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Heo et al.

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(54) **ORGANIC LIGHT EMITTING DISPLAY DEVICE HAVING BANK WITH BANKHOLE**

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H01L 51/52 (2006.01)
H01L 21/02 (2006.01)
H01L 51/50 (2006.01)

(52) **U.S. Cl.**

CPC ***H01L 51/5203*** (2013.01); ***H01L 21/02008*** (2013.01); ***H01L 27/3246*** (2013.01); ***H01L 51/5012*** (2013.01)

(58) **Field of Classification Search**

CPC H01L 27/3246; H01L 27/3248; H01L 27/3283; H01L 27/3295; H01L 51/5012; H01L 51/5253

See application file for complete search history.

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(57) **ABSTRACT**

Disclosed are an organic light emitting display device and a method of manufacturing the same, in which in a white organic light emitting device, an adverse influence of a leakage current leaked through an organic light emitting layer is minimized on an adjacent pixel. The organic light emitting display device includes a first electrode on a substrate, a bank covering a portion of the first electrode, a bank hole provided in the bank, an organic light emitting layer on the first electrode and the bank, and a second electrode on the organic light emitting layer.

16 Claims, 13 Drawing Sheets

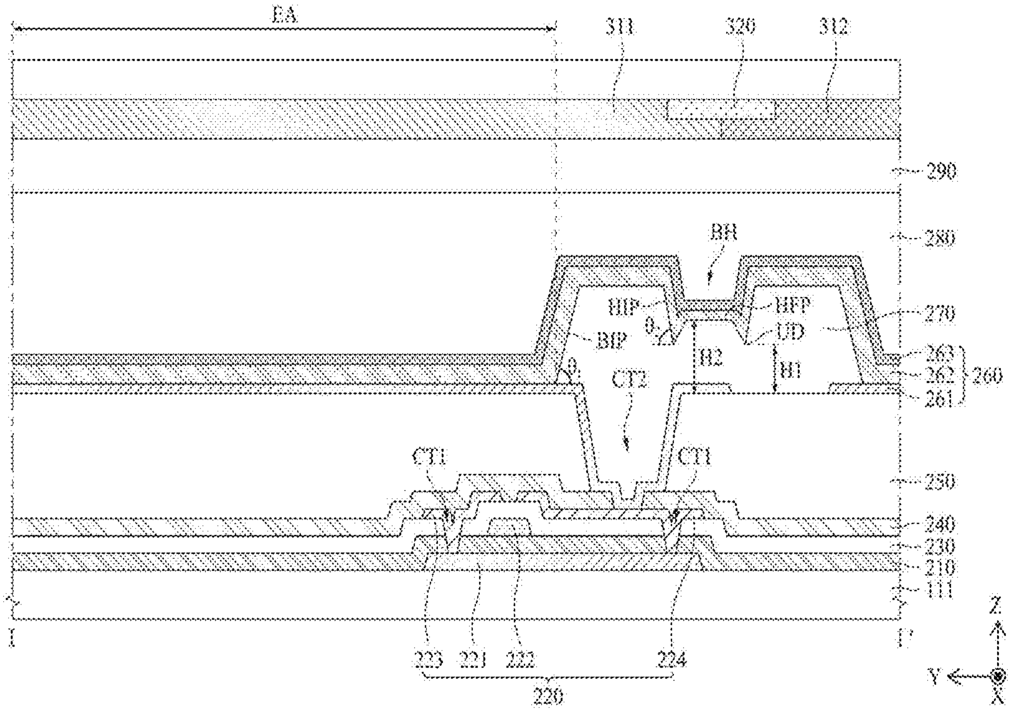
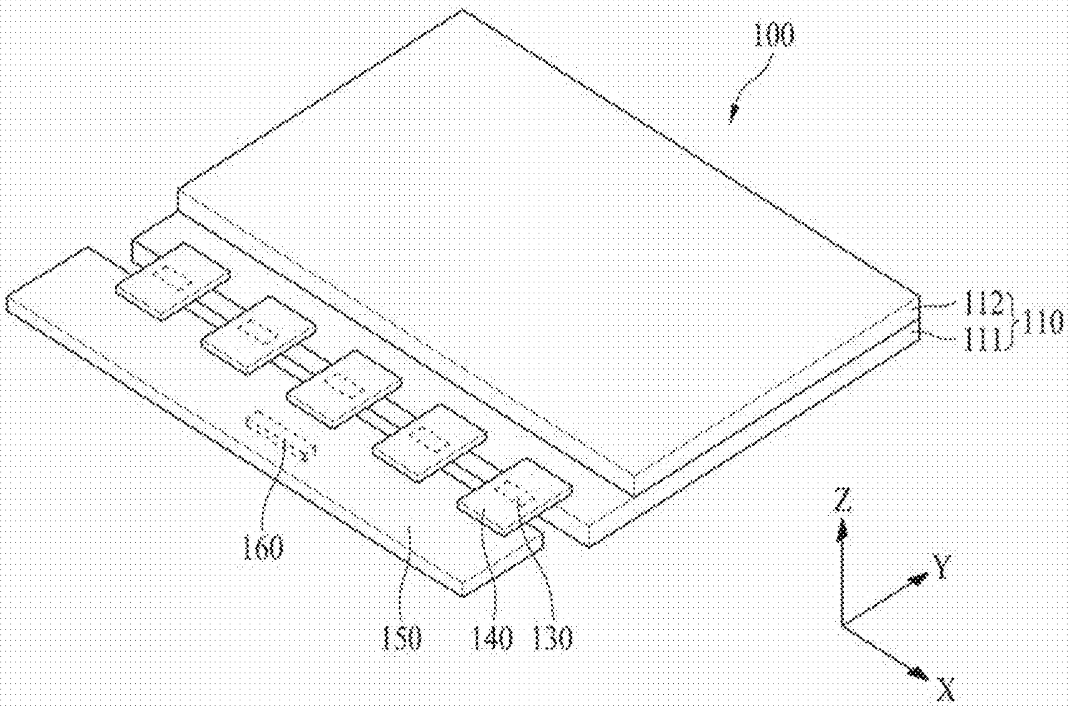


FIG. 1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112
110
111
160
150
140
130
Z
Y
X

