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Jeon et al.

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(54) **ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME**

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H01L 51/00	(2006.01)

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(58) **Field of Classification Search**
CPC H01L 27/3246; H01L 27/3283; H01L 27/3241–3279
See application file for complete search history.

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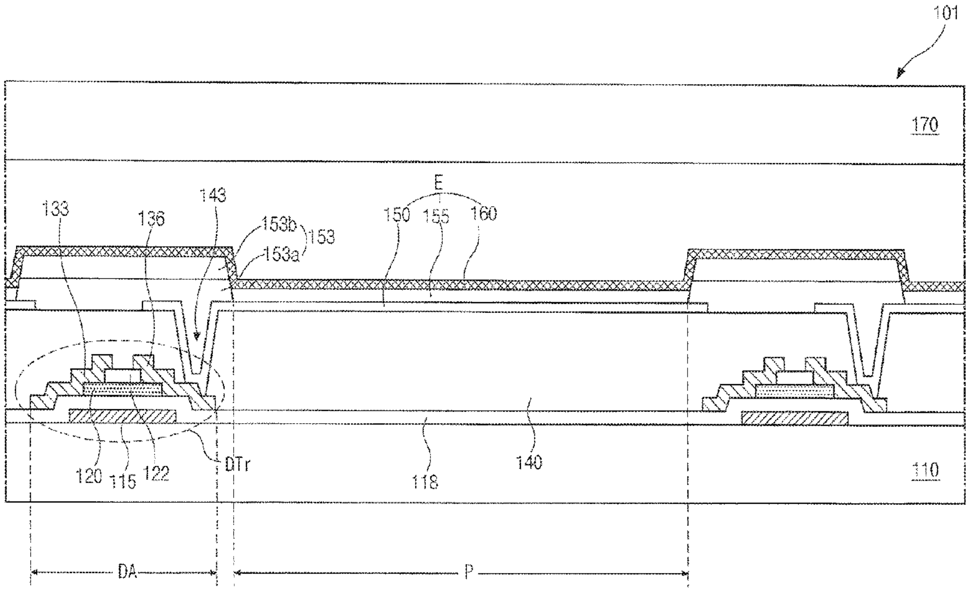
(57) **ABSTRACT**

An organic light emitting diode display device includes a first substrate including a display region, wherein a plurality of pixel regions are defined in the display region; a first electrode over the substrate and in each of the plurality of pixel regions; a bank on edges of the first electrode and surrounding each of the plurality of pixel regions, the bank including a lower layer having a hydrophilic property and an upper layer having a hydrophobic property; an organic emitting layer on the first electrode and in each of the plurality of pixel regions surrounded by the bank; and a second electrode on the organic emitting layer and covering an entire surface of the display region.

67 Claims, 15 Drawing Sheets



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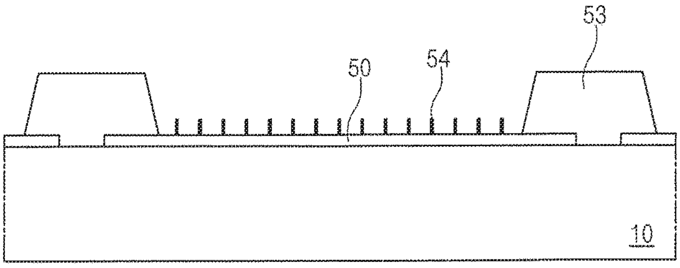

