US 20140339509A1

(19) **United States**

(12) **Patent Application Publication**

Choi et al.

(10) **Pub. No.: US 2014/0339509 A1**

(43) **Pub. Date: Nov. 20, 2014**

(54) **ORGANIC LIGHT-EMITTING DISPLAY APPARATUS**

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(21) Appl. No.: **14/011,990**

(22) Filed: **Aug. 28, 2013**

(30) **Foreign Application Priority Data**

May 16, 2013 (KR) 10-2013-0056049

Publication Classification

(51) **Int. Cl.**
H01L 27/32 (2006.01)
H01L 51/52 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 27/3211*** (2013.01); ***H01L 51/5275*** (2013.01)
USPC **257/40**

(57) **ABSTRACT**

Provided is an organic light-emitting display apparatus that includes an organic light-emitting device that includes a plurality of sub-pixels that emit different light colors; an encapsulating film formed on the organic light-emitting device; a lens layer that is formed on the encapsulating film and includes convex surfaces that are disposed on regions corresponding to the sub-pixels and protrude in a light emission direction and a direction opposite to the light emission direction; and an anti-reflection film that is formed on the lens layer to prevent reflection of external light and includes color filters on regions corresponding to each of the sub-pixels.

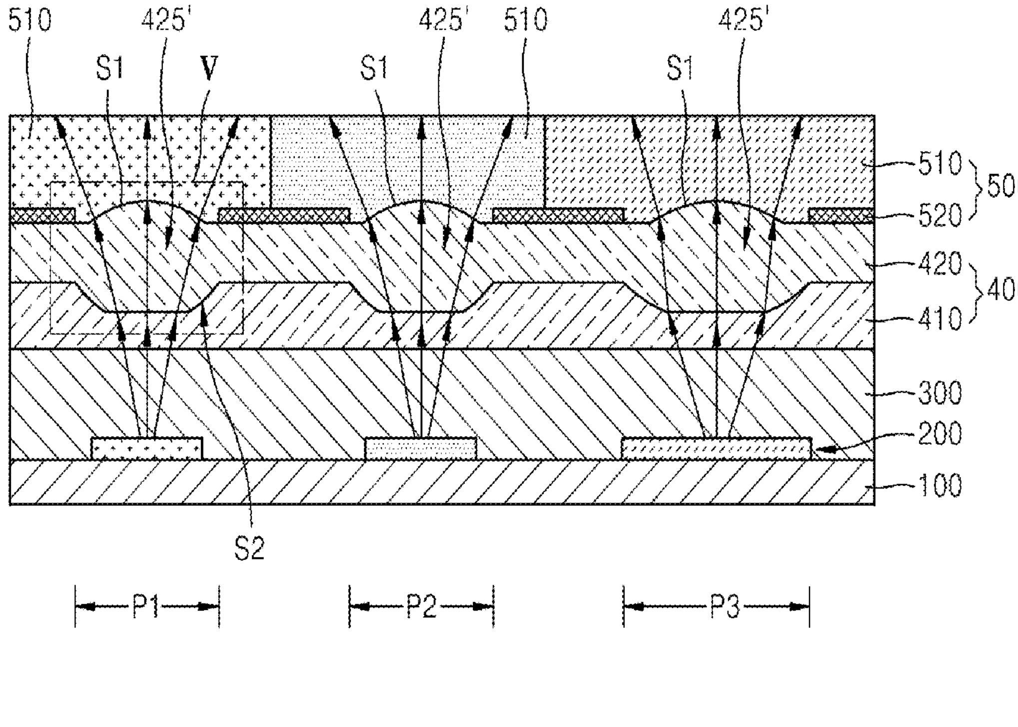


FIG. 1

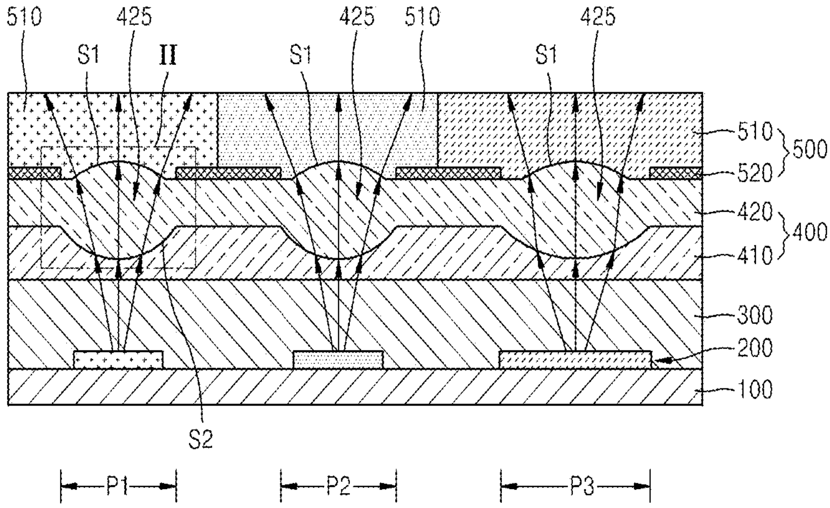

510
425
S1
II
S1
425
510
S1
425
510
500
520
420
400
410
300
200
100
S2
P1
P2
P3

FIG. 2

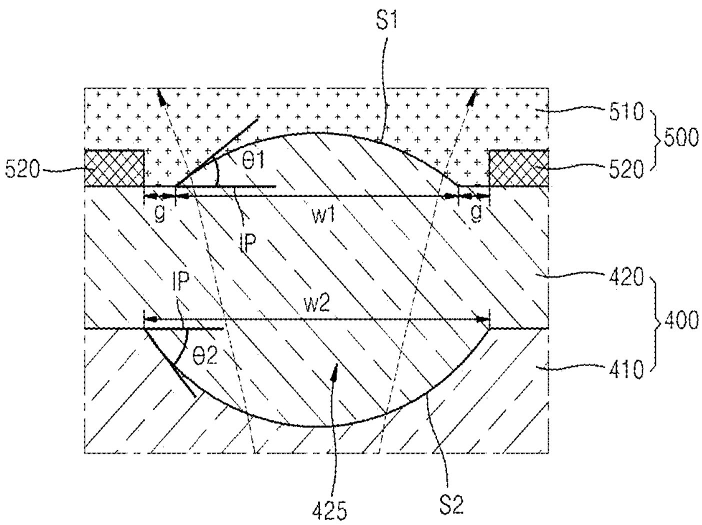

S1
510
500
520
520
θ1
g
w1
g
IP
IP
w2
420
400
θ2
410
425
S2

FIG. 3

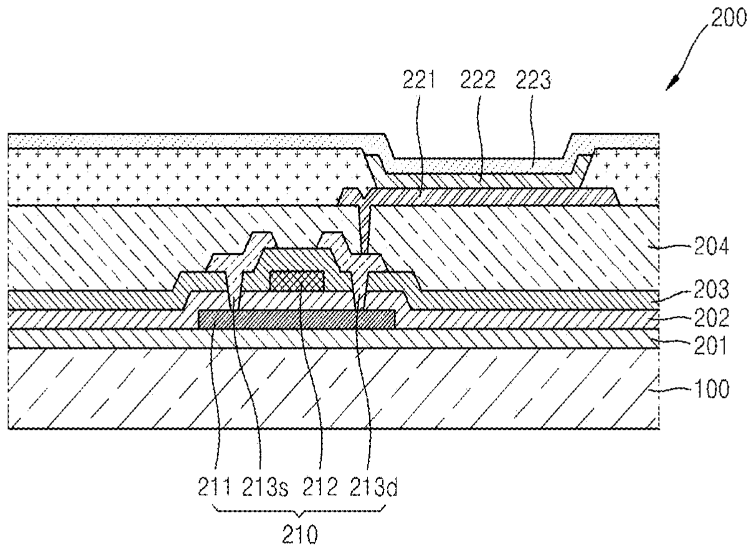

200
221
222
223
204
203
202
201
100
211
213s
212
213d
210

FIG. 4

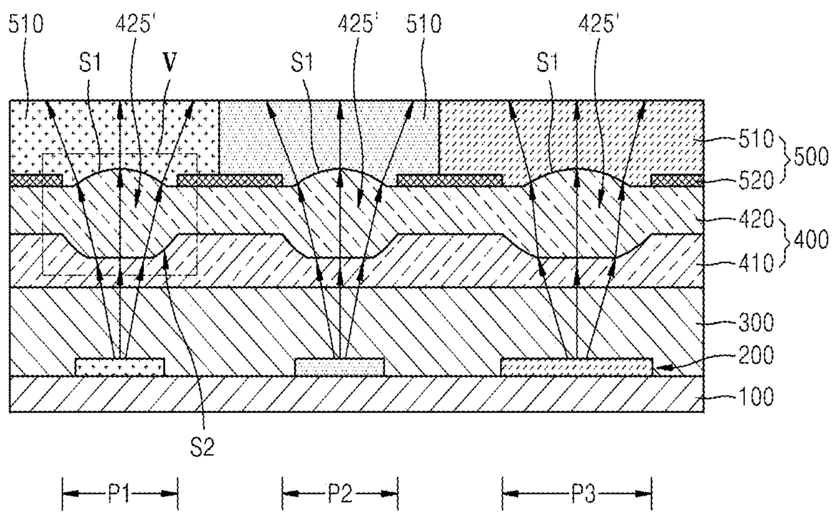

510
425'
S1
V
425'
510
S1
425'
S1
510
500
520
420
400
410
300
200
100
S2
P1
P2
P3

FIG. 5

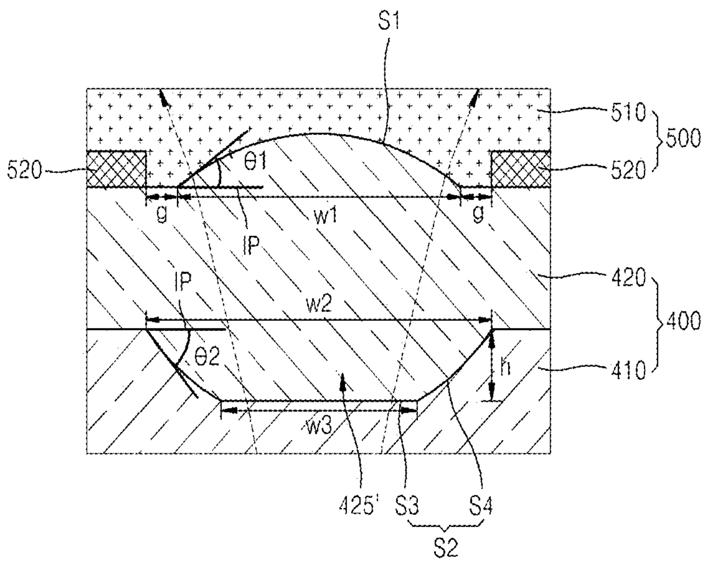

S1
510
500
520
520
θ1
g
w1
g
IP
IP
420
400
w2
θ2
h
410
w3
425'
S3
S4
S2

FIG. 6

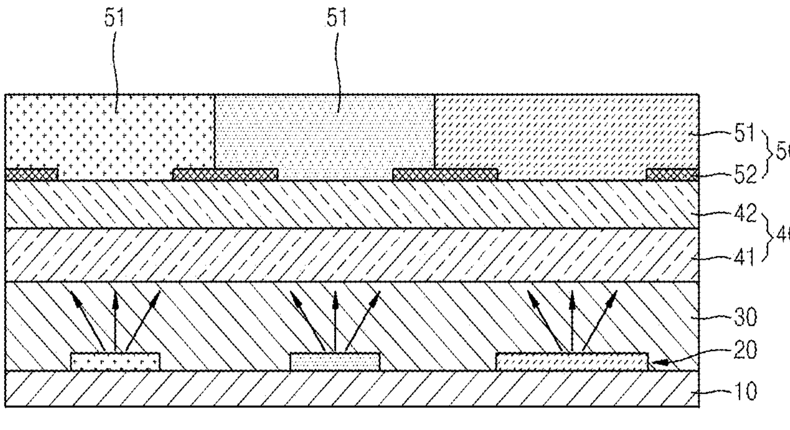

51
51
51
50
52
42
40
41
30
20
10

FIG. 7A

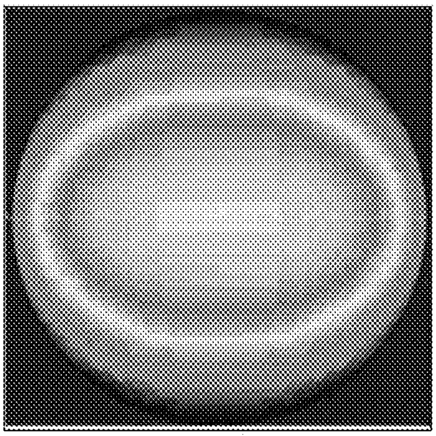
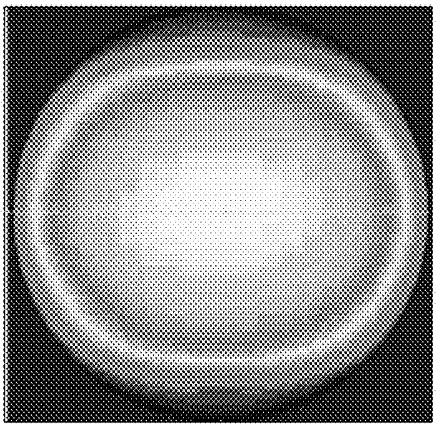


FIG. 7B



ORGANIC LIGHT-EMITTING DISPLAY APPARATUS

[0001] This application claims priority to Korean Patent Application No. 10-2013-0056049, filed on May 16, 2013, and all the benefits accruing therefrom under 35 U.S.C. §119, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] The invention relates to an organic light-emitting display apparatus.

[0004] 2. Description of the Related Art

