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(54) **DISPLAY APPARATUS**

(71) Applicant: **Samsung Display Co., LTD.**, Yongin-si (KR)

(72) Inventors: **Wonhak CHOI**, Yongin-si (KR); **Gunwoo KO**, Yongin-si (KR); **Junghyun CHO**, Yongin-si (KR); **Beohmrock CHOI**, Yongin-si (KR)

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(57) **ABSTRACT**

A display apparatus includes: a substrate; a first pixel electrode disposed on the substrate; a pixel-defining layer covering an edge of the first pixel electrode and defining a first pixel opening exposing a central portion of the first pixel electrode; an intermediate insulating layer interposed between the substrate and the pixel-defining layer and including a first portion defining a first intermediate opening having an area greater than an area of the first pixel opening in a plan view; a first intermediate layer contacting the first pixel electrode through the first pixel opening and including a first emission layer; and a common electrode disposed over the first pixel electrode with the first intermediate layer interposed therebetween and defining a plurality of first emission openings arranged outside the first pixel opening in the plan view.

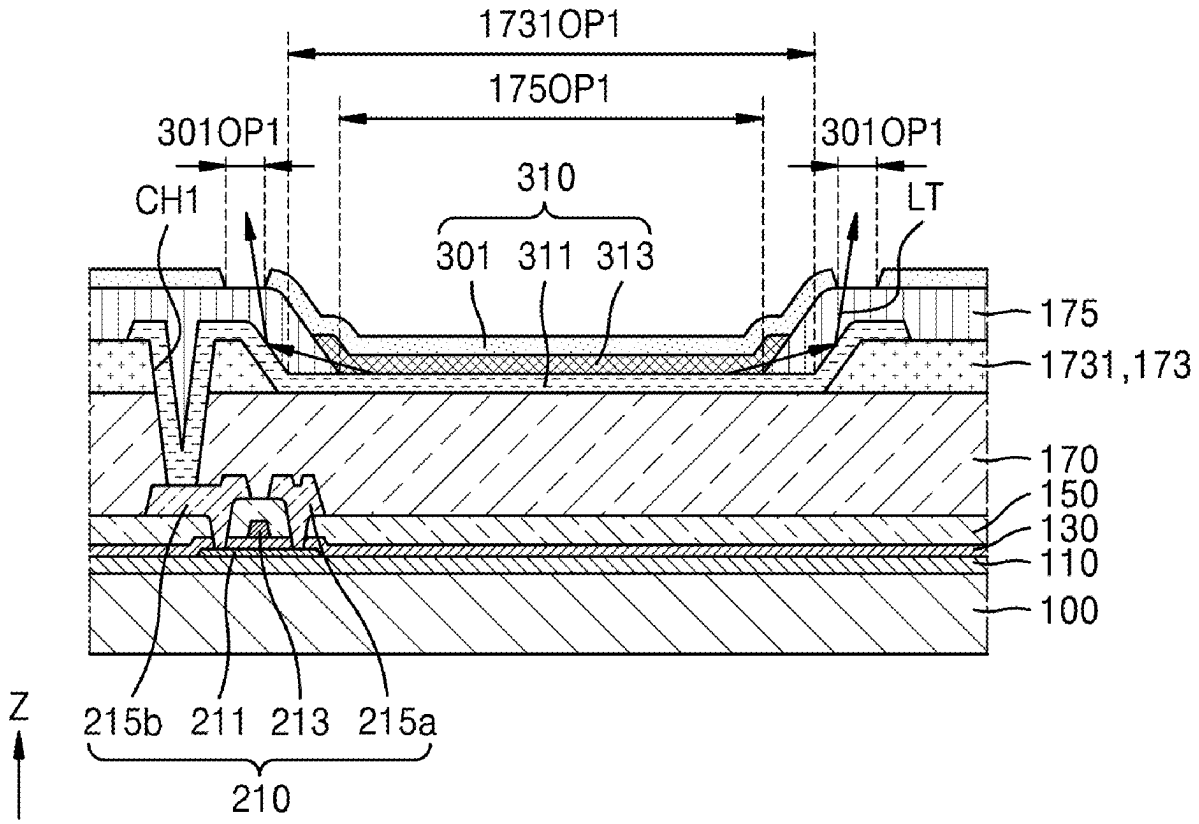
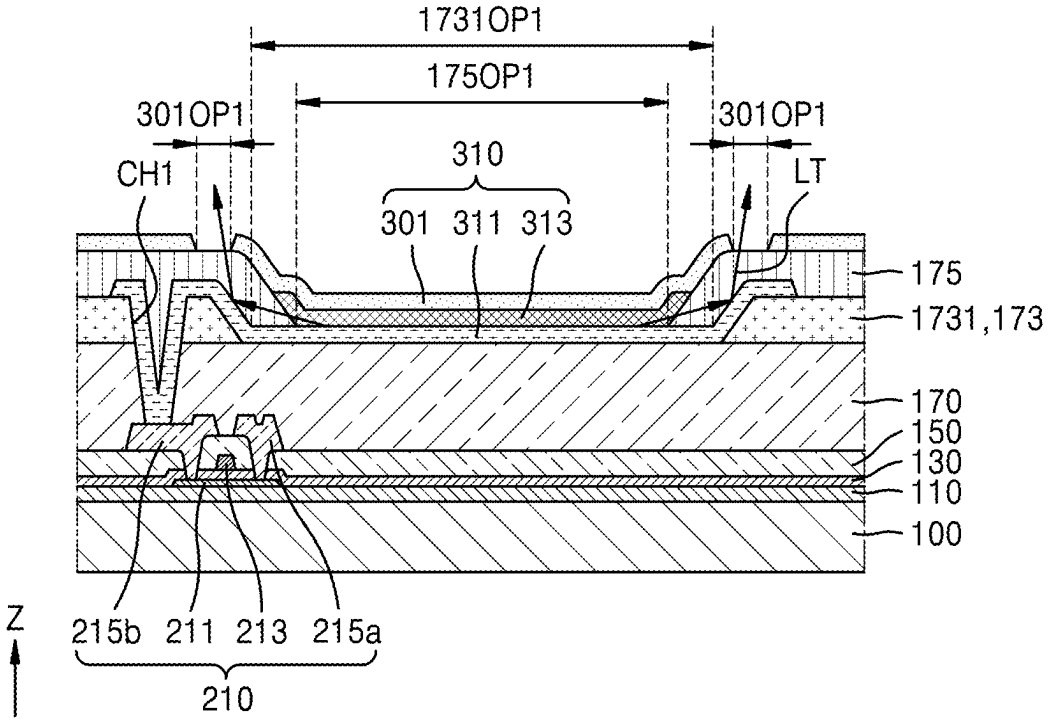


FIG. 1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301OP1
301OP1
310
CH1
LT
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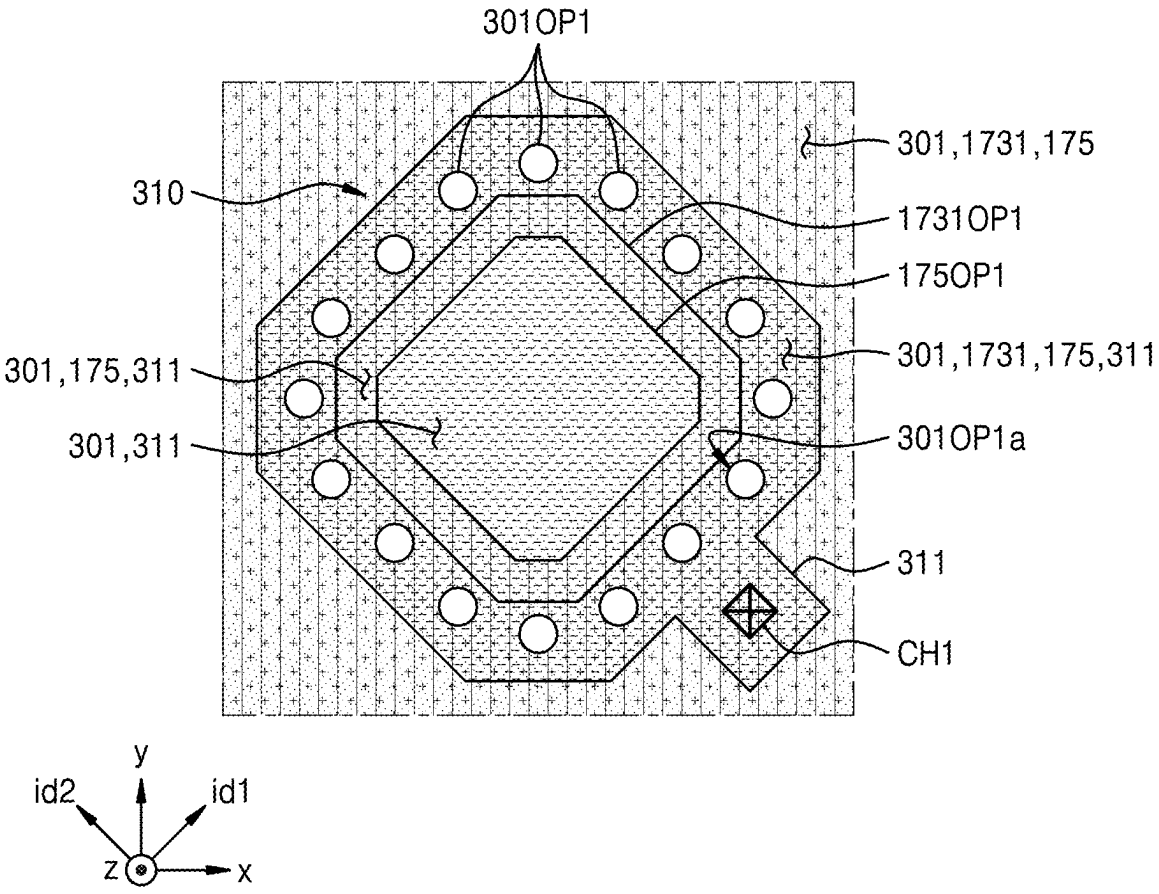
170
150
130
110
100
Z
215b 211 213 215a
210