FIG. 1A
Related Art

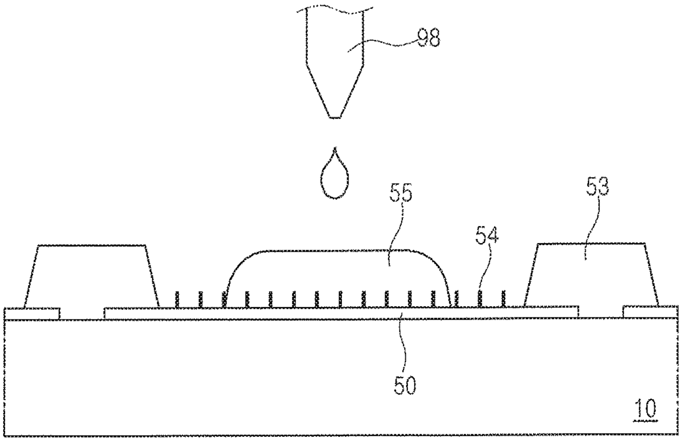

FIG. 1B
Related Art

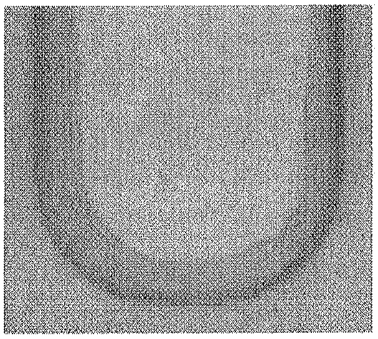

FIG. 2
Related Art

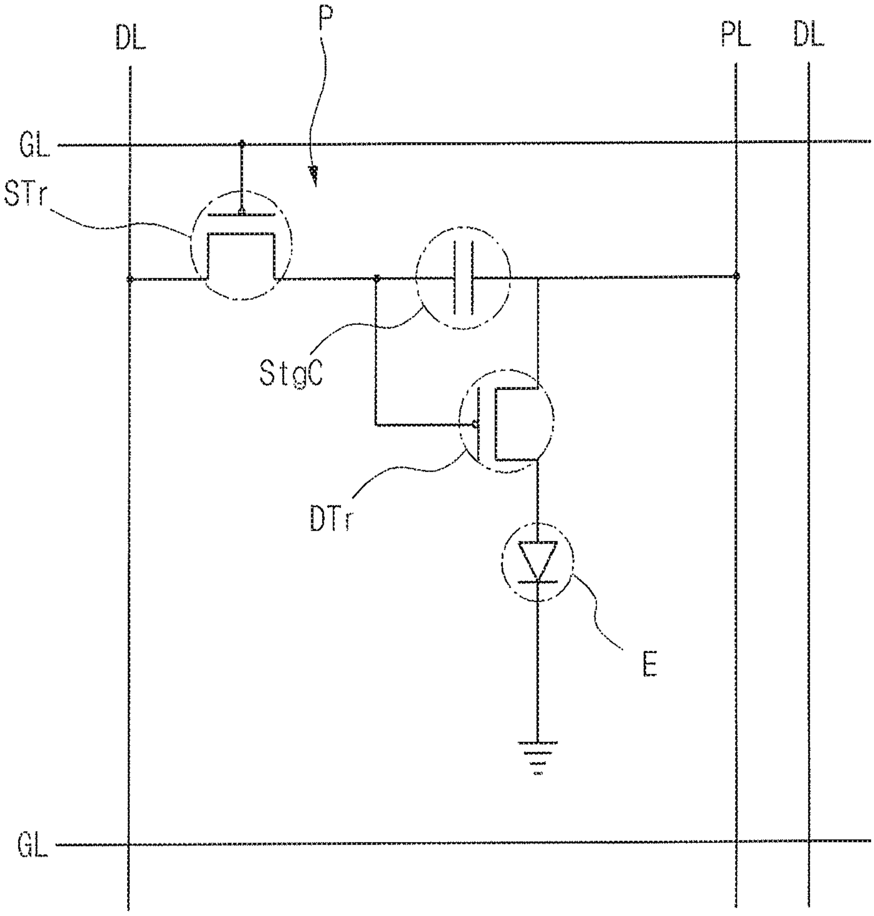

FIG. 3

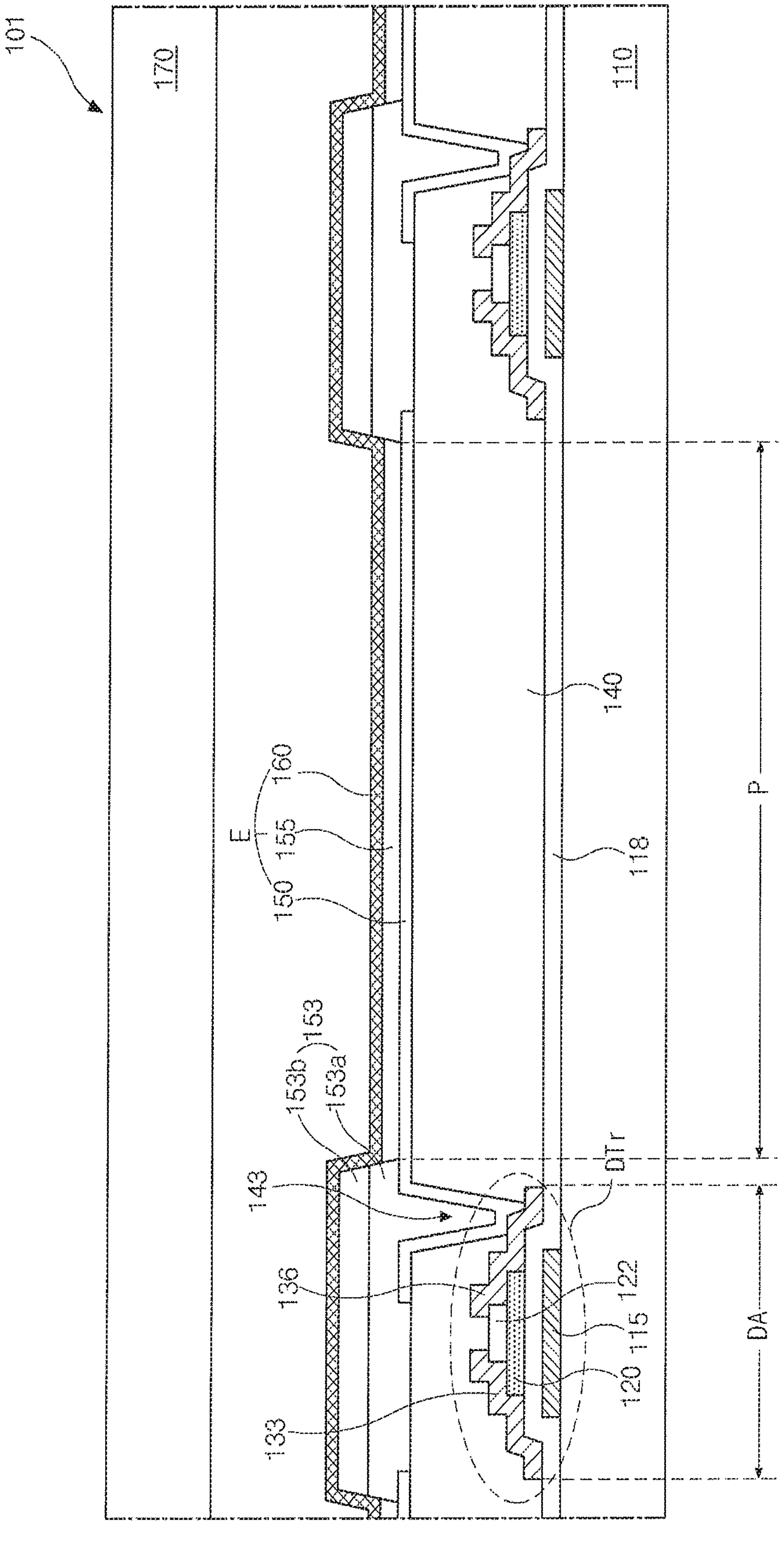
101
170
110
160
E
155
150
140
118
P
153b
153a
153
143
136
133
122
115
120
DTr
DA

FIG. 4

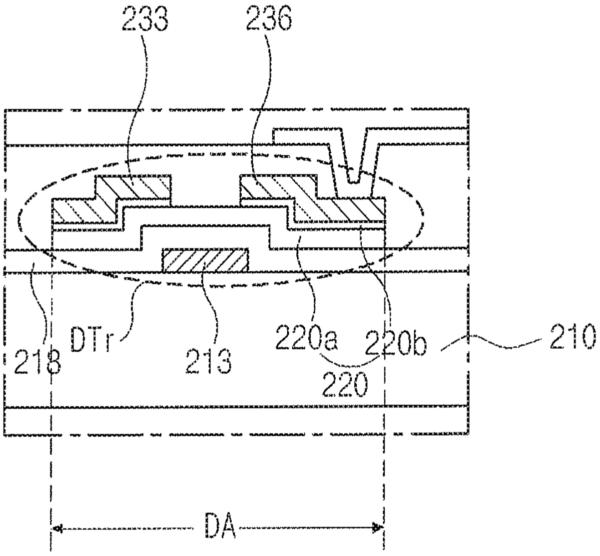
233
236
218
DTr
213
220a
220b
220
210
DA

FIG. 5

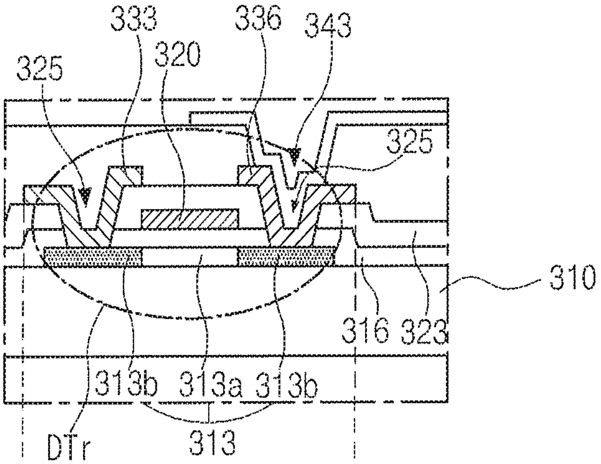
333
336
343
320
325
325
310
316
323
313b
313a
313b
313
DTr
DA