[0005] An organic light-emitting display apparatus is a self-emissive type display apparatus that does not require an additional light source, is able to be operated at a relatively low voltage, can be configured as a lightweight and thin film type, and has high quality characteristics such as wide viewing angles, high contrast and short response times, and thus, draws attention as a next generation display apparatus.

[0006] An organic light-emitting display apparatus realizes a full-color by using color light, such as three lights of red, green and blue colors. In order to realize a high-quality color image regardless of a user's viewing angle, there is a need to develop an organic light-emitting display apparatus having a high optical efficiency and a large lateral viewing angle.

SUMMARY

[0007] One or more exemplary embodiment of the invention provides a structure of an organic light-emitting display apparatus.

[0008] According to an exemplary embodiment of the invention, there is provided an organic light-emitting display apparatus including: an organic light-emitting device layer including: a plurality of sub-pixels which emits lights of different colors, and an organic light-emitting device in each sub-pixel; an encapsulating film on the organic light-emitting device layer; a lens layer on the encapsulating film and including: a lens unit corresponding to the each sub-pixel and including facing convex surfaces respectively protruding in a light emission direction, and a direction opposite to the light emission direction; and an anti-anti-reflection film on the lens layer and including a color filter corresponding to the each sub-pixel.

[0009] The anti-reflection film may further include a light blocking unit between neighboring sub-pixels.

[0010] The plurality of sub-pixels is arranged in a direction, and the light blocking unit may be separated from the convex surface protruding in the light emission direction among the convex surfaces of the lens unit, by a predetermined gap along the direction in which the plurality of sub-pixels is arranged.

[0011] The convex surface protruding in the light emission direction among the convex surfaces of the lens unit has a width smaller than that of the convex surface protruding in a direction opposite to the light emission direction, the widths taken in the direction in which the plurality of sub-pixels is arranged.

