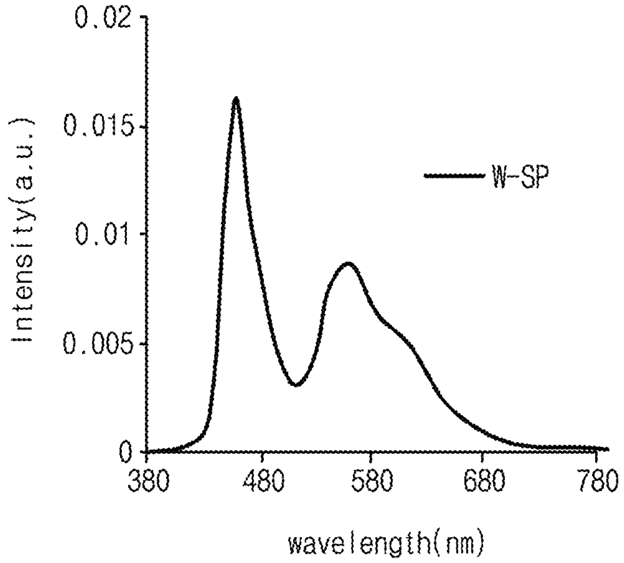
380
480
580
680
780
wavelength(nm)

FIG. 4B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Intensity(a.u.)
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480
580
680
780
wavelength(nm)

FIG. 5

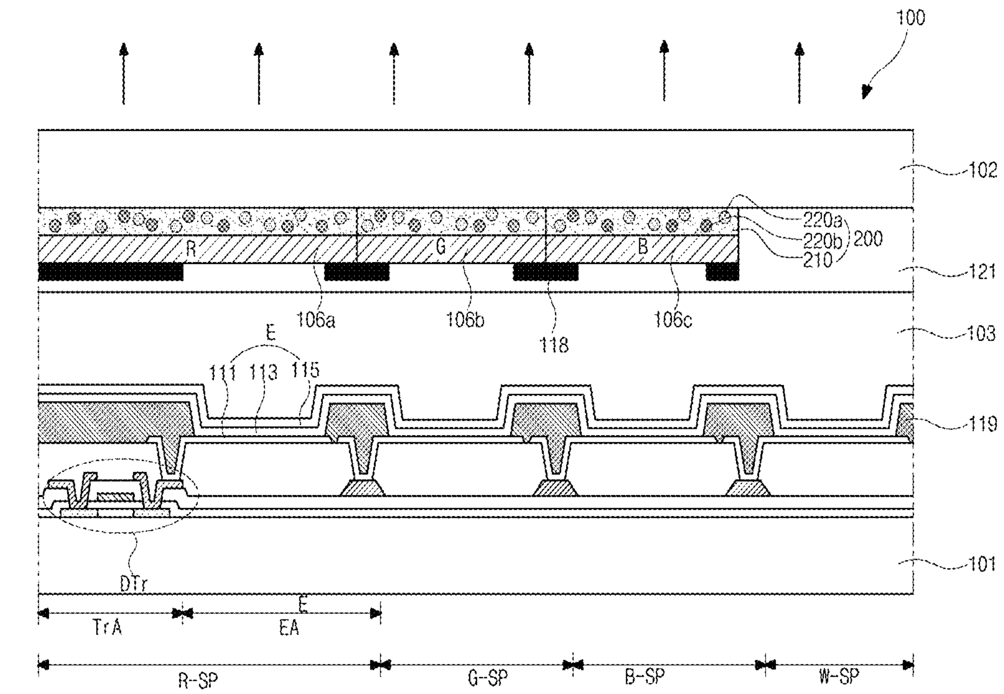

100
102
220a
220b
200
210
121
R
G
B
106a
106b
118
106c
103
E
111
113
115
119
DTr
101
E
TrA
EA
R-SP
G-SP
B-SP
W-SP

FIG. 6

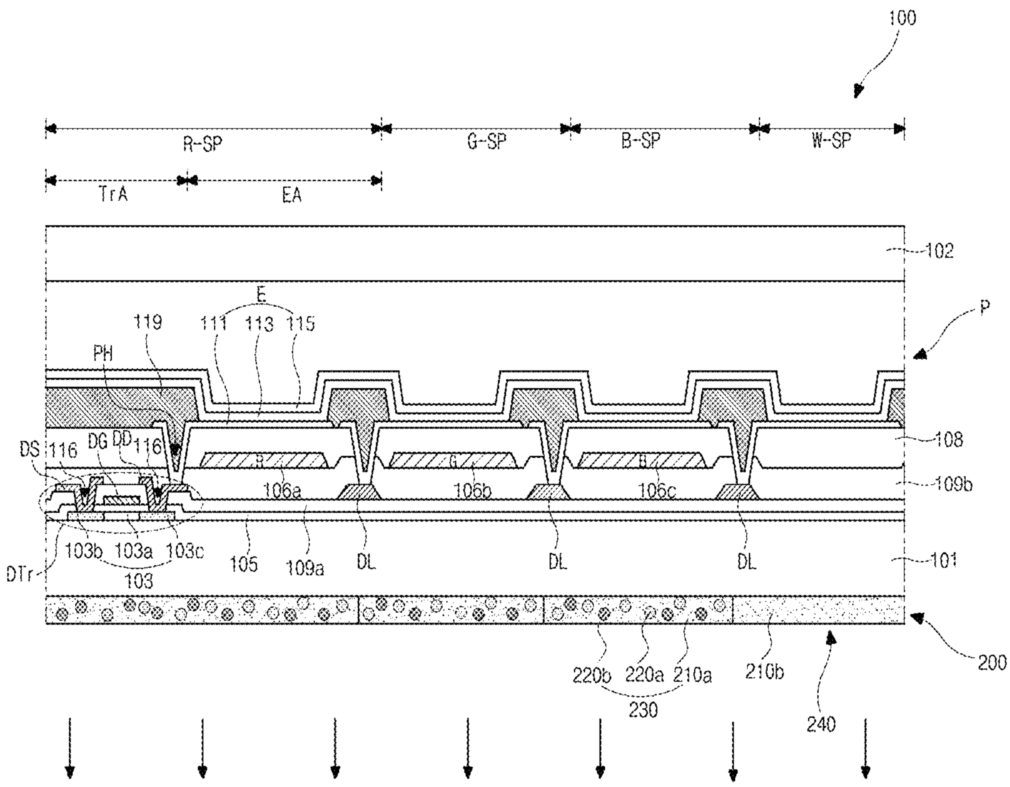
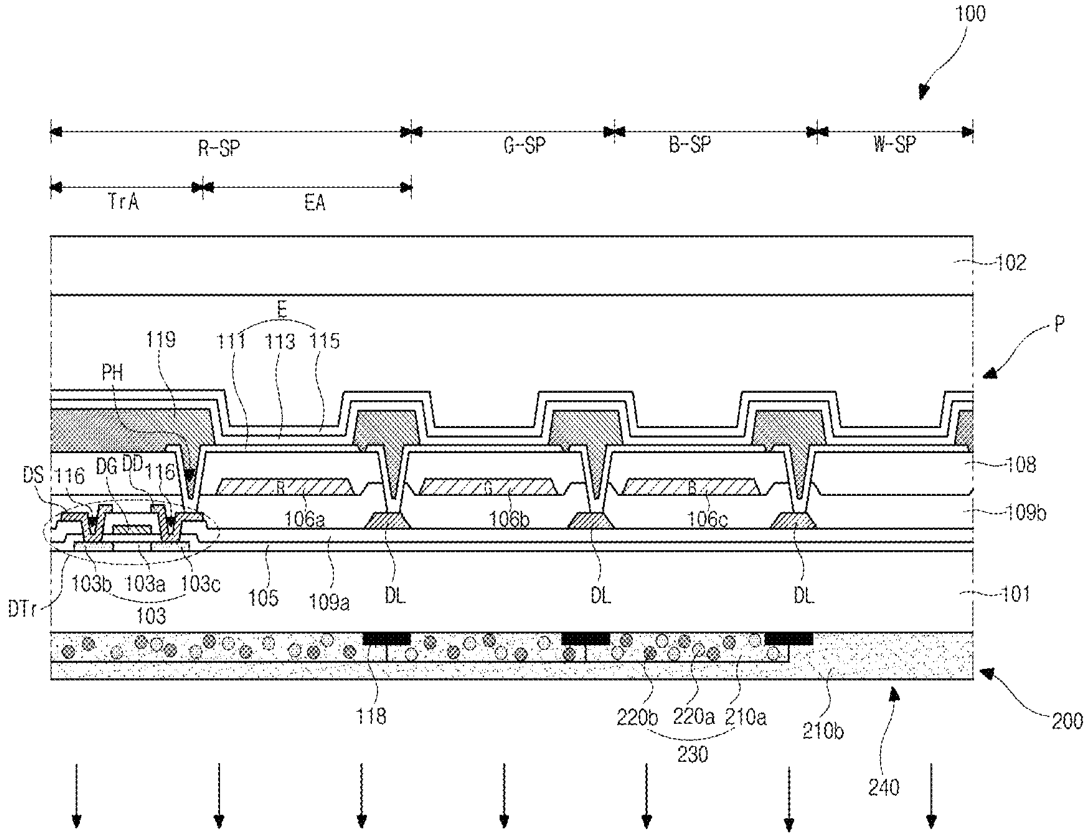

100
R-SP
G-SP
B-SP
W-SP
TrA
EA
102
E
P
119
111
113
115
PH
108
DS
116
DG
DD
116
R
G
B
106a
106b
106c
109b
103b
103a
103c
105
109a
DL
DL
DL
101
DTr
103
220b
220a
210a
210b
200
230
240

FIG. 7


100
R-SP
G-SP
B-SP
W-SP
TrA
EA
102
E
P
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111
113
115
PH
108
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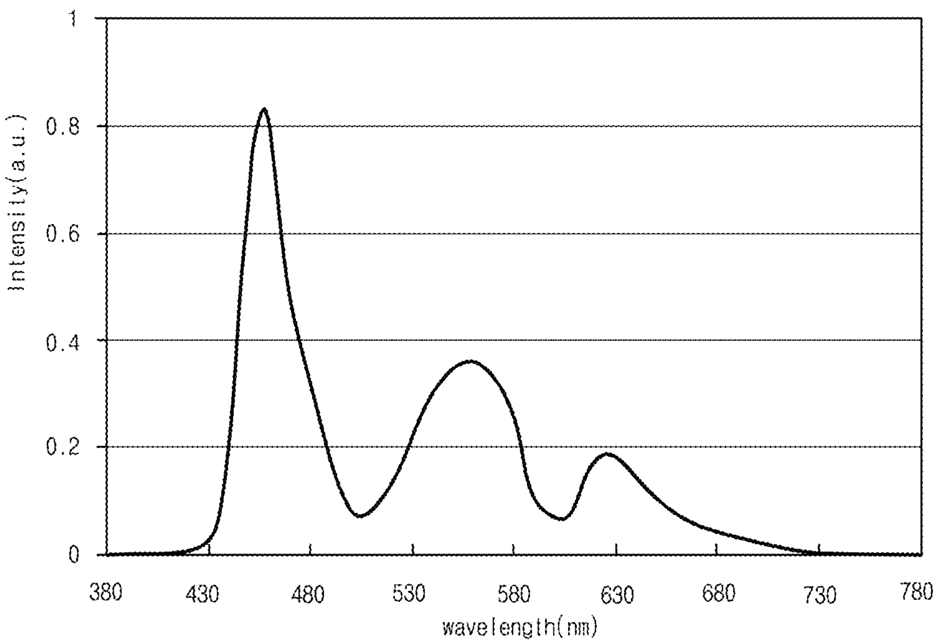
116
DG
DD
116
R
G
B
106a
106b
106c
109b
103b
103a
103c
105
109a
DL
DL
DL
101
DTr
103
118
220b
220a
210a
210b
230
240
200