FIG. 6

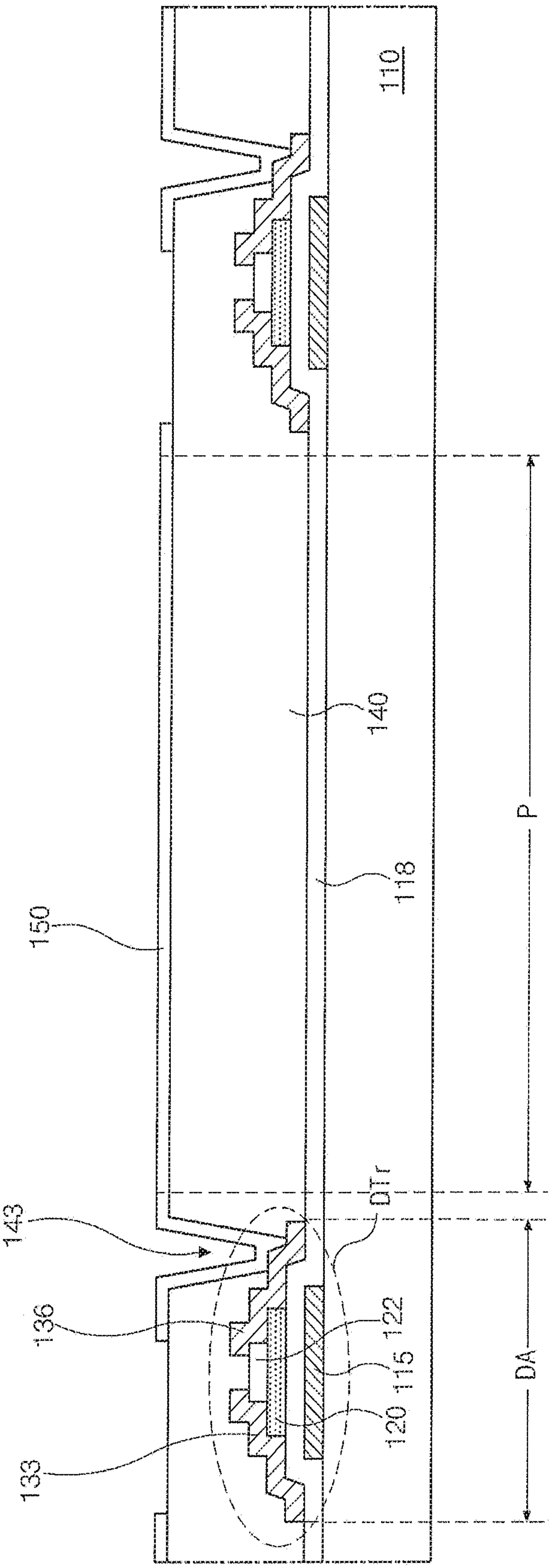

FIG. 7A

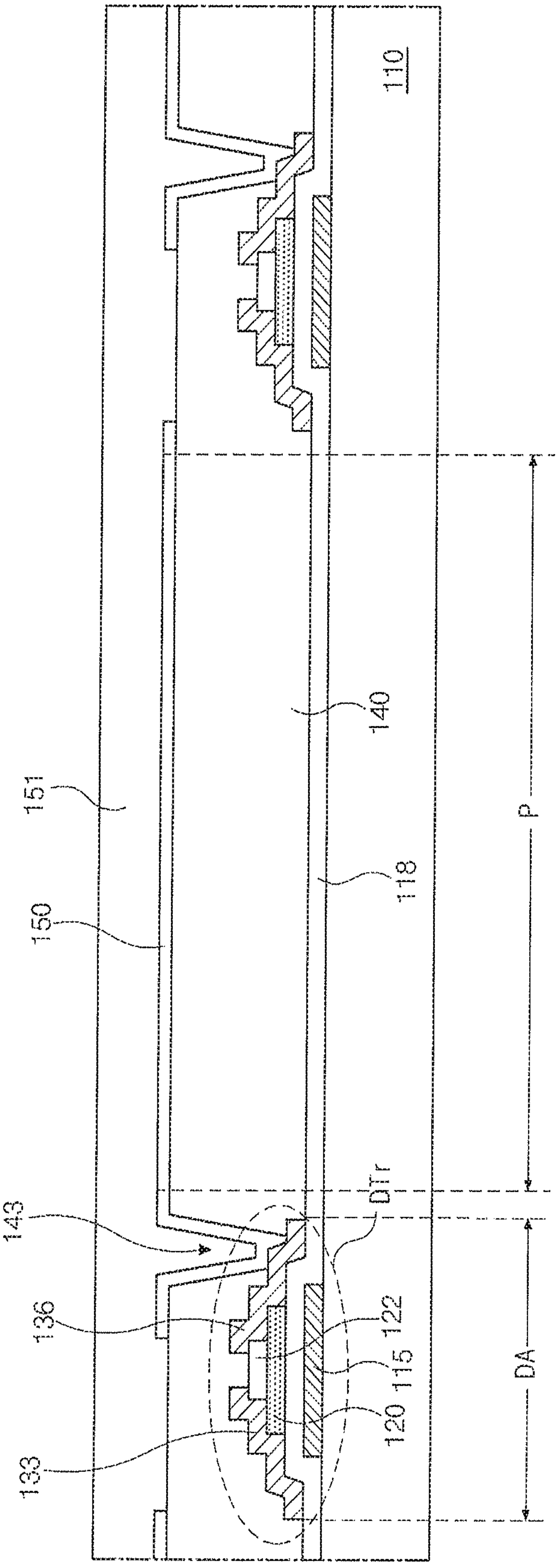

FIG. 7B

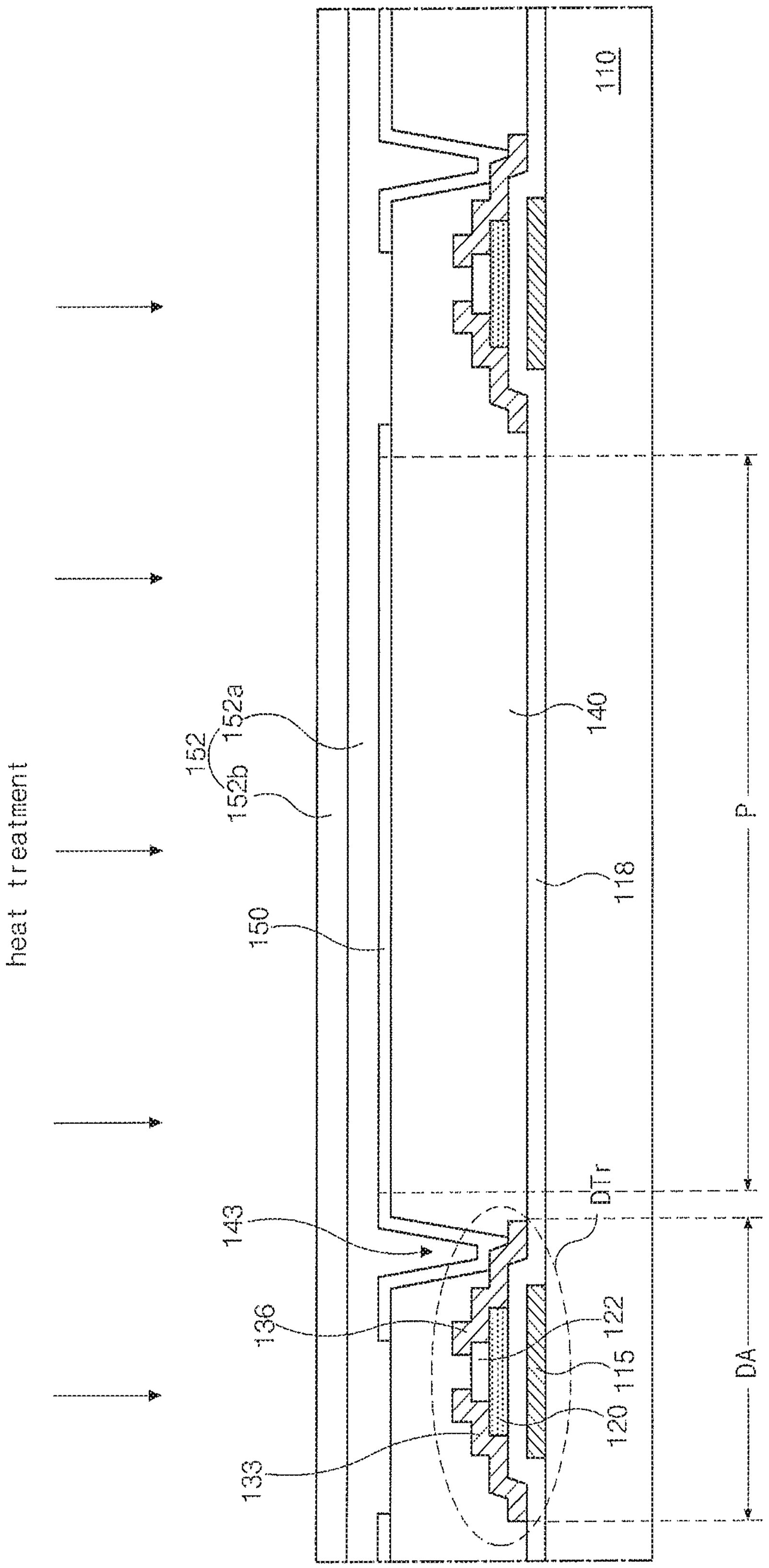
heat treatment
152a
152
152b
150
140
118
P
143
DTr
136
122
115
120
133
DA
110

FIG. 7C

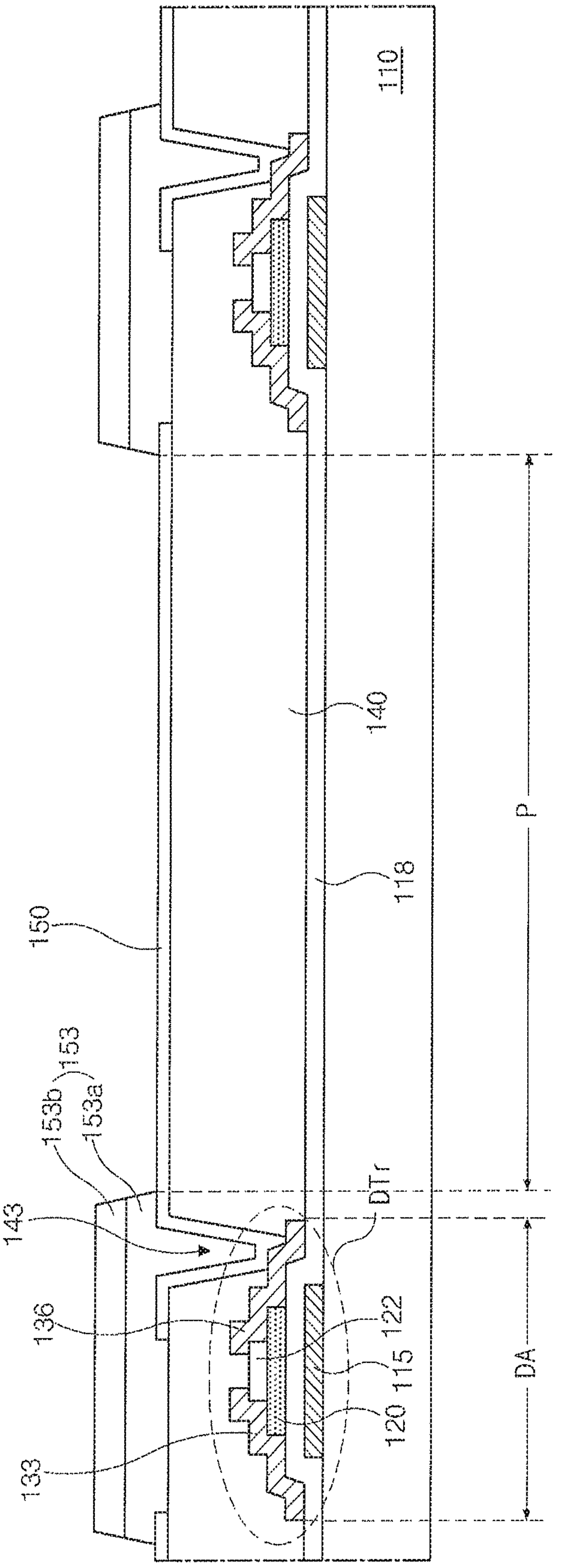

FIG. 7D

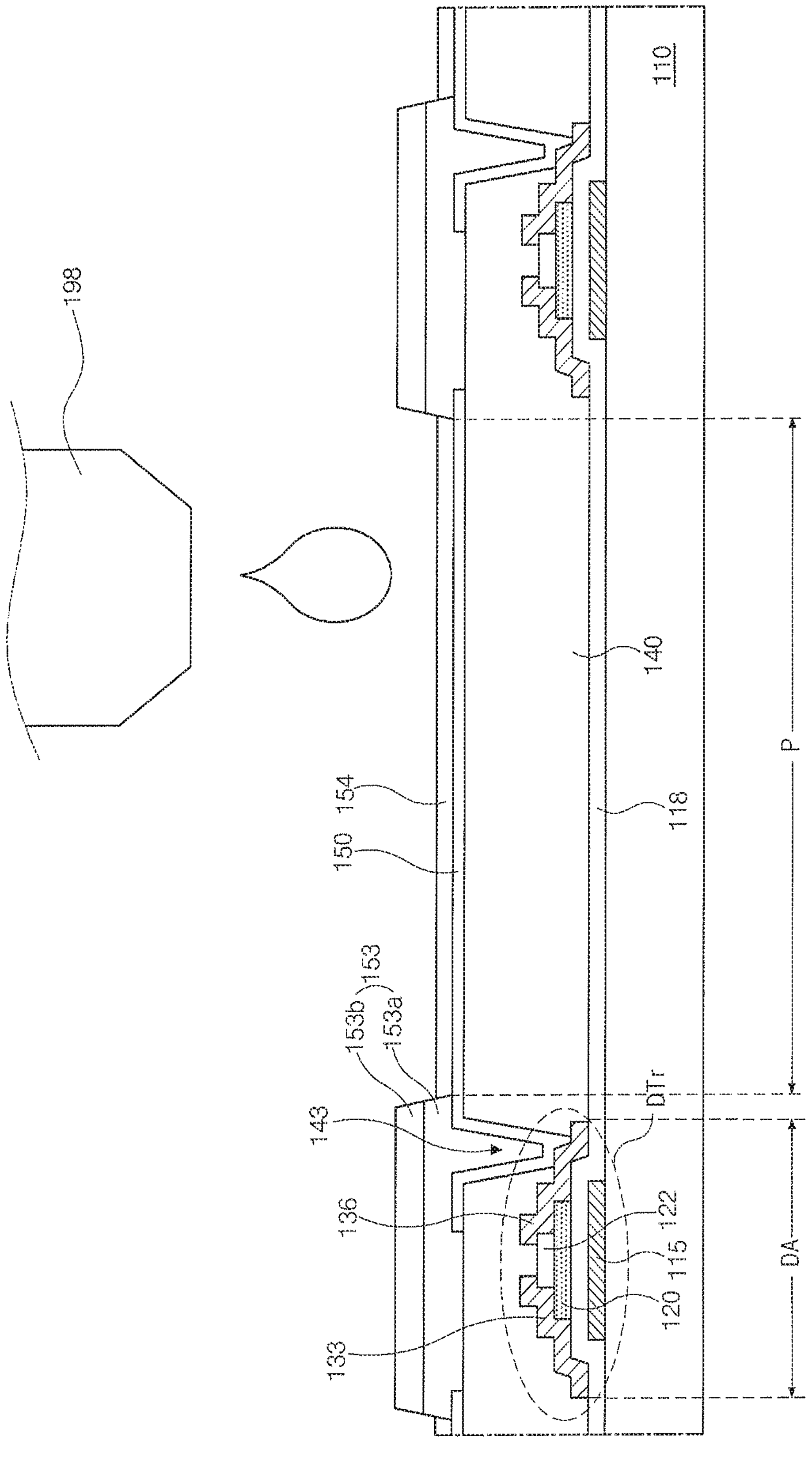
198
110
140
118
P
154
150
153b
153a
153
143
136
133
DTr
122
115
120
DA