[0012] The lens layer may further include: a first lens sub-layer on the encapsulating film and having a first refractive index; and a second lens sub-layer on the first lens sub-layer, having a second refractive index. The second lens sub-layer may include a first convex surface protruding in the light emission direction among the convex surfaces of the lens unit, and a second convex surface protruding in the direction opposite to the light emission direction among the convex surfaces of the lens unit. A first surface of the first lens sub-layer may contact the second lens sub-layer and include a concave surface corresponding to the second convex surface of the second lens sub-layer.

[0013] The second refractive index may be greater than the first refractive index.

[0014] The first refractive index may be about 1.3 or less, and the second refractive index may be in a range from about 1.7 to about 1.9.

[0015] An imaginary surface may extend in a direction in which the plurality of sub-pixels is arranged. A first inclination angle formed by the first convex surface at an edge of the first convex surface, with respect to the imaginary surface, may be smaller than a second inclination angle formed by the second convex surface at an edge of the second convex surface, with respect to the imaginary surface.

[0016] The first inclination angle may be in a range from about 15° to about 25°.

[0017] The second inclination angle may be in a range from about 30° to about 40°.

[0018] The convex surface protruding in the direction opposite to the light emission direction among the convex surfaces of the lens unit, may include: curved convex surfaces respectively protruding from opposing edges of the convex surface, and a flat surface between the curved convex surfaces.

[0019] According to another exemplary embodiment of the invention, there is provided an organic light-emitting display apparatus including: an organic light-emitting device layer including: a plurality of sub-pixels which emits red, green and blue light, and an organic light-emitting device in each sub-pixel; an encapsulating film on the organic light-emitting device layer; a lens layer on the encapsulating film and including: a first convex surface corresponding to each sub-pixel and protruding in a light emission direction, and a second convex surface facing the first convex surface and protruding in a direction opposite to the light emission direction; and an anti-reflection film on the lens layer.

[0020] The lens layer may further include: a first lens sub-layer on the encapsulating film and having a low refractive index; and a second lens sub-layer on the first lens sub-layer and having a high refractive index. The second lens sub-layer may include the first convex surface protruding in the light emission direction and the second convex surface protruding in the direction opposite to the light emission direction.