FIG. 2

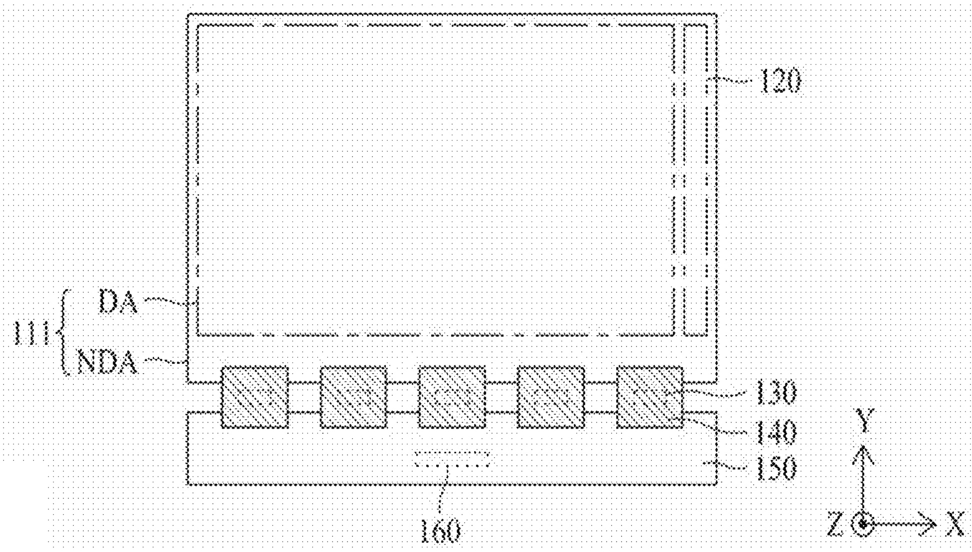

120
DA
111
NDA
130
140
150
160
Y
Z
X

FIG. 3

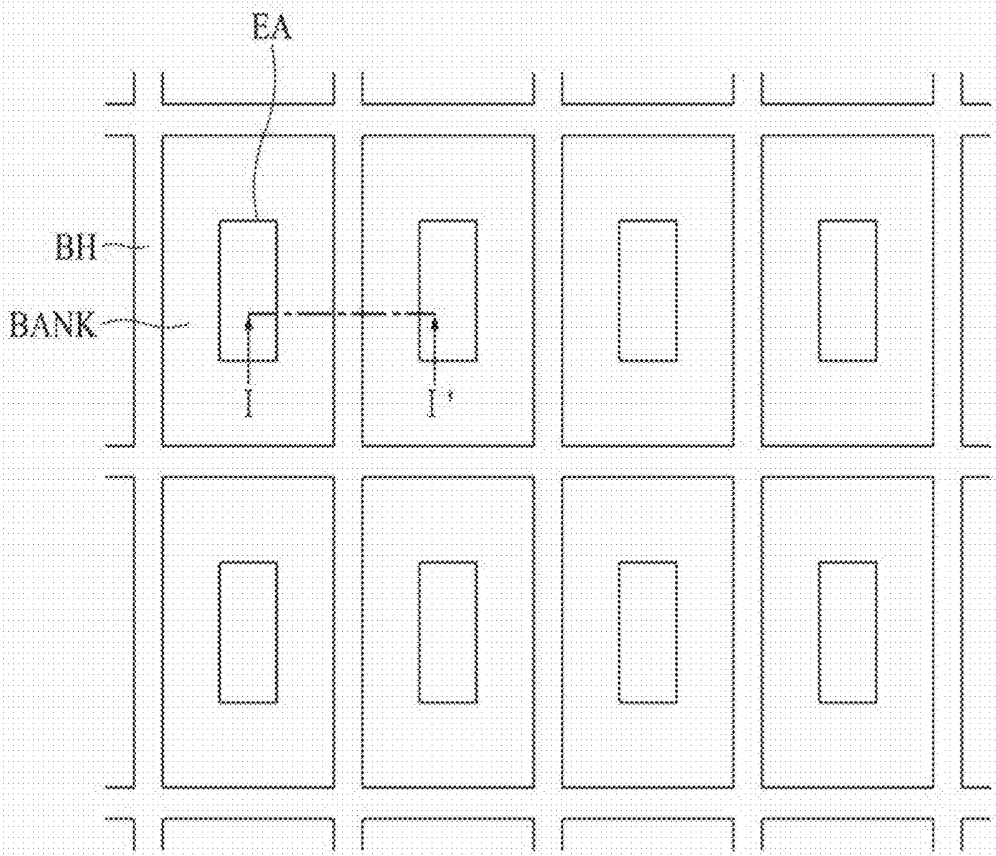
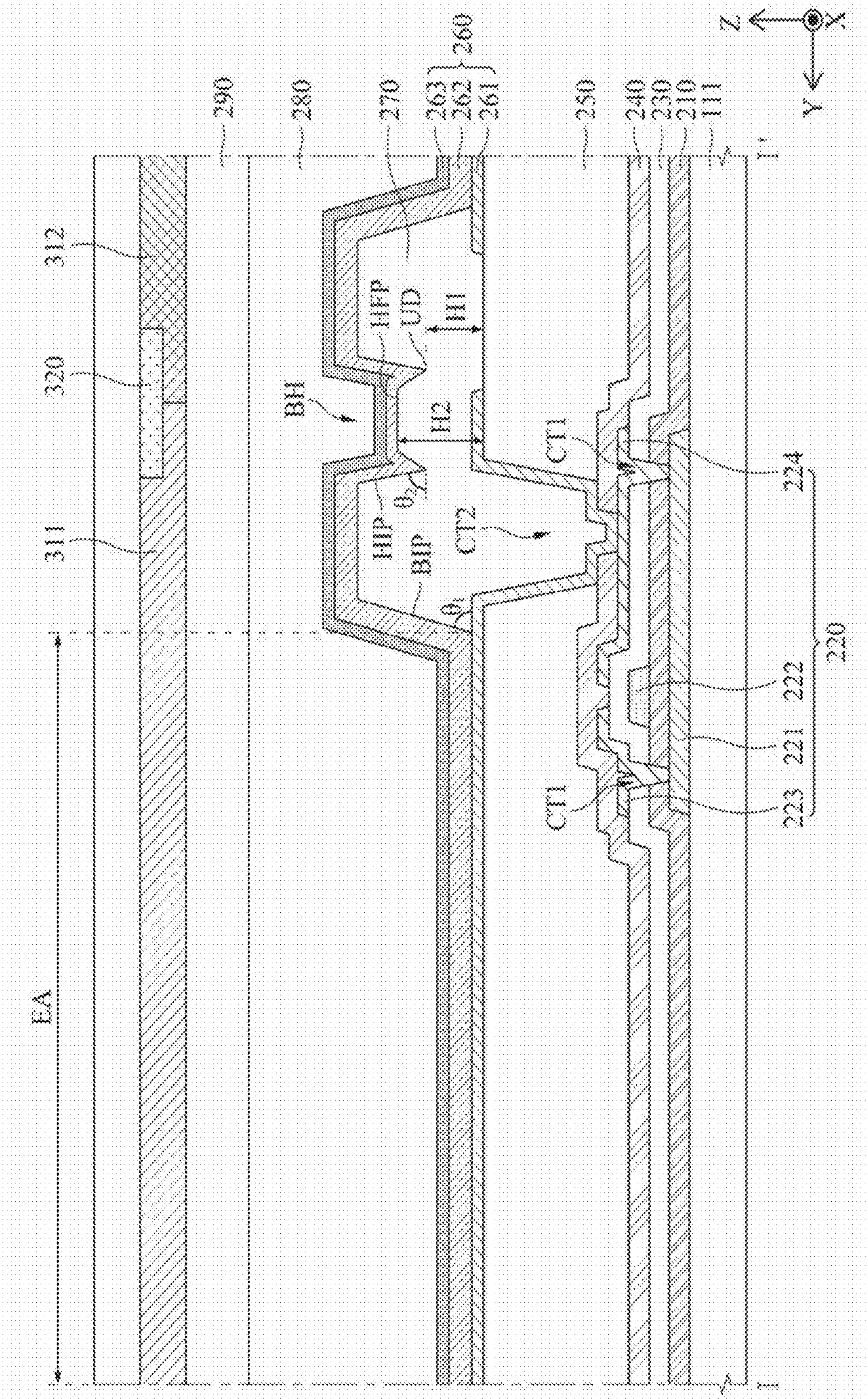
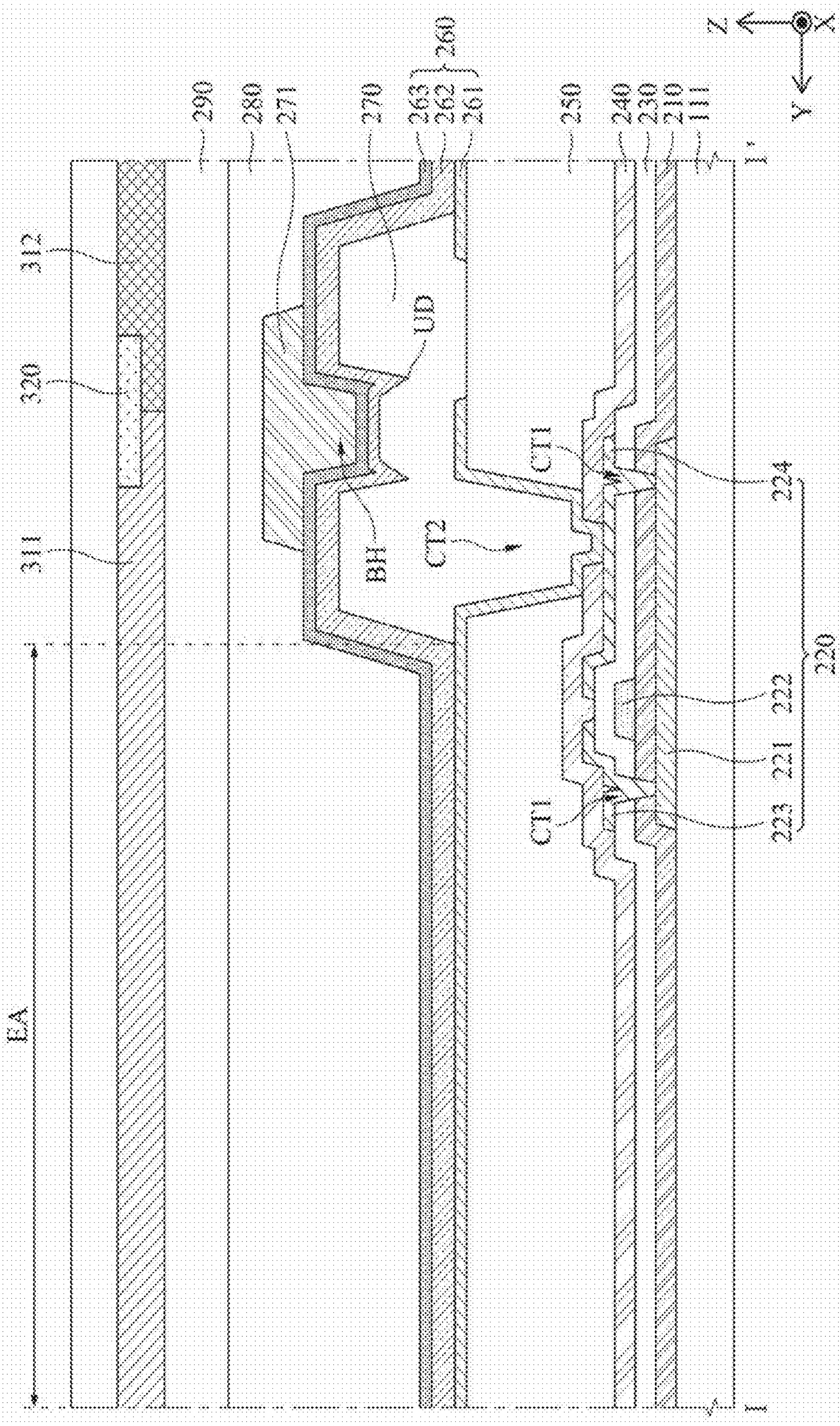


FIG. 4



290
280
270
263
262
261
260
250
240
230
210
111
I'
I
Z
X
Y
312
320
311
HFP
UD
H1
H2
BH
CT1
CT2
224
HP
BIP
222
221
223
220
EA

FIG. 5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290
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271
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261
260
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240
230
210
111
I'
312
320
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UD
BH
CT2
CT1
CT1
224
222
221
223
220
EA
I

FIG. 6

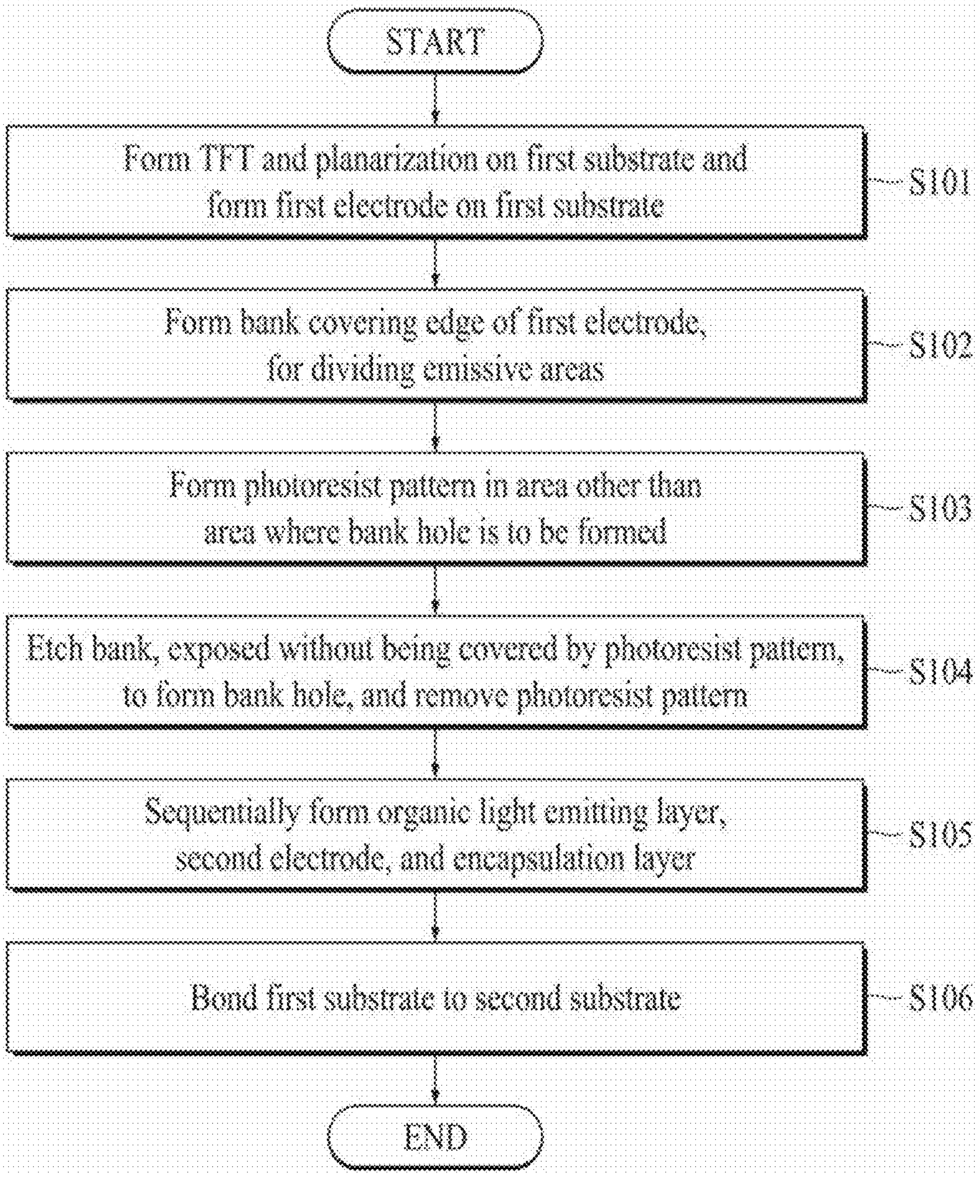

START
Form TFT and planarization on first substrate and form first electrode on first substrate
S101
Form bank covering edge of first electrode, for dividing emissive areas
S102
Form photoresist pattern in area other than area where bank hole is to be formed
S103
Etch bank, exposed without being covered by photoresist pattern, to form bank hole, and remove photoresist pattern
S104
Sequentially form organic light emitting layer, second electrode, and encapsulation layer
S105
Bond first substrate to second substrate
S106
END