FIG. 8


Intensity(a.u.)
1
0.8
0.6
0.4
0.2
0
380
430
480
530
580
630
680
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780
wavelength(nm)

FIG. 9A

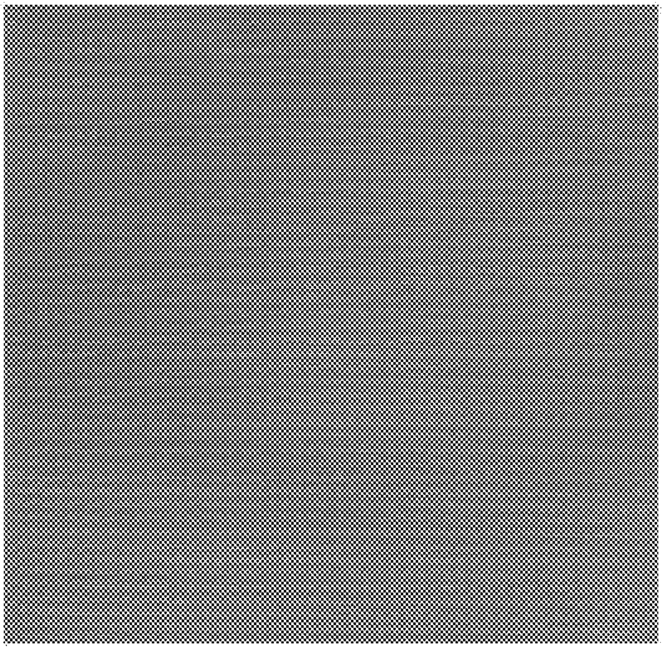


FIG. 9B

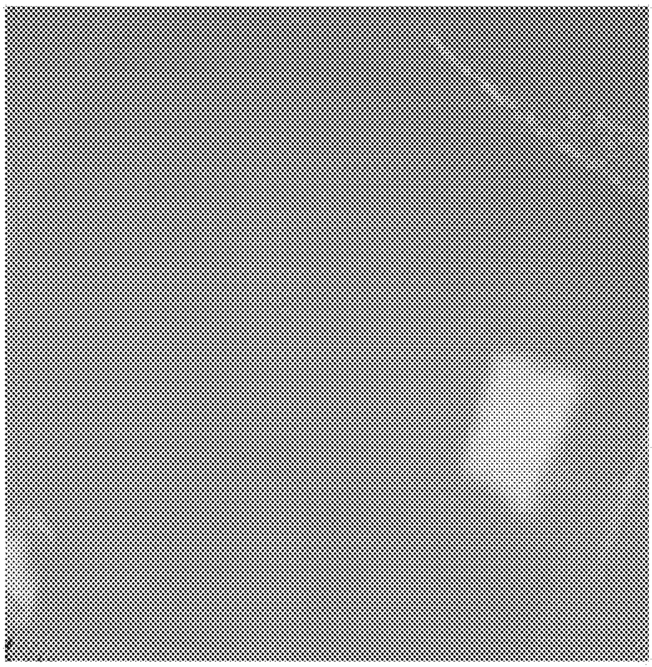


FIG. 10A

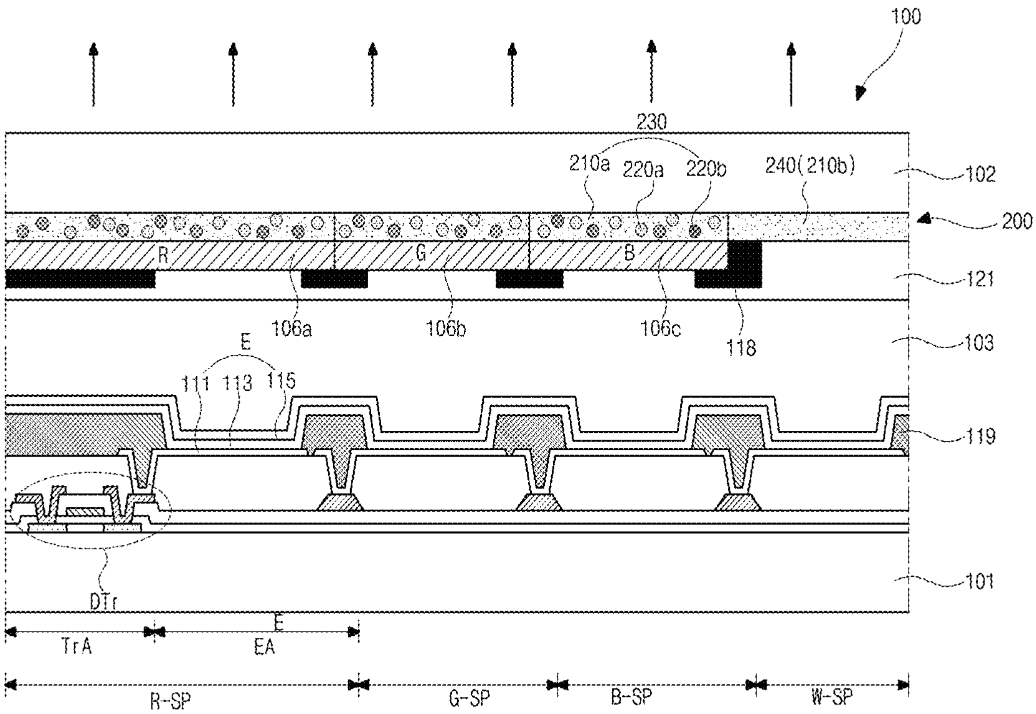


FIG. 10B

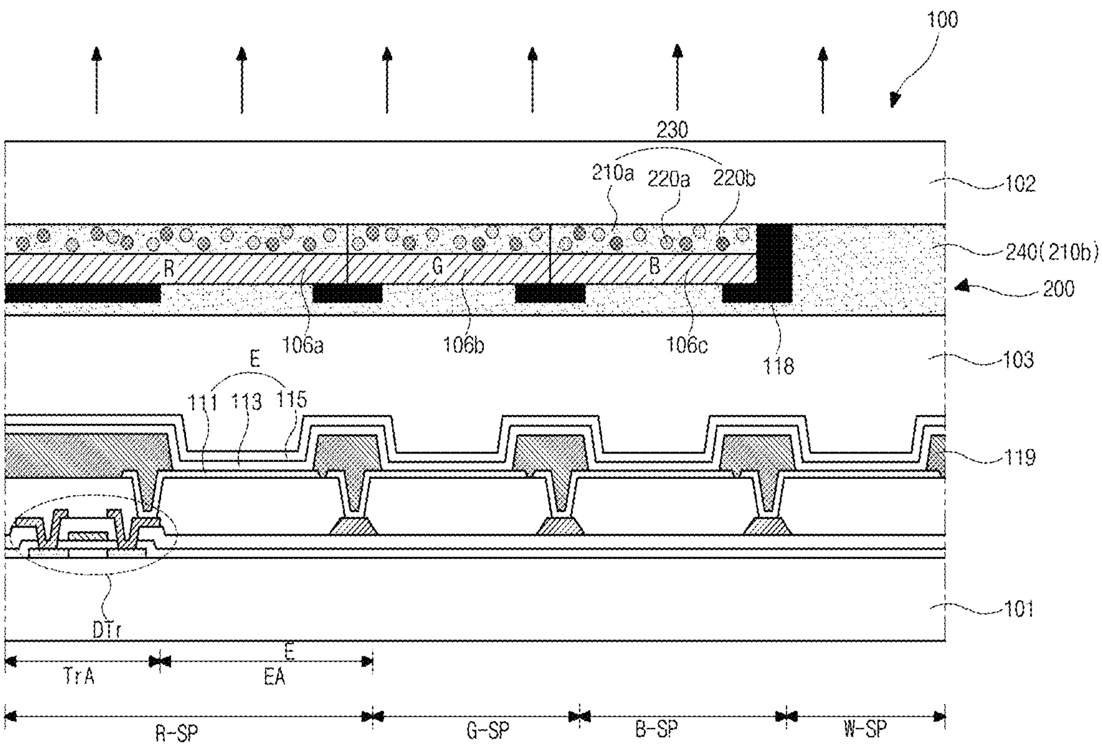
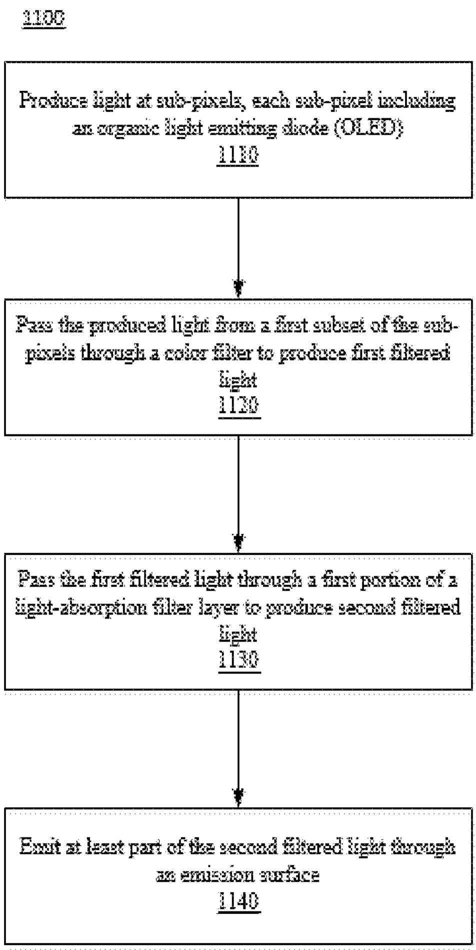


FIG. 11


1100
Produce light at sub-pixels, each sub-pixel including an organic light emitting diode (OLED)
1110
Pass the produced light from a first subset of the sub-pixels through a color filter to produce first filtered light
1120
Pass the first filtered light through a first portion of a light-absorption filter layer to produce second filtered light
1130
Emit at least part of the second filtered light through an emission surface
1140

ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the priority from and the benefit of Republic of Korea Patent Application Nos. 10-2017-0169326 and 10-2018-0110904 filed in Republic of Korea on Dec. 11, 2017 and Sep. 17, 2018, respectively, which are hereby incorporated by reference in its entirety.

BACKGROUND

Technical Field

The present disclosure relates to an organic light emitting diode display (OLED), and particularly, to an OLED that can improve a color reproduction range.

Discussion of the Related Art

With the advent of the information society, information display devices for processing and displaying a large amount of information have been drawing interest, including for application in portable information devices. Accordingly, various types of flat display devices of lightweight and thin profile have been developed and spotlighted.

For example, the types of flat display devices include a liquid crystal display device (LCD), a plasma display panel device (PDP), a field emission display device (FED), an electroluminescent display device (ELD), and an organic light emitting diode display device (OLED). These flat display devices have advantages of thin profile, lightweight, low power consumption, and the like, and therefore have replaced cathode ray tube (CRT) devices rapidly.

Among the flat display devices, the OLED is a self-luminescent device. As such, it can be lightweight and have a thin profile because it does not require a backlight used, for example, to supply light in the LCD.

Further, compared with the LCD, the OLED has advantages of an excellent viewing angle and contrast ratio, low power consumption, operation in low DC voltage, a fast response speed, being equipped to withstand an external impact because of its solid internal components, and a wide operating temperature range.

In addition, since processes of manufacturing the OLED are relatively simple, a production cost of the OLED can be reduced in comparison with that of the LCD.