FIG. 2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310
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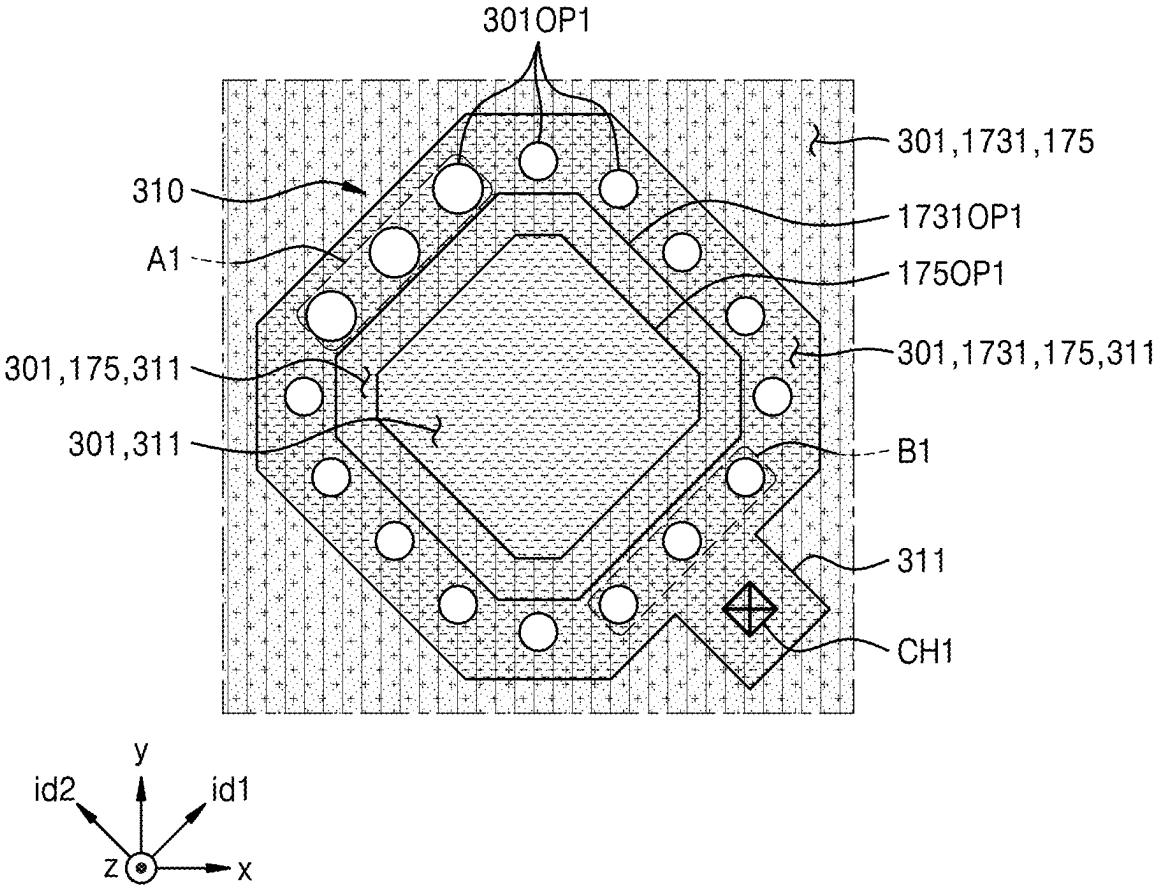
301,311
301OP1a
311
CH1
y
id2
id1
z
x

FIG. 3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301,1731,175
310
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A1
175OP1
301,175,311
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301,311
B1
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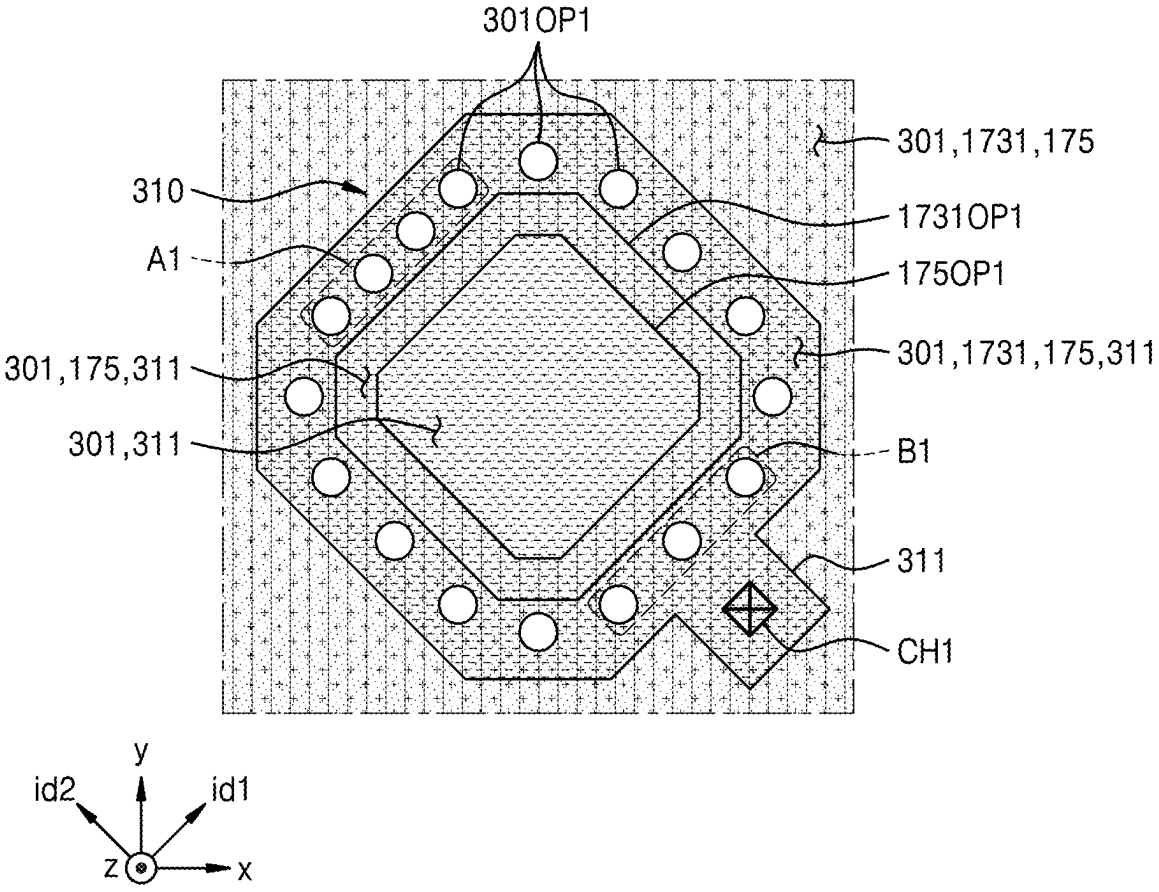
CH1
y
id2
id1
z
x

FIG. 4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1731OP1
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175OP1
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301,311
B1
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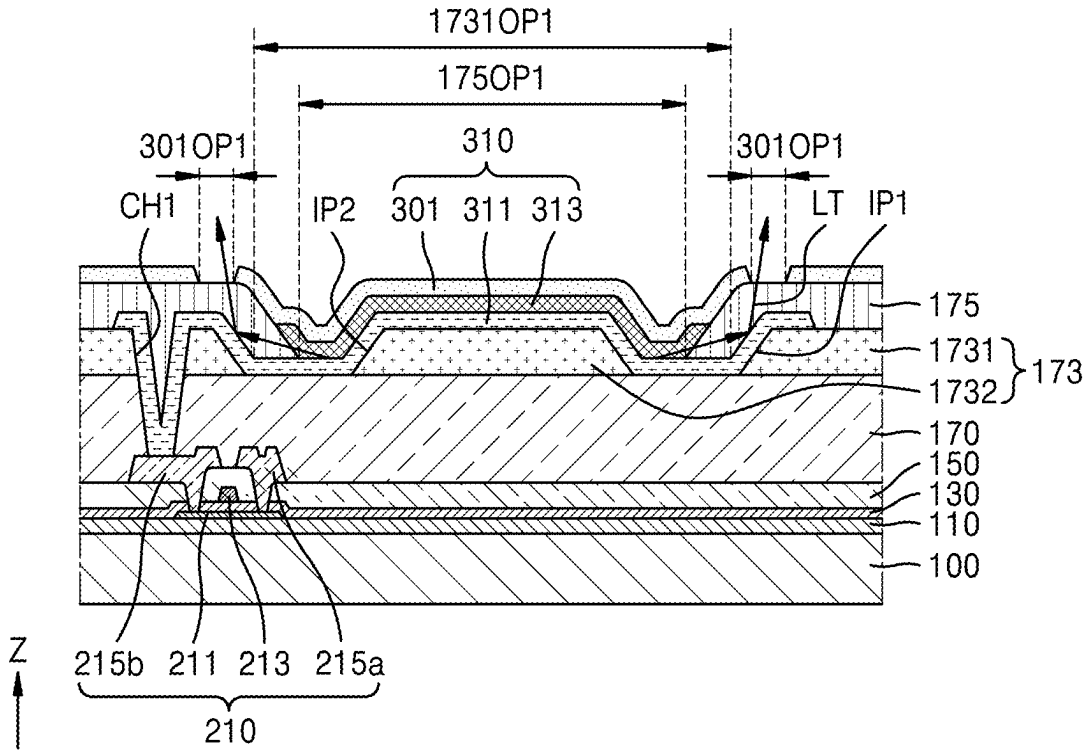
CH1
y
id2
id1
z
x

FIG. 5


1731OP1
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301OP1
310
301OP1
CH1
IP2
301
311
313
LT
IP1
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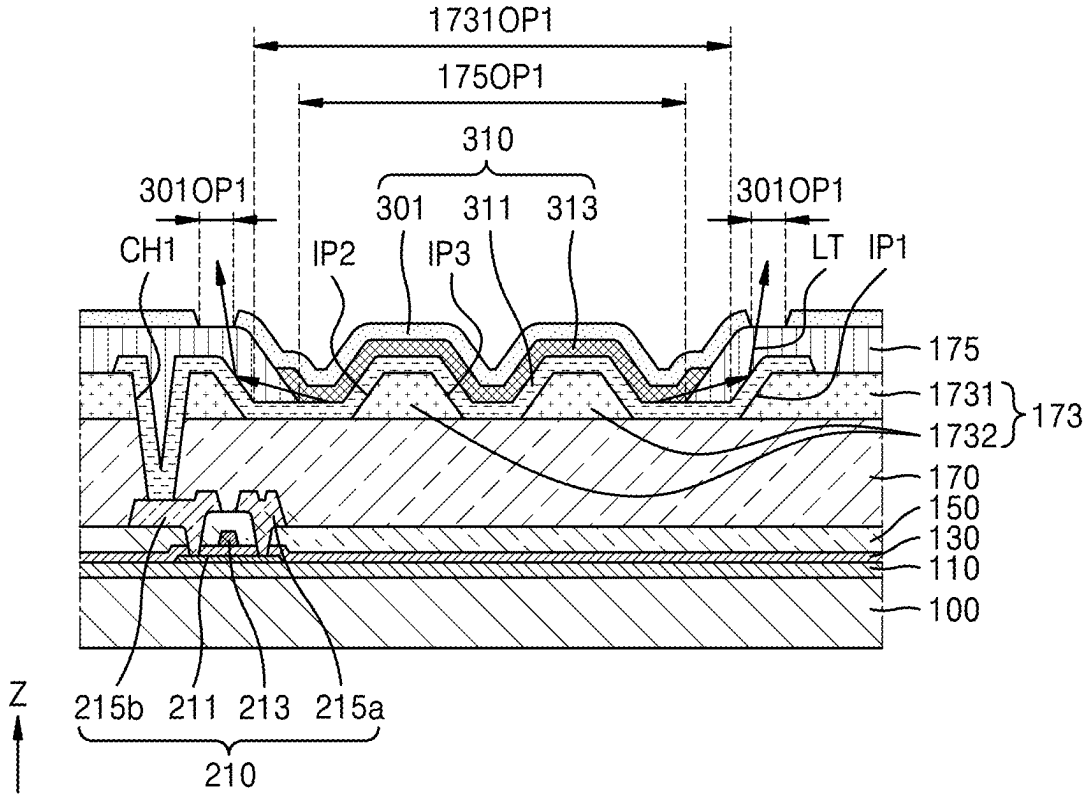
1731
1732
173
170
150
130
110
100
Z
215b
211
213
215a
210