FIG. 7A

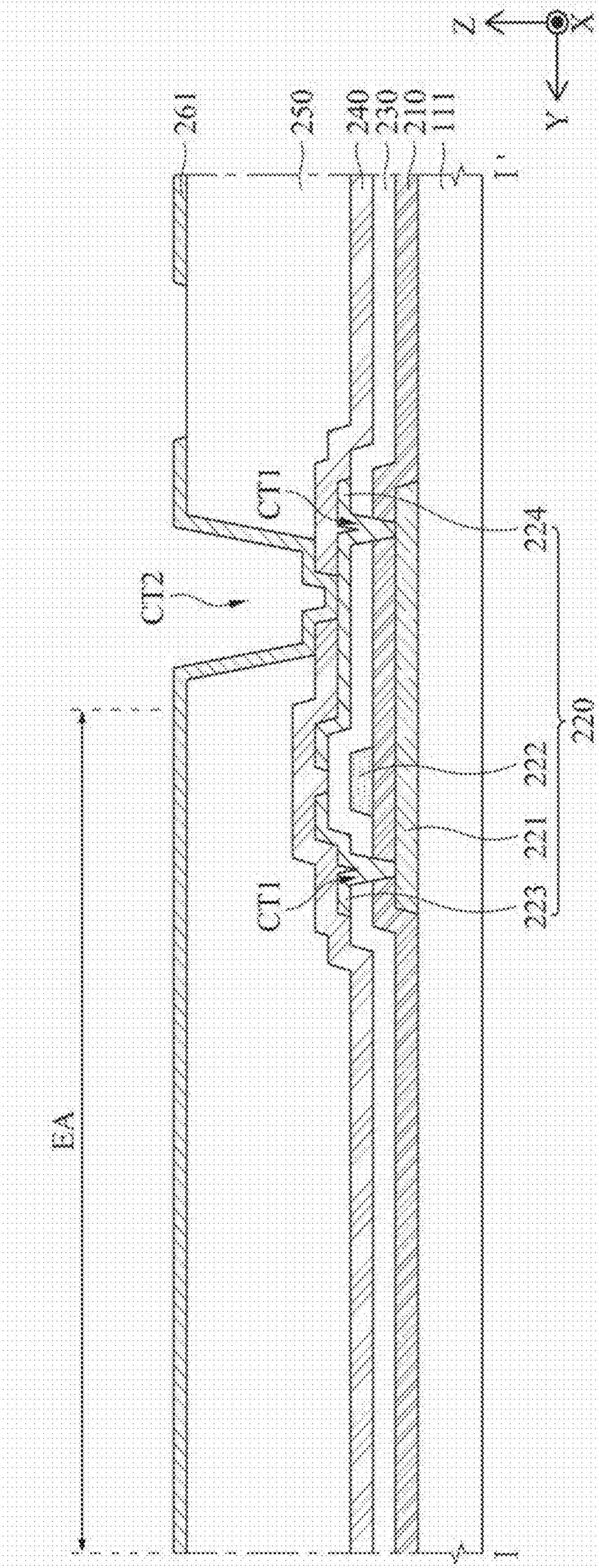


FIG. 7B

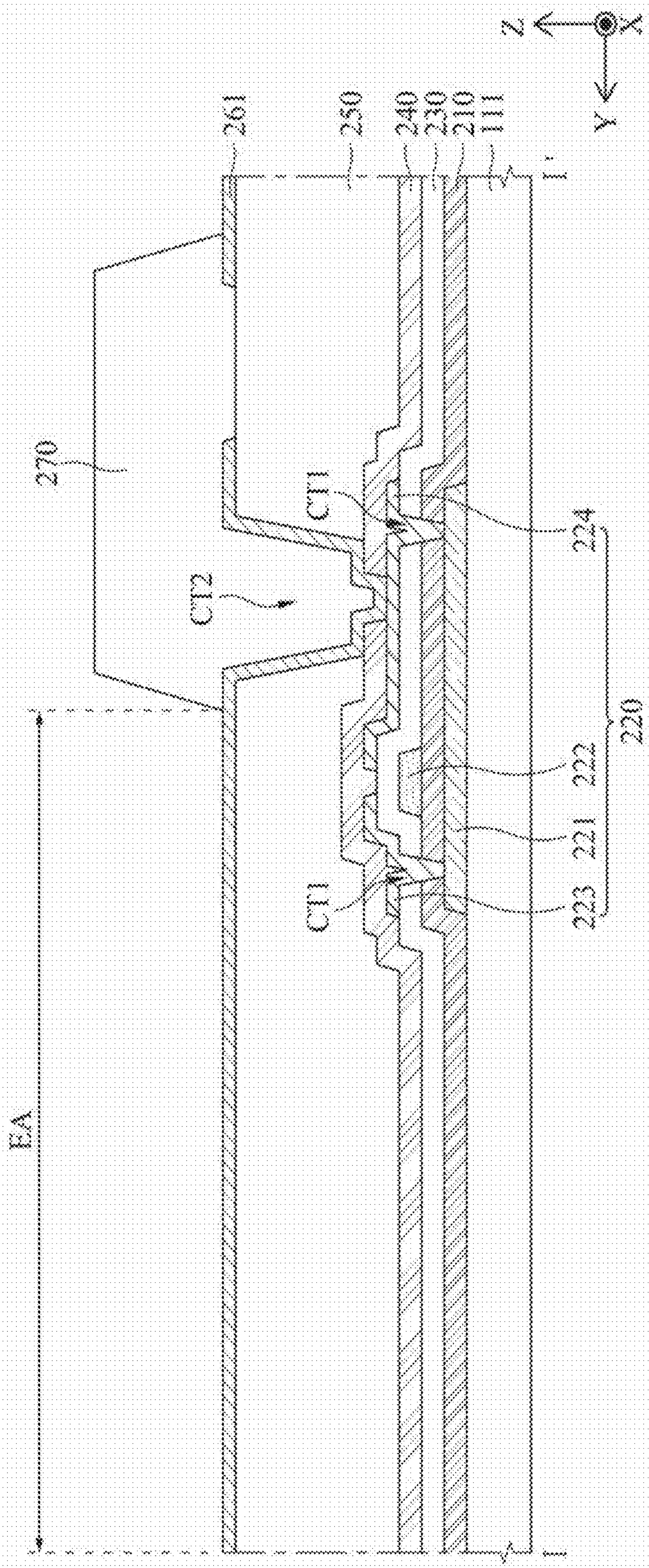
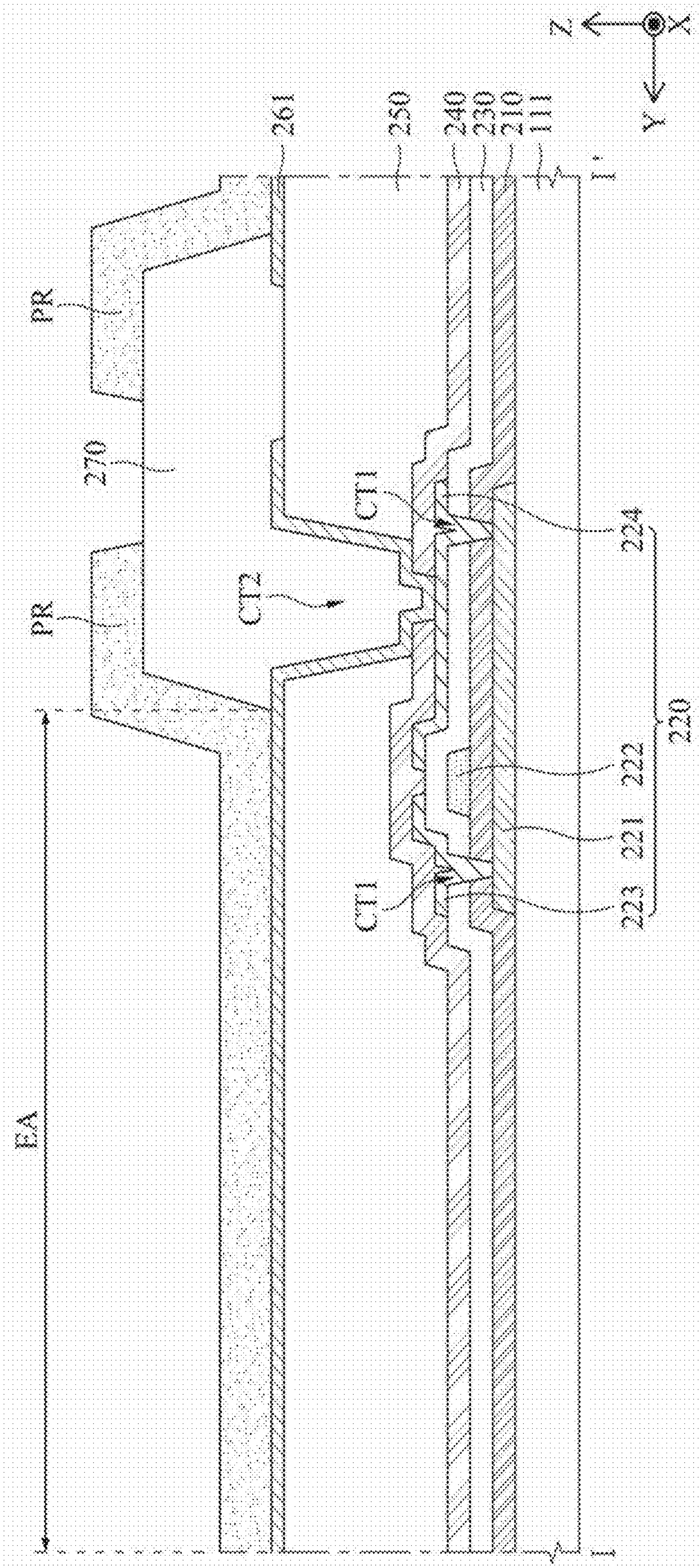

Z
X
Y
261
250
240
230
210
111
270
CT1
CT2
224
220
222
221
223
CT1
EA

FIG. 7C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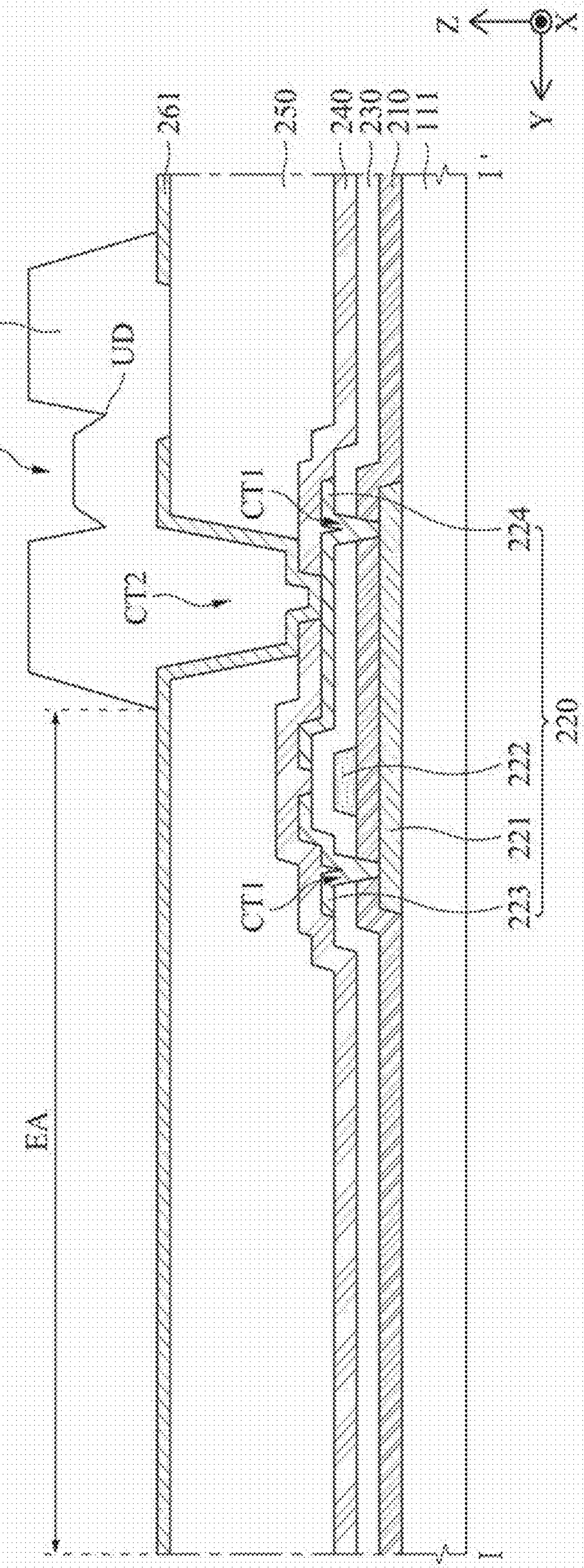
X
Y
261
250
240
230
210
111
I'
PR
270
CT1
224
CT2
PR
220
222
221
CT1
223
EA
I