The OLED includes a unit pixel having red, green and blue sub-pixels, and the red, green and blue sub-pixels include organic light emitting layers emitting red, green and blue lights, respectively. The OLED displays an image by a mixture of the color lights from the red, green and blue sub-pixels.

Since the red, green and blue organic light emitting layers are made of different materials, they have different properties. Accordingly, the red, green and blue sub-pixels have different light emission efficiencies and different lifetimes.

To solve this problems, an OLED using color filters have been suggested.

In this OLED, red, green and blue sub-pixels each include an organic light emitting layer emitting a white light, and include red, green and blue color filters, respectively. Accordingly, a white light from each of the red, green and blue sub-pixels passes through each of the red, green and blue color filters and be output as each red, green and blue

lights, and thus an image is displayed through a combination of the red, green and blue lights.

However, the OLED using the red, green and blue color filters has a problem of low color reproduction range.

In this regard, a white light produced from a backlight unit of an LCD and a white light produced from an organic light emitting diode are different in peak positions and band widths of red, green and blue lights. Thus, red, green and blue color filters optimized for a white light from the backlight unit of the LCD reduces a color reproduction range of the OLED.

SUMMARY

Accordingly, the present disclosure is directed to an OLED that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An aspect of the present disclosure is to provide an OLED that can improve a color reproduction range and a light efficiency.

Additional features and aspects will be set forth in the description that follows, and in part will be apparent from the description, or may be learned by practice of the inventive concepts provided herein. Other features and aspects of the inventive concepts may be realized and attained by the structure particularly pointed out in the written description, or derivable therefrom, and the claims hereof as well as the appended drawings.

To achieve these and other advantages, and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, a display device includes an organic light emitting diode (OLED) with a first electrode common to at least a subset of sub-pixels, second electrodes individually connected to each of the sub-pixels, and an organic light emitting layer between the first electrode and the second electrodes. The display device has a first portion of light-absorption filter layer between the OLED and the emission surface in a subset of sub-pixels, where the first portion has a first valley covering at least a wavelength range of 470 nm to 550 nm, and a second valley covering at least a wavelength range of 570 nm to 620 nm. The display device includes a color filter between the OLED and the first portion of the light-absorption filter layer in the subset of sub-pixels.

To achieve these and other advantages, and in accordance with the purpose of the present disclosure, as embodied and broadly described herein, a method of operating a display device includes producing light at sub-pixels, each of the sub-pixels including an organic light emitting diode (OLED). The produced light from a subset of the sub-pixels is passed through color filters to produce first filtered light. The first filtered light is passed through a first portion of a light-absorption filter layer having a light transmittance curve that has a first valley covering at least a wavelength range of 470 nm to 550 nm, and a second valley covering at least a wavelength range of 570 nm to 620 nm to produce second filtered light. At least a part of the second filtered light through an emission surface of the display device is emitted through an emission surface of the display device.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory, and are intended to provide further explanation of the inventive concepts as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain various principles of the disclosure. In the drawings:

FIG. **1** is a plan view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a first embodiment of the present disclosure;

FIG. **2** is a cross-sectional view taken along a line of FIG. **1**;

FIG. **3**A is a graph showing transmission spectrums of red, green and blue lights transmitted through red, green and blue sub-pixels;

FIG. **3**B is a graph showing a light transmission spectrum for a light-absorption filter layer;

FIG. **3**C is a graph showing transmission spectrums of lights transmitted through an OLED **100** according to a first embodiment of the present disclosure;

FIG. **4**A is a graph showing a spectrum of a white light passing through a white sub-pixel in an OLED including no light-absorption filter layer;

FIG. **4**B is a graph showing a spectrum of a white light passing through a white sub-pixel in an OLED including a light-absorption filter layer according to a first embodiment of the present disclosure;

FIG. **5** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a second embodiment of the present disclosure;

FIG. **6** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a third embodiment of the present disclosure;

FIG. **7** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a fourth embodiment of the present disclosure;

FIG. **8** is a graph showing a light transmission spectrum for an OLED according to a fourth embodiment of the present disclosure;

FIG. **9**A is a picture showing a moire phenomenon;

FIG. **9**B is a picture showing improvement of a moire phenomenon by an OLED according to a fourth embodiment of the present disclosure; and

FIGS. **10**A and **10**B are cross-sectional views illustrating a structure of a unit pixel including four sub-pixels in each of OLEDs according to a fifth embodiment of the present disclosure.

FIG. **11** is a flowchart showing a method of operating an OLED display device, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. The same or like reference numbers may be used throughout the drawings to refer to the same or like parts.

First Embodiment

FIG. **1** is a plan view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a first embodiment of the present disclosure. FIG. **2** is a cross-sectional view taken along a line II-II of FIG. **1**.

The OLED **100** may be a top emission type display device or bottom emission type display device according to a transmission direction (or output direction) of an emitted light. A bottom emission type OLED **100** is described by way of example.

As illustrated in FIGS. **1** and **2**, a unit pixel P of the OLED **100** may include red, green, blue and white sub-pixels R-SP, G-SP, B-SP and W-SP. Each sub-pixel may include an emission region EA, and a bank **119** may be located along a peripheral portion of the emission region EA. A non-emission region NEA may be defined at the bank **119**.

For the purpose of explanations, the four sub-pixels R-SP, G-SP, and B-SP arranged in parallel with the same width are shown by way of example. However, the sub-pixels R-SP, G-SP, and B-SP may have different configurations with different widths.

A switching thin film transistor (TFT) STr and a driving TFT DTr may be formed at the non-emission region NEA of each sub-pixel. At the emission region EA of each sub-pixel, a light emitting diode E including a first electrode **111**, an organic light emitting layer **113**, and a second electrode **115** may be formed.

The emission regions EA of the red, green, blue and white sub-pixels R-SP, G-SP, B-SP and W-SP emits red, green, blue and white lights, respectively. To do this, red, green and blue color filters **106***a*, **106***b* and **106***c* are located at the emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP, respectively, and at the white sub-pixel W-SP, a white light emitted from the organic light emitting layer **113** is transmitted.

The switching TFT STr and the driving TFT DTr may be connected to each other, and the driving TFT DTr may be connected to the light emitting diode E.

A gate line SL, a data line DL, and a power line VDD may be arranged on a substrate **101** to define each of the sub-pixels R-SP, G-SP, B-SP and W-SP.

The switching TFT STr may be formed at the crossing portion of the gate line GL and the data line DL, and may function to select the corresponding sub-pixel.

The switching TFT STr may include a gate electrode SG branching off from the gate line SL, a semiconductor layer, a source electrode SS, and a drain electrode SD.

The driving TFT DTr may function to operate the light emitting diode E of the sub-pixel selected by the corresponding switching TFT STr. The driving TFT DTr may include a gate electrode DG connected to the drain electrode SD of the switching TFT STr, a semiconductor layer **103**, a source electrode DS connected to the power line VDD, and a drain electrode DD.

The drain electrode DD of the driving TFT DTr may be connected to the first electrode **111** of the light emitting diode E.

The organic light emitting layer **113** may be interposed between the first and second electrodes **111** and **115**.

The semiconductor layer **103** may be located at a switching region TrA of each sub-pixel. The semiconductor layer **103** may be made of silicon, and may include an active region **103***a* as a channel at a center portion thereof, and source and drain regions **103***b* and **103***c*, highly doped with impurities, at both sides of the active region **103***a*.

A gate insulating layer **105** may be formed on the semiconductor layer **103**.

The gate electrode DG may be formed on the gate insulating layer **105** corresponding to the active region **103***a*. The gate line GL extending along a direction may be formed on the gate insulating layer **103**.

A first inter-layered insulating layer **109***a* may be located on the gate electrode DG and the gate line GL. The first inter-layered insulating layer **109***a* and the gate insulating layer **105** may include first and second semiconductor contact holes **116** exposing the source and drain regions **103***b* and **103***c*, respectively.

The source and drain electrodes DS and DD may be formed on the first inter-layered insulating layer **109***a* and be spaced apart from each other. The source and drain electrodes DS and DD may contact the source and drain regions **103***b* and **103***c* through the first and second semiconductor contact holes **116**, respectively.

A second inter-layered insulating layer **109***b* may be formed on the source and drain electrodes DS and DD, and the first inter-layered insulating layer **109***a*.

The source and drain electrodes DS and DD, the semiconductor layer **103**, and the gate electrode DG, and the gate insulating layer **105** on the semiconductor layer **103** may form the driving TFT DTr.

Even though not shown in FIG. **2**, the switching TFT STr may have substantially the same structure as the driving TFT DTr.

The driving TFT DTr having a top gate structure with the semiconductor layer **103** formed as a polycrystalline silicon layer or oxide semiconductor layer is described by way of example. Alternatively, the driving TFT DTr and the switching TFT STr may have a bottom gate structure with the semiconductor layer **103** formed as an amorphous silicon layer.

If the semiconductor layer **103** uses an oxide semiconductor layer, a light shielding layer may be formed below the semiconductor layer **103**, and a buffer layer may be formed between the light shielding layer and the semiconductor layer **103**.

The color filters **106***a*, **106***b* and **106***c* may be formed on the second inter-layered insulating layer **109***b* corresponding to the respective emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP.

The color filters **106***a*, **106***b* and **106***c* function to convert a white light emitted from the respective organic light emitting layers **113**. The red, green and blue color filters **106***a*, **106***b* and **106***c* are located at the emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP, respectively.

At the emission region EA of the white sub-pixel W-SP, no color filter is formed, and a white light from the organic light emitting layer **113** is intactly transmitted.

Accordingly, in the OLED **100**, the red, green, blue and white sub-pixels R-SP, G-SP, B-SP and W-SP emit red, green, blue and white colors so that a full color image of high brightness can be achieved.

An overcoat layer **108** may be formed on the color filters **106***a*, **106***b* and **106***c*. The overcoat layer **108** and the second inter-layered insulating layer **109***b* may have a drain contact hole PH exposing the drain electrode DD of the driving TFT DTr.

The first electrode **111** is formed on the overcoat layer **108**. The first electrode **111** is connected to the drain electrode DD of the driving TFT DTr through the drain contact hole PH. The first electrode **111** may be made of a material having a relatively high work function and serve as an anode.

The first electrode **111** may be made of a metal oxide material, for example, ITO, IZO or the like.

Each first electrode **111** may be patterned by each sub-pixel and be formed in each sub-pixel. The bank **119** may be located between the neighboring first electrodes **111**. The first electrodes **111** may be separated from each other with the bank **119** as a boundary of each sub-pixel.

The bank **119** may be located between the neighboring first electrodes **111** and may separate the neighboring first electrodes **111** from each other.

The organic light emitting layer **113** may be formed on the first electrode **111**. The organic light emitting layer **113** may be configured with a single layer made of an emitting material. Alternatively, to increase an emission efficiency, the organic light emitting layer **113** may be configured with multiple layers that may include a hole injection layer, a hole transport layer, an emitting material layer, an electron transport layer, and an electron injection layer.

The second electrode **115** may be formed entirely on the organic light emitting layer **113**. The second electrode **115** may serve as a cathode.

The second electrode **115** may be made of a material having a relatively low work function. The second electrode **115** may be formed with a single layer or multiple layers using a first metal such as Ag and a second metal such as Mg, and the single layer may be made of an alloy of the first and second metals at a predetermined ratio thereof.

In the OLED **100**, when predetermined voltages are applied to the first electrode **111** and the second electrode **115**, holes injected from the first electrode **111** and electrons injected from the second electrode **115** are transported to the organic light emitting layer **113** to form excitons. When the excitons are transitioned from an excited state to a ground state, light is generated and emitted in the form of visible light.