FIG. 7E

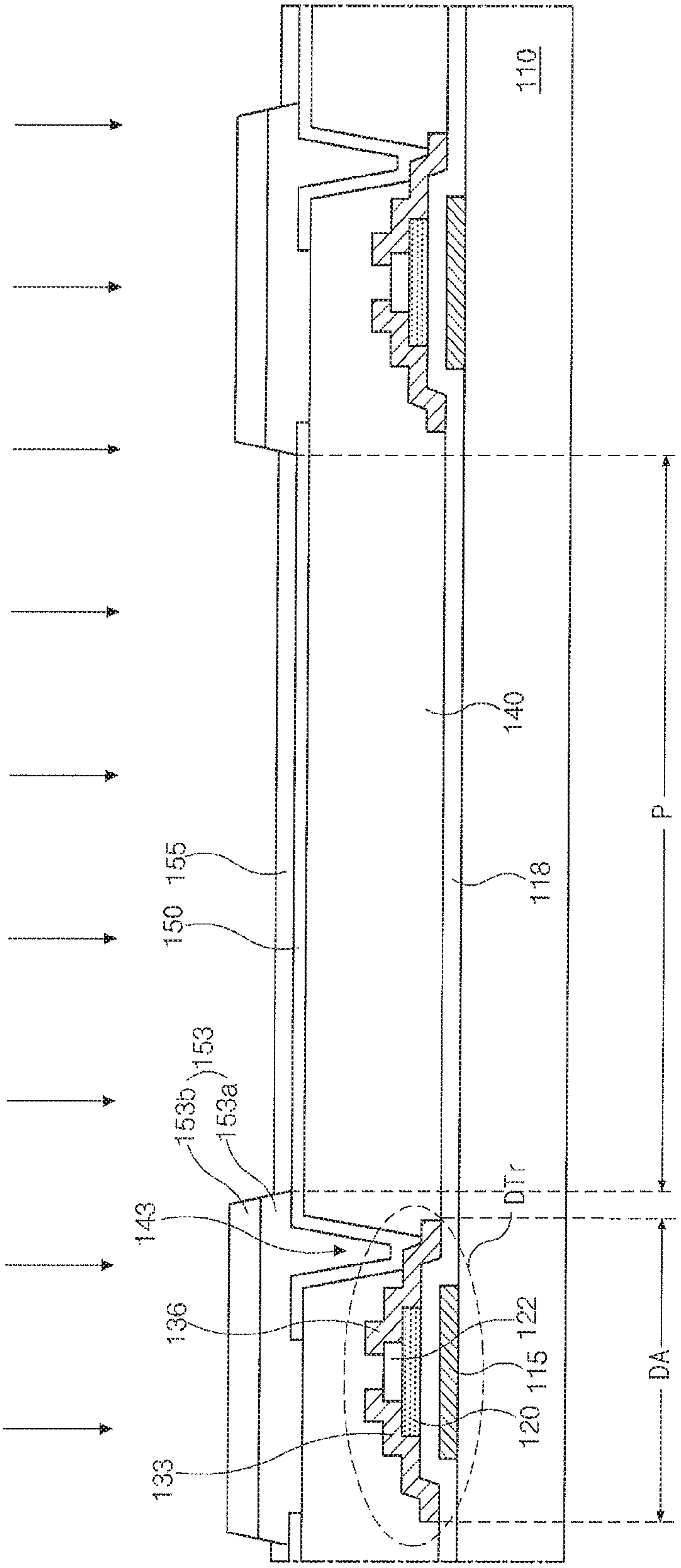
heat treatment
110
140
118
P
DA
DTr
155
150
153b
153a
153
143
136
133
122
115
120

FIG. 7F

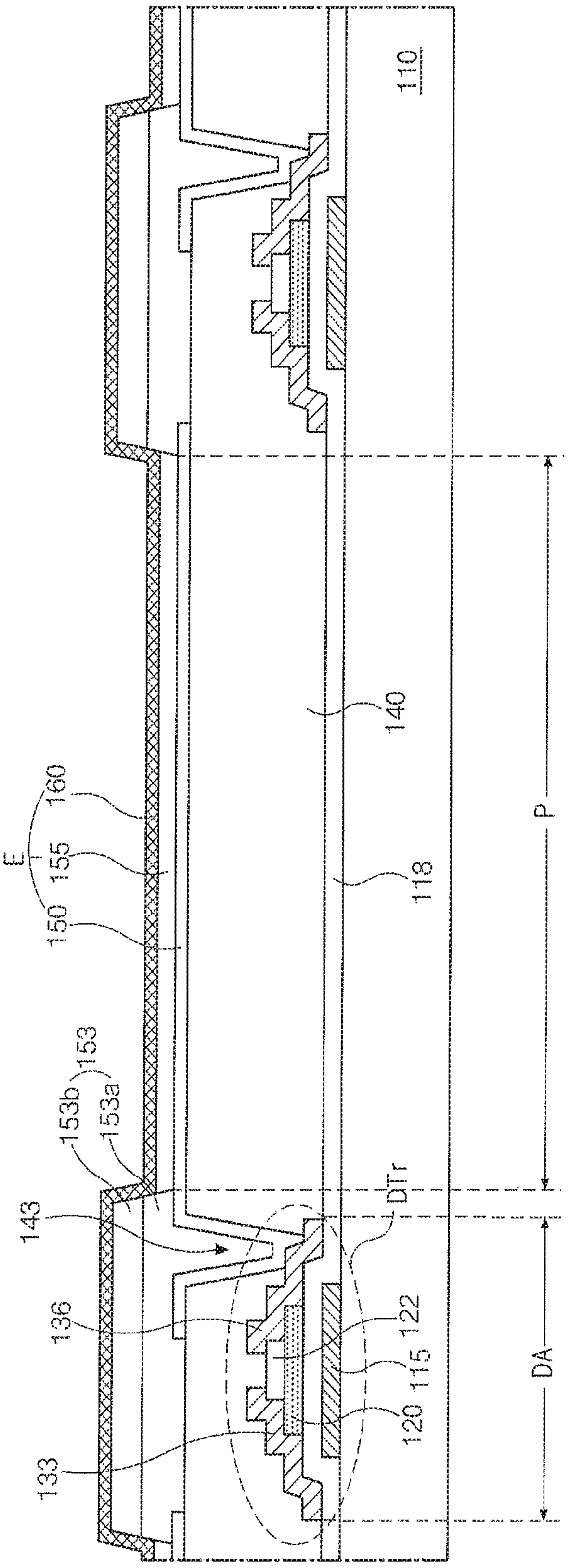
110
140
118
P
E
160
155
150
153
153b
153a
143
136
133
122
115
120
DTr
DA