FIG. 7D



Z
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Y
261
250
240
230
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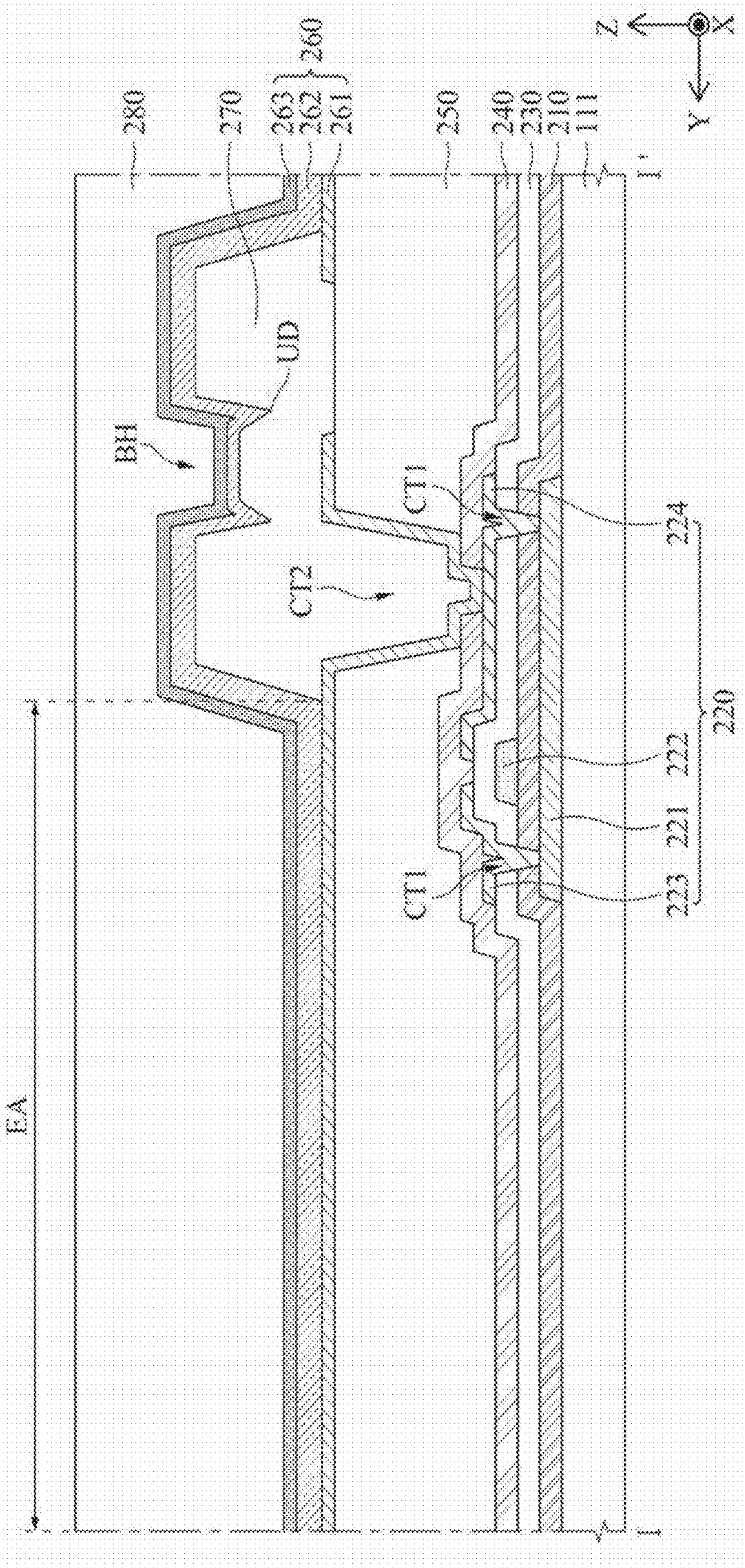
111
I'
270
UD
BH
CT1
CT2
224
220
222
221
223
CT1
EA
I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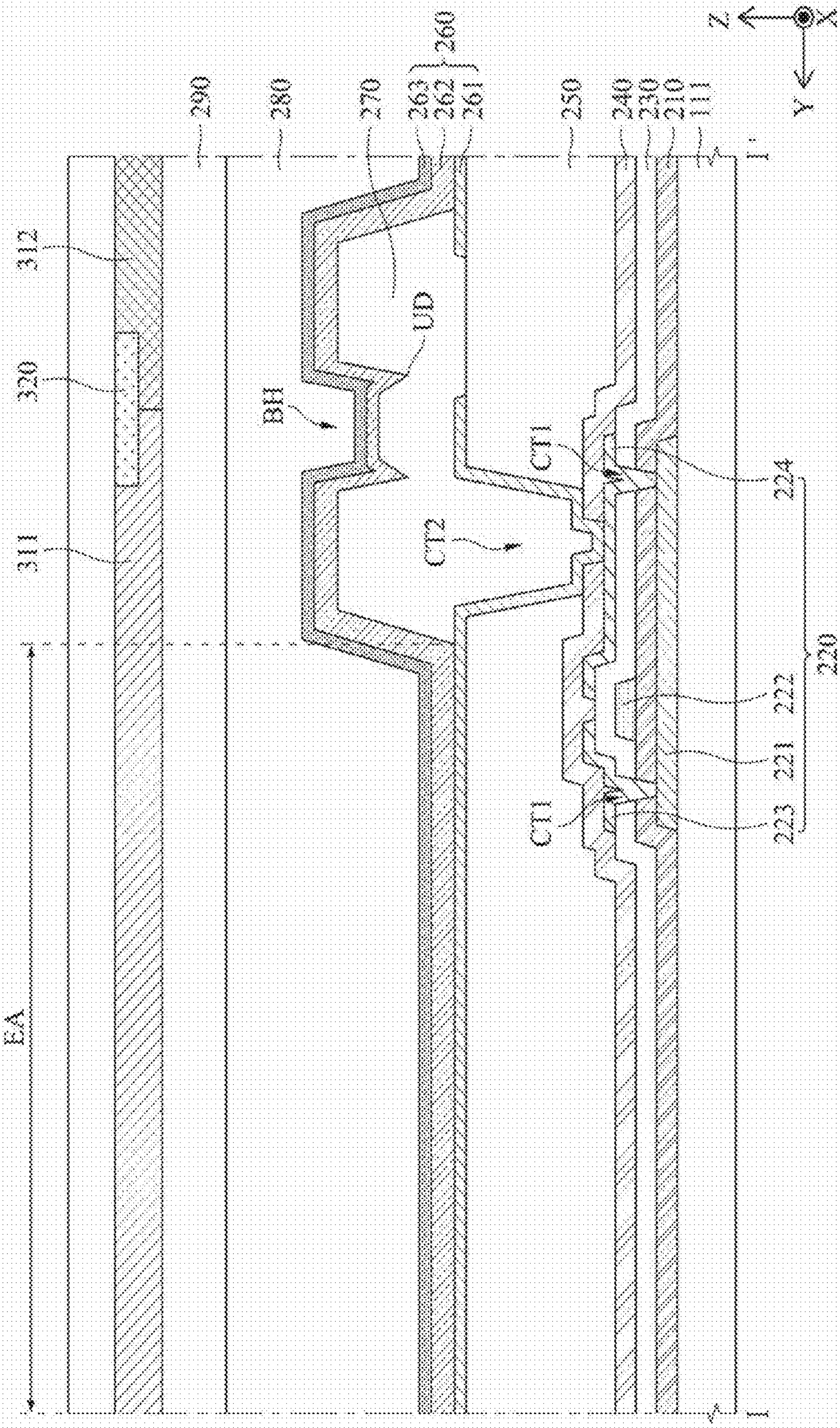
CT2
CT1
224
222
221
223
220
EA
I

FIG. 7E

FIG. 7F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311
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CT1
CT2
CT1
224
222
221
223
220
EA
I'
I
Z
Y
X