As the OLED **100** of this embodiment is a bottom emission type display device. In this case, the second electrode **115** may further include a reflective layer (not shown) made of an opaque conductive material. For example, the reflective layer may be made of an aluminum-palladium-copper (APC) alloy, and the second electrode **115** may have a triple-layered structure of, for example, ITO/APC/ITO. Further, the first electrode **111** may have a thin thickness to transmit a light, and in this case, a light transmittance of the first electrode **111** may be about 45% to 50%.

The protective film **102** in the form of a thin film may be formed on the second electrode **115**, and the OLED **100** may be encapsulated by the protective film **102**.

The protective film **102** may be formed with at least two inorganic protective films to prevent or reduce external oxygen or moisture from permeating inside the OLED **100**. In this case, the protective film **102** may further include an organic protective film between two inorganic protective films to supplement an impact resistance of the inorganic protective films.

In the structure that the organic protective film and the inorganic protective film are alternately stacked, in order to prevent an moisture or oxygen from permeating through a side surface of the organic protective film, the inorganic protective film may be formed to fully enclose the organic protective film.

Accordingly, an external moisture or oxygen can be prevented from permeating inside the OLED **100**.

In the OLED **100** of this embodiment, a light-absorption filter layer **200** may be further formed on an outer side of the substrate **101**.

The light-absorption filter layer **200** may include first light-absorption dyes **220***a* and second light-absorption dyes **220***b* in a transparent resin **210**. The first light-absorption dye **220***a* may has an absorption wavelength range of about 470 nm to 550 nm, and preferably, an absorption wavelength range of about 490 nm. The second light-absorption dye **220***b* may has an absorption wavelength range of about 570 nm to 620 nm, and preferably, an absorption wavelength range of about 590 nm.

The transparent resin **210** may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The first light-absorption dye **220***a* may be formed of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, or boron dipyrromethene (BODIBY) based light-absorption dye. The second light-absorption dye **220***b* may be formed of tetra aza porphyrin (TAP) based light-absorption dye, squarine (SQ) based light-absorption dye, or cyanine (CY) based light-absorption dye. Each of the first and second light-absorption dyes **220***a* and **220***b* may preferably use a combination of at least two selected from a group consisting of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye, and more preferably use a combination of cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye.

The light-absorption filter layer **200** may correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP except for the white sub-pixel W-SP and be located on a transmission direction of lights which pass through the color filters **106***a*, **106***b* and **106***c*. Thus, the light-absorption filter layer **200** does not influence the white sub-pixel W-SP which much influences a brightness of the OLED **100**, and improves a color reproduction range of lights emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP. In the example shown in FIG. **2**, lights emitted from the red, green, and blue sub-pixels R-SP, G-SP, and B-SP are emitted through an emission surface on the light-absorption filter layer **200** while light emitted from the white sub-pixel W-SP is emitted through an emission surface on the substrate **101**.

Accordingly, the OLED **100** of this embodiment can achieve a high brightness without loss of light and improve a color reproduction range, and thus can satisfy 80% or more for BT. 2020.

This refers to FIG. **3**A that is a graph showing transmission spectrums of red, green and blue lights which are transmitted through red, green and blue sub-pixels. Lights transmitted at the red, green and blue sub-pixels R-SP, G-SP and B-SP passes through the red, green and blue color filters **106***a*, **106***b* and **106***c*, respectively. Accordingly, a blue light having a wavelength region of about 380 nm to 560 nm is emitted from the blue sub-pixel B-SP, a green light having a wavelength region of about 460 nm to 6300 nm is emitted from the green sub-pixel B-SP, and a red light having a wavelength region of about 580 nm to 780 nm is emitted from the red sub-pixel R-SP.

A color mixing region where two colors are simultaneously transmitted exists between transmission spectrums of the red, green and blue lights. Thus, the red, green and blue lights include a wavelength region where they overlaps each other.

For example, a first color mixing region A where the blue light and the green light all are transmitted exists at a range of about 470 nm to 550 nm, and thus the blue light transmitted at the blue sub-pixel B-SP may not be a pure blue light but be recognized as a blue light mixed with a green light. This phenomenon also happens to a second color mixing region B between the green light and the blue light. As a result, the OLED **100** may have a disadvantage of a low color reproduction range for emitted colors.

FIG. **3**B is a graph showing a light transmission spectrum for the light-absorption filter layer **200**. Referring to FIG. **3**B, it is seen that a transmittance of a light passing through the light-absorption filter layer **200** is reduced at a first valley C and a second valley D.

The first valley C covers a wavelength range of about 470 nm to 550 nm, and a light of the wavelength range of 470 nm to 550 nm may be absorbed by the first light-absorption dyes **220***a* contained in the light-absorption filter layer **200**. The second valley Ds covers a wavelength range of about 570 nm to 620 nm, and a light of the wavelength range of 570 nm to 620 nm may be absorbed by the second light-absorption dyes **220***b* contained in the light-absorption filter layer **200**. Thus, a transmittance of the wavelength range corresponding to the first and second valleys C and D is reduced.

As described above, in this embodiment, the light-absorption filter layer **200** is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP and be on the traveling direction of lights passing through the color filters **106***a*, **106***b* and **106***c* of the sub-pixels R-SP, G-SP and B-SP. Accordingly, referring to FIG. **3**C which is a graph showing transmission spectrums of lights transmitted through the OLED **100**, it is seen that red, green and blue lights output from the red, green and blue sub-pixels R-SP, G-SP and B-SP do not exist at the first and second color mixing regions A and B.

In other words, it is seen that the first color mixing region A generated in a range of about 470 nm to 550 nm between the blue light and the green light, and the second color mixing region B generated in a range of about 570 nm to 620 nm between the green light and the red light are removed.

This means that, due to a light-absorption property of the light-absorption filter layer **200**, a pure blue light not mixed with a green light is output from the blue sub-pixel B-SP, a pure red light not mixed with a green light is output from the red sub-pixel R-SP, and a pure green light not mixed with a blue light and a red light is output from the green sub-pixel G-SP.

As described above, in this embodiment, the light-absorption filter layer **200** is used. Accordingly, a pure red light is output from the red sub-pixel R-SP, a pure green light is output from the green sub-pixel G-SP, and a pure blue light is output from the blue sub-pixel B-SP. Thus, color reproduction range of lights passing through the red, green and blue sub-pixels R-SP, G-SP and B-SP can be improved.

Therefore, the OLED **100** of this embodiment can achieve 80% or more for BT. 2020.

Prior to improvement of a color reproduction range in experimental results explained below, a color gamut and a color reproduction range (CRR) may be defined or explained below.

The color gamut is to represent physical characteristics relevant to a color expression of a device acquiring, processing or outputting an image as a figure (mostly a triangle) shown on a color coordinate. A representative color gamut is NTSC, BT. 709, sRGB, Adobe RGB, DCI, BT. 2020 or the like.

In this embodiment, a color reproduction range is explained based on BT. 2020 used for a color reproduction range of a next-generation display device. BT. 2020 is a standard of 4K/UHD advised by ITU, and has a color reproduction region much broader than NTSC, Adobe RGB, DCI and sRGB.

A value that is a ratio (%) of a color gamut area relative to a reference color gamut area may be referred to as a color reproduction range. In this embodiment, a color reproduction range is expressed as an overlapping ratio (%) instead of a ratio (%) of a relative color gamut area, and the overlapping ratio (%) means a ratio (%) of a color gamut area overlapping a reference color gamut area.

The OLED **100** of this embodiment includes the light-absorption filter layer **200** located on the traveling direction of lights passing through the color filters **106***a*, **106***b* and **106***c*. Accordingly, a color reproduction range can be improved and the OLED **100** can satisfy 80% or more for BT. 2020.

TABLE 1

	Color gamut		
	overlapping ratio (%) for BT. 2020	overlapping ratio (%) for DCI	Brightness efficiency (%)
Sample 1	73%	97.8%	100%
Sample 2	80%	99%	99%
Sample 3	90%	99%	75%

Table 1 shows simulation results of measuring overlapping ratios for BT. 2020 of the OLED of this embodiment. Samples 2 and 3 are OLEDs **100** including the light-absorption filter layer **200**, and are different in contents of the first and second absorption dyes **220***a* and **220***b* and have the same configuration.

Sample 1 is an OLED including no light-absorption filter layer **200**.

Referring to Table 1, Sample 2 has a brightness efficiency similar to that of the Sample 1, and satisfies an overlapping ratio of 80% for BT. 2020 compared with Sample 1 merely satisfying an overlapping ratio of 73% for BT. 2020.

As such, since the OLED **100** of this embodiment includes the light-absorption filter layer **200** on the color filters **106***a*, **106***b* and **106***c*, a color reproduction range can be improved and the OLED **100** satisfies 80% or more for BT. 2020 that is a 4K/UHD standard advised by ITU.

Sample 3 satisfies an overlapping ratio of 90% for BT. 2020. As the contents of the first and second light-absorption dyes **220***a* and **220***b* increase, more clear red, green and blue lights can be output from the red, green and blue sub-pixels R-SP, G-SP and B-SP.

However, as the contents of the first and second light-absorption dyes **220***a* and **220***b* increase, an amount of a light absorbed by the first and second light-absorption dyes **220***a* and **220***b* increases and a brightness efficiency is reduced.

In this embodiment, since the light-absorption filter layer **200** is arranged corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-PS except for the white sub-pixel W-SP, a brightness of the OLED **100** may not be much influenced. FIG. **4**A is a graph showing a spectrum of a white light passing through a white sub-pixel in an OLED including no light-absorption filter layer **200**, and FIG. **4**B is a graph showing a spectrum of a white light passing through the white sub-pixel W-SP in the OLED **100** including the light-absorption filter layer **200** according to the first embodiment of the present disclosure.

Referring to FIGS. **4**A and **4**B, the OLED **100** of this embodiment includes the light-absorption filter layer **200** on the traveling direction of the light passing through the color filters **106***a*, **106***b* and **106***c*, and the light-absorption filter layer **200** is not formed to correspond to the white sub-pixel W-SP. Accordingly, a white light from the white sub-pixel W-SP of this embodiment have substantially the same spectrum as a white light from the white sub-pixel of the OLED including no light-absorption filter layer **200**.

The white light from the white sub-pixel W-SP contributes to a brightness of the OLED **100**. Thus, even though the OLED **100** includes the light-absorption filter layer **200** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, a loss of brightness by the white light output from the white sub-pixel W-SP is hardly made.

As described above, the OLED **100** of this embodiment includes the light-absorption filter layer **200** which is located on an output path of lights passing through the color filters **106***a*, **106***b* and **106***c*, and includes the first light-absorption dye **220***a* having a absorption wavelength range of about 470 nm to 550 nm and the second light-absorption dye **220***b* having a absorption wavelength range of about 570 nm to 620 nm. Thus, the OLED **100** can achieve a high brightness without loss of brightness, and can improve a color reproduction range and obtain 80% or greater for BT. 2020.

Even though not shown in the drawings, in case that the OLED **100** is configured as a top emission type display device, the light-absorption filter layer **200** is not located at the outer side of the substrate **101** but is located on the protective film **102** such that the light-absorption filter layer **200** is located on the emission direction of the light passing through the color filters **106***a*, **106***b* and **106***c*. In this case, a white light from the organic light emitting layer **113** passes through the color filter **106***a*, **106***b* or **106***c* and then passes through the light-absorption filter layer **200**.

Further, a polarizing plate may be located on the substrate **101** or protective film **102** at the light output side in order to prevent reduction of a contrast by an external light.

In other words, when the OLED **100** is in a driving mode to display an image, the polarizing plate is formed on the transmission direction of light from the organic light emitting layer **113** and thus a contrast can increase.