[0021] A first surface of the first lens sub-layer may contact the second lens sub-layer may and include a concave surface corresponding to the second convex surface of the second lens sub-layer.

[0022] The second convex surface may include curved convex surfaces respectively protruding from opposing edges of the second convex surface, and a flat surface between the curved convex surface and corresponding to a central region of the each sub-pixel.

[0023] The anti-reflection film may include: a color filter corresponding to each of the sub-pixels; and a light blocking unit between the sub-pixels.

[0024] The plurality of sub-pixels may be arranged in a direction, and the first convex surface may be separated from the light blocking unit along the direction in which the sub-pixels is arranged.

[0025] An imaginary surface may extend in a direction in which the plurality of sub-pixels is arranged, and a first inclination angle formed by the first convex surface at an edge of the first convex surface, with respect to the imaginary surface, may have a value different from that of a second inclination angle formed by the second convex surface at an edge of the second convex surface, with respect to the imaginary surface.

[0026] The first inclination angle may be smaller than the second inclination angle.

[0027] The first inclination angle may be in a range from about 15° to about 25°, and the second inclination angle may be in a range from about 30° to about 40°.

[0028] According to one or more exemplary embodiment of the invention, an organic light-emitting display apparatus having a high front brightness and a large lateral viewing angle is provided.

[0029] Also, the organic light-emitting display apparatus includes an anti-reflection film that includes color filters and light blocking layers, and a lens layer having a relatively small thickness is on a thin film encapsulating layer, and thus, the organic light-emitting display apparatus may have a high resistance to bending.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and other features and advantages of the invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

[0031] FIG. **1** is a schematic cross-sectional view illustrating an exemplary embodiment of an organic light-emitting display apparatus according to the invention;

[0032] FIG. **2** is an enlarged view of region II of FIG. **1**; and

[0033] FIG. **3** is a cross-sectional view of an exemplary embodiment of a single sub-pixel region of the organic light-emitting display apparatus of FIG. **1**;

[0034] FIG. **4** is a schematic cross-sectional view illustrating another exemplary embodiment of an organic light-emitting display apparatus according to the invention;

[0035] FIG. **5** is an enlarged view of region V of FIG. **4**;

[0036] FIG. **6** is a schematic cross-sectional view illustrating an organic light-emitting display apparatus according to a comparative example;

[0037] FIG. **7**A is a simulation image showing intensity of light emitted from a single pixel of the exemplary embodiment of the organic light-emitting display apparatus described with reference to FIGS. **1** and **2**, according to the invention; and

[0038] FIG. **7**B is a simulation image showing intensity of light emitted from a single pixel of the comparative example of the organic light-emitting display apparatus described with reference to FIG. **6**.

DETAILED DESCRIPTION

[0039] While exemplary embodiments are capable of various modifications and alternative forms, embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit exemplary embodiments to the particular forms disclosed, but on the contrary, exemplary embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of the invention. In describing the invention, when practical descriptions with respect to related known function and configuration may unnecessarily make unclear of the scope of the invention, the descriptions thereof will be omitted.

[0040] It will be understood that, although the terms "first", "second", etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. The terminologies used herein are for the purpose of describing embodiments only and are not intended to be limiting of exemplary embodiments.

[0041] As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including" when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the symbol "/" may be interpreted as "and" or "or" according to the circumstance.

[0042] In the drawings, thicknesses may be exaggerated for clarity of layers and regions. Like reference numerals are used to like elements throughout the specification. When a layer, a film, a region or a panel is referred to as being "on" another element, it can be directly on the other layer or substrate, or intervening layers may also be present.

[0043] Spatially relative terms, such as "lower," "upper" and the like, may be used herein for ease of description to describe the relationship of one element or feature to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "lower" relative to other elements or features would then be oriented "above" relative to the other elements or features. Thus, the exemplary term "lower" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0044] Embodiments of the invention are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

[0045] "About" or "approximately" as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, "about" can mean within one or more standard deviations, or within ±30%, 20%, 10%, 5% of the stated value.

[0046] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0047] Hereinafter, the invention will be described in detail with reference to the accompanying drawings.

[0048] FIG. **1** is a schematic cross-sectional view illustrating an exemplary embodiment of an organic light-emitting display apparatus according to the invention. FIG. **2** is an enlarged view of region II of FIG. **1**. FIG. **3** is a cross-sectional view of an exemplary embodiment of a single sub-pixel region of the organic light-emitting display apparatus of FIG. **1**.

[0049] Referring to FIG. **1**, the organic light-emitting display apparatus may include a substrate **100**, an organic light-emitting device layer including one or more organic light-emitting device **200** disposed on the substrate **100**, an encapsulating film **300**, a lens layer **400**, and an anti-reflection film **500**.

[0050] The substrate **100** may include a plastic having a high thermal resistance and durability. However, the substrate **100** according to the invention is not limited thereto, and the substrate **100** may include various materials, such as a metal or glass.

[0051] The organic light-emitting device **200** is disposed on the substrate **100**. The organic light-emitting device layer including a plurality of organic light-emitting devices **200** may include a plurality of sub-pixels P**1**, P**2** and P**3** defined therein that emits light of different colors. In one exemplary embodiment, for example, the organic light-emitting device layer may include a plurality of first sub-pixels P**1** that emit red light, a plurality of second sub-pixels P**2** that emit green light, and a plurality of third sub-pixels P**3** that emit blue light.

[0052] Referring to FIG. **3**, the organic light-emitting device **200** may include a buffer layer **201** that is on the substrate **100** to block penetration of foreign materials and moisture to a remainder of the organic light-emitting device **200**, a thin film transistor **210** on the buffer layer **201**, a first electrode **221** connected to the thin film transistor **210**, a second electrode **223** that faces the first electrode **221**, and an intermediate layer **222** that is disposed between the first and second electrodes **221** and **223** and includes an organic light-emitting layer.