FIG. 8

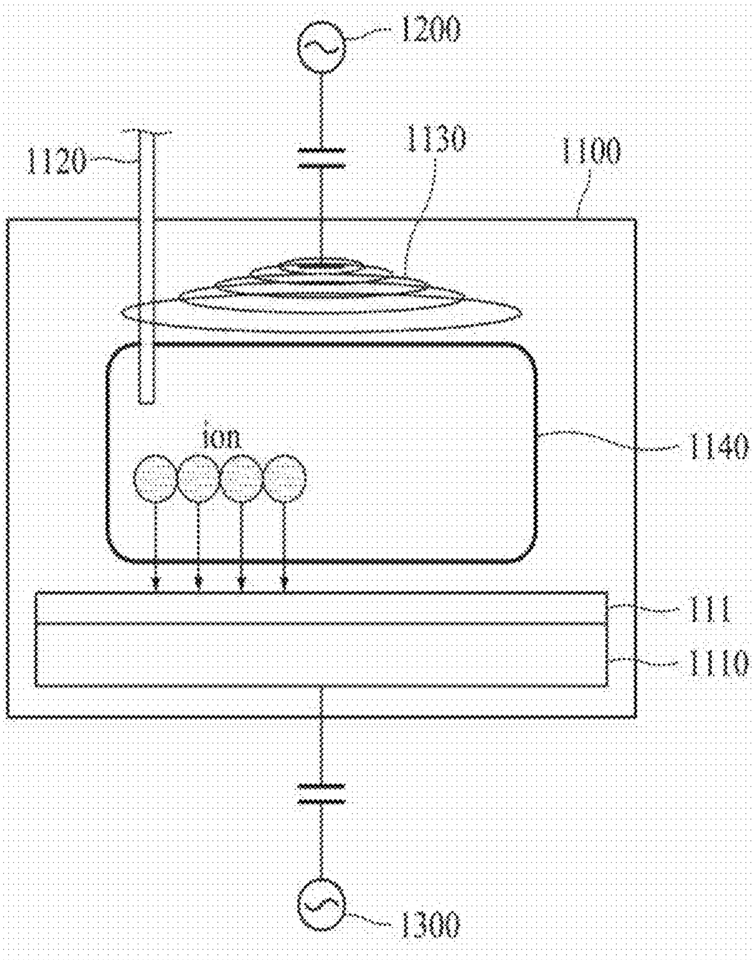


FIG. 9A

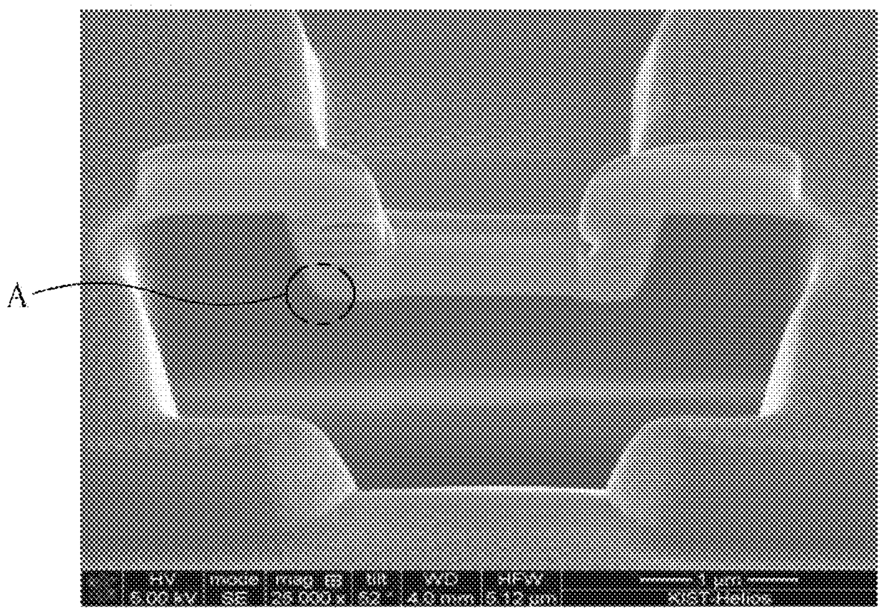
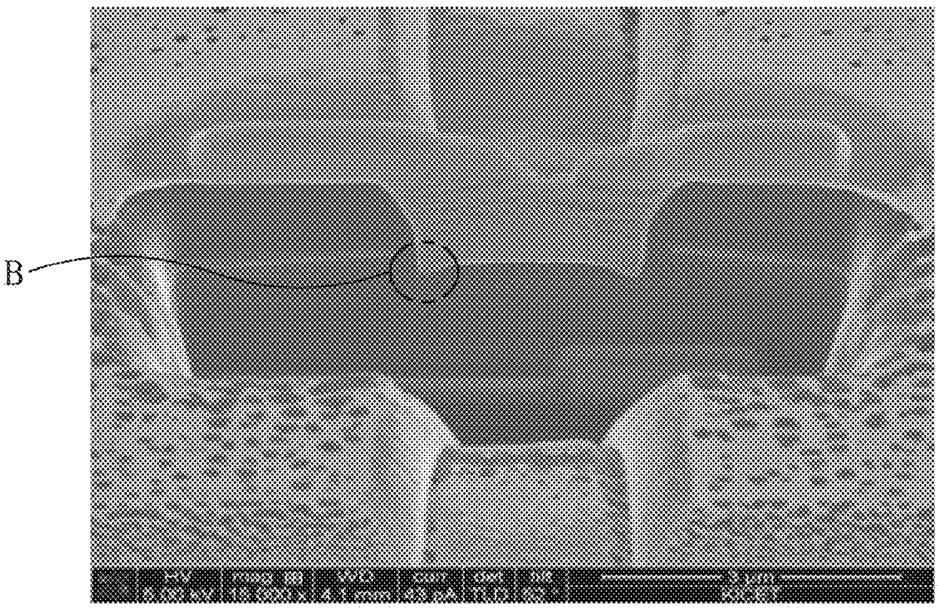


FIG. 9B



ORGANIC LIGHT EMITTING DISPLAY DEVICE HAVING BANK WITH BANKHOLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority benefit of the Korean Patent Application No. 10-2016-0111882 filed on Aug. 31, 2016, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present disclosure relates to an organic light emitting display device and a method of manufacturing the same.

Discussion of the Related Art

With the advancement of information-oriented society, various requirements for display devices for displaying an image are increasing. Therefore, various display devices such as liquid crystal display (LCD) devices, plasma display panel (PDP) devices, organic light emitting display devices, etc. are being used recently.

As a type of display device, organic light emitting display devices are self-emitting display devices and are better in viewing angle and contrast ratio than LCD devices. Also, since the organic light emitting display devices do not need a separate backlight, it is possible to lighten and thin the organic light emitting display devices, and the organic light emitting display devices are excellent in power consumption. Furthermore, the organic light emitting display devices are driven with a low direct current (DC) voltage, have a fast response time, and are low in manufacturing cost.

The organic light emitting display devices each include a plurality of pixels each including an organic light emitting device and a bank which divides the pixels for defining the pixels. The bank may act as a pixel defining layer. The organic light emitting device includes an anode electrode, a hole transporting layer, an organic light emitting layer, and an electron transporting layer, and a cathode electrode. In this instance, when a high-level voltage is applied to the anode electrode and a low-level voltage is applied to the cathode electrode, a hole and an electron respectively move to the organic light emitting layer through the hole transporting layer and the electron transporting layer and are combined with each other in the organic light emitting layer to emit light.

The organic light emitting device include a red organic light emitting device emitting red light, a green organic light emitting device emitting green light, and a blue organic light emitting device emitting blue light, or include only a white organic light emitting device emitting white light. If the organic light emitting device includes the white organic light emitting device, the organic light emitting layer and the cathode electrode may be provided in the pixels in common. That is, the organic light emitting layer and the cathode electrode may be connected to each other between adjacent pixels.

In order to enhance a color reproduction rate and emission efficiency, the white organic light emitting device may be provided in a tandem structure of two or more stacks where two or more organic light emitting layers are stacked. The tandem structure of two or more stacks needs a charge generating layer disposed between adjacent organic light emitting layers. However, in a structure where the organic light emitting layer and the cathode electrode are connected to each other between adjacent pixels, a current can leak from one pixel to an adjacent pixel due to the charge generating layer. That is, the adjacent pixel is affected by the leaked current. In this instance, the adjacent pixel cannot emit desired light due to the leaked current, causing a reduction in a color reproduction rate. Particularly, in high-resolution small display devices applied to virtual reality (VR) devices, smartphones, etc., an interval between pixels is narrow, and for this reason, the adjacent pixel is more affected by the leaked current.

SUMMARY OF THE INVENTION

Accordingly, the present disclosure is directed to provide an organic light emitting display device and a method of manufacturing the same that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An aspect of the present disclosure is directed to provide an organic light emitting display device and a method of manufacturing the same, in which in a white organic light emitting device, an adverse influence of a leakage current leaked through an organic light emitting layer is minimized on an adjacent pixel

Additional advantages and features of the disclosure will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the disclosure. The objectives and other advantages of the disclosure may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the disclosure, as embodied and broadly described herein, there is provided an organic light emitting display device including a first electrode on a substrate, a bank covering a portion of the first electrode, a bank hole provided in the bank, an organic light emitting layer on the first electrode and the bank, and a second electrode on the organic light emitting layer.

In another aspect of the present disclosure, there is provided a method of manufacturing an organic light emitting display device including forming a first electrode on a first substrate, forming a bank covering a portion of the first electrode, forming a photoresist pattern in an area other than an area where a bank hole is to be formed, forming the bank hole by etching an exposed bank uncovered by the photoresist pattern, removing the photoresist pattern, and sequentially forming an organic light emitting layer, a second electrode, and an encapsulation layer on the first electrode and the bank.

It is to be understood that the foregoing general description and the following detailed description of the present disclosure are by example and explanatory and are intended to provide further explanation of the disclosure as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a perspective view illustrating an organic light emitting display device according to an embodiment of the present disclosure;

FIG. **2** is a plan view illustrating a first substrate, a gate driver, a source drive integrated circuit (IC), a flexible film, a circuit board, and a timing controller of FIG. **1**;

FIG. **3** is an example diagram illustrating a bank, a bank hole, and emissive areas of pixels in a display area according to an embodiment of the present disclosure;

FIG. **4** is a cross-sectional view illustrating an example taken along line I-I' of FIG. **3**;

FIG. **5** is a cross-sectional view illustrating another example taken along line I-I' of FIG. **3**;

FIG. **6** is a flowchart illustrating a method of manufacturing an organic light emitting display device according to an embodiment of the present disclosure;

FIGS. **7**A to **7**F are cross-sectional views taken along line I-I' of FIG. **3** for describing a method of manufacturing an organic light emitting display device according to an embodiment of the present disclosure;

FIG. **8** is an example diagram illustrating a high frequency inductive coupled plasma apparatus for forming a bank hole area according to an embodiment of the present disclosure; and

FIGS. **9**A and **9**B are photomicrographs showing an instance where a bank hole is formed in a plasma etching process and an instance where a bank hole is formed in a high frequency inductive coupled plasma process according to embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

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

Advantages and features of the present disclosure, and implementation methods thereof will be clarified through following embodiments described with reference to the accompanying drawings. The present disclosure may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present disclosure to those skilled in the art. Further, the present disclosure is only defined by scopes of claims.

A shape, a size, a ratio, an angle, and a number disclosed in the drawings for describing embodiments of the present disclosure are merely an example, and thus, the present disclosure is not limited to the illustrated details. Like reference numerals refer to like elements throughout. In the following description, when the detailed description of the relevant known function or configuration is determined to unnecessarily obscure the important point of the present disclosure, the detailed description will be omitted.

In an instance where 'comprise', 'have', and 'include' described in the present specification are used, another part may be added unless 'only~' is used. The terms of a singular form may include plural forms unless referred to the contrary.

In construing an element, the element is construed as including an error range although there is no explicit description.

In describing a position relationship, for example, when a position relation between two parts is described as 'on~', 'over~', 'under~', and 'next~', one or more other parts may be disposed between the two parts unless 'just' or 'direct' is used.

In describing a time relationship, for example, when the temporal order is described as 'after~', 'subsequent~', 'next~', and 'before~', an instance which is not continuous may be included unless 'just' or 'direct' is used.

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. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of the present disclosure.

An X axis direction, a Y axis direction, and a Z axis direction should not be construed as only a geometric relationship where a relationship therebetween is vertical, and may denote having a broader directionality within a scope where elements of the present disclosure operate functionally.

The term "at least one" should be understood as including any and all combinations of one or more of the associated listed items. For example, the meaning of "at least one of a first item, a second item, and a third item" denotes the combination of all items proposed from two or more of the first item, the second item, and the third item as well as the first item, the second item, or the third item.

Features of various embodiments of the present disclosure may be partially or overall coupled to or combined with each other, and may be variously inter-operated with each other and driven technically as those skilled in the art can sufficiently understand. The embodiments of the present disclosure may be carried out independently from each other, or may be carried out together in co-dependent relationship.

Hereinafter, example embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

FIG. **1** is a perspective view illustrating an organic light emitting display device **100** according to an embodiment of the present disclosure. FIG. **2** is a plan view illustrating a first substrate, a gate driver, a source drive integrated circuit (IC), a flexible film, a circuit board, and a timing controller of FIG. **1**.

Referring to FIGS. **1** and **2**, the organic light emitting display device **100** according to an embodiment of the present disclosure may include a display panel **110**, a gate driver **120**, a source drive IC **130**, a flexible film **140**, a circuit board **150**, and a timing controller **160**.

The display panel **110** may include a first substrate **111** and a second substrate **112**. The second substrate **112** may be an encapsulation substrate. The first substrate **111** and the second substrate **112** may each be plastic, glass, or the like.

A plurality of gate lines, a plurality of data lines, and a plurality of pixels may be provided on one surface of the first substrate **111** facing the second substrate **112**. The pixels may be respectively provided in a plurality of areas defined by an intersection structure of the gate lines and the date lines.