FIG. 7G

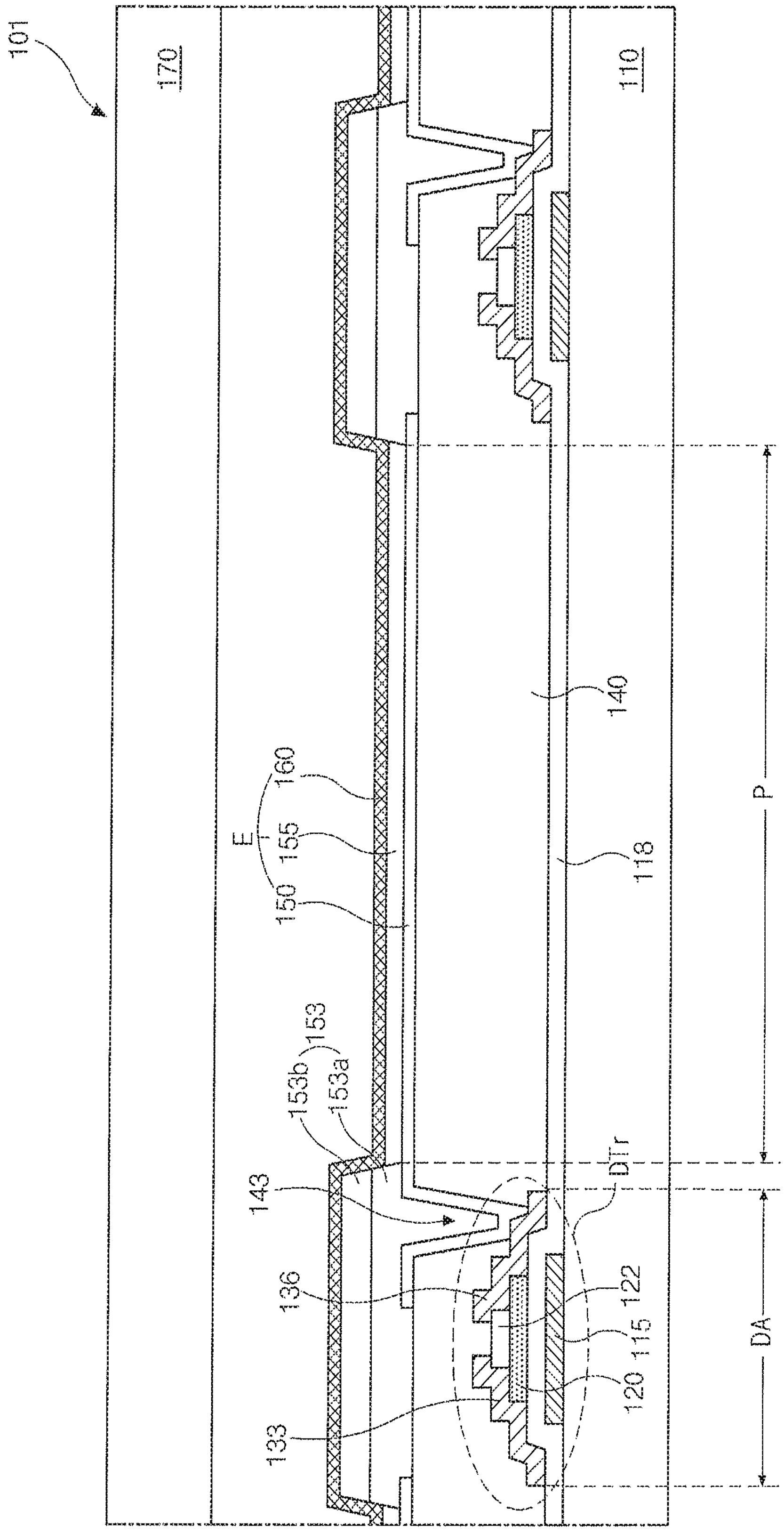
101
170
110
140
160
E
155
150
118
P
153b
153
153a
143
DTr
136
122
115
120
133
DA