The polarizing plate may be a circular polarizing plate to prevent an external light, and include a phase retardation plate and a linear polarizing plate. The phase retardation plate and the linear polarizing plate may be stacked such that the linear polarizing plate is located close to an incident side of an external light and the phase retardation plate is located at the inside of the linear polarizing plate.

The light-absorption filter layer **200** may be located on an outer surface of the substrate **101** or protective film **102**, and the polarizing plate may be located on an outer surface of the light-absorption filter layer **200**. Alternatively, the polarizing plate may be located on the substrate **101** or protective film **102**, and the light-absorption filter layer **200** may be located on an outer surface of the polarizing plate.

The light-absorption filter layer **200** may be included as a component in the polarizing plate. For example, the light-absorption filter layer **200** may be located between the linear polarizing plate and the phase retardation plate.

Second Embodiment

FIG. **5** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a second embodiment of the present disclosure.

Explanations of the same or similar parts of the above embodiment may be omitted.

Referring to FIG. **5**, the OLED **100** of this embodiment may include a first substrate **101** on which a driving TFT DTr and a light emitting diode E are formed, and a second substrate **102** facing the first substrate **101**. The first and second substrates **101** and **102** may be coupled to each other using a protective layer **103** having an adhesion property to form the OLED **100**.

On the first substrate **101**, a switching TFT and the driving TFT DTr are formed in each of the sub-pixels R-SP, G-SP, B-SP and W-SP. A first electrode **111** is formed on the driving TFT DTr, an organic light emitting layer **113** is formed on the first electrode **111**, and the second electrode **115** is formed on the organic light emitting layer **113**.

The first and second electrodes **111** and **115**, and the organic light emitting layer **113** forms the light emitting diode E. A bank **119** is located at a boundary of each sub-pixel and separates the sub-pixels R-SP, G-SP, B-SP and W-SP.

On an inner surface of the second substrate **102**, red, green and blue color filters **106***a*, **106***b* and **106***c* may be formed to correspond to the respective sub-pixels R-SP, G-SP and B-SP, and a black matrix **118** surrounding each color filter and corresponding a boundary of each sub-pixel may be formed. A planarization layer **121** may be located on the red, green and blue color filters **106***a*, **106***b* and **106***c* and the black matrix **118**.

The protective layer **103** is interposed between the first and second substrates **101** and **102**. The protective layer **103** may be made of a transparent resin having a adhesion property.

In the OLED **100**, when predetermined voltages are applied to the first electrode **111** and the second electrode **115**, holes injected from the first electrode **111** and electrons injected from the second electrode **115** are transported to the organic light emitting layer **113** to form excitons. When the excitons are transitioned from an excited state to a ground state, light is generated and emitted in the form of visible light.

The OLED **100** of this embodiment may be a top emission type display device in which a light emitted from the organic light emitting layer **113** is output to the outside through the second electrode **115**. In this case, a light from the organic light emitting layer **113** of the red sub-pixel R-SP realizes a red light while passing through the red color filter **106***a*. Similarly, a light from the organic light emitting layer **113** of the green sub-pixel G-SP realizes a green light while passing through the green color filter **106***b*, and a light from the organic light emitting layer **113** of the blue sub-pixel B-SP realizes a blue light while passing through the blue color filter **106***c*. In the white sub-pixel W-SP, a white light from the organic light emitting layer **113** passes through the planarization layer **121**.

Accordingly, the OLED **100** can display a full color image.

The OLED **100** of this embodiment includes a light-absorption filter layer **200** between the second substrate **102** and the red, green and blue color filters **106***a*, **106***b* and **106***c*.

The light-absorption filter layer **200** may include first light-absorption dyes **220***a* and second light-absorption dyes **220***b* in a transparent resin **210**. The first light-absorption dye **220***a* may has a absorption wavelength range of about 470 nm to 550 nm, and preferably, a absorption wavelength range of about 490 nm. The second light-absorption dye **220***b* may has a absorption wavelength range of about 570 nm to 620 nm, and preferably, a absorption wavelength range of about 590 nm.

The transparent resin **210** may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The first light-absorption dye **220***a* may be formed of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, or boron dipyrromethene (BODIBY) based light-absorption dye. The second light-absorption dye **220***b* may be formed of tetra aza porphyrin (TAP) based light-absorption dye, squarine (SQ) based light-absorption dye, or cyanine (CY) based light-absorption dye. Each of the first and second light-absorption dyes **220***a* and **220***b* may preferably use a combination of at least two selected from a group consisting of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye, and more preferably use a combination of cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye.

The light-absorption filter layer **200** may correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP except for the white sub-pixel W-SP and be located on a transmission direction of lights which pass through the color filters **106***a*, **106***b* and **106***c*. Thus, the light-absorption filter layer **200** does not influence the white sub-pixel W-SP which much influences a brightness of the OLED **100**, and improves a color reproduction range of lights emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP. The lights from the white, red, green, and blue sub-pixels W-SP, R-SP, G-SP, and B-SP are emitted through an emission surface on the second substrate **102**.

Accordingly, the OLED **100** of this embodiment can achieve a high brightness without loss of light and improve a color reproduction range, and thus can satisfy 80% or more for BT. 2020.

Third Embodiment

FIG. **5** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a third embodiment of the present disclosure.

Explanations of the same or similar parts of the above embodiments may be omitted.

The OLED **100** may be a top emission type display device or bottom emission type display device according to a light transmission direction. A bottom emission type OLED **100** is described by way of example.

Referring to FIG. **6**, in the OLED **100**, the substrate **101** having a driving TFT DTr and a light emitting diode E may be encapsulated by a protective film **102**.

The driving TFT DTr is formed at a switching region TrA in each sub-pixel. The driving TFT DTr includes source and drain electrodes DS and DD, a semiconductor layer **103** including source and drain regions **103***b* and **103***c* contacting the source and drain electrodes DS and DD, a gate insulating layer **105**, and a gate electrode DG.

A first inter-layered insulating layer **109***a* may be located on the gate electrode DG. The first inter-layered insulating layer **109***a* and the gate insulating layer **105** may include first and second semiconductor contact holes **116** exposing the source and drain regions **103***b* and **103***c*, respectively.

The source and drain electrodes DS and DD may be formed on the first inter-layered insulating layer **109***a* and be spaced apart from each other. The source and drain electrodes DS and DD may contact the source and drain regions **103***b* and **103***c* through the first and second semiconductor contact holes **116**, respectively.

A second inter-layered insulating layer **109*b*** may be formed on the source and drain electrodes DS and DD, and the first inter-layered insulating layer **109*a***.

Even though not shown in FIG. **2**, the switching TFT STr may have substantially the same structure as the driving TFT DTr.

The driving TFT DTr having a top gate structure with the semiconductor layer **103** formed as a polycrystalline silicon layer or oxide semiconductor layer is described by way of example. Alternatively, the driving TFT DTr and the switching TFT STr may have a bottom gate structure with the semiconductor layer **103** formed as an amorphous silicon layer.

If the semiconductor layer **103** uses an oxide semiconductor layer, a light shielding layer may be formed below the semiconductor layer **103**, and a buffer layer may be formed between the light shielding layer and the semiconductor layer **103**.

The substrate **101** may be made of a glass material. Alternatively, the substrate **101** may be made of a transparent plastic material such as a polyimide material, which is bendable or flexible. Polyimide having a high heat resistance may be preferred, considering that a high temperature deposition process is performed for the substrate **101**. An entire surface of the substrate **101** may be covered with at least one buffer layer.

The driving thin film transistor DTr in the switching region TrA may have a characteristic in which a threshold voltage thereof is shifted by light. To prevent this, the OLED **100** of this embodiment may further include a light shielding layer provided below the semiconductor layer **103**.

The light shielding layer is provided between the substrate **101** and the semiconductor layer **103** to block light incident on the semiconductor layer **103** through the substrate **101** and to minimize or prevent a change in a threshold voltage of a transistor caused by an external light. The light shielding layer may be covered with the buffer layer.

The color filters **106*a***, **106*b*** and **106*c*** may be formed on the second inter-layered insulating layer **109*b*** corresponding to the respective emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP.

The color filters **106*a***, **106*b*** and **106*c*** function to convert a white light emitted from the respectively organic light emitting layers **113**. The red, green and blue color filters **106*a***, **106*b*** and **106*c*** are located at the emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP, respectively.

At the emission region EA of the white sub-pixel W-SP, no color filter is formed, and a white light from the organic light emitting layer **113** is intactly transmitted.

Accordingly, in the OLED **100**, the red, green, blue and white sub-pixels R-SP, G-SP, B-SP and W-SP emit red, green, blue and white colors so that a full color image of high brightness can be achieved. The lights from the white, red, green, and blue sub-pixels W-SP, R-SP, G-SP, and B-SP are emitted through an emission surface on the second substrate **102**.

Each of the color filters **106*a***, **106*b*** and **106*c*** may include quantum dots which conduct an reemission according to a white light emitted from the organic light emitting layer **113** and have a size capable of emitting a light with a color set at each sub-pixel. The quantum dot may include at least one selected from a group consisting of CdS, CdSe, CdTe, ZnS, ZnSe, ZnTe, HgS, HgSe, HgTe, CdSeS, CdSeTe, CdSTe, ZnSeS, ZnSeTe, ZnSTe, HgSeS, HgSeTe, HgSTe, CdZnS, CdZnSe, CdZnTe, CdHgS, CdHgSe, CdHgTe, HgZnS, HgZnSe, HgZnTe, CdZnSeS, CdZnSeTe, CdZnSTe, CdHgSeS, CdHgSeTe, CdHgSTe, HgZnSeS, HgZnSeTe, HgZnSTe, GaN, GaP, GaAs, AlN, AlP, AlAs, InN, InP, InAs, GaNP, GaNAs, GaPAs, AlNP, AlNAs, AlPAs, InNP, InNAs, InPAs, GaAlNP, GaAlNAs, GaAlPAs, GaInNP, GaInNAs, GaInPAs, InAlNP, InAlNAs, InAlPAs and SbTe.

For example, the red color filter **106*a*** of the red sub-pixel R-SP may include quantum dots of CdSe or InP, the green color filter **106*b*** of the green sub-pixel G-SP may include quantum dots of CdZnSeS, and the blue color filter **106*c*** of the blue sub-pixel B-SP may include quantum dots of ZnSe. The OLED **100** with the color filters **106*a***, **106*b*** and **106*c*** having the quantum dots can have a higher color reproduction range.

An overcoat layer **108** may be formed on the color filters **106*a***, **106*b*** and **106*c***. The overcoat layer **108** and the second inter-layered insulating layer **109*b*** may have a drain contact hole PH exposing the drain electrode DD of the driving TFT DTr.

The first electrode **111** is formed on the overcoat layer **108**. The first electrode **111** is connected to the drain electrode DD of the driving TFT DTr through the drain contact hole PH. The first electrode **111** may be made of a material having a relatively high work function and serve as an anode.

The first electrode **111** may be made of a metal oxide material, for example, ITO, IZO or the like.

Each first electrode **111** may be patterned by each sub-pixel and be formed in each sub-pixel. The bank **119** may be located between the neighboring first electrodes **111**. The first electrodes **111** may be separated from each other with the bank **119** as a boundary of each sub-pixel.

The bank **119** may be located between the neighboring first electrodes **111** and may separate the neighboring first electrodes **111** from each other.

The organic light emitting layer **113** may be formed on the first electrode **111**. The organic light emitting layer **113** may be configured with a single layer made of an emitting material. Alternatively, to increase an emission efficiency, the organic light emitting layer **113** may be configured with multiple layers that may include a hole injection layer, a hole transport layer, an emitting material layer, an electron transport layer, and an electron injection layer.