FIG. 6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301OP1
301
311
313
301OP1
CH1
IP2
IP3
LT
IP1
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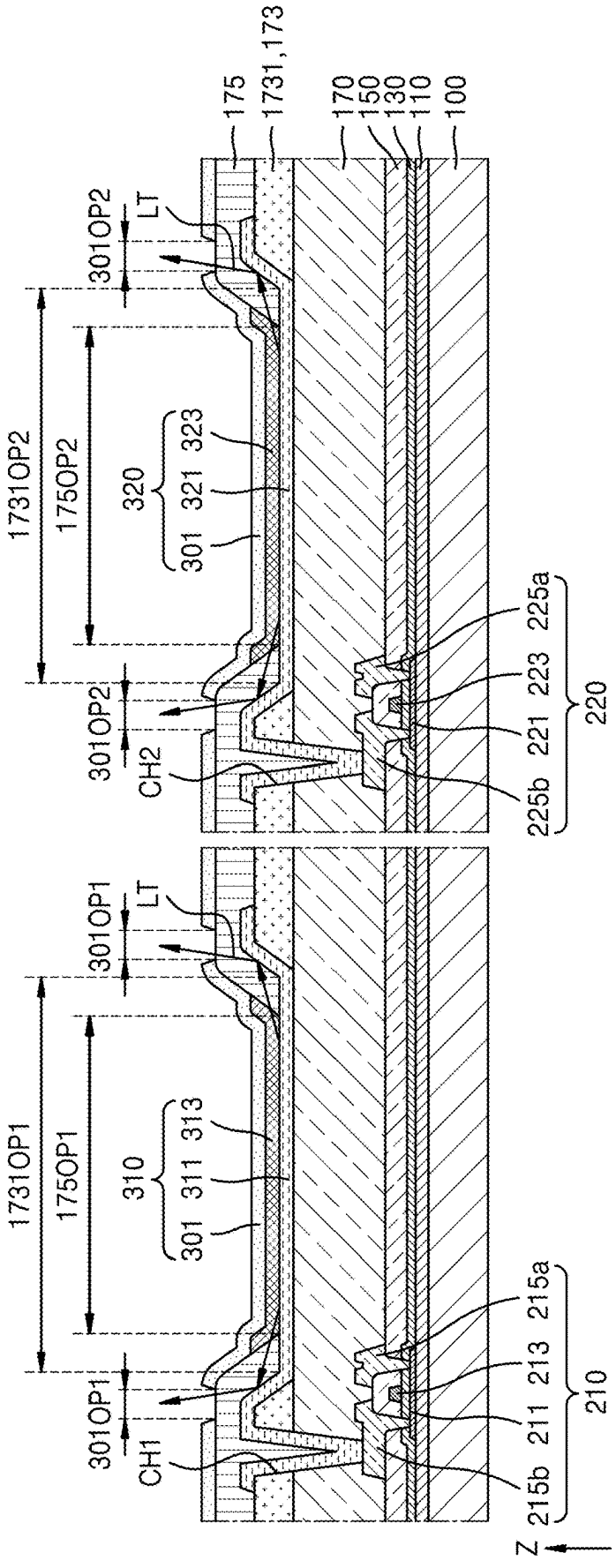
100
Z
215b
211
213
215a
210

FIG. 7


175
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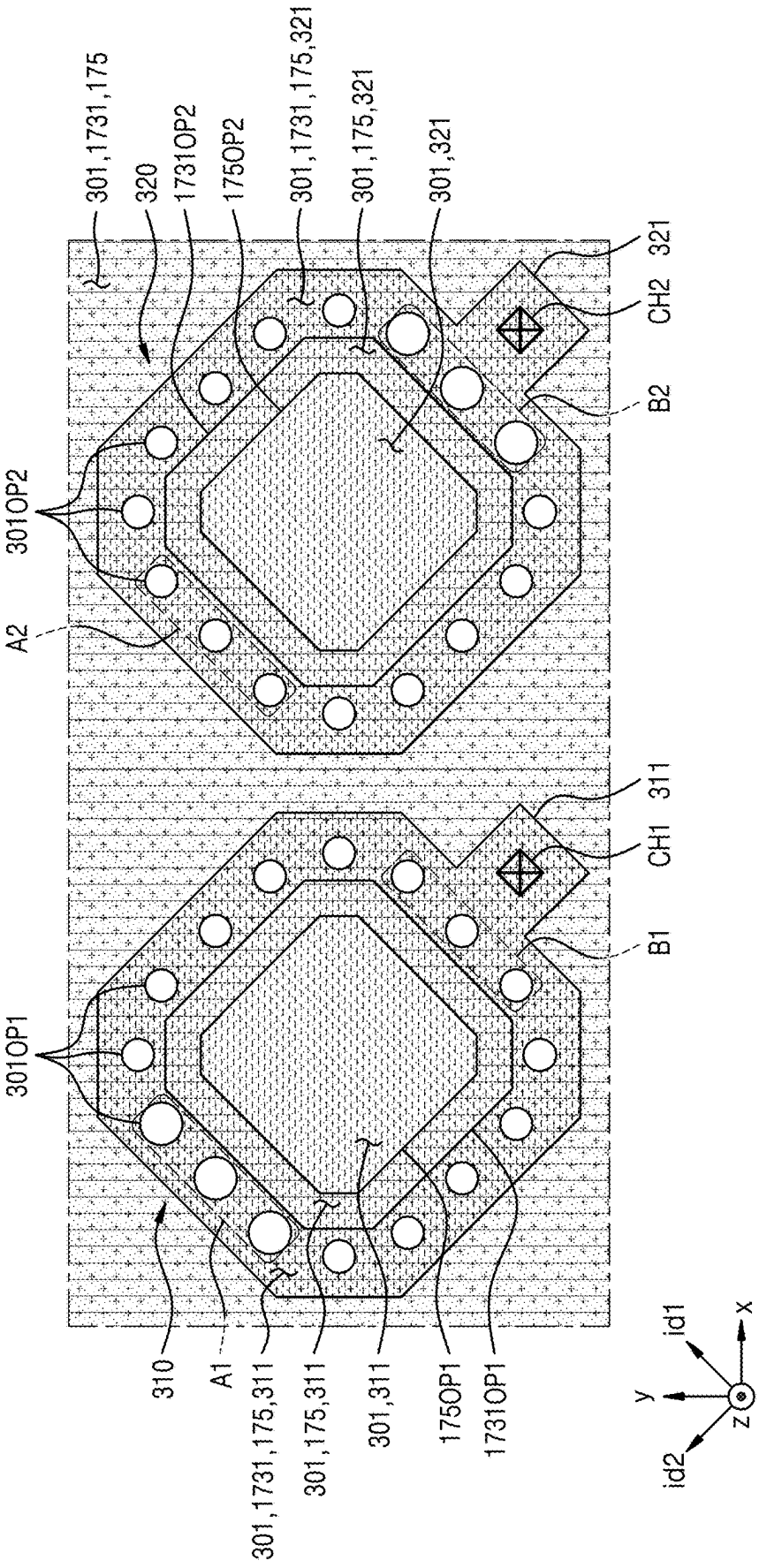
170
150
130
110
100
3010P2
LT
1731OP2
175OP2
320
323
321
301
3010P2
CH2
225a
223
221
225b
220
3010P1
LT
1731OP1
175OP1
310
313
311
301
3010P1
CH1
215a
213
211
215b
210
Z

FIG. 8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175OP2
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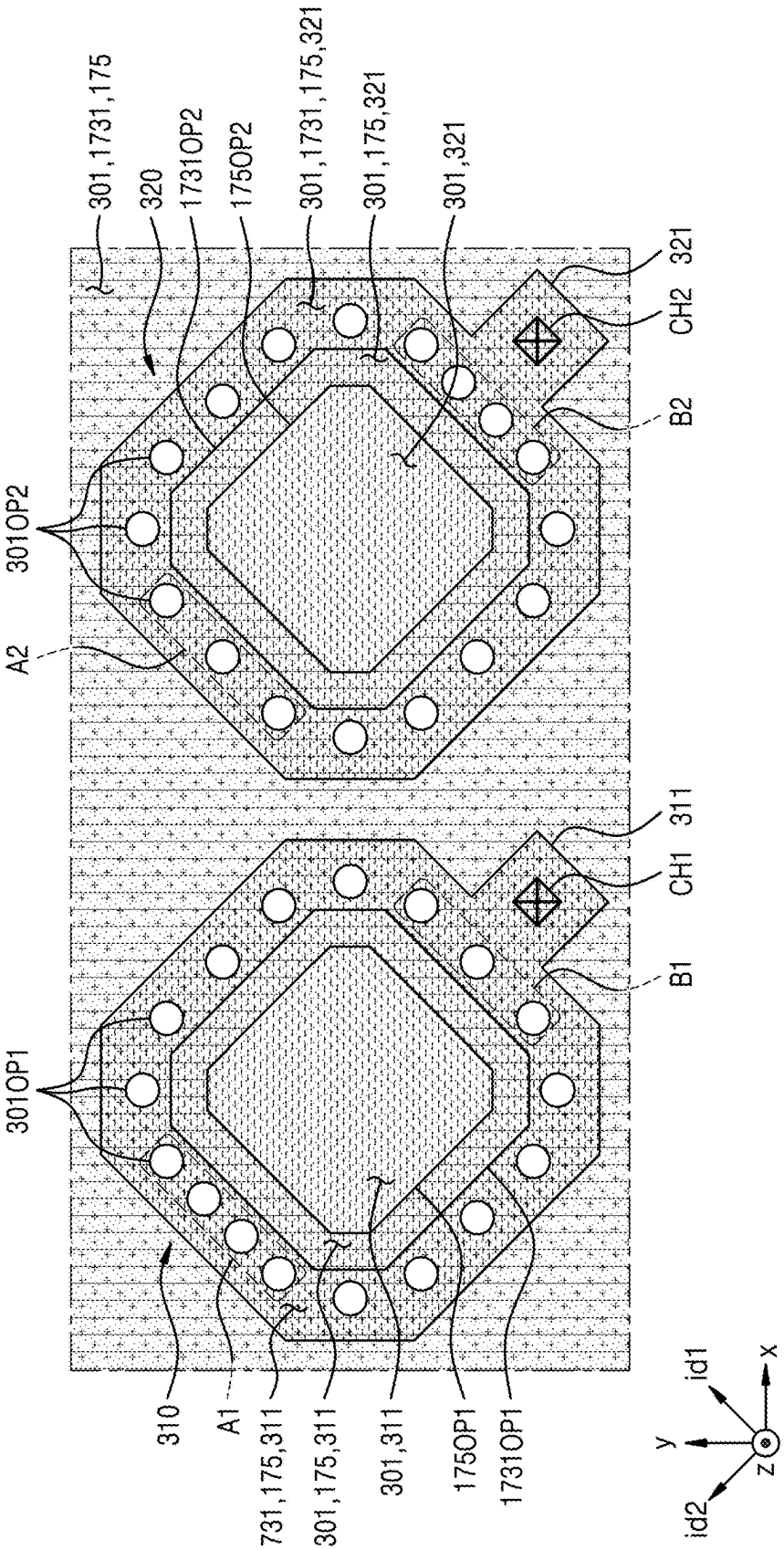
301,175,321
301,321
321
CH2
B2
3010P2
A2
311
CH1
B1
3010P1
310
A1
301,1731,175,311
301,175,311
301,311
175OP1
1731OP1
id1
x
y
z
id2