FIG. 7H

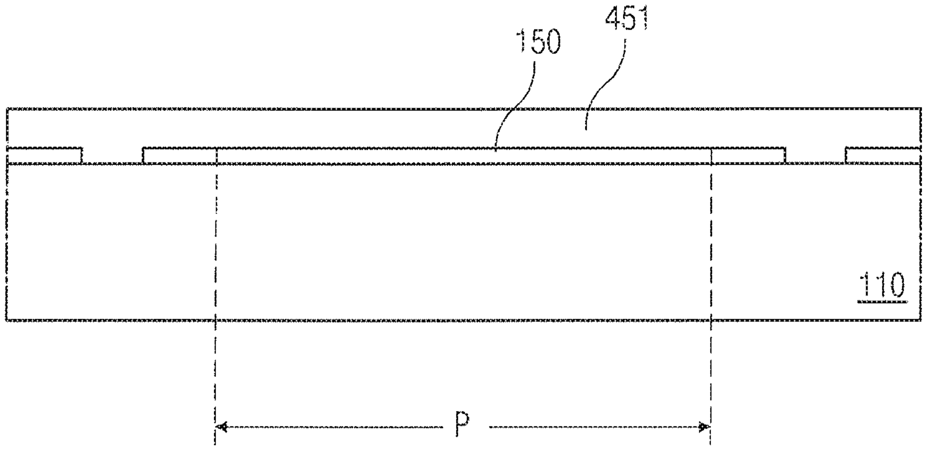

FIG. 8A

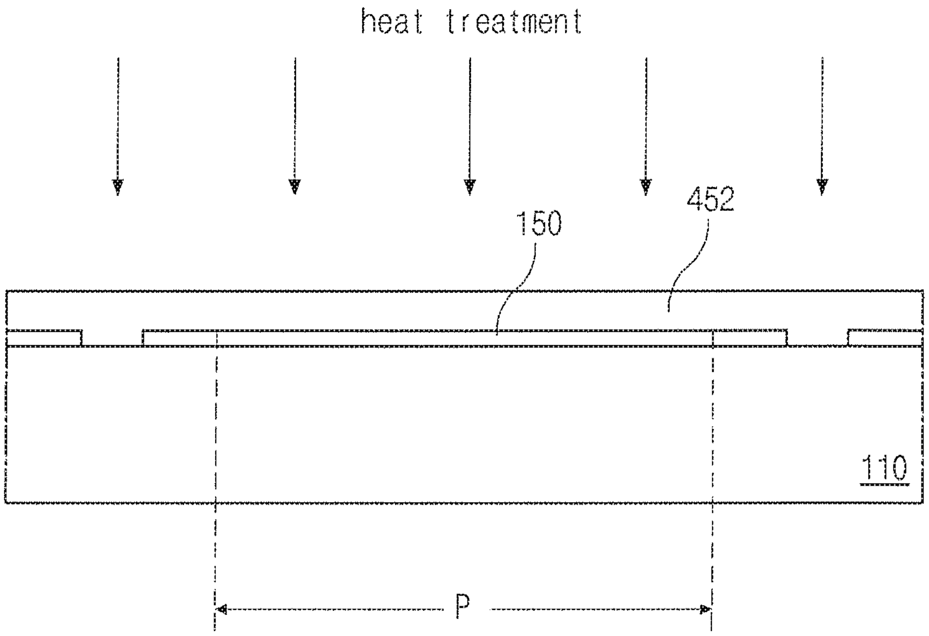

FIG. 8B

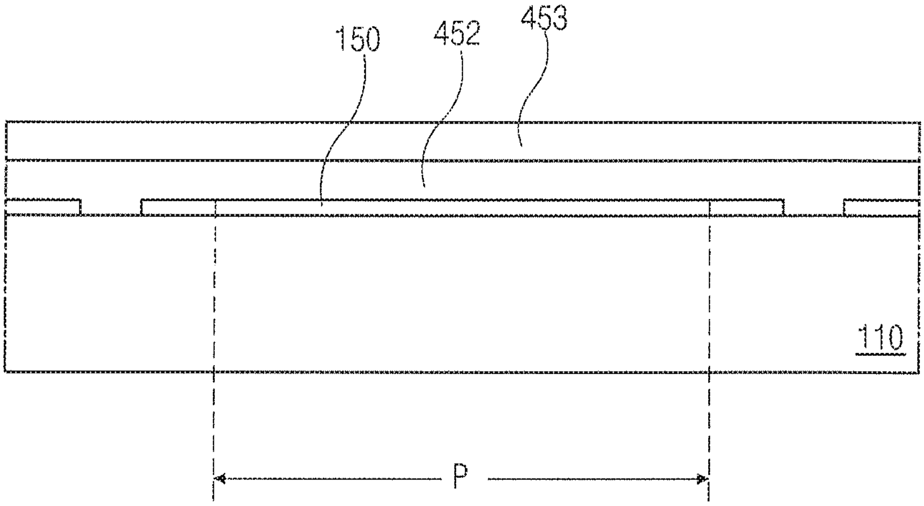

FIG. 8C

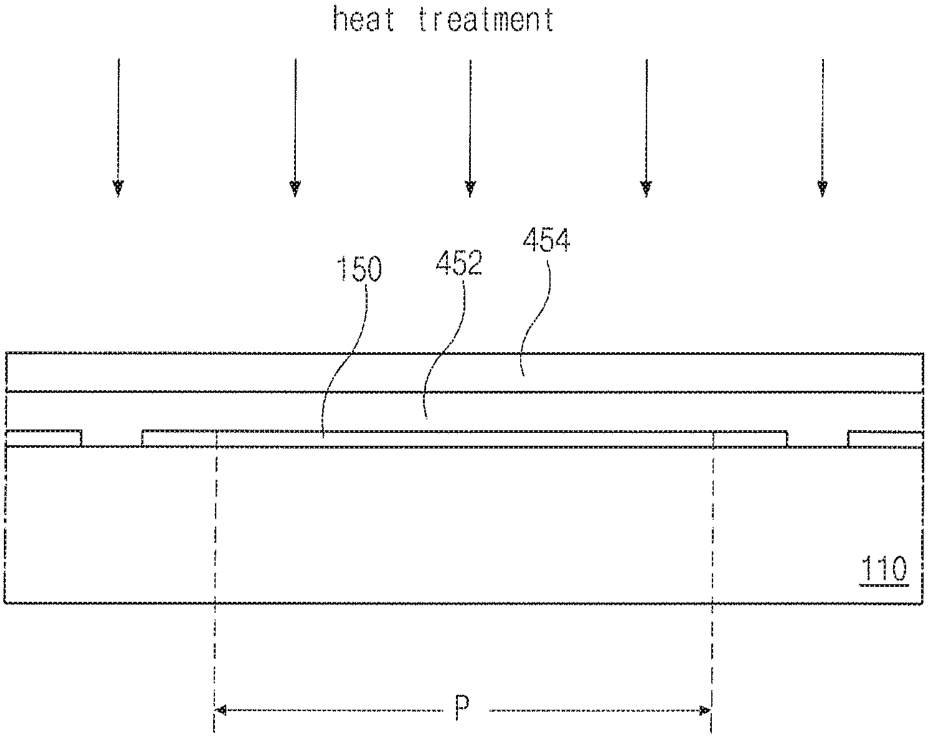

FIG. 8D

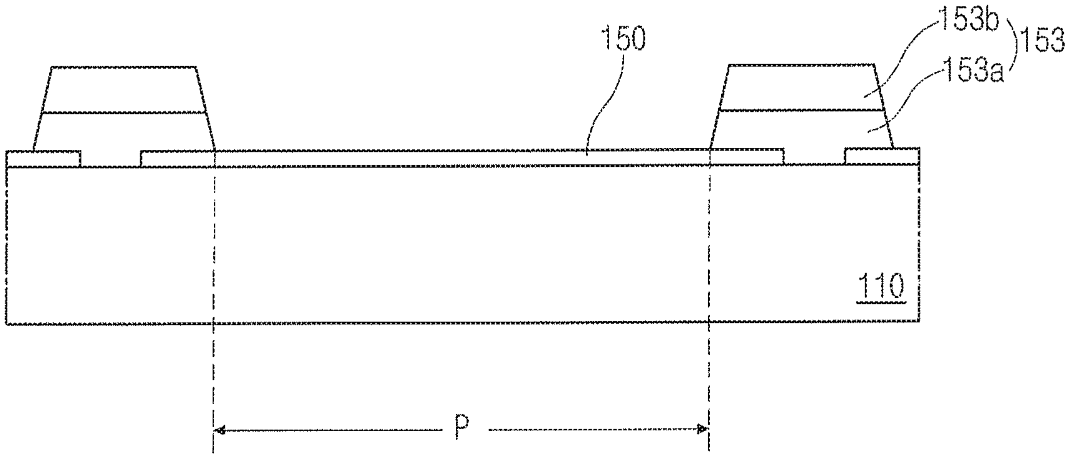

FIG. 8E

ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

The present application claims the benefit of Korean Patent Application No. 10-2012-0131546 filed in Korea on Nov. 20, 2012, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field of the Disclosure

The disclosure relates to an organic light emitting diode (OLED) display device, which may be referred to as an organic electroluminescent display device, and more particularly, to an OLED display device having a bank of a double-layered structure and a method of fabricating the same.

Discussion of the Related Art

An OLED display device of new flat panel display devices has high brightness and low driving voltage. The OLED display device is a self-emitting type and has excellent view angle characteristics, contrast ratio, a response time, etc.

Accordingly, the OLED display device is widely used for a television, a monitor, a mobile phone, etc.

The OLED display device includes an array element and an organic light emitting diode. The array element includes a switching thin film transistor (TFT), which is connected to a gate line and a data line, a driving TFT, which is connected to the switching TFT, and a power line, which is connected to the driving TFT. The organic light emitting diode includes a first electrode, which is connected to the driving TFT, and further includes an organic emitting layer and a second electrode.

In the OLED display device, light from the organic emitting layer passes through the first electrode or the second electrode to display an image. A top emission type OLED display device, where the light passes through the second electrode, has an advantage in an aperture ratio.

Generally, the organic emitting layer is formed by a thermal deposition method using a shadow mask. However, the shadow mask sags because the shadow mask becomes larger with an increase in sizes of display devices. As a result, there is a problem in deposition uniformity in the larger display device. In addition, since a shadow effect is generated in the thermal deposition method using the shadow mask, it is very difficult to fabricate a high resolution OLED display device, e.g., above 250 PPI (pixels per inch).

Accordingly, a new method instead of the thermal deposition method using the shadow mask has been introduced.

In the new method, a liquid phase organic emitting material is sprayed or dropped in a region surrounded by a wall using an ink jet apparatus or a nozzle-coating apparatus and cured to form the organic emitting layer.

FIGS. **1**A and **1**B are schematic cross-sectional views showing an OLED display device in steps of forming an organic emitting layer by spraying or dropping a liquid phase organic emitting material.

To spray or drop the liquid phase organic emitting material by the ink jet apparatus or the nozzle-coating apparatus, a bank **53**, which is formed on the first electrode **50** and surrounds a pixel region P, is required to prevent the liquid phase organic emitting material from flooding into a next pixel region P. Accordingly, as shown in FIG. **1**A, the bank **53** is formed on edges of the first electrode **50** before forming the organic emitting layer **55**.

The bank **53** is formed of an organic material including fluorine (F) such that the bank **53** has a hydrophobic property. The hydrophobic bank **53** prevents the organic emitting material, which has a hydrophilic property, from being formed on the bank **53** and flooding into the next pixel region P due to a mis-alignment of the ink jet apparatus or the nozzle-coating apparatus or an excessive amount of the organic emitting material.

The bank **53** may be formed by a mask process, which includes light-exposing and developing steps after the organic insulating material including fluorine is applied to an entire surface of the substrate **10**.

Next, as shown in FIG. **1**B, by spraying or dropping the liquid phase organic emitting material from a head of the ink-jet apparatus or a nozzle of the nozzle-coating apparatus into the pixel region P, which is surrounded by the bank **53**, the pixel region P is filled with the organic emitting material. The organic emitting material is dried and cured by heat to form the organic emitting layer **55**.

However, fluorine residues **54** may remain in the pixel region P when the bank **53** is formed, and the fluorine residues **54** may hinder the liquid phase organic emitting material from being spread in the pixel region P when the liquid phase organic emitting material is sprayed or dropped. Accordingly, as shown in FIG. **2**, which is a picture showing a part of one pixel region in the related art OLED display device, the organic emitting layer is not formed around the hydrophobic bank, or a portion of the organic emitting layer around the hydrophobic bank has a thinner thickness than portions in other regions. Thus, dark images are displayed in edges of the pixel region. In addition, the OLED display device is degraded fast due to the difference in thicknesses, and the lifetime of the OLED display device is shortened.

SUMMARY

An organic light emitting diode display device includes a first substrate including a display region, wherein a plurality of pixel regions are defined in the display region; a first electrode over the substrate and in each of the plurality of pixel regions; a bank on edges of the first electrode and surrounding each of the plurality of pixel regions, the bank including a lower layer having a hydrophilic property and an upper layer having a hydrophobic property; an organic emitting layer on the first electrode and in each of the plurality of pixel regions surrounded by the bank; and a second electrode on the organic emitting layer and covering an entire surface of the display region.

In another aspect, a method of fabricating an organic light emitting diode display device includes forming a first electrode over a first substrate including a display region, which includes a plurality of pixel regions, the first electrode formed in each of the plurality of pixel regions; forming a bank on edges of the first electrode and surrounding each of the plurality of pixel regions, the bank including a lower layer having a hydrophilic property and an upper layer having a hydrophobic property; forming an organic emitting layer on the first electrode and in each of the plurality of pixel regions surrounded by the bank; and forming a second electrode on the organic emitting layer, the second electrode covering an entire surface of the display region.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIGS. **1**A and **1**B are schematic cross-sectional views showing an OLED display device in steps of forming an organic emitting layer by spraying or dropping a liquid phase organic emitting material.

FIG. **2** is a picture showing a part of one pixel region in the related art OLED display device.

FIG. **3** is a circuit diagram of one pixel region of an OLED device.

FIG. **4** is a schematic cross-sectional view of an OLED display device according to an embodiment of the present invention.

FIG. **5** is a schematic cross-sectional view of an OLED display device according to one modified embodiment of the present invention.

FIG. **6** is a schematic cross-sectional view of an OLED display device according to another modified embodiment of the present invention.

FIGS. **7**A to **7**H are cross-sectional views showing a fabricating process of an OLED display device according to an embodiment of the present invention.

FIGS. **8**A to **8**E are cross-sectional views showing a fabricating process of on OLED display device according to another example of the embodiment of the present invention.

DETAILED DESCRIPTION

Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings.

FIG. **3** is a circuit diagram of one pixel region of an OLED device.

As shown in FIG. **3**, an OLED display device includes a switching thin film transistor (TFT) STr, a driving TFT DTr, a storage capacitor StgC and an emitting diode E in each pixel region P.

On a substrate (not shown), a gate line GL along a first direction and a data line DL along a second direction are formed. The gate line GL and the data line DL cross each other to define the pixel region P. A power line PL for providing a source voltage to the emitting diode E is formed to be parallel to and spaced apart from the data line DL.

The switching TFT STr is connected to the gate and data lines GL and DL, and the driving TFT DTr and the storage capacitor StgC are connected to the switching TFT STr and the power line PL. The emitting diode E is connected to the driving TFT DTr.

A first electrode of the emitting diode E is connected to a drain electrode of the driving TFT DTr, and a second electrode of the emitting diode E is grounded.

When the switching TFT STr is turned on by a gate signal applied through the gate line GL, a data signal from the data line DL is applied to the gate electrode of the driving TFT DTr and an electrode of the storage capacitor StgC. When the driving TFT DTr is turned on by the data signal, an electric current is supplied to the emitting diode E from the power line PL. As a result, the emitting diode E emits light.