Each of the pixels may include a thin film transistor (TFT) and an organic light emitting device which includes a first electrode, an organic light emitting layer, and a second electrode. When a gate signal is input through a gate line, each of the pixels may supply a certain current to the organic light emitting device by using the TFT according to a data voltage supplied through a data line. Therefore, the organic light emitting device of each of the pixels may emit light having certain brightness according to the certain current. A structure of each of the pixels will be described in detail with reference to FIGS. **3** to **6**.

The display panel **110**, as illustrated in FIG. **2**, may be divided into a display area DA, where the pixels are provided to display an image, and a non-display area NDA which does not display an image. The gate lines, the data lines, and the pixels may be provided in the display area DA. The gate driver **120** and a plurality of pads may be provided in the non-display area NDA.

The gate driver **120** may sequentially supply gate signals to the gate lines according to a gate control signal input from the timing controller **160**. The gate driver **120** may be provided in the non-display area NDA outside one side or both sides of the display area DA of the display panel **110** in a gate driver-in panel (GIP) type. Alternatively, the gate driver **120** may be manufactured as a driving chip and may be mounted on a flexible film, and moreover, may be attached on the non-display area NDA outside the one side or the both sides of the display area DA of the display panel **110** in a tape automated bonding (TAB) type.

The source drive IC **130** may receive digital video data and a source control signal from the timing controller **160**. The source driver IC **130** may convert the digital video data into analog data voltages according to the source control signal and may respectively supply the analog data voltages to the data lines. If the source drive IC **130** is manufactured as a driving chip, the source drive IC **130** may be mounted on the flexible film **140** in a chip-on film (COF) type or a chip-on plastic (COP) type.

A plurality of pads such as data pads may be provided in the non-display area NDA of the display panel **110**. Lines connecting the pads to the source drive IC **130** and lines connecting the pads to lines of the circuit board **150** may be provided on the flexible film **140**. The flexible film **140** may be attached on the pads by using an anisotropic conductive film, and thus, the pads may be connected to the lines of the flexible film **140**.

The circuit board **150** may be attached on the flexible film **140** which is provided in plurality. A plurality of circuits implemented as driving chips may be mounted on the circuit board **150**. For example, the timing controller **160** may be mounted on the circuit board **150**. The circuit board **150** may be a printed circuit board (PCB) or a flexible printed circuit board (FPCB).

The timing controller **160** may receive the digital video data and a timing signal from an external system board through a cable of the circuit board **150**. The timing controller **160** may generate a gate control signal for controlling an operation timing of the gate driver **120** and a source control signal for controlling the source drive IC **130** which is provided in plurality, based on the timing signal. The timing controller **160** may supply the gate control signal to the gate driver **120** and may supply the source control signal to the plurality of source drive ICs **130**.

FIG. **3** is an example diagram illustrating a bank, a bank hole, and emissive areas of pixels in a display area. In FIG. **3**, for convenience of description, only a bank BANK, a bank hole BH, and emissive areas EA of pixels are illustrated.

Each of the pixels may include one emissive area. The emissive area may denote an area where a first electrode corresponding to an anode electrode, an organic light emitting layer, and a second electrode corresponding to a cathode electrode are sequentially stacked, and a hole from the first electrode and an electron from the second electrode are combined with each other in the organic light emitting layer to emit light.

The emissive area EA may be divided into a red emissive area which emits red light by using a red color filter, a green emissive area which emits green light by using a green color filter, a blue emissive area which emits blue light by using a blue color filter, and a white emissive area which emits white light without a color filter. A red pixel including the red emissive area, a green pixel including the green emissive area, a blue pixel including the blue emissive area, and a pixel including the white emissive area may be defined as one unit pixel.

The bank BANK may divide the emissive areas EA and may define the emissive areas EA. The bank BANK may be formed to surround each of the emissive areas EA. The bank hole BH corresponding to a recessed portion may be formed in the bank BANK. The bank hole BH may be formed between adjacent emissive areas EA.

FIG. **4** is a cross-sectional view illustrating an example taken along line I-I' of FIG. **3**.

Referring to FIG. **4**, a buffer layer may be formed on one surface of the first substrate **111** facing the second substrate **112**. The buffer layer may be formed on the one surface of the first substrate **111**, for protecting a plurality of TFTs **220** and a plurality of organic light emitting devices (or organic light emitting structures) **260** from water or moisture which penetrates through the first substrate **111** vulnerable to penetration of water. The buffer layer may include a plurality of inorganic layers which are alternately stacked. For example, the buffer layer may be formed of a multilayer where one or more inorganic layers of silicon oxide (SiOx), silicon nitride (SiNx), and SiON are alternately stacked. The buffer layer may be omitted.

The TFTs **220** may be formed on the buffer layer. Each of the TFTs **220** may include an active layer **221**, a gate electrode **222**, a source electrode **223**, and a drain electrode **224**. In FIG. **4**, the TFTs **220** are exemplarily illustrated as being formed in a top gate type where the gate electrode **222** is disposed on the active layer **221**, but is not limited thereto. In other embodiments, the TFTs **220** may be formed in a bottom gate type where the gate electrode **222** is disposed under the active layer **221** or a double gate type where the gate electrode **222** is disposed both on and under the active layer **221**.

The active layer **221** may be formed on the buffer layer. The active layer **221** may be formed of a silicon-based semiconductor material or an oxide-based semiconductor material. A light blocking layer for blocking external light incident on the active layer **221** may be formed between the buffer layer and the active layer **221**.

A gate insulation layer **210** may be formed on the active layer **221**. The gate insulation layer **210** may be formed of an inorganic layer, for example, silicon oxide (SiOx), silicon nitride (SiNx), or a multilayer thereof.

The gate electrode **222** and a gate line may be formed on the gate insulation layer **210**. The gate electrode **222** and the gate line may each be formed of a single layer or a multilayer which includes one of molybdenum (Mo), chromium (Cr), titanium (Ti), nickel (Ni), neodymium (Nd), and copper (Cu), or an alloy thereof.

An interlayer dielectric **230** may be formed on the gate electrode **222** and the gate line. The interlayer dielectric **230** may be formed of an inorganic layer, for example, SiOx, SiNx, or a multilayer thereof.

The source electrode **223**, the drain electrode **224**, and a data line may be formed on the interlayer dielectric **230**.

Each of the source electrode **223** and the drain electrode **224** may contact the active layer **221** through a corresponding contact hole CT**1** which passes through the gate insulation layer **210** and the interlayer dielectric **230**. The source electrode **223**, the drain electrode **224**, and the data line may each be formed of a single layer or a multilayer which includes one of Mo, Cr, Ti, Ni, Nd, and Cu, or an alloy thereof.

A passivation layer **240** for insulating the TFTs **220** may be formed on the source electrode **223**, the drain electrode **224**, and the data line. The passivation layer **240** may be formed of an inorganic layer, for example, SiOx, SiNx, or a multilayer thereof.

A planarization layer **250** for planarizing a step height caused by the TFTs **220** may be formed on the passivation layer **240**. The planarization layer **250** may be formed of an organic layer such as acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like.

An organic light emitting device **260** and a bank **270** may be formed on the planarization layer **250**. The organic light emitting device **260** may include a first electrode **261**, an organic light emitting layer **262**, and a second electrode **263**. The first electrode **261** may be an anode electrode, and the second electrode **263** may be a cathode electrode.

The first electrode **261** may be formed on the planarization layer **250**. The first electrode **261** may be connected to the source electrode **223** of the TFT **220** through a contact hole which passes through the passivation layer **240** and the planarization layer **250**. The first electrode **261** may be formed of a metal material, having a high reflectivity, such as a stacked structure (Ti/Al/Ti) of aluminum (Al) and titanium (Ti), a stacked structure (ITO/Al/ITO) of Al and ITO, an APC alloy, a stacked structure (ITO/APC/ITO) of an APC alloy and ITO, and/or the like. The APC alloy may be an alloy of Ag, palladium (Pd), and Cu.

The bank **270** may be formed to cover a portion of the first electrode **261** on the planarization layer **250**, for dividing the emissive areas EA. For example, the bank **270** may be formed to cover an edge of the first electrode **261**. That is, the bank **270** may define the emissive areas EA. Also, an area where the bank **270** is provided may not emit light, and thus, may correspond to a non-emissive area.

A bank hole BH may be formed in the bank **270**. The bank hole BH may include a sidewall HIP, a floor HFP, and an undercut portion UP between the sidewall HIP and the floor HFP. An inclined angle "θ_2" of the sidewall HIP of the bank hole BH may be set greater than an inclined angle "θ_1" of a side BIP of the bank **270**. As the inclined angle "θ_2" of the sidewall HIP of the bank hole BH gets closer to 90 degrees, a thickness of the organic light emitting layer **262** formed on the sidewall HIP of the bank hole BH may be thinned. As the thickness of the organic light emitting layer **262** is thinned, a resistance of the organic light emitting layer **262** increases, and thus, the amount of current leaked through the organic light emitting layer **262** is reduced.

Moreover, a height H**1** of the undercut portion UP may be set lower than a height H**2** of the floor HFP. That is, the undercut portion UP of the bank hole BH may be formed in an undercut shape so as to be deeper recessed than a center of the bank hole BH. As the height H**1** of the undercut portion UP becomes lower than the height H**2** of the floor HFP, a thickness of the organic light emitting layer **262** formed in the undercut portion UP may be thinned. As the thickness of the organic light emitting layer **262** is thinned, the resistance of the organic light emitting layer **262** increases, thereby the amount of current leaked through the organic light emitting layer **262** is reduced.

The bank **270** may be formed of an organic layer such as acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like.

The organic light emitting layer **262** may be formed on the first electrode **261** and the bank **270**. The organic light emitting layer **262** may be a common layer which is formed in the emissive areas EA in common, and may be a white light emitting layer that emits white light. In this instance, the organic light emitting layer **262** may be formed in a tandem structure of two or more stacks. Each of the stacks may include a hole transporting layer, at least one light emitting layer, and an electron transporting layer.

Moreover, a charge generating layer may be formed between adjacent stacks. The charge generating layer may include an n-type charge generating layer, disposed adjacent to a lower stack, and a p-type charge generating layer which is formed on the n-type charge generating layer and is disposed adjacent to an upper stack. The n-type charge generating layer may inject an electron into the lower stack, and the p-type charge generating layer may inject a hole into the upper stack. The n-type charge generating layer may be formed of an organic layer which is doped with alkali metal, such as lithium (Li), sodium (Na), potassium (K), or cesium (Cs), or alkali earth metal such as magnesium (Mg), strontium (Sr), barium (Ba), or radium (Ra). The p-type charge generating layer may be an organic layer which is formed by doping a dopant on an organic host material having an ability to transport holes.

The organic light emitting layer **262** may be formed in a deposition process or a solution process, and if the organic light emitting layer **262** is formed in the deposition process, the organic light emitting layer **262** may be formed in an evaporation process. A layer formed in the evaporation process is not good in step coverage characteristic. If the inclined angle "θ_2" of the sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**.

That is, in an embodiment of the present disclosure, since the bank hole BH corresponding to a recessed portion is formed in the bank **270**, a length of a current leakage path which passes through the organic light emitting display layer **262** between adjacent emissive areas EA may be set longer than an instance where the bank hole **270** is not provided. Also, in an embodiment of the present disclosure, since the inclined angle "θ_2" of the sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**. Accordingly, in an embodiment of the present disclosure, the resistance of the organic light emitting layer **262** may increase, thereby an adverse influence of a leakage current leaked through the organic light emitting layer **262** is minimized on an adjacent pixel.