FIG. 9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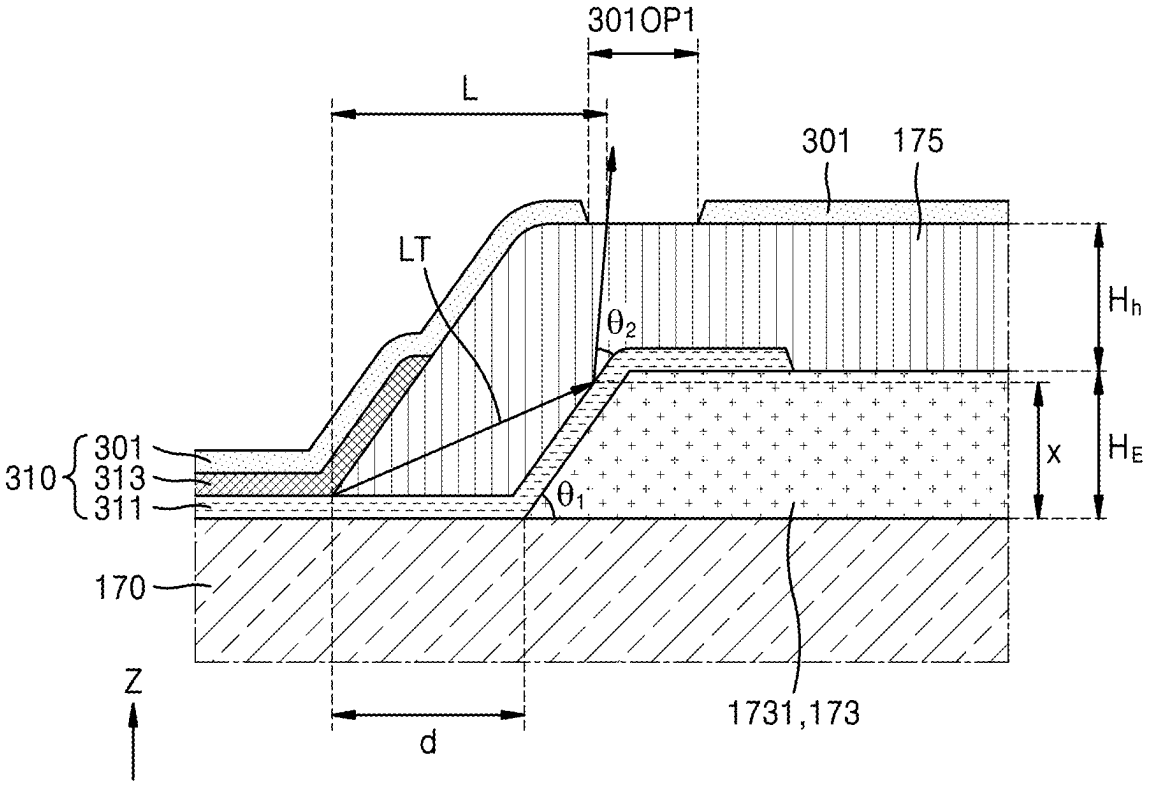
320
1731OP2
175OP2
301,1731,175,321
301,175,321
301,321
321
CH2
B2
3010P2
A2
311
CH1
B1
3010P1
310
A1
301,1731,175,311
301,175,311
301,311
175OP1
1731OP1
id1
x
y
z
id2

FIG. 10



DISPLAY APPARATUS

[0001] This application claims priority to Korean Patent Application No. 10-2024-0020673, filed on Feb. 13, 2024, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which in its entirety is herein incorporated by reference.

BACKGROUND

1. Field

[0002] One or more embodiments relate to a display apparatus, more particularly, to a display apparatus on which a high-quality image is displayed.

2. Description of the Related Art

[0003] Display apparatuses may include a plurality of display devices and may display an image by using light emitted from the display devices. In such display apparatuses, the light extraction rate may be raised to facilitate outward extraction of light emitted from an emission layer included in a display device, which may lead to reduced power consumption of the display apparatuses.

SUMMARY

[0004] Display apparatuses in related arts may not be capable of displaying a high-quality image without raising the light extraction rate.

[0005] To overcome various issues including the aforementioned one, one or more embodiments include a display apparatus on which a high-quality image is displayed. However, such technical aspect is provided merely as an example, and thus does not pose a limitation on the scope of the disclosure.

[0006] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments of the disclosure.

[0007] According to one or more embodiments, a display apparatus includes: a substrate; a first pixel electrode disposed on the substrate; a pixel-defining layer covering an edge of the first pixel electrode and defining a first pixel opening exposing a central portion of the first pixel electrode; an intermediate insulating layer interposed between the substrate and the pixel-defining layer and including a first portion defining a first intermediate opening which is wider than the first pixel opening in a plan view; a first intermediate layer contacting the first pixel electrode through the first pixel opening and including a first emission layer; and a common electrode disposed over the first pixel electrode with the first intermediate layer interposed therebetween and defining a plurality of first emission openings arranged outside the first pixel opening in the plan view.

[0008] The first pixel electrode may extend over the first portion of the intermediate insulating layer.

[0009] The display apparatus may further include a thin-film transistor disposed under the first pixel electrode, where the first pixel electrode may be electrically connected to the thin-film transistor through a contact hole passing through the first portion of the intermediate insulating layer.

[0010] In the plan view, the plurality of first emission openings may be arranged along an edge of the first pixel opening.

[0011] In the plan view, a total area of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than a total area of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

[0012] In the plan view, an area of each of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than an area of each of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

[0013] In the plan view, a total number of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than a total number of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

[0014] An area of each of the first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be equal to an area of each of the first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings in the plan view.

[0015] The plurality of first emission openings may have the same area from each other in the plan view.

[0016] In the plan view, an end of at least one of the plurality of first emission openings in a direction to the center portion of the first pixel electrode may be on the first pixel electrode.

[0017] In the plan view, an end of at least one of the plurality of first emission openings in a direction to the center portion of the first pixel electrode may be between an edge of the first intermediate opening and the edge of the first pixel electrode.

[0018] The intermediate insulating layer may further include a second portion interposed between the substrate and the first pixel electrode, disposed in the first intermediate opening in the plan view, and apart from the first portion.

[0019] An edge of the first portion in a direction to the second portion may include a first inclined portion inclining with respect to a major surface of the substrate, and an edge of the second portion may include a second inclined portion inclining with respect to the major surface of the substrate.

[0020] The second portion may define a recess or a hole corresponding to a center of the first pixel electrode.

[0021] An inner side surface of the recess or the hole defined in the second portion may include a third inclined portion inclining with respect to the major surface of the substrate.

[0022] The display apparatus may further include a second pixel electrode disposed on the substrate and a second intermediate layer contacting the second pixel electrode and including a second emission layer, where the pixel-defining layer may define a second pixel opening exposing a central portion of the second pixel electrode and may cover an edge of the second pixel electrode, and the common electrode may be disposed over the second pixel electrode with the second intermediate layer interposed therebetween and may define a plurality of second emission openings arranged outside the second pixel opening in the plan view.

[0023] From among layers included in the first intermediate layer, a layer other than the first emission layer may be

integrally formed with a corresponding layer from among layers included in the second intermediate layer, other than the second emission layer.

[0024] In the plan view, a total area of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than a total area of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and a total area of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings may be less than a total area of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

[0025] In the plan view, an area of each of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than an area of each of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and an area of each of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings may be less than an area of each of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

[0026] In the plan view, a total number of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be greater than a total number of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and a total number of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings may be less than a total number of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

[0027] An area of each of the first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings may be equal to an area of each of the first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and an area of each of the second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings may be equal to an area of each of the second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings in the plan view.

[0028] The plurality of first emission openings may have the same area from each other, and the plurality of second emission openings may have the same area from each other in the plan view.

[0029] Other aspects, features, and advantages which are different than those described above will become apparent from the below detailed description, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and other aspects, features, and advantages of certain embodiments of the disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0031] FIG. **1** is a schematic cross-sectional view of a portion of a display apparatus according to an embodiment;

[0032] FIG. **2** is a schematic plan view of some components of the display apparatus of FIG. **1**;

[0033] FIG. **3** is a schematic plan view of some components of a display apparatus according to an embodiment;

[0034] FIG. **4** is a schematic plan view of some components of a display apparatus according to an embodiment;

[0035] FIG. **5** is a schematic cross-sectional view of a portion of a display apparatus according to an embodiment;

[0036] FIG. **6** is a schematic cross-sectional view of a portion of a display apparatus according to an embodiment;

[0037] FIG. **7** is a schematic cross-sectional view of a portion of a display apparatus according to an embodiment;

[0038] FIG. **8** is a schematic plan view of some components of a display apparatus according to an embodiment;

[0039] FIG. **9** is a schematic plan view of some components of a display apparatus according to an embodiment; and

[0040] FIG. **10** is a schematic cross-sectional view of some components of a display apparatus according to an embodiment.

DETAILED DESCRIPTION

[0041] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, "a", "an," "the," and "at least one" do not denote a limitation of quantity, and are intended to include both the singular and plural, unless the context clearly indicates otherwise. For example, "an element" has the same meaning as "at least one element," unless the context clearly indicates otherwise. "At least one" is not to be construed as limiting "a" or "an." "Or" means "and/or." As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Throughout the disclosure, the expression "at least one of a, b or c" indicates only a, only b, only c, both a and b, both a and c, both b and c, all of a, b, and c, or variations thereof.

[0042] As embodiments allow for various changes and numerous embodiments, exemplary embodiments will be illustrated in the drawings and described in detail in the written description. The effects, features of the disclosure and methods for achieving the same may be clarified by referring to the following detailed embodiments along with the drawings. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein.

[0043] Hereinafter, embodiments of the disclosure are explained in detail referring to the attached drawings. When referring to the drawings, like reference numerals may denote like or corresponding elements, and repeated descriptions thereof are omitted.

[0044] It will be understood that when a component, such as a layer, a film, a region, or a plate, is referred to as being "on" another component, the component can be directly on the other component or intervening components may be present thereon. Sizes of components in the drawings may be exaggerated or reduced for convenience of explanation.

In other words, since sizes and thicknesses of components in the drawings are arbitrarily illustrated for convenience of explanation, the disclosure is not limited thereto.