[0053] The thin film transistor **210** may include an active layer **211**, a gate electrode **212**, a source electrode **213***s* and a drain electrode **213***d*. A first insulating layer **202** may be interposed between the gate electrode **212** and the active layer **211** as a gate insulating layer to insulate the gate electrode **212** and the active layer **211** from each other. The active layer **211** may include a channel region disposed in the middle of the active layer **211**, and a source region and a drain region that are respectively disposed on both sides of the channel region. The active layer **211** may include amorphous silicon, crystalline silicon or semiconductor oxide, but not being limited thereto.

[0054] In an exemplary embodiment of manufacturing the organic light-emitting device **200**, the source region and the drain region respectively disposed at opposing edges of the channel region may be formed (e.g., provided) by doping a high concentration dopant by using a gate electrode **212** as a self-aligned mask. In FIG. **3**, a top gate type thin film transistor **210** is depicted. However, the thin film transistor according to the invention is not limited thereto, and as another exemplary embodiment of the invention, a bottom gate type thin film transistor may be employed.

[0055] The source electrode **213***s* and the drain electrode **213***d* are disposed on the gate electrode **212**, and a second insulating layer **203** therebetween. The source electrode **213***s* and the drain electrode **213***d* are physically and/or electrically connected to the source region and the drain region of the active layer **211**, respectively. A third insulating layer **204** may be disposed on the source electrode **213***s* and the drain electrode **213***d*.

[0056] One of the source electrode **213***s* and the drain electrode **213***d* may be physically and/or electrically connected to the first electrode **221**. The intermediate layer **222** which includes the organic light-emitting layer, and the second electrode **223**, may be disposed on the first electrode **221**.

[0057] The structure depicted in FIG. **3** is included in each of the sub-pixels P**1**, P**2** and P**3**, and the organic light-emitting layer included in the intermediate layer **222** of each of the first, second, and third sub-pixels P**1**, P**2** and P**3** includes an organic material that emits a color light such as red, green and blue color light. The organic light-emitting layer that emits red, green and blue color light may include a low or high molecule organic material. The organic light-emitting layer, the intermediate layer **222** may further include at least one of a hole transport layer, a hole injection layer, an electron transport layer or an electron injection layer.

[0058] Referring again to FIG. **1**, the encapsulating film **300** is disposed on the organic light-emitting device **200** to reduce or effectively prevent penetration of foreign materials and/or external agents into the organic light-emitting device **200**. In an exemplary embodiment, the encapsulating film **300** may be directly on the organic light-emitting device **200**, but not being limited thereto or thereby. In an exemplary embodiment of manufacturing the organic light-emitting display apparatus, the encapsulating film **300** may be an encapsulating thin film that is formed (e.g., provided) by alternately stacking an organic layer and an inorganic layer. The organic layer may include an acryl based resin, an epoxy based resin or a polymer based material such as polyimide and polyethylene, or a combination of these materials. The inorganic layer may include a metal oxide, a metal nitride, a metal carbonate or a combination of these materials.

[0059] The lens layer **400** may be disposed on the encapsulating film **300**. In an exemplary embodiment, the lens layer **400** may be directly on a whole surface of the encapsulating film **300**, but not being limited thereto or thereby. The lens layer **400** may include a lens unit **425** on a region of the organic light-emitting display apparatus corresponding to each of the sub-pixels P**1**, P**2** and P**3**.

[0060] The anti-reflection film **500** is disposed on the lens layer **400** to reduce or effectively prevent external light reflection. The anti-reflection film **500** may include one or more color filter **510** at regions corresponding to the sub-pixels P**1**, P**2** and P**3**, and a light blocking unit **520** between adjacent color filters **510** (or regions between the sub-pixels P**1**, P**2** and P**3**). Since a small amount of light that enters into the color filters **510** is reflected, an external light visibility is increased and an image definition may be increased. The light blocking units **520** disposed on the regions, that is, non-emission regions between the sub-pixels P**1**, P**2** and P**3** reduce contrast caused by lower reflection of external light, and may include a black matrix that absorbs the wavelength of a visible light region. Here, the lower reflection indicates the reflection of external light by an electrode or a wire of the organic light-emitting device **200** and/or the substrate **100** that are under the anti-reflection film **500**.

[0061] The lens unit **425** included in the lens layer **400** may be a biconvex lens. In one exemplary embodiment, for example, the lens unit **425** may include a first convex surface S**1** that protrudes in an emission direction (hereinafter, a first direction) of light emitted from the organic light-emitting device **200**, and a second convex surface S**2** that protrudes in a direction opposite (hereinafter, a second direction) to the emission direction of light.

[0062] The lens layer **400** includes flat regions (e.g., non-emission regions) between the neighboring sub-pixels P**1**, P**2** and P**3**, and corrugate regions disposed on regions corresponding to the sub-pixels P**1**, P**2**, and P**3**. Here, the corrugate surface corresponds to the convex surfaces of the lens unit **425**. In one exemplary embodiment, for example, the lens unit **425** may be defined by at least one of the plural layers that form the lens layer **400** that includes a corrugate surface.

[0063] According to the illustrated embodiment, the lens layer **400** may include a first lens sub-layer **410** disposed on the encapsulating film **300** and a second lens sub-layer **420** disposed on the first lens sub-layer **410**. Here, the second lens sub-layer **420** may form the lens unit **425** by including convex portions that protrude in the first and second directions from a substantially planar main portion. A first surface of the first lens sub-layer **410**, that is, an upper surface that contacts the second lens sub-layer **420**, may include a concave recess having a shape corresponding to a convex surface of the second lens sub-layer **420** that protrudes in the second direction.

[0064] Referring again to FIG. **1**, light from the organic light-emitting device **200** is emitted in all directions. Here, the lens unit **425** collects light incident to regions outside the sub-pixels P**1**, P**2** and P**3**, that is, non-emission regions and emits the collected light to outside the organic light-emitting device **200**. That is, the second lens sub-layer **420** includes the lens unit **425** to collect light that is subsequently emitted in substantially all directions, and thus, the brightness of a front surface and lateral viewing angles of the organic light-emitting device **200** may be increased. The brightness of the front surface of the organic light-emitting device **200** may further be increased by the first lens sub-layer **410** including a material having a relatively low refractive index and the second lens sub-layer **420** including a material having a relatively high refractive index.