The second electrode **263** may be formed on the organic light emitting layer **262**. The second electrode **263** may be a common layer which is formed in the emissive areas EA in common. The second electrode **263** may be formed of a transparent conductive material (or TCO), such as indium tin oxide (ITO) or indium zinc oxide (IZO) capable of transmitting light, or a semi-transmissive conductive material such as Mg, Ag, or an alloy of Mg and Ag. A capping layer may be formed on the second electrode **263**.

The second electrode **263** may be formed in a physical vapor deposition (PVD) process such as a sputtering process. A layer formed in the PVD process such as the sputtering process is good in step coverage characteristic. Accordingly, despite the bank hole BH, the second electrode **263** may be deposited to have a uniform thickness in comparison with the organic light emitting layer **262**.

An encapsulation layer **280** may be formed on the second electrode **263**. The organic light emitting layer **262** and the second electrode **263** are formed in the bank hole BH. However, since the bank hole BH is not filled with the organic light emitting layer **262** and the second electrode **263**, the encapsulation layer **280** may be formed to fill the bank hole BH.

The encapsulation layer **280** prevents oxygen or water from penetrating into the organic light emitting layer **262** and the second electrode **263**. To this end, the encapsulation layer **280** may include at least one inorganic layer and at least one organic layer.

For example, the encapsulation layer **280** may include a first inorganic layer, an organic layer, and a second inorganic layer. In this instance, the first inorganic layer may be formed on the second electrode **263** to cover the second electrode **263**. The organic layer may be formed on the first inorganic layer to cover the first inorganic layer. The organic layer may be formed to have a sufficient thickness for preventing particles from penetrating into the organic light emitting layer **262** and the second electrode **263** via the first inorganic layer. The second inorganic layer may be formed on the organic layer to cover the organic layer.

The first and second inorganic layers may each be formed of silicon nitride, aluminum nitride, zirconium nitride, titanium nitride, hafnium nitride, tantalum nitride, silicon oxide, aluminum oxide, titanium oxide, and/or the like. The organic layer may be formed of acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like.

A plurality of color filters **311** and **312** and a black matrix **320** may be formed on one surface of the second substrate **112** facing the first substrate **111**. The color filters **311** and **312** may be disposed in an area corresponding to the emissive areas EA. The color filters **311** and **312** may each be formed of an organic layer including a certain pigment such as a red pigment, a green pigment, a blue pigment, and/or the like.

The black matrix **320** may be disposed between the color filters **311** and **312**. The black matrix **320** may be provided in a non-emissive area instead of the emissive areas EA. The black matrix **300** may be formed of an organic layer including a black pigment.

The encapsulation layer **280** of the first substrate **111** may be adhered to the color filters **311** and **312** of the second substrate **112** by using an adhesive layer **290**, and thus, the first substrate **111** may be bonded to the second substrate **112**. The adhesive layer **290** may be a transparent adhesive resin.

As described above, in an embodiment of the present disclosure, since the bank hole BH corresponding to a recessed portion is formed on the bank **270**, a length of a current leakage path which passes through the organic light emitting display layer **262** between adjacent emissive areas EA may be set longer than an instance where the bank hole **270** is not provided. Also, in an embodiment of the present disclosure, since the inclined angle "θ_2" of sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**. Accordingly, in an embodiment of the present disclosure, the resistance of the organic light emitting layer **262** may increase, thereby an adverse influence of a leakage current leaked through the organic light emitting layer **262** is minimized on an adjacent pixel. In an embodiment of the present disclosure, the bank hole BH may be aligned with the black matrix **320**.

FIG. **5** is a cross-sectional view illustrating another example taken along line I-I' of FIG. **3**. Except that an organic light emitting display device further includes a black bank **271**, an organic light emitting display device illustrated in FIG. **5** is substantially as described above with reference to FIG. **4**.

The black bank **271** may be formed on a second electrode **263**. The black bank **271** may be formed to fill a bank hole BH. If the black bank **271** is formed on the second electrode **263**, the black matrix **320** may be omitted. The black bank **271** may be formed of an organic layer including a black pigment.

In an embodiment of the present disclosure, the black bank **271** blocks light traveling from one emissive area EA to an adjacent emissive area EA, thereby preventing occurrence of color mixture.

FIG. **6** is a flowchart illustrating a method of manufacturing an organic light emitting display device according to an embodiment of the present disclosure. FIGS. **7**A to **7**F are cross-sectional views taken along line I-I' for describing a method of manufacturing an organic light emitting display device according to an embodiment of the present disclosure.

The cross-sectional views illustrated in FIGS. **7**A to **7**F relate to the method of manufacturing the organic light emitting display device illustrated in FIG. **5**, and thus, like reference numerals refer to like elements. Hereinafter, a method of manufacturing an organic light emitting display device according to an embodiment of the present disclosure will be described in detail with reference to FIGS. **6** and **7**A to **7**F.

First, as in FIG. **7**A, a TFT **220**, a planarization layer **250**, and a first electrode **261** of an organic light emitting layer **260** may be formed.

In detail, before the TFT **220** is formed, a buffer layer may be formed on a first substrate **111**, for protecting the TFT **220** from water penetrating through a substrate **100**. The buffer layer may include a plurality of inorganic layers which are alternately stacked, for protecting the TFT **220** and the organic light emitting device **260** from water which penetrates through the first substrate **111** vulnerable to penetration of water. For example, the buffer layer may be formed of a multilayer where one or more inorganic layers of silicon oxide (SiOx), silicon nitride (SiNx), and SiON are alternately stacked. The buffer layer may be formed by using a chemical vapor deposition (CVD) process.

Subsequently, an active layer **221** of the TFT **220** may be formed on the buffer layer. In detail, an active metal layer may be formed all over the buffer layer by using a sputtering process, a metal organic chemical vapor (MOCVD) process, and/or the like. Subsequently, the active layer **221** may be formed by patterning the active metal layer through a mask process using a photoresist pattern. The active layer **211** may be formed of a silicon-based semiconductor material, an oxide-based semiconductor material, and/or the like.

Subsequently, a gate insulation layer **210** may be formed on the active layer **221**. The gate insulation layer **210** may be formed of an inorganic layer, for example, silicon oxide (SiOx), silicon nitride (SiNx), or a multilayer thereof.

Subsequently, a gate electrode **222** of the TFT **220** may be formed on the gate insulation layer **210**. In detail, a first metal layer may be formed all over the gate insulation layer **210** by using a sputtering process, an MOCVD process, and/or the like. Subsequently, the gate electrode **222** may be formed by patterning the first metal layer through a mask process using a photoresist pattern. The gate electrode **222** may be formed of a single layer or a multilayer which includes one of molybdenum (Mo), chromium (Cr), titanium (Ti), nickel (Ni), neodymium (Nd), and copper (Cu), or an alloy thereof.

Subsequently, an interlayer dielectric **230** may be formed on the gate electrode **222**. The interlayer dielectric **230** may be formed of an inorganic layer, for example, SiOx, SiNx, or a multilayer thereof.

Subsequently, a plurality of contact holes CT**1** which pass through the gate insulation layer **210** and the interlayer dielectric **230** to expose the active layer **211** may be formed.

Subsequently, a source electrode **223** and a drain electrode **224** of the TFT **220** may be formed on the interlayer dielectric **230**. In detail, a second metal layer may be formed all over the interlayer dielectric **230** by using a sputtering process, an MOCVD process, and/or the like. Subsequently, the source electrode **223** and the drain electrode **224** may be formed by patterning the second metal layer through a mask process using a photoresist pattern. Each of the source electrode **223** and the drain electrode **224** may contact the active layer **221** through a corresponding contact hole CT**1** which passes through the gate insulation layer **210** and the interlayer dielectric **230**. The source electrode **223** and the drain electrode **224** may each be formed of a single layer or a multilayer which includes one of Mo, Cr, Ti, Ni, Nd, and Cu, or an alloy thereof.

Subsequently, a passivation layer **240** may be formed on the source electrode **223** and the drain electrode **224** of the TFT **220**. The passivation layer **240** may be formed of an inorganic layer, for example, SiOx, SiNx, or a multilayer thereof. The passivation layer **240** may be formed by using a CVD process.

Subsequently, a planarization layer **250** for planarizing a step height caused by the TFT **220** may be formed on the passivation layer **240**. The planarization layer **250** may be formed of an organic layer such as acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like.

Subsequently, a first electrode **261** of the organic light emitting device **260** may be formed on the planarization layer **250**. In detail, a third metal layer may be formed all over the planarization layer **250** by using a sputtering process, an MOCVD process, and/or the like. Subsequently, the first electrode **261** may be formed by patterning the third metal layer through a mask process using a photoresist pattern. The first electrode **261** may be connected to the source electrode **223** of the TFT **220** through a contact hole CT**2** which passes through the passivation layer **240** and the planarization layer **250**. The first electrode **261** may be formed of a metal material, having a high reflectivity, such as a stacked structure (Ti/Al/Ti) of aluminum (Al) and titanium (Ti), a stacked structure (ITO/Al/ITO) of Al and ITO, an APC alloy, a stacked structure (ITO/APC/ITO) of an APC alloy and ITO, and/or the like. (S**101** of FIG. **6**)

Second, as in FIG. **7**B, a bank **270** covering an edge of the first electrode **261** may be formed for dividing a plurality of emissive areas EA.

The bank **270** may be formed of an organic layer such as acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like. (S**102** of FIG. **6**)

Third, as in FIG. **7**C, a photoresist pattern PR may be formed in an area other than an area where a bank hole BH is to be formed. (S**103** of FIG. **6**)

Fourth, as in FIG. **7**D, the bank hole BH may be formed by etching the bank **270** which is exposed without being covered by the photoresist pattern PR, and the photoresist pattern PR may be removed.

In detail, as in FIG. **8**, the bank hole BH may be formed by using a high frequency inductive coupled plasma apparatus. The high frequency inductive coupled plasma apparatus may include a chamber **1100**, a first power supply unit **1200**, and a second power supply unit **1300**.

The chamber **1100** may include a substrate positioning frame **1110** on which the substrate **111** is positioned, a gas supply unit **1120** that distributes a gas to a portion on the substrate positioning frame **1110**, and an antenna **1130** that is disposed over the substrate positioning frame **1110**. The gas supply unit **1120** may be configured with a plurality of gas supply units, and the plurality of gas supply units may respectively distribute different gases to a reaction space **1140** of the chamber **1100**. For example, a first gas supply unit may distribute a source gas to the reaction space **1140** of the chamber **1110**, and a second gas supply unit may distribute a reactant gas to the reaction space **1140** of the chamber **1110**. The antenna **1130** may use one coil which is wound in a spiral shape, or may use a plurality of coils which have different diameters, arranged on the same plane in a concentric circle shape, and connected to the first power supply unit **1200** in parallel. The chamber **1100** may further include an exhaust port that exhausts a residual material.

The first power supply unit **1200** may be connected to the antenna **1130** and may supply a first radio frequency (RF) power. The second power supply unit **1300** may be connected to the substrate positioning frame **1110** and may supply a second RF power. For example, the first RF power may be applied at 13.56 MHz, and the second RF power may be applied at 6 MHz.

The high frequency inductive coupled plasma apparatus may distribute a gas to the inside of the chamber **1100** through the gas supply unit **1120**, and the first and second power supply units **1200** and **1300** may apply the first and second RF powers, thereby isotropic-etching the first substrate **111** by using a physical impact of ions. The high frequency inductive coupled plasma apparatus may individually control a plasma density and ion energy. As a result, the bank **270** which is exposed without being covered by the photoresist pattern PR may be etched, and thus, the bank hole BH may be formed.