[0045] In the following examples, the x-axis, the y-axis and the z-axis are not limited to three axes of the rectangular coordinate system, and may be interpreted in a broader sense. For example, the x-axis, the y-axis, and the z-axis may be perpendicular to one another, or may represent different directions that are not perpendicular to one another.

[0046] It will be understood that although terms such as "first" and "second" may be used herein to describe various components, these components should not be limited by these terms and these terms are only used to distinguish one component from another component.

[0047] In an embodiment below, it will be further understood that the terms "comprises" and/or "comprising" used herein specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

[0048] As used herein, "A and/or B" represents the case of A, B, or A and B. Also, "at least one of A and B" represents the case of A, B, or A and B.

[0049] It will be understood that when a layer, region, or component is referred to as being "connected" to another layer, region, or component, it may be "directly connected" to the other layer, region, or component or may be "indirectly connected" to the other layer, region, or component with other layer, region, or component interposed therebetween. For example, it will be understood that when a layer, region, or component is referred to as being "electrically connected" to another layer, region, or component, it may be "directly electrically connected" to the other layer, region, or component or may be "indirectly electrically connected" to other layer, region, or component with other layer, region, or component interposed therebetween.

[0050] FIG. **1** is a schematic cross-sectional view of a display apparatus according to an embodiment, and FIG. **2** is a schematic plan view of some components of the display apparatus of FIG. **1**. As used herein, the "plan view" is defined as a view seen from the direction (i.e., z-axis direction) perpendicular to a major surface (x-y plane) of the substrate **100**.

[0051] A display apparatus according to an embodiment may include a substrate **100**, a first organic light-emitting device **310**, which is a first display device disposed on the substrate **100**, and an encapsulation layer (not shown) covering the first organic light-emitting device **310**.

[0052] The substrate **100** may include various materials having flexible or bendable characteristics, for example, polymer resin, such as polyethersulfone ("PES"), polyacrylate, polyetherimide ("PEI"), polyethylene naphthalate ("PEN"), polyethylene terephthalate ("PET"), polyphenylene sulfide ("PPS"), polyarylate ("PAR"), polyimide ("PI"), polycarbonate ("PC"), or cellulose acetate propionate ("CAP"). The substrate **100** may be modified in variously and may have a multi-layer structure including two layers including the aforementioned polymer resin and an inorganic material interposed between the two layers (e.g., silicon oxide, silicon nitride, or silicon oxynitride). Moreover, when the substrate **100** is not bendable, the substrate **100** may include glass, etc.

[0053] The first organic light-emitting device **310** may be disposed on the substrate **100**, and a first pixel circuit electrically connected to the first organic light-emitting device **310** to control a degree of emission thereof may be interposed between the substrate **100** and the first organic light-emitting device **310**. FIG. **1** illustrates one first thin-film transistor **210** which may be included in the first pixel circuit.

[0054] As illustrated in FIG. **1**, the first thin-film transistor **210** may include a semiconductor layer **211** including amorphous silicon, polycrystalline silicon, or an organic semiconductor material, a gate electrode **213**, a source electrode **215***a*, and a drain electrode **215***b*. Although FIG. **1** illustrates that the first thin-film transistor **210** includes the source electrode **215***a* and the drain electrode **215***b*, the disclosure is not limited thereto. For another example, the source electrode **215***a* and/or the drain electrode **215***b* may be a part of wiring. Or, the first thin-film transistor **210** may not include the source electrode **215***a* and/or the drain electrode **215***b*, and a source region and a drain region of the semiconductor layer **211** may serve as the source electrode and the drain electrode, respectively. For example, the first thin-film transistor **210** may not include a source electrode, and the source region of the semiconductor layer **211** of the first thin-film transistor **210** may be integrated with a drain region of another thin-film transistor. In this case, although the first thin-film transistor **210** does not include a source electrode, and the another thin-film transistor does not include a drain electrode, in a pixel circuit diagram, a drain electrode of the another thin-film transistor may be illustrated as being electrically connected to a source electrode of the first thin-film transistor **210**. This may also be applied to embodiments described below and variations thereof.

[0055] To secure the insulating characteristics of the semiconductor layer **211** and the gate electrode **213**, a gate insulating film **130** including an inorganic material, such as silicon oxide, silicon nitride, and/or silicon oxynitride may be interposed between the semiconductor layer **211** and the gate electrode **213**. In addition, an interlayer-insulating film **150** including an inorganic material, such as silicon oxide, silicon nitride, and/or silicon oxynitride may be disposed on the gate electrode **213**, and the source electrode **215***a* and the drain electrode **215***b* may be disposed on the interlayer-insulating film **150**. An insulating film including an inorganic material may be formed by chemical vapor deposition ("CVD") or atomic layer deposition ("ALD"). This may also be applied to embodiments described below and variations thereof.

[0056] A buffer layer **110** including an inorganic material, such as silicon oxide, silicon nitride, and/or silicon oxynitride may be interposed between the first thin-film transistor **210** and the substrate **100**. The buffer layer **110** may increase the smoothness of a surface of the substrate **100** or prevent or minimize permeation of impurities from the substrate **100**, etc. into the semiconductor layer **211** of the first thin-film transistor **210**.

[0057] The gate electrode **213** may include, for example, a metal such as molybdenum, aluminum, etc. and may be formed by sputter, etc. The gate electrode **213** may have a single-layer structure or a multi-layer structure. For example, the gate electrode **213** may have a two-layer structure including Mo/Al.

[0058] The source electrode **215***a* and the drain electrode **215***b* may include a metal, such as titanium, aluminum, etc. and may have a single-layer or multi-layer structure. For

example, the source electrode **215***a* and the drain electrode **215***b* may have a three-layer structure including titanium/aluminum/titanium.

[0059] A planarization layer **170** may be disposed on the first thin-film transistor **210**. For example, as illustrated in FIG. **1**, when the first organic light-emitting device **310** is disposed on the first thin-film transistor **210**, the planarization layer **170** may generally planarize an upper portion of the first thin-film transistor **210**. The planarization layer **170** may include, for example, an organic material, such as benzocyclobutene ("BCB"), hexamethyldisiloxane ("HMDSO"), etc. Although FIG. **1** illustrates the planarization layer **170** as having a single-layer structure, the planarization layer **170** may be variously modified and may have a multi-layer structure.

[0060] In a display region of the substrate **100**, a first display device may be disposed on the planarization layer **170**. The first display device may be, for example, the first organic light-emitting device **310** including a first pixel electrode **311**, a common electrode **301**, and a first intermediate layer **313** arranged therebetween and including a first emission layer.

[0061] As illustrated in FIG. **1**, the first pixel electrode **311** may be in contact with any one of the source electrode **215***a* and the drain electrode **215***b* through a first contact hole CH**1** formed in the planarization layer **170**, etc. and may be electrically connected to the first thin-film transistor **210**. The first pixel electrode **311** may include a transparent conductive layer including a transparent conductive oxide, such as ITO, In_2O_3, IZO, etc. and a reflective layer including a metal, such as Al, Ag, etc. For example, the first pixel electrode **311** may have a three-layer structure including ITO/Ag/ITO.

[0062] A pixel-defining layer **175** may be disposed on the planarization layer **170**. The pixel-defining layer **175** may define a pixel by including a first pixel opening **175**OP**1** exposing a central portion of the first pixel electrode **311**. In addition, as illustrated in FIG. **1**, the pixel-defining layer **175** may prevent generation of arc, etc. at an edge of the first pixel electrode **311** by increasing a distance between the edge of the first pixel electrode **311** and the common electrode **301** on the first pixel electrode **311**. The pixel-defining layer **175** may include an organic material such as polyimide or HMDSO.

[0063] An intermediate insulating layer **173** may be interposed between the substrate **100** and the pixel-defining layer **175**, more specifically, between the planarization layer **170** and the pixel-defining layer **175**. The intermediate insulating layer **173** may include a first portion **1731** as illustrated in FIG. **1**. Similar to the pixel-defining layer **175** defining the first pixel opening **175**OP**1**, the first portion **1731** of the intermediate insulating layer **173** may define a first intermediate opening **1731**OP**1**. When seen from a direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, an area of the first intermediate opening **1731**OP**1** may be greater than an area of the first pixel opening **175**OP**1**. That is, when seen from the direction perpendicular to the substrate **100** (z-axis direction), the first pixel opening **175**OP**1** may be arranged in the first intermediate opening **1731**OP**1**.

[0064] The edge of the first pixel electrode **311** described above may be disposed on the first portion **1731** of the intermediate insulating layer **173**. Accordingly, a part of the first pixel electrode **311** may be arranged on an inner side surface of the first intermediate opening **1731**OP**1**, which is an inclined portion, as illustrated in FIG. **1**. Moreover, as the area of the first intermediate opening **1731**OP**1** of the first portion **1731** of the intermediate insulating layer **173** is greater than the area of the first pixel opening **175**OP**1** of the pixel-defining layer **175** as described above, the pixel-defining layer **175** may cover a part of the first pixel electrode **311** arranged on the inner side surface of the first intermediate opening **1731**OP**1**.

[0065] As described above, the first pixel electrode **311** may be in contact with any one of the source electrode **215***a* and the drain electrode **215***b* through the first contact hole CH**1** formed in the planarization layer **170**, etc. and may be electrically connected to the first thin-film transistor **210**. As the first portion **1731** of the intermediate insulating layer **173** is interposed between the planarization layer **170** and the pixel-defining layer **175**, the first contact hole CH**1** may be formed not only in the planarization layer **170** but also in the first portion **1731** of the intermediate insulating layer **173**. The first pixel electrode **311** may be electrically connected to the first thin-film transistor **210** through the first contact hole CH**1**.

[0066] The first intermediate layer **313** of the first organic light-emitting device **310** may include a low-molecular substance or a high-molecular substance. When the first intermediate layer **313** include a low-molecular substance, the first intermediate layer **313** may have a structure in which a hole injection layer ("HIL"), a hole transport layer ("HTL"), a first emission layer ("EML"), an electron transport layer ("ETL"), an electron injection layer ("EIL") etc. are stacked in a single or combined structure and may be formed by vacuum deposition. When the first intermediate layer **313** include a high-molecular substance, the first intermediate layer **313** may have a structure including a HTL and an EML. In this case, the HTL may include poly(3,4-ethylenedioxythiophene) ("PEDOT"), and the EML may include a polymer material such as a polyphenylenevinylene ("PPV")-based material, a polyfluorene-based material, etc. The first intermediate layer **313** may be formed through screen printing, inkjet printing, laser induced thermal imaging ("LITI"), etc.

[0067] However, the first intermediate layer **313** is not limited thereto and may have various other structures. The first emission layer of the first intermediate layer **313** may have a shape corresponding to the first pixel electrode **311**; however, layers of the first intermediate layer **313** other than the first emission layer may be integrated over the first pixel electrode **311** and other pixel electrodes. The first intermediate layer **313** may be in contact with the first pixel electrode **311** through the first pixel opening **175**OP**1** of the pixel-defining layer **175**.