In this case, when the driving TFT DTr is turned on, a level of an electric current applied from the power line PL to the emitting diode E is determined such that the emitting diode E can produce a gray scale. The storage capacitor StgC serves to maintain the voltage of the gate electrode of the driving TFT DTr when the switching TFT STr is turned off. Accordingly, even if the switching TFT STr is turned off, a level of an electric current applied from the power line PL to the emitting diode E is maintained to a next frame.

FIG. **4** is a schematic cross-sectional view of an OLED display device according to an embodiment of the present invention. For convenience of explanation, a driving area (DA) wherein a driving TFT DTr is formed, a pixel region P where an emitting diode E is formed, and a switching area (not shown) where a switching TFT (not shown) are defined.

As shown in FIG. **4**, an OLED display device **101** of the present invention includes a first substrate **110**, where the driving TFT DTr, the switching TFT (not shown) and the emitting diode E are formed, and a second substrate **170** for encapsulation. The second substrate **170** may be an inorganic insulating film or an organic insulating film.

A gate line (not shown) and a data line (not shown) are formed on the first substrate **110**. The gate line and the data line cross each other to define the pixel region P. A power line (not shown) for providing a voltage to the emitting diode E is formed to be parallel to and spaced apart from the data line.

In each pixel region P, the switching TFT is connected to the gate line and the data line, and the driving TFT DTr and the storage capacitor StgC are connected to the switching TFT and the power line.

The driving TFT DTr includes a gate electrode **115**, a gate insulating layer **118**, an oxide semiconductor layer **120**, an etch-stopper **122**, a source electrode **133** and a drain electrode **136**. The gate insulating layer **118** covers the gate electrode **115**, and the oxide semiconductor layer **120** is disposed on the gate insulating layer **118**. The oxide semiconductor layer **120** corresponds to the gate electrode **115**. The etch-stopper **122** covers a center of the oxide semiconductor layer **120**. The source electrode **133** and the drain electrode **136** are disposed on the etch-stopper **122** and spaced apart from each other. The source electrode **133** and the drain electrode **136** contact both ends of the oxide semiconductor layer **120**, respectively. Although not shown, the switching TFT has substantially the same structure as the driving TFT DTr.

In FIG. **4**, each of the driving TFT DTr and the switching TFT includes the oxide semiconductor layer **120** of an oxide semiconductor material. Alternatively, as shown in FIG. **5**, each of the driving TFT DTr and the switching TFT may include a gate electrode **213**, a gate insulating layer **218**, a semiconductor layer **220** including an active layer **220***a* of intrinsic amorphous silicon and an ohmic contact layer **220***b* of impurity-doped amorphous silicon, a source electrode **233** and a drain electrode **236**. In FIGS. **4** and **5**, the driving TFT DTr has a bottom gate structure where the gate electrode **115** or **213** is positioned at a lowest layer.

Meanwhile, each of the driving TFT DTr and the switching TFT may have a top gate structure where the semiconductor layer is positioned at a lowest layer. Namely, as shown in FIG. **6**, each of the driving TFT DTr and the switching TFT may include a semiconductor layer **313**, which includes an active region **313***a* of intrinsic polysilicon and impurity-doped regions **313***b* at both sides of the active region **313***a*, on a first substrate **310**, a gate insulating layer **316**, a gate electrode **320** corresponding to the active region **313***a* of the semiconductor layer **313**, an interlayer insulating layer **323** having semiconductor contact holes **325**, which expose the impurity-doped regions **313***b* of the semiconductor layer **313**, and source and drain electrodes **333** and **336** respectively connected to the impurity-doped regions **313***b* through the semiconductor contact holes **325**.

The top gate structure TFT requires the interlayer insulating layer **323** in comparison to the bottom gate structure TFT. In the top gate structure TFT, the gate line (not shown) is formed on the gate insulating layer **316**, and the data line (not shown) is formed on the interlayer insulating layer **323**.

Referring again to FIG. **4**, a passivation layer **140**, which includes a drain contact hole **143** exposing the drain electrode **136** of the driving TFT DTr, is formed over the driving TFT DTr and the switching TFT. For example, the passivation layer **140** may be formed of an organic insulating material, e.g., photo-acryl, to have a flat top surface.

A first electrode **150**, which contacts the drain electrode **136** of the driving TFT DTr through the drain contact hole **143**, is formed on the passivation layer **140** and separately in each pixel region P.

The first electrode **150** is formed of a conductive material having a relatively high work function, e.g., about 4.8 eV to 5.2 eV. For example, the first electrode **150** may be formed of a transparent conductive material such as indium-tin-oxide (ITO) to serve as an anode.

When the first electrode **150** is formed of the transparent conductive material, a reflection layer (not shown) may be formed under the first electrode **150** to increase emission efficiency in a top emission type OLED display device. For example, the reflection layer may be formed of a metallic material, such as aluminum (Al) or Al alloy such as AlNd, having a relatively high reflectivity.

With the reflection layer, the light from an organic emitting layer **155**, which is formed on the first electrode **150**, is reflected by the reflection layer such that the emission efficiency is increased. As a result, the OLED display device has an improved brightness property.

A bank **153** having a double-layered structure, which includes a lower layer **153***a* and an upper layer **153***b*, is formed on the first electrode **150** along boundaries of the pixel region P. The bank **153** overlaps edges of the first electrode **150** such that a center of the first electrode **150** is exposed by the bank **153**.

The lower layer **153***a* of the bank **153** has a hydrophilic property, and the upper layer **153***b* has a hydrophobic property.

The organic emitting layer **155** is formed in each pixel region P surrounded by the bank **153** having the double-layered structure. The organic emitting layer **155** includes red, green and blue emitting materials in respective pixel regions P.

The organic emitting layer **155** is formed by forming an organic emitting material layer and curing the organic emitting material layer. The organic emitting material layer is formed by coating, i.e., spraying or dropping a liquid phase organic emitting material by an ink jet apparatus or a nozzle-coating apparatus.

In the OLED display device **101** including the bank **153** of a double-layered structure, which includes the lower layer **153***a* having the hydrophilic property and the upper layer **153***b* having the hydrophobic property, hydrophobic residues hardly remain on the first electrode **150** after patterning the bank **153**, and the liquid phase organic emitting material can be spread well in the pixel region P surrounded by the bank **153** when the material is sprayed or dropped.

Furthermore, since force drawing the organic emitting material is generated due to the lower layer **153***a* having the hydrophobic property, the organic emitting material is spread better, and the organic emitting layer **155** is formed in edges of the pixel region P adjacent to the bank **153**. Accordingly, the organic emitting layer **155** has a uniform thickness in the pixel region P due to the bank **153** having the double-layered structure.

FIG. **4** shows a single-layered organic emitting layer **155**. Alternatively, to improve emission efficiency, the organic emitting layer **155** may have a multi-layered structure. For example, the organic emitting layer **155** may include a hole injecting layer, a hole transporting layer, an emitting material layer, an electron transporting layer and an electron injecting layer stacked on the first electrode **150** as an anode. The organic emitting layer **155** may be a quadruple-layered structure of a hole transporting layer, an emitting material layer, an electron transporting layer and an electron injecting layer or a triple-layered structure of a hole transporting layer, an emitting material layer and an electron transporting layer.

A second electrode **160** is formed on the organic emitting layer **155** and covers an entire surface of a display region of the first substrate **110**. The second electrode **160** is formed of a metallic material having a relatively low work function, e.g., Al, Al alloy such as AlNd, silver (Ag), magnesium (Mg), gold (Au), or Al—Mg alloy (AlMg). The second electrode **160** serves as a cathode.

The first electrode **150**, the organic emitting layer **155** and the second electrode **160** constitute the emitting diode E.

A seal pattern (not shown) of a sealant or a frit material is formed on edges of the first substrate **110** or the second substrate **170**. The first and second substrates **110** and **170** are attached using the seal pattern. A space between the first and second substrates **110** and **170** has a vacuum condition or an inert gas condition. The second substrate **170** may be a flexible plastic substrate or a glass substrate.

Alternatively, the second substrate **170** may be a film contacting the second electrode **160**. In this instance, the film-type second substrate is attached to the second electrode **160** by an adhesive layer.

In addition, an organic insulating film or an inorganic insulating film may be formed on the second electrode **160** as a capping layer. In this instance, the organic insulating film or the inorganic insulating film serves as the encapsulation film without the second substrate **170**.

Hereinafter, a method of fabricating the OLED display device is explained with reference to drawings.

FIGS. **7**A to **7**H are cross-sectional views showing a fabricating process of an OLED display device according to an embodiment of the present invention. The explanation is focused on a bank having a double-layered structure.

As shown in FIG. **7**A, the gate line (not shown), the data line (not shown) and the power line (not shown) are formed on the first substrate **110**. In addition, the switching TFT (not shown) connected to the gate and data lines and the driving TFT DTr connected to the switching TFT and the power line are formed in the switching area (not shown) and in the driving area DA, respectively.

As explained above, each of the switching TFT and the driving TFT DTr has a bottom gate type TFT including the gate electrode **115** of FIG. **4** or **213** of FIG. **5** as a lowest layer or a top gate type TFT including the semiconductor layer **313** of FIG. **6** as a lowest layer. The bottom gate type TFT includes the oxide semiconductor layer **120** of FIG. **4** or the amorphous silicon semiconductor layer **220** of FIG. **5** including the active layer **220***a* and the ohmic contact layer **220***b*, and the top gate type TFT includes the poly-silicon semiconductor layer **313** of FIG. **6**.