An inclined angle "θ_2" of a sidewall HIP of the bank hole BH may be set greater than an inclined angle "θ_1" of a side BIP of the bank **270**. Also, a height H**1** of an undercut portion UD may be set lower than a height H**2** of the floor HFP. That is, an edge of the bank hole BH may be deeper recessed than a center of the bank hole BH.

In a plasma etching process, the bank hole BH may be formed through isotropic etching based on a chemical reaction of ions under a condition where an electron density is about $10^9/cm^3$ and pressure is 100 to 1000 mTorr. That is, in the plasma etching process, the isotropic etching may be performed, and thus, as in FIG. **9**A, the height H**1** of the undercut portion UD is not set lower than the height H**2** of the floor HFP.

In a high frequency inductive coupled plasma process, however, the bank hole BH may be formed through isotropic etching based on a physical impact of ions under a condition where an electron density is about $10^{11}/cm^3$ and pressure is 1 to 10 mTorr. That is, in the high frequency inductive coupled plasma process, electric fields may more concentrate on an edge than a center of the bank hole BH. Therefore, in the high frequency inductive coupled plasma process, the bank hole BH may be formed in order for the edge of the bank hole BH to be deeper recessed than the center of the bank hole BH. That is, the height H1 of the undercut portion UD may be set lower than the height H2 of the floor HFP.

Moreover, the gas supplied through the gas supply unit **1120** for forming the bank hole BH may be a mixed gas of O_2 and CF_4. (S**104** of FIG. **6**)

Fifth, as in FIG. **7**E, an organic light emitting layer **262**, a second electrode **263**, and an encapsulation layer **280** may be sequentially formed on the first electrode **261** and the bank **270**.

In detail, the organic light emitting layer **262** may be a common layer which is formed in the emissive areas EA in common. In this instance, the organic light emitting layer **262** may be a white light emitting layer that emits white light.

In an instance where the organic light emitting layer **262** is a white light emitting layer, the organic light emitting layer **262** may be formed in a tandem structure of two or more stacks. Each of the stacks may include a hole transporting layer, at least one light emitting layer, and an electron transporting layer.

Moreover, a charge generating layer may be formed between adjacent stacks. The charge generating layer may include an n-type charge generating layer, disposed adjacent to a lower stack, and a p-type charge generating layer which is formed on the n-type charge generating layer and is disposed adjacent to an upper stack. The n-type charge generating layer may inject an electron into the lower stack, and the p-type charge generating layer may inject a hole into the upper stack. The n-type charge generating layer may be formed of an organic layer which is doped with alkali metal, such as lithium (Li), sodium (Na), potassium (K), or cesium (Cs), or alkali earth metal such as magnesium (Mg), strontium (Sr), barium (Ba), or radium (Ra). The p-type charge generating layer may be an organic layer which is formed by doping a dopant on an organic host material having an ability to transport holes.

The organic light emitting layer **262** may be formed in a deposition process or a solution process, and if the organic light emitting layer **262** is formed in the deposition process, the organic light emitting layer **262** may be formed in an evaporation process. A layer formed in the evaporation process is not good in step coverage characteristic. If the inclined angle "θ_2" of the sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**.

That is, in an embodiment of the present disclosure, since the bank hole BH corresponding to a recessed portion is formed on the bank **270**, a length of a current leakage path which passes through the organic light emitting display layer **262** between adjacent emissive areas EA may be set longer than an instance where the bank hole **270** is not provided. Also, in an embodiment of the present disclosure, since the inclined angle "θ_2" of the sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**. Accordingly, in an embodiment of the present disclosure, the resistance of the organic light emitting layer **262** may increase, and thus, an adverse influence of a leakage current leaked through the organic light emitting layer **262** is minimized on an adjacent pixel.

Subsequently, a second electrode **263** may be formed on the organic light emitting layer **262**. The second electrode **263** may be a common layer which is formed in the emissive areas EA in common. The second electrode **263** may be formed of a transparent conductive material (or TCO), such as indium tin oxide (ITO) or indium zinc oxide (IZO) capable of transmitting light, or a semi-transmissive conductive material such as Mg, Ag, or an alloy of Mg and Ag. A capping layer may be formed on the second electrode **263**.

The second electrode **263** may be formed in a physical vapor deposition (PVD) process such as a sputtering process. A layer formed in the PVD process such as the sputtering process is good in step coverage characteristic. Accordingly, despite the bank hole BH, the second electrode **263** may be deposited to have a uniform thickness in comparison with the organic light emitting layer **262**.

A black bank **271**, as in FIG. **5**, may be formed on THE second electrode **263**. The black bank **271** may be formed to fill a bank hole BH. If the black bank **271** is formed on the second electrode **263**, the black matrix **320** may be omitted. The black bank **271** may be formed of an organic layer including a black pigment.

In an embodiment of the present disclosure, the black bank **271** blocks light traveling from one emissive area EA to an adjacent emissive area EA, thereby preventing occurrence of color mixture.

Subsequently, an encapsulation layer **280** may be formed on the second electrode **263**. Since the bank hole BH is not filled with the organic light emitting layer **262** and the second electrode **263**, the encapsulation layer **280** may be formed to fill the bank hole BH.

The encapsulation layer **280** prevents oxygen or water from penetrating into the organic light emitting layer **262** and the second electrode **263**. To this end, the encapsulation layer **280** may include at least one inorganic layer and at least one organic layer.

For example, the encapsulation layer **280** may include a first inorganic layer **281**, an organic layer **282**, and a second inorganic layer **283**. In this instance, the first inorganic layer **281** may be formed to cover the second electrode **263**. The organic layer **282** may be formed to cover the first inorganic layer **281**. The organic layer **282** may be formed to have a sufficient thickness for preventing particles from penetrating into the organic light emitting layer **262** and the second electrode **263** via the first inorganic layer **281**. The second inorganic layer **283** may be formed to cover the organic layer **282**.

The first and second inorganic layers **281** and **283** may each be formed of silicon nitride, aluminum nitride, zirconium nitride, titanium nitride, hafnium nitride, tantalum nitride, silicon oxide, aluminum oxide, titanium oxide, and/or the like. The organic layer **282** may be formed of acryl resin, epoxy resin, phenolic resin, polyamide resin, polyimide resin, and/or the like. (S**105** of FIG. **6**)

Sixth, as in FIG. **7**F, the encapsulation layer **280** of the first substrate **111** may be adhered to the color filters **311** and **312** of the second substrate **112** by using an adhesive layer **290**. Therefore, the first substrate **111** may be bonded to the second substrate **112**. The adhesive layer **290** may be a transparent adhesive resin. (S**106** of FIG. **6**)

As described above, in an embodiment of the present disclosure, since the bank hole BH corresponding to a recessed portion is formed on the bank **270**, a length of a current leakage path which passes through the organic light emitting display layer **262** between adjacent emissive areas EA may be set longer than an instance where the bank hole **270** is not provided. Also, in an embodiment of the present disclosure, since the inclined angle "θ_2" of the sidewall HIP of the bank hole BH is set greater than the inclined angle "θ_1" of the side BIP of the bank **270**, a thickness of the organic light emitting layer **262** on the sidewall HIP of the bank hole BH may be set thinner than that of the organic light emitting layer **262** on the side BIP of the bank **270**. Accordingly, in an embodiment of the present disclosure, the resistance of the organic light emitting layer **262** may increase, and thus, an adverse influence of a leakage current leaked through the organic light emitting layer **262** is minimized on an adjacent pixel.

Moreover, in the embodiments of the present disclosure, since the bank hole corresponding to a recessed portion is formed on the bank, a length of a current leakage path which passes through the organic light emitting display layer between adjacent emissive areas may be set longer than an instance where the bank hole is not provided. Also, in the embodiments of the present disclosure, since the inclined angle of the sidewall of the bank hole is set greater than the inclined angle of the side of the bank, a thickness of the organic light emitting layer on the sidewall of the bank hole may be set thinner than that of the organic light emitting layer on the side of the bank. Accordingly, in the embodiments of the present disclosure, the resistance of the organic light emitting layer may increase, and thus, an adverse influence of a leakage current leaked through the organic light emitting layer is minimized on an adjacent pixel.

Moreover, in the embodiments of the present disclosure, the black bank may be formed on the second electrode to fill the bank hole. As a result, in the embodiments of the present disclosure, light emitted from one emissive area cannot travel to an adjacent emissive area, thereby preventing occurrence of color mixture.

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

What is claimed is:

1. An organic light emitting display device comprising:
- a first electrode on a substrate;
- a bank covering a portion of the first electrode;
- a bank hole provided in the bank;
- an organic light emitting layer on the first electrode and the bank; and
- a second electrode on the organic light emitting layer,
- wherein the bank hole includes a sidewall, a floor, and an undercut portion between the sidewall and the floor.

2. The organic light emitting display device of claim **1**, wherein a thickness of the organic light emitting layer on a side of the bank is thicker than a thickness of the organic light emitting layer on the sidewall of the bank hole.

3. The organic light emitting display device of claim **1**, wherein an inclined angle of a side of the bank is less than an inclined angle of the sidewall of the bank hole.

4. The organic light emitting display device of claim **1**, wherein a height of the undercut portion of the bank hole is lower than a height of the floor of the bank hole.

5. The organic light emitting display device of claim **1**, wherein the organic light emitting layer and the second electrode are provided in the bank hole.

6. The organic light emitting display device of claim **1**, further comprising:
- an encapsulation layer on the second electrode, the encapsulation layer being filled into the bank hole.

7. The organic light emitting display device of claim **1**, further comprising:
- a black bank on the second electrode, the black bank being filled into the bank hole.

8. The organic light emitting display device of claim **1**, wherein
- an area where the first electrode, the organic light emitting layer, and the second electrode are sequentially stacked is defined as an emissive area, and
- the bank hole is disposed between adjacent emissive areas.

9. The organic light emitting display device of claim **8**, wherein the bank divides the emissive area.

10. An organic light emitting display device comprising:
- a first substrate;
- a plurality of pixels on the first substrate, each pixel containing an emissive area;
- a plurality of banks respectively surrounding the emissive areas of the plurality of pixels;
- a bank hole provided in the plurality of banks, and disposed between adjacent emissive areas; and
- an organic light emitting layer on each bank,
- wherein the bank hole includes a sidewall, a floor, and an undercut portion between the sidewall and the floor.

11. The organic light emitting display device of claim **10**, further comprising:
- a second substrate facing the first substrate; and
- a plurality of color filters and a black matrix on the second substrate,
- wherein the bank hole is aligned with the black matrix.

12. The organic light emitting display device of claim **10**, wherein a thickness of the organic light emitting layer on a side of each bank is thicker than a thickness of the organic light emitting layer on the sidewall of the bank hole.

13. The organic light emitting display device of claim **10**, wherein an inclined angle of a side of each bank is less than an inclined angle of the sidewall of the bank hole.

14. The organic light emitting display device of claim **10**, wherein a height of the undercut portion of the bank hole is lower than a height of the floor of the bank hole.

15. The organic light emitting display device of claim **10**, wherein the organic light emitting layer is provided in the bank hole.

16. The organic light emitting display device of claim **10**, further comprising:
- at least one of encapsulation layer and a black bank filling the bank hole.

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专利名称(译)	具有带孔的堤的有机发光显示装置		
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摘要(译)

公开了一种有机发光显示装置及其制造方法，其中在白色有机发光装置中，在相邻像素上最小化泄漏通过有机发光层的漏电流的不利影响。有机发光显示装置包括在基板上的第一电极，覆盖第一电极的一部分的堤，设置在堤中的堤孔，在第一电极和堤上的有机发光层，以及在第二电极上的第二电极。有机发光层。