[0065] The first lens sub-layer **410** may include an organic material having the relatively low refractive index, and the second lens sub-layer **420** may include an organic material having the relatively high refractive index. Alternatively, the first lens sub-layer **410** may include an inorganic material having the relatively low refractive index, and the second lens sub-layer **420** may include an inorganic material having the relatively high refractive index. In one exemplary embodiment, for example, the first lens sub-layer **410** may include an organic material or an inorganic material having a refractive index of about 1.3 or less, and the second lens sub-layer **420** may include an organic material or an inorganic material having a refractive index in a range from about 1.7 to about 1.9.

[0066] The organic material having a low refractive index may include at least one selected from an acryl based resin such as acrylic and acrylates, a polyacryl based resin, a polyimide based resin, an epoxy resin and a melanin resin, and a combination thereof. The organic material having a high refractive index may include at least one selected from a polysiloxane based resin, a polyacryl based resin, a polyimide based resin, an epoxy region and an acryl group resin, and a combination thereof. The inorganic material having a low refractive index may include at least one selected from a silicon based resin, and an inorganic material such as a siloxane based, a dimethylsiloxane based, and a phenyltrichlorosilane based material, and a combination thereof. The inorganic material having a high refractive index may include at least one selected from a silicon group resin, and an inorganic material such as a siloxane based, a dimethylsiloxane based and a phenyltrichlorosilane based material, and a combination thereof.

[0067] The first convex surface S**1** and the second convex surface S**2** of the lens unit **425** may have different widths taken in a direction parallel with the substrate **100**. Referring to FIG. **2**, a width w**1** of the first convex surface S**1** may be smaller than a width w**2** of the second convex surface S**2**. In view of the direction which is an arranging direction (hereinafter, a width direction) of the sub-pixels P**1**, P**2** and P**3**, the light blocking units **520** are disposed on opposing sides of the first convex surface S**1** and separated from opposing edges of the first convex surface S**1**. An edge of the first convex surface S**1** is separated by a predetermined gap g taken in the arranging direction from a respective light blocking unit **520**.

[0068] Light from the organic light-emitting device **200** is refracted by the second convex surface S**2** formed by the second lens sub-layer **420** having a high refractive index, after passing through the first lens sub-layer **410**, and afterwards, is emitted through the first convex surface S**1**, as illustrated by the arrowed-lines in FIG. **1**. If the opposing edges of the first convex surface S**1** contact the light blocking units **520**, respectively, all of the light emitted through the edges of the first convex surface S**1**, for example, the opposing edges of the first convex surface S**1** may be absorbed by the light blocking units **520**, and thus, the optical efficiency of the organic light-emitting device **200** may be greatly reduced. However, in the lens unit **425** according to the illustrated embodiment, both of the opposing edges of the first convex surface S**1** that protrudes in the first direction are separated from the light blocking units **520** in the arranging direction, and thus, the absorption of light that is emitted through the lens unit **425** by the light blocking units **520** may be reduced or effectively be prevented.

[0069] At edges of the lens unit **425**, for example, at opposing ends of the lens unit **425**, the first and second convex surfaces S**1** and S**2** form a predetermined angle with respect to an imaginary surface IP that extends along the width direction of the lens unit **425**. That is, at the edge of the first convex surface S**1**, the first convex surface S**1** of the lens unit **425** forms a first inclination angle θ**1** with respect to the imaginary surface IP **1**, and at the edge of the second convex surface S**2**, the second convex surface S**2** of the lens unit **425** forms a second inclination angle θ**2** with respect to the imaginary surface IP. Through the structure of the lens unit **425** that has the first and second inclination angles θ**1** and θ**2**, a lateral viewing angle of light emitted from the organic light-emitting device **200** may be ensured.

[0070] As an exemplary embodiment of the invention, the first inclination angle θ**1** that is formed by the first convex surface S**1** with respect to the imaginary surface IP that extends along the width direction of the lens unit **425** may have a different value from a value of the second inclination angle θ2 that is formed by the second convex surface **S2** with respect to the imaginary surface IP at the edge of the second convex surface **S2**. As described above, the lens unit **425** collects light emitted towards front side from the organic light-emitting device **200**. Furthermore, since the light blocking units **520** are disposed on both edges of the lens unit **425** light, it is desirable to increase collecting efficiency of the light and to reduce or effectively prevent light passed through the lens unit **425** from being absorbed by the light blocking units **520**.

[0071] For this, the first inclination angle θ**1** is smaller than the second inclination angle θ**2**, that is, the second inclination angle θ**2** may be greater than the first inclination angle θ**1**. In one exemplary embodiment, for example, the second inclination angle θ**2** may be in a range from about 30 degrees (°) to about 40°, and the first inclination angle θ**1** may be in a range from about 15° to about 25°. If the second inclination angle θ**2** exceeds or is outside the above range, the intensity of light collected may be reduced, and most of the light passed through the lens unit **425** may be absorbed by the light blocking units **520**. If the first inclination angle θ**1** exceeds or is outside the above range, most of the light passed through the edges of the first convex surface **S1** may be absorbed by the light blocking units **520**.

[0072] According to the illustrated embodiment, a size of the lens unit **425** included in the sub-pixel **P3** that emits blue light may be greater than that of the lens unit **425** included in the sub-pixels **P2** and **P3** that emit color light other than the blue light. Blue light emitted from the organic light-emitting device **200** has a relatively lower brightness and light emission efficiency than red and green lights. Therefore, the size of the lens unit **425** included in the sub-pixel **P3** that emits blue light may be greater than that of the lens unit **425** included in the sub-pixels **P2** and **P3** that emit red and green lights, and the light collecting efficiency of blue light may be increased. The size of the lens unit **425** may refer to the width of the pixel taken in the arranging direction, such as being in the same direction as the widths w**1** and w**2** of the convex surfaces **S1** and **S2**.