The second electrode **115** may be formed entirely on the organic light emitting layer **113**. The second electrode **115** may serve as a cathode.

The second electrode **115** may be made of a material having a relatively low work function. The second electrode **115** may be formed with a single layer or multiple layers using a first metal such as Ag and a second metal such as Mg, and the single layer may be made of an alloy of the first and second metals at a predetermined ratio thereof.

In the OLED **100**, when predetermined voltages are applied to the first electrode **111** and the second electrode **115**, holes injected from the first electrode **111** and electrons injected from the second electrode **115** are transported to the organic light emitting layer **113** to form excitons. When the excitons are transitioned from an excited state to a ground state, light is generated and emitted in the form of visible light.

As the OLED **100** of this embodiment is a bottom emission type display device. In this case, the second electrode **115** may further include a reflective layer (not shown) made of an opaque conductive material. For example, the reflective layer may be made of an aluminum-palladium-copper (APC) alloy, and the second electrode **115** may have a triple-layered structure of, for example, ITO/APC/ITO. Further, the first electrode **111** may have a thin thickness to transmit a light, and in this case, a light transmittance of the first electrode **111** may be about 45% to 50%.

The protective film **102** in the form of a thin film may be formed on the second electrode **115**, and the OLED **100** may be encapsulated by the protective film **102**.

The protective film **102** may be formed with at least two inorganic protective films to prevent or reduce external oxygen or moisture from permeating inside the OLED **100**. In this case, the protective film **102** may further include an organic protective film between two inorganic protective films to supplement an impact resistance of the inorganic protective films.

In the structure that the organic protective film and the inorganic protective film are alternately stacked, in order to prevent an moisture or oxygen from permeating through a side surface of the organic protective film, the inorganic protective film may be formed to fully enclose the organic protective film.

Accordingly, an external moisture or oxygen can be prevented from permeating inside the OLED **100**.

In the OLED **100** of this embodiment, a light-absorption filter layer **200** may be further formed on an outer side of the substrate **101**.

The light-absorption filter layer **200** may include (or be divided into) a first light-absorption pattern **230** which is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and a second light-absorption pattern **240** which is located to correspond to the white sub-pixel W-SP. The first and second light-absorption patterns **230** and **240** may form the same plane (or may be coplanar).

The first light-absorption pattern **230** may include first light-absorption dyes **220*a*** and second light-absorption dyes **220*b*** in a first transparent resin **210*a***. The first light-absorption dye **220*a*** may has a absorption wavelength range of about 470 nm to 550 nm, and preferably, a absorption wavelength range of about 490 nm. The second light-absorption dye **220*b*** may has a absorption wavelength range of about 570 nm to 620 nm, and preferably, a absorption wavelength range of about 590 nm.

The first transparent resin **210*a*** may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The first light-absorption dye **220*a*** may be formed of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, or boron dipyrromethene (BODIBY) based light-absorption dye. The second light-absorption dye **220*b*** may be formed of tetra aza porphyrin (TAP) based light-absorption dye, squarine (SQ) based light-absorption dye, or cyanine (CY) based light-absorption dye. Each of the first and second light-absorption dyes **220*a*** and **220*b*** may preferably use a combination of at least two selected from a group consisting of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye, and more preferably use a combination of cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye.

The second light-absorption pattern **240** may be formed of only second transparent resin **210*b***. The second transparent resin **210*b*** may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The second transparent resin **210*b*** may be made of the same material as the first transparent resin **210*a***. It is preferable that the first and second transparent resins **210*a*** and **210*b*** have a visible light transmittance of 98% or greater and the same refractive index.

The first and second transparent resins **210*a*** and **210*b*** may have a refractive index of about 1.7 to 2.1.

In the light-absorption filter layer **200**, the first light-absorption pattern **230** including the first and second light-absorption dyes **220*a*** and **220*b*** is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and the second light-absorption pattern **240** including no light-absorption dyes is located to correspond to the white sub-pixel W-SP. Thus, the light-absorption filter layer **200** does not influence the white sub-pixel W-SP which much influences a brightness of the OLED **100**, and improves a color reproduction range of lights emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP.

Accordingly, the OLED **100** of this embodiment can achieve a high brightness without loss of light and improve a color reproduction range, and thus can satisfy 80% or more for BT. 2020.

Further, in the OLED **100** of this embodiment, since the first light-absorption pattern **230** including the first and second light-absorption dyes **220*a*** and **220*b*** is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and the second light-absorption pattern **240** including no light-absorption dyes is located to correspond to the white sub-pixel W-SP, a screen distortion phenomenon caused by a refractive index difference between the white sub-pixel W-SP, and the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented.

In this regard, when a light from the organic light emitting layer **113** passes through the color filters **106*a***, **106*b*** or **106*c*** and then is output to the outside, a light passing through the first light-absorption pattern **230** is refracted in a certain direction and then output due to a difference between a refractive index of the first transparent resin **210*a*** of the first light-absorption pattern **230** and a refractive index of the outside (i.e., an air).

If the second light-absorption pattern **240** is not formed to correspond to the white sub-pixel W-SP, a refraction direction of a light emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP is different from a refraction direction of a light emitted from the white sub-pixel W-SP. Because of the difference of the light refraction direction, a screen distortion may happen.

However, in the OLED **100** of this embodiment, the second light-absorption pattern **240** formed of the second transparent resin **210*b***, which has transmittance and refractive index that are similar to those of the first transparent resin **210*a*** of the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, is located to correspond to the white sub-pixel W-SP. Accordingly, a screen distortion phenomenon caused by the light refraction direction difference between the white sub-pixel W-SP, and the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented.

Further, in case that only the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels

R-SP, G-SP and B-SP is used, a boundary between the red, green and blue sub-pixels R-SP, G-SP and B-SP where the first light-absorption pattern **230** is located, and the white sub-pixel W-SP where no light-absorption pattern is located may be distinctly recognized. This may cause a moire phenomenon by the boundaries of the first light-absorption patterns **230**.

The moire phenomenon means that interference patterns are shown when periodic patterns are superimposed. As the boundaries of the first light-absorption patterns **230** are seen, the moire phenomenon may happen.

As the sub-pixels R-SP, G-SP, B-SP and W-SP of the OLED **100** become minute in order to realize a high resolution, the moire phenomenon intensifies. This is because that as the sub-pixels R-SP, G-SP, B-SP and W-SP of the OLED **100** become minute, the first light-absorption pattern **230** also becomes minute.

To reduce the moire phenomenon, it is preferable that the superimposed patterns, and more exactly the first light-absorption patterns **230** are formed with shape and period of the boundaries being random.

However, since the sub-pixels R-SP, G-SP, B-SP and W-SP are required to be periodic and repetitive, it is difficult to form the first light-absorption patterns **230** non-periodically and non-repetitively.

In the OLED **100** of this embodiment, the second light-absorption pattern **240**, which has transmittance and refractive index similar to the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, is formed to correspond to the white sub-pixel W-SP. Thus, the boundary of the first light-absorption pattern **230** may be recognized ambiguous. In the example shown in FIG. **6**, lights emitted from the red, green, and blue sub-pixels R-SP, G-SP, and B-SP are emitted through an emission surface on the first light-absorption pattern **230** while light emitted from the white sub-pixel W-SP is emitted through an emission surface on the second light-absorption pattern **240**.

Accordingly, the moire phenomenon due to the boundaries of the first light-absorption patterns **230** can be prevented or reduced.

Fourth Embodiment

FIG. **7** is a cross-sectional view illustrating a structure of a unit pixel including four sub-pixels in an OLED according to a fourth embodiment of the present disclosure.

Explanations of the same or similar parts of the above embodiments may be omitted.

The OLED **100** may be a top emission type display device or bottom emission type display device according to a light transmission direction. A bottom emission type OLED **100** is described by way of example.

Referring to FIG. **7**, in the OLED **100**, the substrate **101** having a driving TFT DTr and a light emitting diode E may be encapsulated by a protective film **102**.

On the first substrate **101**, a switching TFT and the driving TFT DTr are formed in each of the sub-pixels R-SP, G-SP, B-SP and W-SP. A first electrode **111** is formed on the driving TFT DTr, an organic light emitting layer **113** is formed on the first electrode **111**, and the second electrode **115** is formed on the organic light emitting layer **113**.

The driving TFT DTr includes a semiconductor layer **103** including source and drain regions **103*b*** and **103*c***, a gate insulating layer **105** and a gate electrode DG on the semiconductor layer **103**, and source and drain electrodes DS and DD which are on a first inter-layered insulating layer **109*a*** and contact the source and drain regions **103*b*** and **103*c*** through first and second semiconductor contact holes **116**, respectively.

The color filters **106*a***, **106*b*** and **106*c*** may be formed on the second inter-layered insulating layer **109*b***, which is on the source and drain electrodes DS and DD, and correspond to respective emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP.

The color filters **106*a***, **106*b*** and **106*c*** function to convert a white light emitted from the respective organic light emitting layers **113**. The red, green and blue color filters **106*a***, **106*b*** and **106*c*** are located at the emission regions EA of the red, green and blue sub-pixels R-SP, G-SP and B-SP, respectively.

At the emission region EA of the white sub-pixel W-SP, no color filter is formed, and a white light from the organic light emitting layer **113** is intactly transmitted.

Accordingly, in the OLED **100**, the red, green, blue and white sub-pixels R-SP, G-SP, B-SP and W-SP emit red, green, blue and white colors so that a full color image of high brightness can be achieved.

An overcoat layer **108** may be formed on the color filters **106*a***, **106*b*** and **106*c***. The overcoat layer **108**. The first electrode **111**, the organic light emitting layer **113** and the second electrode **115** are located sequentially on the overcoat layer **108**.

The first electrode **111** contacts the drain electrode DD of the driving TFT DTr through the drain contact hole PH. The first electrode **111**, the organic light emitting layer **113** and the second electrode **115** constitute the light emitting diode E. The bank **119** may be located at a boundary of each sub-pixel and separate the sub-pixels R-SP, G-SP, B-SP and W-SP.

In the OLED **100** of this embodiment, a light-absorption filter layer **200** may be further formed on an outer side of the substrate **101**.

The light-absorption filter layer **200** may include (or be divided into) a first light-absorption pattern **230** which is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and a second light-absorption pattern **240** which is located to be on the first light-absorption pattern **230** and to correspond to the white sub-pixel W-SP.

The first light-absorption pattern **230** may include first light-absorption dyes **220*a*** and second light-absorption dyes **220*b*** in a first transparent resin **210*a***. The first light-absorption dye **220*a*** may has a absorption wavelength range of about 470 nm to 550 nm, and preferably, a absorption wavelength range of about 490 nm. The second light-absorption dye **220*b*** may has a absorption wavelength range of about 570 nm to 620 nm, and preferably, a absorption wavelength range of about 590 nm.

The first transparent resin **210*a*** may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The first light-absorption dye **220*a*** may be formed of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, or boron dipyrromethene (BODIBY) based light-absorption dye. The second light-absorption dye **220*b*** may be formed of tetra aza porphyrin (TAP) based light-absorption dye, squarine (SQ) based light-absorption dye, or cyanine (CY) based light-absorption dye. Each of the first and second light-absorption dyes **220*a*** and **220***b* may preferably use a combination of at least two selected from a group consisting of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye, and more preferably use a combination of cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye.

The second light-absorption pattern **240** may be formed of only second transparent resin **210***b*. The second transparent resin **210***b* may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The second transparent resin **210***b* may be made of the same material as the first transparent resin **210***a*. It is preferable that the first and second transparent resins **210***a* and **210***b* have a visible light transmittance of 98% or greater and the same refractive index.