[0068] The common electrode **301** may be disposed over the display region in which a plurality of display devices are arranged and cover the display region. That is, the common electrode **301** may be integrated with the first organic light-emitting device **310** and other organic light-emitting devices and may correspond to the first pixel electrode **311** and other pixel electrodes. The common electrode **301** may include a transparent conductive layer including ITO, In_2O_3, or IZO or may include a semi-transmissive film including a metal such as Al, Ag, etc. For example, the common electrode **301** may include a semi-transmissive film including MgAg.

[0069] As holes supplied from the first pixel electrode **311** and electrons supplied from the common electrode **301** form excitons in the first emission layer, the first organic light-emitting device **310** may generate light from the first emission layer. As such, a part of light generated from the first emission layer may proceed in a front direction (+z direction) of the display apparatus and may be extracted to the outside through the common electrode **301**, and another part may proceed in a direction to the first pixel electrode **311** (−z direction) and may be reflected from the first pixel electrode **311** to proceed in the front direction (+z direction) and to be extracted to the outside through the common electrode **301**.

[0070] Another part of the light generated from the first emission layer may proceed in a lateral direction. FIG. **1** illustrates an example of a travel route of light LT proceeding in the lateral direction. In the display apparatus according to an embodiment, as described above, a part of the first pixel electrode **311** may be arranged on the inner side surface of the first intermediate opening **1731**OP**1**, which is an inclined portion. Accordingly, as illustrated in FIG. **1**, the light LT proceeding in the lateral direction from the first emission layer may be reflected at a part of the first pixel electrode **311** arranged on the inner side surface of the first intermediate opening **1731**OP**1**, which is an inclined portion and then proceed in the front direction (+z direction) of the display apparatus. In the display apparatus according to an embodiment, the common electrode **301** may define a plurality of first emission openings **301**OP**1** therein, and light reflected from a part of the first pixel electrode **311** arranged on the inner side surface of the first intermediate opening **1731**OP**1**, which is an inclined portion, may be extracted to the outside through the first emission openings **301**OP**1** of the common electrode **301**.

[0071] As described above, although the common electrode **301** includes a transparent conductive layer including ITO, In_2O_3, or IZO, not 100% of light incident onto the common electrode **301** may be transmitted through the common electrode **301**. In addition, to increase the conductivity of the common electrode **301**, the common electrode **301** may include in addition to a transparent conductive layer a semi-transmissive film including a metal such as Al, Ag, etc., and accordingly, the transmittance of the light incident onto the common electrode **301** may be further lowered.

[0072] However, in the display apparatus according to an embodiment, the common electrode **301** may include the plurality of first emission openings **301**OP**1** as described above. Accordingly, the light LT proceeding in the lateral direction from the first emission layer may be reflected from a portion of the first pixel electrode **311** arranged on the inner side surface of the first intermediate opening **1731**OP**1**, which is an inclined portion, pass through the first emission openings **301**OP**1** of the common electrode **301** and then proceed in the front direction (+z direction) of display apparatus. Thus, by increasing the ratio of the light LT proceeding to the outside in the lateral direction from the first emission layer, the overall outward extraction of the light generated from the first emission layer may be increased.

[0073] More specifically, as illustrated in FIG. **2**, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, the common electrode **301** may define the plurality of first emission openings **301**OP**1** arranged outside the first pixel opening **175**OP**1**. The plurality of first emission openings **301**OP**1** may be arranged apart from each other. As described above, as holes supplied from the first pixel electrode **311** and electrons supplied from the common electrode **301** form excitons in the first emission layer, light may be generated from the first emission layer. Accordingly, the electrons may be smoothly provided to the first emission layer through the common electrode **301**. In the display apparatus according to an embodiment, as the common electrode **301** has the plurality of first emission openings **301**OP**1**, electrons may move through and between the plurality of first emission openings **301**OP**1** and smoothly migrate to the first emission layer.

[0074] Although FIG. **2** illustrates each of the plurality of first emission openings **301**OP**1** has a circular shape, the disclosure is not limited thereto. For another example, the shape may be changed to a tetragonal shape, etc., and a tetragonal shape and a circular shape may be used combinedly. This may also be applied to embodiments described below and variations thereof.

[0075] As illustrated in FIGS. **1** and **2**, when seen from the direction perpendicular to the substrate **100** (z-axis direction), an end **301**OP**1***a* of at least one of the plurality of first emission openings **301**OP**1** in a direction to the center portion of the first pixel electrode **311** may be arranged on the first pixel electrode **311**. More specifically, the end **301**OP**1***a* of the at least one of the plurality of first emission openings **301**OP**1** in the direction to the center portion of the first pixel electrode **311** may be arranged at an edge of the first intermediate opening **1731**OP**1** and an edge of the first pixel electrode **311**. FIG. **2** illustrates that the end **301**OP**1***a* of each of the plurality of first emission openings **301**OP**1** in the direction to the center portion of the first pixel electrode **311** may be interposed between the edge of the first intermediate opening **1731**OP**1** and the edge of the first pixel electrode **311**.

[0076] As described above, as holes supplied from the first pixel electrode **311** and electrons supplied from the common electrode **301** form excitons in the first emission layer, light may be generated from the first emission layer. Accordingly, the electrons may be smoothly provided to the first emission layer through the common electrode **301**. To this end, by arranging the plurality of first emission openings **301**OP**1** of the common electrode **301** outside the first intermediate opening **1731**OP**1**, electrons may be smoothly provided to the first emission layer from the common electrode **301** in the first pixel opening **175**OP**1** arranged in the first intermediate opening **1731**OP**1**.

[0077] The plurality of first emission openings **301**OP**1** of the common electrode **301** may be arranged along the edge of the first pixel opening **175**OP**1**, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view. The plurality of first emission openings **301**OP**1** may have the same area from each other, and may be arranged at regular intervals. In FIG. **2**, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, a direction between the x-axis direction and the y-axis direction is defined as the first inclination direction (+id**1** direction), and a direction between the −x-axis direction and the y-axis direction is defined as the second inclination direction (+id**2** direction). In FIG. **2**, three first emission openings **301**OP**1** are arranged in the first inclination direction (+id**1** direction) from the first pixel opening **175**OP**1**, three first emission openings **301**OP**1** are arranged in the opposite direction (−id**1** direc-

tion) of the first inclination direction from the first pixel opening **175**OP**1**, three first emission openings **301**OP**1** are arranged in the second inclination direction (+id**2** direction) from the first pixel opening **175**OP**1**, three first emission openings **301**OP**1** are arranged in the opposite direction (−id**2** direction) of the second inclination direction from the first pixel opening **175**OP**1**, one first emission opening **301**OP**1** is arranged in each of +x direction, −x direction, +y direction, and −y direction from the first pixel opening **175**OP**1**, and thus a plurality of first emission openings **301**OP**1** having the same area from each other are arranged at regular intervals.

[0078] However, the disclosure is not limited thereto. For another example, as illustrated in the plan view of FIG. **3** schematically showing some components of the display apparatus according to an embodiment, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, the total area of the first emission openings arranged on one side of the first pixel opening **175**OP**1** in the second inclination direction (+id**2** direction) from among the plurality of first emission openings **301**OP**1** may be greater than the total area of the first emission openings arranged on another side of the first pixel opening **175**OP**1** in the opposite direction (−id**2** direction) of the second inclination direction. In FIG. **3**, the total area of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than the total area of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**. More specifically, in FIG. **3**, an area of each of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than an area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**.

[0079] In an ideal display apparatus, even when a viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not change. However, in an actual display apparatus, as the planarization layer **170** may not be completely flat, and thus pixel electrodes may incline, when a viewing angle at which the display region is seen changes, colors of an image displayed on the display region may change.

[0080] In the display apparatus according to the embodiment, as described above in relation to FIG. **3**, the total area of the first emission openings arranged in a particular portion, e.g., portion A**1**, from among the plurality of first emission openings **301**OP**1** may be greater than the total area of the first emission openings arranged in another particular portion, e.g., portion B**1**, from among the plurality of first emission openings **301**OP**1**. Accordingly, in the first organic light-emitting device **310**, portion A**1** may emit a relatively greater amount of light than portion B**1**. This eventually means that when seen from the second inclination direction (+id**2** direction) in which portion A**1** is located with respect to the center of the first organic light-emitting device **310**, colors of light emitted from the first organic light-emitting device **310** may be more visible than when seen from the opposite direction (−id**2** direction) of the second inclination direction in which portion B**1** is located with respect to the center of the first organic light-emitting device **310**.

[0081] As such, as the total area of the first emission openings arranged on one side of the first pixel opening **175**OP**1** from among the plurality of first emission openings **301**OP**1** is greater than the total area of the first emission openings arranged on another side of the first pixel opening **175**OP**1**, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized. That is, if color of an image displayed on the display region changes according to the change of the viewing angle because the planarization layer **170** is not completely flat and thus pixel electrodes incline, it is possible to minimize such color change by changing the total area of the first emission openings arranged on one side of the first pixel opening **175**OP**1**.

[0082] As described above, in FIG. **3**, the area of each of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than the area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**. However, the disclosure is not limited thereto.

[0083] For example, unlike the description of FIG. **3**, the total area of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1** may be less than the total area of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1**. More specifically, the area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1** may be less than the area of each of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1**. In this case, the area of each of the first emission openings arranged in portions other than portion A**1** and portion B**1** from among the plurality of first emission openings **301**OP**1** may be identical to the area of each of the first emission openings arranged in portion A**1**. As such, as the area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1** is less than the area of each of the first emission openings arranged in other portions, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized. This may also be applied to embodiments described below and variations thereof.

[0084] Or, as illustrated in the plan view of FIG. **4** schematically showing some components of the display apparatus according to an embodiment, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, the number of the first emission openings arranged on one side of the first pixel opening **175**OP**1** in the second inclination direction (+id**2** direction) from among the plurality of first emission openings **301**OP**1** may be greater than the number of the first emission openings arranged on another side of the first pixel opening **175**OP**1** in the opposite direction (−id**2** direction) of the second inclination direction. In FIG. **4**, the number of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than the number of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**.

[0085] Accordingly, in the first organic light-emitting device **310**, portion A**1** may emit a relatively greater amount of light than portion B**1**. This eventually means that when

seen from the second inclination direction (+id2 direction) in which portion A1 is located with respect to the center of the first organic light-emitting device **310**, colors of light emitted from the first organic light-emitting device **310** may be more visible than when seen from the opposite direction (−id2 direction) of the second inclination direction in which portion B1 is located with respect to the center of the first organic light-emitting device **310**.

[0086] As such, as the number of the first emission openings arranged on one side of the first pixel opening **175**OP1 in the second inclination direction (+id2 direction) from among the plurality of first emission openings **301**OP1 is greater than the number of the first emission openings arranged on another side of the first pixel opening **175**OP1 in the opposite direction (−id2 direction) of the second inclination direction, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized.

[0087] In this case, as illustrated in FIG. **4**, the plurality of first emission openings **301**OP1 may have the same area from each other. Or, the area of each of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1 may be identical to the area of each of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1. Alternatively, while the structure of FIG. **4** is maintained, the area of each of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1 may be greater than the area of each of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1 in a plan view.