[0073] In FIG. **1**, a single lens unit **425** is included in each of the sub-pixels **P1**, **P2** and **P3**, but the invention is not limited thereto. As another exemplary embodiment of the invention, a plurality of lens units **425** may be disposed in each of the sub-pixels **P1**, **P2** and **P3**. Where the plurality of lens units **425** is disposed in each of the sub-pixels **P1**, **P2** and **P3**, the conditions of widths and inclination angles with respect to the first convex surface **S1** and the second convex surface **S2** of each of the lens units **425** are the same as the conditions described above. Also, edges or boundaries of the convex surfaces that protrude in the first direction of the lens units **425** are separated from the light blocking units **520**.

[0074] As described above, through the lens unit **425**, the light blocking units **520** disposed separated from opposing edges of the lens unit **425**, and the anti-reflection film **500** having color filters **510**, the reflection of external light is suppressed, lateral viewing angles are ensured, and a color shift of lateral viewing angles is reduced or effectively prevented, thereby increasing image quality.

[0075] FIG. **4** is a schematic cross-sectional view illustrating another exemplary embodiment of an organic light-emitting display apparatus according to the invention. FIG. **5** is an enlarged view of region V of FIG. **4**.

[0076] Referring to FIGS. **4** and **5**, the organic light-emitting display apparatus according to the illustrated embodiment is different from the organic light-emitting display apparatus described with reference to FIGS. **1** and **2** in that a lens unit **425'** has a different shape from that of the lens unit **425**.

[0077] Referring to FIGS. **4** and **5**, the lens unit **425'** includes a first convex surface **S1** that protrudes in a first direction and a second convex surface **S2** that protrudes in a second direction from a substantially planar main portion. However, a central region of the second convex surface **S2** may include a flat surface **S3**. In the exemplary embodiment described with reference to FIGS. **1** and **2**, both surfaces, that is, the first and second convex surfaces **S1** and **S2** of the lens unit **425** are entirely curved surfaces. However, according to the illustrated exemplary embodiment, the first convex surface **S1** of the lens unit **425'** is an entirely curved surface, and the second convex surface **S2** may include the flat surface **S3**.

[0078] Light emitted from the central region of each of the sub-pixels **P1**, **P2** and **P3** of the organic light-emitting device **200** has a high intensity, and thus, the second convex surface **S2** includes the flat surface **S3** in the center region and a curved surface **S4** on an edge region, so that a region corresponding to the center of the sub-pixel directly transmits light generated from the organic light-emitting device **200** and the edge region collects light.

[0079] A total width w**2** of the second convex surface **S2** is in a range from about **7** micrometers (μm) to about 13 μm, a width w**3** of the flat surface **S3** may be in a range from about 2 μm to about 6 μm, and a height h of the second convex surface **S2** taken from the flat region of the lens layer **400** may be in a range from about 0.5 μm to about 3.5 μm. However, when the lens unit **425'** is included in the sub-pixel **P3** emits a blue light, in order to increase an efficiency of blue light, the total width w**2** of the second convex surface **S2** may be in a range from about 17 μm to about 23 μm, and the width w**3** of the flat surface **S3** may be in a range from about 8 μm to about 12 μm.

[0080] In the illustrated exemplary embodiment, the first inclination angle θ**1** may be in a range from about 15° to about 25°, and the second inclination angle θ**2** may be in a range from about 30° to about 40°. Also, similar to the exemplary embodiment described with reference to FIGS. **1** and **2**, the total width w**2** of the second convex surface **S2** is greater than the total width w**1** of the first convex surface **S1**.

[0081] FIG. **6** is a schematic cross-sectional view illustrating an organic light-emitting display apparatus according to a comparative example. FIG. **7**A is a simulation image showing the intensity of light emitted from a single pixel of the exemplary embodiment of the organic light-emitting display apparatus described with reference to FIGS. **1** and **2**, according to the invention. FIG. **7**B is a simulation image showing the intensity of light emitted from a single pixel of the comparative example of the organic light-emitting display apparatus described with reference to FIG. **6**. Here, it is denoted that the single pixel includes red color sub-pixel **P1**, green color sub-pixel **P2**, and blue color sub-pixel **P3**.

[0082] Referring to FIG. **6**, the organic light-emitting display apparatus according to the comparative example includes a substrate **10**, an organic light-emitting device **20** disposed on the substrate **10**, an encapsulating film **30**, and an anti-reflection film **50**. However, a first entirely planar layer **41** having a low refractive index and a second entirely planar layer **42** having a high refractive index, of an optical layer **40**, are included between the encapsulating film **30** and the anti-reflection film **50**, and not a lens unit.

[0083] Referring to FIGS. **7**A and **7**B, it is confirmed that brightness of a central region of the image of FIG. **7**B for light emitted from a single pixel of the comparative example of is greater than that of a central region of the image of FIG. **7**A for light emitted from a single pixel of the exemplary embodiment of the organic light-emitting display apparatus described with reference to FIGS. **1** and **2**. That is, an efficiency of a front surface at the central region of a pixel of the exemplary embodiment of the organic light-emitting display apparatus according to the invention is increased by approximately 15% when compared to that of the comparative example. Also, in regard to an overall light efficiency, the exemplary embodiment shows a light efficiency that is approximately 16.6% greater than the comparative example.

[0084] While the invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. An organic light-emitting display apparatus comprising:

an organic light-emitting device layer comprising:

a plurality of sub-pixels which emits lights of different colors, and

an organic light-emitting device in each sub-pixel;

an encapsulating film on the organic light-emitting device layer;

a lens layer on the encapsulating film and comprising:

a lens unit corresponding to the each sub-pixel and comprising facing convex surfaces respectively protruding in a light emission direction, and a direction opposite to the light emission direction; and

an anti-anti-reflection film on the lens layer and comprising a color filter corresponding to the each sub-pixel.