The first and second transparent resins **210***a* and **210***b* may have a refractive index of about 1.7 to 2.1.

In the light-absorption filter layer **200**, the first light-absorption pattern **230** including the first and second light-absorption dyes **220***a* and **220***b* is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and the second light-absorption pattern **240** including no light-absorption dyes is located to be on the first light-absorption pattern **230** and to correspond to the white sub-pixel W-SP. The second light-absorption pattern **240** contacts at least a surface of the first light-absorption pattern **230**. Thus, the light-absorption filter layer **200** does not influence the white sub-pixel W-SP which much influences a brightness of the OLED **100**, and improves a color reproduction range of lights emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP. In the example shown in FIG. **7**, lights emitted from the white, red, green, and blue sub-pixels W-SP, R-SP, G-SP, and B-SP are emitted through an emission surface on the second light-absorption pattern **240**.

Accordingly, the OLED **100** of this embodiment can achieve a high brightness without loss of light and improve a color reproduction range, and thus can satisfy 80% or more for BT. 2020.

FIG. **8** is a graph showing a spectrum of a white light emitted from the organic light emitting diode **113** and passing through the light-absorption filter layer **200** including the first and second light-absorption patterns **230** and **240**.

When the white light from the organic light emitting layer **113** passes through the light-absorption filter layer **200**, a light of a wavelength range of about 470 nm to 550 nm and about 570 nm to 620 nm may be absorbed by the first light-absorption dyes **220***a* of the first light-absorption pattern **230**, a transmittance at such the wavelength range may be reduced.

Thus, pure red, green and blue lights can be realized without color mixing regions.

As described above, in this embodiment, the light-absorption filter layer **200** including the first and second light-absorption patterns **230** and **240** is located on the transmission direction of a light passing through the color filters **106***a*, **106***b* and **106***c*. Therefore, the OLED **100** of this embodiment can improve a color reproduction range and satisfy 80% or more for BT. 2020.

TABLE 2

	Overlapping ratio (%) for BT. 2020	Brightness efficiency (%)
Sample 1	73%	100%
Sample 2	80%	99%
Sample 4	80.4%	99%

Table 2 shows simulation results of measuring overlapping ratios for BT. 2020 of the OLED of this embodiment. Sample 1 is an OLED including no light-absorption filter layer **200**. Sample 2 is an OLED according to the first embodiment of the present disclosure. Sample 4 is an OLED according to the fourth embodiment of the present disclosure, which include the light absorption filter layer **200** including the first and second light-absorption patterns **230** and **240**. Referring to Table 2, it is seen that Sample 4 i.e., the OLED **100** of this embodiment satisfies an overlapping ratio of 80.4% for BT. 2020.

Further, it is seen that the OLED **100** of this embodiment has a brightness efficiency close to that of Sample 1 i.e., the OLED with no light-absorption filter layer.

As such, the light-absorption filter layer **200** significantly influences improvement of a color reproduction range but does not significantly influences a brightness efficiency.

Accordingly, in this embodiment, since the light-absorption filter layer **200** including the first and second light-absorption patterns **230** and **240** is located on the transmission direction of a light passing through the color filters **106***a*, **106***b* and **106***c*, the OLED **100** can improve a color reproduction range and satisfy 80% or more for BT. 2020 that is a 4K/UHD standard advised by ITU.

Further, it is seen that a brightness efficiency of Sample 4 is not much different from that of Sample 2. This means that even though the second light-absorption pattern **240** is located on the first light-absorption pattern **230** in the OLED **100** of this embodiment, the second light-absorption pattern **240** does not influence a brightness efficiency.

Further, in the OLED **100** of this embodiment, the light-absorption filter layer **200** is configured such that the second light-absorption pattern **240** formed of the second transparent resin **210***b*, which has transmittance and refractive index that are similar to those of the first transparent resin **210***a* of the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, is located to correspond to the white sub-pixel W-SP as well. Accordingly, a screen distortion phenomenon caused by a refractive index difference between the white sub-pixel W-SP, and the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented.

Further, since the second light-absorption pattern **240** is located to correspond to the white sub-pixel W-SP, a moire phenomenon caused by a distinct recognition of a boundary between the red, green and blue sub-pixels R-SP, G-SP and B-SP where the first light-absorption pattern **230** is located can be prevented.

Further, since the second light-absorption pattern **240** is located even on the first light-absorption pattern **230**, a recognition of a boundary of the first light-absorption pattern **230** that may be formed at each of the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented.

In this regard, the first light-absorption pattern **230** may be formed singly (or integrally) to correspond to all of the red, green and blue sub-pixels R-SP, G-SP and B-SP. Alternatively, each first light-absorption pattern **230** may be patterned to correspond to each of the red, green and blue sub-pixels R-SP, G-SP and B-SP. When the first light-absorption patterns **230** may be respectively patterned at the red, green and blue sub-pixels R-SP, G-SP and B-SP, the first light-absorption patterns **230** are formed periodically and repetitively.

In this case, as shown in FIG. **9**A, a moire phenomenon may be seen.

However, in this embodiment, the second light-absorption pattern **240** is located even on the first light-absorption pattern **230**. Thus, as shown in FIG. **9**B, the boundary of each first light-absorption pattern **230** may not be seen by the second light-absorption pattern **240**.

Thus, the moire phenomenon due to the first light-absorption pattern **230** can be prevented or reduced.

Further, when the first light-absorption pattern **230** is formed at each of the red, green and blue sub-pixels R-SP, G-SP and B-SP, a black matrix **118** may be formed between the neighboring first light-absorption patterns **230** (or formed at the boundary of each first light-absorption patterns **230**).

In the case that the black matrix **118** is formed between the neighboring first light-absorption patterns **230**, a color mixing of lights of the red, green and blue sub-pixels R-SP, G-SP and B-SP when the lights passing through the first light-absorption patterns **230** can be prevented or reduced.

Further, in order to further increase an efficiency of a blue light emitted from the blue sub-pixel B-SP, the first light-absorption pattern **230** may be located to correspond to the red and green sub-pixels R-SP and G-SP except for the blue sub-pixel B-SP.

Even though not shown in the drawings, in case that the OLED **100** is configured as a top emission type display device, the light-absorption filter layer **200** is not located at the outer side of the substrate **101** but is located on the protective film **102** such that the light-absorption filter layer **200** is located on the emission direction of the light passing through the color filters **106***a*, **106***b* and **106***c*. In this case, a white light from the organic light emitting layer **113** passes through the color filter **106***a*, **106***b* or **106***c* and then passes through the light-absorption filter layer **200**.

Further, a polarizing plate may be located on the substrate **101** or protective film **102** at the light output side in order to prevent reduction of a contrast by an external light.

In other words, when the OLED **100** is in a driving mode to display an image, the polarizing plate is formed on the transmission direction of light from the organic light emitting layer **113** and thus a contrast can increase.

The polarizing plate may be a circular polarizing plate to prevent an external light, and include a phase retardation plate and a linear polarizing plate. The phase retardation plate and the linear polarizing plate may be stacked such that the linear polarizing plate is located close to an incident side of an external light and the phase retardation plate is located at the inside of the linear polarizing plate.

The light-absorption filter layer **200** may be located on an outer surface of the substrate **101** or protective film **102**, and the polarizing plate may be located on an outer surface of the light-absorption filter layer **200**. Alternatively, the polarizing plate may be located on the substrate **101** or protective film **102**, and the light-absorption filter layer **200** may be located on an outer surface of the polarizing plate.

The light-absorption filter layer **200** may be included as a component in the polarizing plate. For example, the light-absorption filter layer **200** may be located between the linear polarizing plate and the phase retardation plate.

Fifth Embodiment

FIGS. **10**A and **10**B are cross-sectional views illustrating a structure of a unit pixel including four sub-pixels in each of OLEDs according to a fifth embodiment of the present disclosure.

Explanations of the same or similar parts of the above embodiments may be omitted.

Referring to FIGS. **10**A and **10**B, the OLED **100** of this embodiment may include a first substrate **101** on which a driving TFT DTr and a light emitting diode E are formed, and a second substrate **102** facing the first substrate **101**. The first and second substrates **101** and **102** may be coupled to each other using a protective layer **103** having an adhesion property to form the OLED **100**.

On the first substrate **101**, a switching TFT and the driving TFT DTr are formed in each of the sub-pixels R-SP, G-SP, B-SP and W-SP. A first electrode **111** is formed on the driving TFT DTr, an organic light emitting layer **113** is formed on the first electrode **111**, and the second electrode **115** is formed on the organic light emitting layer **113**.

The first and second electrodes **111** and **115**, and the organic light emitting layer **113** forms the light emitting diode E. A bank **119** is located at a boundary of each sub-pixel and separates the sub-pixels R-SP, G-SP, B-SP and W-SP.

On an inner surface of the second substrate **102**, red, green and blue color filters **106***a*, **106***b* and **106***c* may be formed to correspond to the respective sub-pixels R-SP, G-SP and B-SP, and a black matrix **118** surrounding each color filter and corresponding a boundary of each sub-pixel may be formed.

The protective layer **103** is interposed between the first and second substrates **101** and **102**. The protective layer **103** may be made of a transparent resin having a adhesion property.

In the OLED **100**, when predetermined voltages are applied to the first electrode **111** and the second electrode **115**, holes injected from the first electrode **111** and electrons injected from the second electrode **115** are transported to the organic light emitting layer **113** to form excitons. When the excitons are transitioned from an excited state to a ground state, light is generated and emitted in the form of visible light.

The OLED **100** of this embodiment may be a top emission type display device in which a light emitted from the organic light emitting layer **113** is output to the outside through the second electrode **115**. In this case, a light from the organic light emitting layer **113** of the red sub-pixel R-SP realizes a red light while passing through the red color filter **106***a*. Similarly, a light from the organic light emitting layer **113** of the green sub-pixel G-SP realizes a green light while passing through the green color filter **106***b*, and a light from the organic light emitting layer **113** of the blue sub-pixel B-SP realizes a blue light while passing through the blue color filter **106***c*. In the white sub-pixel W-SP, a white light from the organic light emitting layer **113** passes through the planarization layer **121**. The lights from the white, red, green, and blue sub-pixels W-SP, R-SP, G-SP, and B-SP are emitted through an emission surface on the second substrate **102**.

Accordingly, the OLED **100** can display a full color image.

Referring to FIG. **10**A, the OLED **100** of this embodiment may include a light-absorption filter layer **200** between the second substrate **102** and the red, green and blue color filters **106***a*, **106***b* and **106***c*.

The light-absorption filter layer **200** may include a first light-absorption pattern **230** which is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and a second light-absorption pattern **240** which is located to correspond to the white sub-pixel W-SP. The first and second light-absorption patterns **230** and **240** may form the same plane.

To planarize the second substrate **102**, a planarization layer **121** may be located on the red, green and blue color filters **106***a*, **106***b* and **106***c* and the black matrix **118**.

Alternatively, referring to FIG. **10**B, the first light-absorption pattern **230** may be formed between the second substrate **102** and the red, green and blue color filters **106***a*, **106***b* and **106***c*, and the second light-absorption pattern **240** may be formed to cover the white sub-pixel W-PS, the red, green and blue color filters **106***a*, **106***b* and **106***c* and the black matrix **118**.

In other words, the second light-absorption pattern **240** may serve as a planarization layer to planarize the second substrate **102**.

The first light-absorption pattern **230** may include first light-absorption dyes **220***a* and second light-absorption dyes **220***b* in a first transparent resin **210***a*. The first light-absorption dye **220***a* may has a absorption wavelength range of about 470 nm to 550 nm, and preferably, a absorption wavelength range of about 490 nm. The second light-absorption dye **220***b* may has a absorption wavelength range of about 570 nm to 620 nm, and preferably, a absorption wavelength range of about 590 nm.