[0088] Unlike the description of FIG. **4**, the number of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1 may be smaller than the number of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1. In this case, the number of the first emission openings arranged on one side of the first pixel opening **175**OP1 in the first inclination direction (+id1 direction) from among the plurality of first emission openings **301**OP1 and the number of the first emission openings arranged on another side of the first pixel opening **175**OP1 in the opposite direction (−id1 direction) of the first inclination direction may be identical to the number of the first emission openings arranged in portion A1. As such, as the number of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1 is smaller than the number of the first emission openings arranged in other portions, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized. This may also be applied to embodiments described below and variations thereof.

[0089] FIG. **5** is a schematic cross-sectional view of a portion of the display apparatus according to an embodiment. The display apparatus according to the embodiment may be different from the display apparatus described above in relation to FIG. **1** in that the intermediate insulating layer **173** further includes a second portion **1732** in addition to the first portion **1731**. The second portion **1732** may be interposed between the substrate **100** and the first pixel electrode **311**, more specifically, between the planarization layer **170** and the first pixel electrode **311**. The second portion **1732** may be arranged in the first intermediate opening **1731**OP1 and may be arranged apart from the first portion **1731**.

[0090] As described above, the edge of the first pixel electrode **311** may be disposed over the first portion **1731** of the intermediate insulating layer **173**. Accordingly, a part of the first pixel electrode **311** may be arranged on the inner side surface of the first intermediate opening **1731**OP1, which is a first inclined portion IP1. That is, the first inclined portion IP1 may be an edge of the first portion **1731** in the direction to the second portion **1732**, and the first inclined portion IP1 may be a surface inclining with respect to the major surface (i.e., plane made by x-axis and y-axis) of the substrate **100**. Similarly, an edge of the second portion **1732** which may have a shape of an island may include a second inclined portion IP2 inclining with respect to the major surface of the substrate **100**.

[0091] In the display apparatus according to the embodiment, due to the presence of the second inclined portion IP2, a greater amount of light generated from the first emission layer included in the first intermediate layer **313** may be directed to a portion of the first pixel electrode **311** arranged on the first inclined portion IP1. Accordingly, by increasing an amount of light extracted to the outside through the first emission openings **301**OP1 of the common electrode **301**, the luminance of an image implemented by the display apparatus may be improved without causing an increase in power consumption of the display apparatus.

[0092] Moreover, as illustrated in FIG. **2** schematically showing a cross-sectional view of a part of the display apparatus according to an embodiment, the second portion **1732** of the intermediate insulating layer **173** may define a recess or a hole which correspond to the center of the first pixel electrode **311**. In an embodiment, FIG. **6** illustrates that the second portion **1732** defines a hole, and the first pixel electrode **311** is in contact with the planarization layer **170** through the hole. An inner side surface of the recess or the hole may include a third inclined portion IP3 inclining with respect to the major surface of the substrate **100**.

[0093] Although the first organic light-emitting device **310**, which is a first display device, is described in detail so far, the same or similar descriptions on the first display apparatus may also be applied to other display apparatuses. Hereinafter, a second organic light-emitting device is described along with the first organic light-emitting device **310**.

[0094] FIG. **7** is a schematic cross-sectional view of a portion of the display apparatus according to an embodiment. In addition to the first organic light-emitting device **310** described above, FIG. **7** illustrates a second thin-film transistor **220** and a second organic light-emitting device **320** electrically connected to the second thin-film transistor **220**.

[0095] Similar to the first thin-film transistor **210**, the second thin-film transistor **220** may include a semiconductor layer **221**, a gate electrode **223**, a source electrode **225***a*, and a drain electrode **225***b*. As the descriptions about the components of the first thin-film transistor **210** may also be applied to the components of the second thin-film transistor **220**, any redundant description thereon may be omitted.

[0096] The second organic light-emitting device **320** may be arranged a second pixel electrode **321**, the common electrode **301**, and a second intermediate layer **323** arranged

therebetween and including a second emission layer. The second pixel electrode **321** may be electrically connected to the second thin-film transistor **220** through a second contact hole CH**2** formed in the first portion **1731** of the intermediate insulating layer **173** and the planarization layer **170**. The descriptions on the first pixel electrode **311** and the first intermediate layer **313** may be applied to the second pixel electrode **321** and the second intermediate layer **323** as well.

[0097] Although FIG. **7** illustrates that first intermediate layer **313** and the second intermediate layer **323** are arranged apart from each other for convenience, the disclosure is not limited thereto. The first emission layer of the first intermediate layer **313** may have an island shape corresponding to the first pixel electrode **311**, and the second emission layer of the second intermediate layer **323** may have an island shape corresponding to the second pixel electrode **321**. However, each of layers of the first intermediate layer **313** other than the first emission layer may be integrated with a corresponding layer from among layers of the second intermediate layer **323** other than the second emission layer.

[0098] The pixel-defining layer **175** may define a pixel by including a second pixel opening **175**OP**2** exposing a central portion of the second pixel electrode **321**. As described above, as the first portion **1731** of the intermediate insulating layer **173** may be interposed between the planarization layer **170** and the pixel-defining layer **175**, the first portion **1731** of the intermediate insulating layer **173** may define a second intermediate opening **1731**OP**2**. When seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, an area of the second intermediate opening **1731**OP**2** may be greater than an area of the second pixel opening **175**OP**2**. That is, when seen from the direction perpendicular to the substrate **100** (z-axis direction), the second pixel opening **175**OP**2** may be arranged in the second intermediate opening **1731**OP**2**. Similar to the first pixel electrode **311**, an edge of the second pixel electrode **321** may be disposed over the first portion **1731** of the intermediate insulating layer **173**. Accordingly, a part of the second pixel electrode **321** may be arranged on an inner side surface of the second intermediate opening **1731**OP**2**, which is an inclined portion, as illustrated in FIG. **7**.

[0099] In the display apparatus according to the embodiment, as the common electrode **301** defines second emission openings **301**OP**2** in addition to the first emission openings **301**OP**1**, light reflected from a portion of the second pixel electrode **321** arranged on the inner side surface of the second intermediate opening **1731**OP**2**, which is an inclined portion, may be extracted to the outside through the second emission openings **301**OP**2** of the common electrode **301**. Accordingly, the light extraction efficiency may increase in the second organic light-emitting device **320**.

[0100] As illustrated in FIG. **7**, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, the common electrode **301** may define the plurality of second emission openings **301**OP**2** arranged outside the second pixel opening **175**OP**2**. The plurality of second emission openings **301**OP**2** may be arranged apart from each other. As holes supplied from the second pixel electrode **321** and electrons supplied from the common electrode **301** form excitons in the second emission layer, light may be generated from the second emission layer. Accordingly, the electrons may be smoothly provided to the second emission layer through the common electrode **301**. In the display apparatus according to an embodiment, as the common electrode **301** has the plurality of second emission openings **301**OP**2**, electrons may move through and between the plurality of second emission openings **301**OP**2** and smoothly migrate to the second emission layer.

[0101] When seen from the direction perpendicular to the substrate **100** (z-axis direction), the descriptions on the positions of the plurality of first emission openings **301**OP**1** with respect to the first pixel electrode **311** or the first intermediate opening **1731**OP**1** may also be applied to positions of the plurality of second emission openings **301**OP**2** with respect to the second pixel electrode **321** or the second intermediate opening **1731**OP**2**. Accordingly, any redundant description thereon may be omitted.

[0102] FIG. **8** is a schematic plan view of some components of the display apparatus according to an embodiment. FIG. **8** illustrates that, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, a total area of first emission openings arranged on one side of the first pixel opening **175**OP**1** in the second inclination direction (+id**2** direction) from among the plurality of first emission openings **301**OP**1** is greater than a total area of first emission openings arranged on another side of the first pixel opening **175**OP**1** in the opposite direction (−id**2** direction) of the second inclination direction. That is, in FIG. **8**, the total area of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than the total area of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**. More specifically, in FIG. **8**, an area of each of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** is greater than an area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**.

[0103] Moreover, FIG. **8** illustrates that, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, a total area of second emission openings arranged on one side of the second pixel opening **175**OP**2** in the opposite direction (−id**2** direction) of the second inclination direction from among the plurality of second emission openings **301**OP**2** is greater than a total area of second emission openings arranged on another side of the second pixel opening **175**OP**2** in the second inclination direction (+id**2** direction). That is, in FIG. **8**, the total area of the second emission openings arranged in portion B**1** from among the plurality of second emission openings **301**OP**2** is greater than the total area of the second emission openings arranged in portion A**2** from among the plurality of second emission openings **301**OP**2**. More specifically, in FIG. **8**, an area of each of the second emission openings arranged in portion B**2** from among the plurality of second emission openings **301**OP**2** is greater than an area of each of the second emission openings arranged in portion A**2** from among the plurality of second emission openings **301**OP**2**.

[0104] For example, the first organic light-emitting device **310** may be the first display apparatus emitting red light, and the second organic light-emitting device **320** may be the second display apparatus emitting blue light. In this case, red light may be emitted relatively more from portion A**1** than from portion B**1**, and blue light may be emitted relatively more from portion B**2** than from portion A**2**. Accordingly, when the display region is seen from the second inclination direction (+id**2** direction), red light may be relatively more visible, and when the display region is seen from the

opposite direction (−id2 direction) of the second inclination direction, blue light may be relatively more visible. When the first emission openings **301**OP1 have the same area from each other, the second emission openings **301**OP2 have the same area from each other, and the colors of a displayed image change according to a viewing angle, through such adjustment, the color change of the displayed image according to a viewing image may be minimized.

[0105] FIG. **8** illustrates that the area of each of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1 is greater than the area of each of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1, and the area of each of the second emission openings arranged in portion B2 from among the plurality of second emission openings **301**OP2 is greater than the area of each of the second emission openings arranged in portion A2 from among the plurality of second emission openings **301**OP2. However, the disclosure is not limited thereto.

[0106] For example, unlike the description of FIG. **8**, the area of each of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1 may be less than the area of each of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1, and the area of each of the second emission openings arranged in portion A2 from among the plurality of second emission openings **301**OP2 may be less than the area of each of the second emission openings arranged in portion B2 from among the plurality of second emission openings **301**OP2 in a plan view. In this case, an area of each of first emission openings arranged in portions other than portions A1 and B1 from among the plurality of first emission openings **301**OP1 may be identical to the area of each of the first emission openings arranged in portion A1, and an area of each of second emission openings arranged in portions other than portions A2 and B2 from among the plurality of second emission openings **301**OP2 may be identical to the area of each of the second emission openings arranged in portion B2. Through such configuration, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized. This may also be applied to embodiments described below and variations thereof.

[0107] Or, as illustrated in the plan view of FIG. **9** schematically showing some components of the display apparatus according to an embodiment, when seen from the direction perpendicular to the substrate **100** (z-axis direction), i.e., in a plan view, the number of the first emission openings arranged on one side of the first pixel opening **175**OP1 in the second inclination direction (+id2 direction) from among the plurality of first emission openings **301**OP1 may be greater than the number of the first emission openings arranged on another side of the first pixel opening **175**OP1 in the opposite direction (−id2 direction) of the second inclination direction. In addition, the number of the second emission openings arranged on side of the second pixel opening **175**OP2 in the opposite direction (−id2 direction) of the second inclination direction from among the plurality of second emission openings **301**OP2 may be greater than the number of the second emission openings arranged on another side of the second pixel opening **175**OP2 in the second inclination direction (+id2 direction). FIG. **9** illustrates that the number of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1 is greater than the number of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1, and the number of the second emission openings arranged in portion B2 from among the plurality of second emission openings **301**OP2 is greater than the number of the second emission openings arranged in portion A2 from among the plurality of second emission openings **301**OP2.