2. The organic light-emitting display apparatus of claim **1**, wherein the anti-reflection film further comprises a light blocking unit between neighboring sub-pixels.

3. The organic light-emitting display apparatus of claim **2**, wherein

the plurality of sub-pixels is arranged in a direction, and

the light blocking unit is separated from the convex surface protruding in the light emission direction among the convex surfaces of the lens unit, by a predetermined gap along the direction in which the plurality of sub-pixels is arranged.

4. The organic light-emitting display apparatus of claim **3**, wherein the convex surface protruding in the light emission direction among the convex surfaces of the lens unit has a width smaller than that of the convex surface protruding in a direction opposite to the light emission direction, the widths taken in the direction in which the plurality of sub-pixels is arranged.

5. The organic light-emitting display apparatus of claim **1**, wherein the lens layer further comprises:

a first lens sub-layer on the encapsulating film and having a first refractive index; and

a second lens sub-layer on the first lens sub-layer, having a second refractive index, and comprising:

a first convex surface protruding in the light emission direction among the convex surfaces of the lens unit, and

a second convex surface protruding in the direction opposite to the light emission direction among the convex surfaces of the lens unit,

wherein a first surface of the first lens sub-layer contacts the second lens sub-layer and comprises a concave surface corresponding to the second convex surface of the second lens sub-layer.

6. The organic light-emitting display apparatus of claim **5**, wherein the second refractive index is greater than the first refractive index.

7. The organic light-emitting display apparatus of claim **6**, wherein

the first refractive index is about 1.3 or less, and

the second refractive index is in a range from about 1.7 to about 1.9.

8. The organic light-emitting display apparatus of claim **5**, wherein

an imaginary surface extends in a direction in which the plurality of sub-pixels is arranged, and

a first inclination angle formed by the first convex surface at an edge of the first convex surface, with respect to the imaginary surface, is smaller than a second inclination angle formed by the second convex surface at an edge of the second convex surface, with respect to the imaginary surface.

9. The organic light-emitting display apparatus of claim **8**, wherein the first inclination angle is in a range from about 15° to about 25°.

10. The organic light-emitting display apparatus of claim **8**, wherein the second inclination angle is in a range from about 30° to about 40°.

11. The organic light-emitting display apparatus of claim **1**, wherein the convex surface protruding in the direction opposite to the light emission direction among the convex surfaces of the lens unit, comprises:

curved convex surfaces respectively protruding from opposing edges of the convex surface, and

a flat surface between the curved convex surfaces.

12. An organic light-emitting display apparatus comprising:

an organic light-emitting device layer comprising:

a plurality of sub-pixels which emits red, green and blue light, and

an organic light-emitting device in each sub-pixel;

an encapsulating film on the organic light-emitting device layer;

a lens layer on the encapsulating film and comprising:

a first convex surface corresponding to each sub-pixel and protruding in a light emission direction, and

a second convex surface facing the first convex surface and protruding in a direction opposite to the light emission direction; and

an anti-reflection film on the lens layer.

13. The organic light-emitting display apparatus of claim **12**, wherein the lens layer further comprises:

a first lens sub-layer on the encapsulating film and having a low refractive index; and

a second lens sub-layer on the first lens sub-layer and having a high refractive index,

wherein the second lens sub-layer comprises the first convex surface protruding in the light emission direction and the second convex surface protruding in the direction opposite to the light emission direction.

14. The organic light-emitting display apparatus of claim **13**, wherein a first surface of the first lens sub-layer contacts the second lens sub-layer and comprises a concave surface corresponding to the second convex surface of the second lens sub-layer.

15. The organic light-emitting display apparatus of claim **13**, wherein the second convex surface comprises:

curved convex surfaces respectively protruding from opposing edges of the second convex surface, and

a flat surface between the curved convex surface and corresponding to a central region of the each sub-pixel.

16. The organic light-emitting display apparatus of claim **12**, wherein the anti-reflection film comprises:

a color filter corresponding to the each sub-pixel; and

a light blocking unit between adjacent sub-pixels.

17. The organic light-emitting display apparatus of claim **16**, wherein

the plurality of sub-pixels is arranged in a direction, and

the first convex surface is separated from the light blocking unit along the direction in which the sub-pixels is arranged.

18. The organic light-emitting display apparatus of claim **12**, wherein

an imaginary surface extends in a direction in which the plurality of sub-pixels is arranged, and

a first inclination angle formed by the first convex surface at an edge of the first convex surface, with respect to the imaginary surface, has a value different from that of a second inclination angle formed by the second convex surface at an edge of the second convex surface, with respect to the imaginary surface.

19. The organic light-emitting display apparatus of claim **18**, wherein the first inclination angle is smaller than the second inclination angle.

20. The organic light-emitting display apparatus of claim **18**, wherein

the first inclination angle is in a range from about 15° to about 25°, and

the second inclination angle is in a range from about 30° to about 40°.

* * * * *

专利名称(译)	有机发光显示装置		
公开(公告)号	US20140339509A1	公开(公告)日	2014-11-20
申请号	US14/011990	申请日	2013-08-28
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
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发明人	CHOI, HAE-YUN PARK, WON-SANG LIM, JAE-IK		
IPC分类号	H01L27/32 H01L51/52		
CPC分类号	H01L51/5275 H01L27/3211 H01L27/322 H01L51/5284 G09G3/3208 H01L27/3206 H01L27/326 H01L27/3272 H01L51/5237 H01L51/5259 H01L51/5271 H05B33/04		
优先权	1020130056049 2013-05-16 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供一种有机发光显示装置，其包括有机发光装置，所述有机发光装置包括发射不同光色的多个子像素;在有机发光器件上形成的封装膜;透镜层，其形成在封装膜上并包括凸面，所述凸面设置在与子像素对应的区域上并沿光发射方向和与光发射方向相反的方向突出;以及防反射膜，其形成在透镜层上以防止外部光的反射，并且包括在与每个子像素对应的区域上的滤色器。