The first transparent resin **210***a* may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The first light-absorption dye **220***a* may be formed of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, or boron dipyrromethene (BODIBY) based light-absorption dye. The second light-absorption dye **220***b* may be formed of tetra aza porphyrin (TAP) based light-absorption dye, squarine (SQ) based light-absorption dye, or cyanine (CY) based light-absorption dye. Each of the first and second light-absorption dyes **220***a* and **220***b* may preferably use a combination of at least two selected from a group consisting of pyrrol methin (PM) based light-absorption dye, rhodamin (RH) based light-absorption dye, cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye, and more preferably use a combination of cyanine (CY) based light-absorption dye and tetra aza porphyrin (TAP) based light-absorption dye.

The second light-absorption pattern **240** may be formed of only second transparent resin **210***b*. The second transparent resin **210***b* may be made of a binder resin. For example, the transparent resin **210** may be made of at least one selected from a group consisting of a polyester based binder resin, an acryl based binder resin, a polyurethane based binder resin, a melamine based binder resin, a polyvinyl alcohol based binder resin and a oxazoline based binder resin. Preferably, the transparent resin **210** may be made of an acryl based binder resin.

The second transparent resin **210***b* may be made of the same material as the first transparent resin **210***a*. It is preferable that the first and second transparent resins **210***a* and **210***b* have a visible light transmittance of 98% or greater and the same refractive index.

The first and second transparent resins **210***a* and **210***b* may have a refractive index of about 1.7 to 2.1.

In the light-absorption filter layer **200**, the first light-absorption pattern **230** including the first and second light-absorption dyes **220***a* and **220***b* is located to correspond to the red, green and blue sub-pixels R-SP, G-SP and B-SP, and the second light-absorption pattern **240** including no light-absorption dyes is located to correspond to the white sub-pixel W-SP or is located on the white sub-pixel W-SP, the color filters **106***a*, **106***b* and **106***c* and the black matrix **118**. Thus, the light-absorption filter layer **200** does not influence the white sub-pixel W-SP which much influences a brightness of the OLED **100**, and improves a color reproduction range of lights emitted from the red, green and blue sub-pixels R-SP, G-SP and B-SP.

Accordingly, the OLED **100** of this embodiment can achieve a high brightness without loss of light and improve a color reproduction range, and thus can satisfy 80% or more for BT. 2020.

Further, in the OLED **100** of this embodiment, the light-absorption filter layer **200** is configured such that the second light-absorption pattern **240** formed of the second transparent resin **210***b*, which has transmittance and refractive index that are similar to those of the first transparent resin **210***a* of the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, is located to correspond to the white sub-pixel W-SP. Accordingly, a screen distortion phenomenon caused by a refractive index difference between the white sub-pixel W-SP, and the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented. Further, since the second light-absorption pattern **240** is located to correspond to the white sub-pixel W-SP or is located on the white sub-pixel W-SP, the color filters **106***a*, **106***b* and **106***c* and the black matrix **118**, a moire phenomenon caused by the first light-absorption pattern **230** can be prevented.

Even though not shown in the drawings, in order to prevent reduction of a contrast, a polarizing plate may be located on an outer surface of the second substrate **102**.

In this case, the light-absorption filter layer **200** may be located between the second substrate **102** and the polarizing plate, or may be located on an outer surface of the polarizing plate.

The light-absorption filter layer **200** may be included as a component in the polarizing plate. For example, the light-absorption filter layer **200** may be located between the linear polarizing plate and the phase retardation plate which are included in the polarizing plate.

Further, in order to further increase an efficiency of a blue light emitted from the blue sub-pixel B-SP, the first light-absorption pattern **230** may be located to correspond to the red and green sub-pixels R-SP and G-SP except for the blue sub-pixel B-SP.

As described above, the OLED **100** of this embodiment includes the light-absorption filter layer **200** which is located on an output path of lights passing through the color filters **106***a*, **106***b* and **106***c*, and includes the first light-absorption dye **220***a* having a absorption wavelength range of about 470 nm to 550 nm and the second light-absorption dye **220***b* having a absorption wavelength range of about 570 nm to 620 nm. Thus, the OLED **100** can achieve a high brightness without loss of brightness, and can improve a color reproduction range and obtain 80% or greater for BT. 2020.

Further, in the OLED **100** of this embodiment, the light-absorption filter layer **200** is configured such that the second light-absorption pattern **240** formed of the second transparent resin **210**_b_, which has transmittance and refractive index that are similar to those of the first transparent resin **210**_a_ of the first light-absorption pattern **230** corresponding to the red, green and blue sub-pixels R-SP, G-SP and B-SP, is located to correspond to the white sub-pixel W-SP. Accordingly, a screen distortion phenomenon caused by a refractive index difference between the white sub-pixel W-SP, and the red, green and blue sub-pixels R-SP, G-SP and B-SP can be prevented. Further, since the second light-absorption pattern **240** is located to correspond to the white sub-pixel W-SP or is located on the white sub-pixel W-SP, the color filters **106**_a_, **106**_b_ and **106**_c_ and the black matrix **118**, a moire phenomenon caused by the first light-absorption pattern **230** can be prevented.

FIG. **11** is a flowchart showing a method of operating an OLED display device, according to an embodiment of the present disclosure. The OLED display device includes pixels, each pixel including sub-pixels. The sub-pixels may include one or more of the following: white sub-pixel, red sub-pixel, blue sub-pixel, and green sub-pixel. Light is produced **1110** at sub-pixels, each sub-pixel including an OLED. The produced light from a subset of the sub-pixels (e.g., red, blue and green sub-pixels) is passed **1120** through a color filter to produce a first filtered light. The first filtered light is passed **1130** through a first portion of a light-absorption filter layer having a light transmittance curve that has a first valley between 470 nm and 550 nm and a second valley between 570 nm and 620 nm to produce a second filtered light. At least part of the second filtered light is emitted 1140 through an emission surface. The produced white light from pixels other than the subset of sub-pixels is passed through an emission surface. The produced white light may be passed through a second portion of the light-absorption filter layer, the second portion of the light-absorption filter layer having a same refractive index as that of the first portion.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure without departing from the technical idea or scope of the disclosure. Thus, it is intended that the present disclosure cover the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A display device, comprising:
- an organic light emitting diode (OLED) comprising:
  - a first electrode common to at least a subset of sub-pixels,
  - second electrodes individually connected to each of the sub-pixels, and
  - an organic light emitting layer between the first electrode and the second electrodes;
- an emission surface over the first electrode or the second electrodes;
- a first portion of a light-absorption filter layer between the OLED and the emission surface in a subset of sub-pixels, the first portion of the light absorption filter layer having a light transmittance curve that has a first valley covering at least a wavelength range of 470 nm to 550 nm, and a second valley covering at least a wavelength range of 570 nm to 620 nm; and
- a color filter between the OLED and the first portion of the light-absorption filter layer in the subset of sub-pixels,
- wherein white sub-pixels other than the subset of sub-pixels produce white light which passes through the emission surface.

2. The display device according to claim **1**, further comprising:
- a second portion of the light-absorption filter layer between the OLED and the emission surface at the white sub-pixels, the second portion of light-absorption filter layer having a same refractive index as that of the first portion of the light-absorption filter layer.

3. The display device according to claim **2**, wherein the second portion of the light-absorption filter layer contacts at least a surface of the first portion of the light-absorption filter layer.

4. The display device according to claim **1**, wherein the subset of sub-pixels comprises:
- a red sub-pixel having a red color filter between the organic light emitting layer and the light-absorption filter layer,
- a green sub-pixel having a green color filter between the organic light emitting layer and the light-absorption filter layer, and
- a blue sub-pixel having a blue color filter between the organic light emitting layer and the light-absorption filter layer.

5. The display device according to claim **4**, further comprising a pattern of a black matrix between adjacent ones of the sub-pixels.

6. The display device according to claim **4**, further comprising a planarization layer on the red, green, and blue color filters and a second portion of the light-absorption filter layer that is between the OLED and the emission surface at the white sub-pixels.

7. The display device according to claim **1**, wherein the first portion of light-absorption filter layer includes a first light-absorption dye and a second light-absorption dye each of which includes at least one of pyrrol methin (PM) based dye, rhodamin (RH) based dye, cyanine (CY) based dye and tetra aza porphyrin (TAP) based dye.

8. The display device according to claim **1**, wherein the display device is a top-emission device, and the emission surface is over the first electrode.

9. The display device according to claim **1**, the display device is a bottom-emission device, and the emission surface is over the second electrodes.

10. The display device according to claim **1**, wherein each sub-pixel of the subset of sub-pixels includes a driving thin film transistor (TFT), the driving TFT including a semiconductor layer, a gate insulating layer on the semiconductor layer, a gate electrode on the gate insulating layer, an inter-layered insulating layer on the gate electrode, and source and drain electrodes on the inter-layered insulating layer.

11. The display device of claim **1**, wherein the organic light emitting layer in each sub-pixel of the subset of sub-pixels emits a white light.

12. The display device of claim **1**, wherein the first portion of the light-absorption filter layer in each sub-pixel of the subset of sub-pixels has the light transmittance curve that has the first valley covering at least the wavelength range of 470 nm to 550 nm, and the second valley covering at least the wavelength range of 570 nm to 620 nm.

13. A method of operating a display device, comprising:
- producing light at sub-pixels, each of the sub-pixels including an organic light emitting diode (OLED);
- passing the produced light from a subset of the sub-pixels through color filters to produce first filtered light;
- passing the first filtered light through a first portion of a light-absorption filter layer having a light transmittance curve that has a first valley covering at least a wave-

length range of 470 nm to 550 nm, and a second valley covering at least a wavelength range of 570 nm to 620 nm to produce second filtered light;

emitting at least a part of the second filtered light through an emission surface of the display device; and

passing white light produced by sub-pixels other than the subset of the sub-pixels through the emission surface.

14. The method of claim **13**, wherein passing the white light comprises passing the produced light through a second portion of light-absorption filter layer having a same refractive index as that of the first portion of light-absorption filter layer.

15. The method of claim **13**, wherein passing the produced light from the subset of the sub-pixels comprises:

passing a first portion of the produced light from a red sub-pixel of the subset of sub-pixels through a red color filter;

passing a second portion of the produced light from a green sub-pixel of the subset of sub-pixels through a green color filter; and

passing a third portion of the produced light from a blue sub-pixel of the subset of sub-pixels through a blue color filter.

16. The method of claim **13**, further comprising driving a driving thin film transistor (TFT) for each of the sub-pixels to produce the light.

17. The method of claim **13**, wherein the OLED in each of the sub-pixels emits a white light.

18. The method of claim **13**, wherein the first portion of the light-absorption filter layer in each sub-pixel of the subset of the sub-pixels has the light transmittance curve that has the first valley covering at least the wavelength range of 470 nm to 550 nm, and the second valley covering at least the wavelength range of 570 nm to 620 nm.

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[标]申请(专利权)人(译)	乐金显示有限公司		
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摘要(译)

有机发光二极管(OLED)显示装置包括具有多个子像素的OLED。 吸光滤光层的第一部分在OLED与发射表面之间的与选定的子像素位置相对应的位置处。 吸光滤光层的第一部分包括第一吸光染料和第二吸光染料,使得第一部分具有透光率曲线,该透光率曲线的第一谷在470nm至550nm之间,第二谷在470nm至550nm之间。 570 nm和620 nm。 在选定的子像素位置,OLED和光吸收滤镜之间有一个滤色镜。