[0108] For example, the first organic light-emitting device **310** may be the first display apparatus emitting red light, and the second organic light-emitting device **320** may be the second display apparatus emitting blue light. In this case, red light may be emitted relatively more from portion A1 than from portion B1, and blue light may be emitted relatively more from portion B2 than from portion A2. Accordingly, when the display region is seen from the second inclination direction (+id2 direction), red light may be relatively more visible, and when the display region is seen from the opposite direction (−id2 direction) of the second inclination direction, blue light may be relatively more visible. Through such adjustment, a color change of a displayed image according to a viewing angle may be minimized.

[0109] In this case, as illustrated in FIG. **9**, the plurality of first emission openings **301**OP1 may have the same area from each other, and the plurality of second emission openings **301**OP2 may have the same area from each other.

[0110] Or, unlike the description of FIG. **9**, the number of the first emission openings arranged in portion B1 from among the plurality of first emission openings **301**OP1 may be smaller than the number of the first emission openings arranged in portion A1 from among the plurality of first emission openings **301**OP1, and the number of the second emission openings arranged in portion A2 from among the plurality of second emission openings **301**OP2 may be smaller than the number of the second emission openings arranged in portion B2 from among the plurality of second emission openings **301**OP2. In this case, the number of the first emission openings arranged on one side of the first pixel opening **175**OP1 in the first inclination direction (+id1 direction) from among the first emission openings **301**OP1 and the number of the first emission openings arranged on another side of the first pixel opening **175**OP1 in the opposite direction (−id1 direction) of the first inclination direction may be identical to the number of the first emission openings arranged in portion A1. In addition, the number of the second emission openings arranged on one side of the second pixel opening **175**OP2 in the first inclination direction (+id1 direction) from among the second emission openings **301**OP2 and the number of the second emission openings arranged on another side of the second pixel opening **175**OP2 in the opposite direction (−id1 direction) of the first inclination direction may be identical to the number of the second emission openings arranged in portion B2. Through such configuration, even when the viewing angle at which the display region is seen changes, colors of an image displayed on the display region may not substantially change, or the change may be minimized. This may also be applied to embodiments described below and variations thereof.

[0111] The structure illustrated in FIG. **8** and the structure illustrated in FIG. **9** may be used concurrently. For example,

while the structure of FIG. **8** is maintained, the area of each of the first emission openings arranged in portion A**1** from among the plurality of first emission openings **301**OP**1** may be greater than the area of each of the first emission openings arranged in portion B**1** from among the plurality of first emission openings **301**OP**1**, and the area of each of the second emission openings arranged in portion B**2** from among the plurality of second emission openings **301**OP**2** may be greater than the area of each of the second emission openings arranged in portion A**2** from among the plurality of second emission openings **301**OP**2**.

[0112] Or, the structure of the first organic light-emitting device **310** may be different from the structure of the second organic light-emitting device **320**. For example, the first organic light-emitting device **310** may use the structure illustrated in FIG. **8**, and the second organic light-emitting device **320** may use the structure illustrated in FIG. **9**.

[0113] FIG. **10** is a schematic cross-sectional view of some components of a display apparatus according to an embodiment. As illustrated in FIG. **10**, a distance between an end of the first intermediate layer **313** on the first pixel electrode **311** and an end of the first portion **1731** of the intermediate insulating layer **173** in the direction to the first pixel electrode **311** may be defined as d. In addition, H_E represents the height of the first portion **1731** of the intermediate insulating layer **173**, and H_h represents the height (i.e., the maximum thickness) of the pixel-defining layer **175** on the first portion **1731**. When considering a point of the first pixel electrode **311** located on the inner side surface of the first portion **1731** of the intermediate insulating layer **173**, at which the light LT emitted from the end of the first intermediate layer **313** arrives, the height from the planarization layer **170** to the point may be defined as x. When a taper angle of the first portion **1731** of the intermediate insulating layer **173** is θ_1, and an angle between the light LT reflected on the first pixel electrode **311** and the surface of the first pixel electrode **311** is θ_2 at which the light LT is reflected, a horizontal length L from the end of the first intermediate layer **313** and the point of the pixel-defining layer **175** from which the light LT escapes may be represented by the following formula when $\theta_1+\theta_2$ is 90°:

$$L = d + \frac{x}{\tan\theta_1} + \frac{d\sin\theta_1\cos(\theta_1+\theta_2)}{\sin\theta_2}$$

[0114] When $\theta_1+\theta_2$ is less than 90°, the horizontal length L may be represented by the following formula:

$$L = d + \frac{x}{\tan\theta_1} + \frac{H_h}{\tan(\theta_1-\theta_2)}$$

[0115] θ_2 may be represented by the following formula:

$$\theta_2 = \theta_1 - \frac{180}{\pi}\tan^{-1}\left(\frac{x\tan\theta_1}{x+d\tan\theta_1}\right).$$

[0116] Accordingly, in any case, L may be represented by x, θ_1, d, and/or H_h.

[0117] θ_1 may be about 50° to about 60°, H_E may be about 2 micrometers (μm) to about 3 μm, d may be about 1.5 μm, and H_h may be 1 μm. Thus, when 01 is 55°, and H_E is 2.5 μm, L may be represented by using a function of x. As x is greater than or equal to 0 and less than or equal to H_E, according to the calculation, L may be 0.6 μm to about 2.4 μm. Accordingly, when the distance between the end of the first intermediate layer **313** on the first pixel electrode **311** and the end of the first emission opening **301**OP**1** in the direction to the first pixel electrode **311** is 0.6 μm, and the width of the first emission opening **301**OP**1** is 1.8 μm, light emitted from the first emission layer included in the first intermediate layer **313** and reflected from a portion of the first pixel electrode **311** located on the inner side surface of the first portion **1731** of the intermediate insulating layer **173** may be efficiently extracted to the outside through the first emission opening **301**OP**1** of the common electrode **301**.

[0118] According to an embodiment, a display apparatus on which a high-quality image is displayed may be implemented. However, the scope of the disclosure is not limited to the above-mentioned effects.

[0119] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments. While one or more embodiments have been described with reference to the figures, 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 as defined by the following claims.

What is claimed is:

1. A display apparatus comprising:

a substrate;

a first pixel electrode disposed on the substrate;

a pixel-defining layer covering an edge of the first pixel electrode and defining a first pixel opening exposing a central portion of the first pixel electrode;

an intermediate insulating layer interposed between the substrate and the pixel-defining layer and including a first portion defining a first intermediate opening having an area greater than an area of the first pixel opening in a plan view;

a first intermediate layer contacting the first pixel electrode through the first pixel opening and including a first emission layer; and

a common electrode disposed over the first pixel electrode with the first intermediate layer interposed therebetween and defining a plurality of first emission openings arranged outside the first pixel opening in the plan view.

2. The display apparatus of claim **1**, wherein the first pixel electrode extends over the first portion of the intermediate insulating layer.

3. The display apparatus of claim **2**, further comprising a thin-film transistor disposed under the first pixel electrode, wherein the first pixel electrode is electrically connected to the thin-film transistor through a contact hole passing through the first portion of the intermediate insulating layer.

4. The display apparatus of claim **1**, wherein, in the plan view, the plurality of first emission openings are arranged along an edge of the first pixel opening.

5. The display apparatus of claim **4**, wherein, in the plan view, a total area of first emission openings arranged on one side of the first pixel opening from among the plurality of

first emission openings is greater than a total area of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

6. The display apparatus of claim **4**, wherein, in the plan view, an area of each of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is greater than an area of each of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

7. The display apparatus of claim **4**, wherein, in the plan view, a total number of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is greater than a total number of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

8. The display apparatus of claim **7**, wherein, in the plan view, an area of each of the first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is equal to an area of each of the first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings.

9. The display apparatus of claim **7**, wherein the plurality of first emission openings have a same area from each other in the plan view.

10. The display apparatus of claim **1**, wherein, in the plan view, an end of at least one of the plurality of first emission openings in a direction to the center portion of the first pixel electrode is on the first pixel electrode.

11. The display apparatus of claim **1**, wherein, in the plan view, an end of at least one of the plurality of first emission openings in a direction to the center portion of the first pixel electrode is between an edge of the first intermediate opening and the edge of the first pixel electrode.

12. The display apparatus of claim **1**, wherein the intermediate insulating layer further includes a second portion interposed between the substrate and the first pixel electrode, disposed in the first intermediate opening in the plan view, and apart from the first portion.

13. The display apparatus of claim **12**, wherein an edge of the first portion in a direction to the second portion includes a first inclined portion inclining with respect to a major surface of the substrate, and an edge of the second portion includes a second inclined portion inclining with respect to the major surface of the substrate.

14. The display apparatus of claim **12**, wherein the second portion defines a recess or a hole corresponding to a center of the first pixel electrode.

15. The display apparatus of claim **14**, wherein an inner side surface of the recess or the hole defined in the second portion includes a third inclined portion inclining with respect to a major surface of the substrate.

16. The display apparatus of claim **1**, further comprising:

a second pixel electrode disposed on the substrate; and

a second intermediate layer contacting the second pixel electrode and including a second emission layer,

wherein the pixel-defining layer defines a second pixel opening exposing a central portion of the second pixel electrode and covers an edge of the second pixel electrode, and

the common electrode is disposed over the second pixel electrode with the second intermediate layer interposed therebetween and defines a plurality of second emission openings arranged outside the second pixel opening in the plan view.

17. The display apparatus of claim **16**, wherein, from among layers included in the first intermediate layer, a layer other than the first emission layer is integrally formed with a corresponding layer from among layers included in the second intermediate layer, other than the second emission layer.

18. The display apparatus of claim **16**, wherein, in the plan view, a total area of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is greater than a total area of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and a total area of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings is less than a total area of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

19. The display apparatus of claim **16**, wherein, in the plan view, an area of each of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is greater than an area of each of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and an area of each of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings is less than an area of each of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

20. The display apparatus of claim **16**, wherein, in the plan view, a total number of first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is greater than a total number of first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and a total number of second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings is less than a total number of second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

21. The display apparatus of claim **20**, wherein, in the plan view, an area of each of the first emission openings arranged on one side of the first pixel opening from among the plurality of first emission openings is equal to an area of each of the first emission openings arranged on another side of the first pixel opening from among the plurality of first emission openings, and an area of each of the second emission openings arranged on one side of the second pixel opening from among the plurality of second emission openings is equal to an area of each of the second emission openings arranged on another side of the second pixel opening from among the plurality of second emission openings.

22. The display apparatus of claim **20**, wherein the plurality of first emission openings have a same area from each other, and the plurality of second emission openings have a same area from each other in the plan view.

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