Here, the switching TFT and the driving TFT DTr may be the bottom gate type TFT including an oxide semiconductor layer. Therefore, the gate electrode **115** of the driving TFT DTr is formed on the first substrate **110**, the gate insulating layer **118** is formed on the gate electrode **115**, and the oxide semiconductor layer **120** is formed on the gate insulating layer **118** corresponding to the gate electrode **115**. The etch-stopper **122** is formed on the oxide semiconductor layer **120** and covers the center of the oxide semiconductor layer **120**. The source and drain electrodes **133** and **136** are formed on the etch-stopper **122** and spaced apart from each other.

Next, an organic insulating material, e.g., photo-acryl, is coated over the switching TFT and the driving TFT DTr and is patterned to form the passivation layer **140** having a flat top surface and including the drain contact hole **143**. The drain electrode **136** of the driving TFT DTr is exposed through the drain contact hole **143**.

Next, a transparent conductive material, which has a relatively high work function, is deposited on the passivation layer **140** and patterned to form the first electrode **150**. The first electrode **150** contacts the drain electrode **136** of the driving TFT DTr through the drain contact hole **143** and is separated in each pixel region P. For example, the transparent conductive material may be indium tin oxide (ITO).

Meanwhile, as explained above, the reflection layer (not shown), which includes Al or Al alloy such as AlNd, may be formed under the first electrode **150** and on the passivation layer **140**. The reflection layer may be formed by the same mask process as the first electrode **150**.

Next, as shown in FIG. **7**B, a bank material layer **151** is formed on the first electrode **150** and the passivation layer **140**. For example, the bank material layer **151** may be formed by applying a bank material with a coating apparatus such as a spin-coating apparatus, a bar-coating apparatus, or a slit-coating apparatus. The bank material may be a liquid phase and include a low molecular substance having a hydrophobic property and a high molecular substance having a hydrophilic property mixed at an optimal content ratio. The bank material may also have a photosensitive property and a phase separation property. For example, the low molecular substance may have a molecular weight of several tens to several thousand, more beneficially, more than 10 and under 10,000 and include fluorine (F). The high molecular substance may have a molecular weight of ten thousand to several million, more beneficially, more than 15,000 and less than 1,000,000. The high molecular substance may include a photosensitive polymer, for example, polyimide or acryl.

Next, in FIG. **7**C, a heat-treatment process is performed to the bank material layer **151** of FIG. **7**B. The heat-treatment process may be a soft-baking process. For example, the bank material layer **151** of FIG. **7**B may be heat-treated in an oven or furnace having an inside temperature of 60 degrees of Celsius to 100 degrees of Celsius for several seconds to several hundred seconds or may be heat-treated on a hot plate having a surface temperature of 60 degrees of Celsius to 100 degrees of Celsius for several seconds to several hundred seconds.

The bank material layer **151** of FIG. **7**B is dried and cured by heat through the soft-baking process, and molecules actively move due to the heat. Thus, phase separation occurs. More particularly, relatively heavy molecules having molecular weights of more than 15,000 move to a lower portion of the bank material layer **151** of FIG. **7**B, and relatively light molecules having molecular weights under 10,000 move to an upper portion of the bank material layer **151** of FIG. **7**B.

Meanwhile, solvents and moisture in the bank material layer **151** of FIG. **7**B are removed by the heat during the soft-baking process, and the bank layer **152** having the double-layered structure, which includes a first layer **152***a* of a hydrophilic low molecular substance and a second layer **152***b* of a hydrophobic high molecular substance, is formed.

In FIG. **7**D, an exposing mask (not shown) including a transmitting region and a blocking region is disposed over the bank material layer **152** of FIG. **7**C, and an exposing process to the bank material layer **152** of FIG. **7**C is performed using the exposing mask without an additional photoresist layer.

Here, the bank material layer **152** of FIG. **7**C is shown to have a negative type photosensitive property where an exposed portion of the bank material layer **152** of FIG. **7**C remains after a developing process. Alternatively, the bank material layer **152** of FIG. **7**C may have a positive type photosensitive property, and at this time, a position of the transmitting region and the blocking region is switched.

Next, the bank **153** including the lower layer **153***a* and the upper layer **153***b* is formed by developing the bank layer **152** of FIG. **7**C exposed to light. In this instance, an exposed portion of the bank layer **152** of FIG. **7**C corresponding to the transmitting region of the exposing mask remains, and a non-exposed portion of the bank layer **152** of FIG. **7**C corresponding to the blocking region of the exposing mask is removed by the developing process.

Here, the first layer **152***a* of the bank layer **152** of FIG. **7**C contacting the first electrode **150** does not include fluorine (F), and the second layer **152***b* of the bank layer **152** of FIG. **7**C including fluorine (F) does not contact the first electrode **150**. Accordingly, after the developing process, fluorine residues may be completely removed or the minimum of fluorine residues may remain on the surface of the first electrode **150** even if the fluorine residues are not completely removed.

The bank **153** including the lower layer **153***a* and the upper layer **153***b* corresponds to the boundaries of the pixel region P and overlaps the edges of the first electrode **150**. The lower layer **153***a* of the bank **153** has a hydrophilic property, and the upper layer **153***b* of the bank **153** has a hydrophobic property.

In the meantime, the bank **153** having the double-layered structure may be formed using a photosensitive material having a hydrophilic property and a photosensitive material having a hydrophobic property. This will be explained as another example of the embodiment with reference to FIGS. **8**A to **8**E. FIGS. **8**A to **8**E are cross-sectional views showing a fabricating process of on OLED display device according to another example of the embodiment of the present invention. In FIGS. **8**A to **8**E, the switching and driving TFTs and layers under the first electrode **150** are omitted, and figures show cross-sections of the OLED display device in steps of forming a bank having a double-layered structure.

As shown in FIG. **8**A, a first bank material layer **451** is formed on the first electrode **150** all over the first substrate **110**. The first bank material layer **451** may be formed by applying a photosensitive material having a hydrophilic property, for example, polyimide or acryl, using a coating apparatus (not shown).

Next, in FIG. **8**B, a first bank layer **452** having the hydrophilic property is formed by drying and curing the first bank material layer **451** of FIG. **8**A through a heat-treatment process, for example, the soft-baking process as mentioned above.

The photosensitive material having the hydrophilic property may include a high molecular substance or a low molecular substance.

In FIG. **8**C, a second bank material layer **453** is formed on the first bank layer **452**. The second bank material layer **453** may be formed by applying a photosensitive material having a hydrophobic property, for example, acryl including fluorine (F), using a coating apparatus (not shown).

Next, in FIG. **8**D, a second bank layer **454** having the hydrophobic property is formed by drying and curing the second bank material layer **453** of FIG. **8**C through a heat-treatment process, for example, the soft-baking process as mentioned above. The photosensitive material having the hydrophobic property may include a high molecular substance or a low molecular substance.

Since the first bank layer **452** having the hydrophilic property is already cured, molecules of the photosensitive material having the hydrophobic property do not move into the first bank layer **452** during the soft-baking process of the second bank material layer **453** of FIG. **8**C.

In FIG. **8**E, the first and second bank layers **452** and **454** of FIG. **8**D are exposed to light through an exposing mask (not shown) and developed, thereby forming the bank **153** having a double-layered structure of the hydrophilic lower layer **153***a* and the hydrophobic upper layer **153***b*, which is the same as that in FIG. **7**D.

In another example of the embodiment of the present invention, there is no hydrophobic residue on the first electrode **150**, and thus an organic emitting material, which will be sprayed or dropped, is spread well.

In the meantime, as shown in FIG. **7**E, after forming the bank **153** having the double-layered structure, an organic emitting material layer **154** is formed on the first electrode **150** by spraying or dropping a liquid phase organic emitting material in a region surrounded by the bank **153**, i.e., in the pixel region P, with an ink jet apparatus or a nozzle-coating apparatus **198**.

Even if the organic emitting material is sprayed or dropped on the upper layer **153***b* because of a mis-alignment of the ink jet apparatus or the nozzle-coating apparatus **198**, the organic emitting material is concentrated into a center of the pixel region P because the upper layer **153***b* has the hydrophobic property. In addition, even if an excessive amount of the organic emitting material is sprayed or dropped, the organic emitting material does not flow over the upper layer **153***b* due to the hydrophobic property of the upper layer **153***b*.

Furthermore, since the lower layer **153***a* of the bank **153** has the hydrophilic property, force drawing the liquid phase organic emitting material is generated from sides of the lower layer **153***a* of the bank **153**, and the liquid phase organic emitting material is spread well on the first electrode **150** to contact the sides of the lower layer **153***a* of the bank **153**.

Next, as shown in FIG. **7**F, by performing a curing process, solvents and moisture in the organic emitting material layer **154** of FIG. **7**E are removed such that the organic emitting layer **155** is formed in the pixel region P.

As mentioned above, since the organic emitting layer **155** contacts the sides of the lower layer **153***a* of the bank **153**, the organic emitting layer **155** is also formed around the bank **153** and has a substantially uniform thickness in the pixel region P.

Here, the organic emitting layer **155** has a single-layered structure. Alternatively, to improve emission efficiency, the organic emitting layer **155** may have a multi-layered structure, which may be formed by the same method as that of the single-layered structure or may be formed in an entire surface of a display region by a deposition method. For example, the organic emitting layer **155** may include a hole injecting layer, a hole transporting layer, an emitting material layer, an electron transporting layer and an electron injecting layer stacked on the first electrode **150** as an anode. The organic emitting layer **155** may be a quadruple-layered structure of the hole transporting layer, the emitting material layer, the electron transporting layer and an electron injecting layer or a triple-layered structure of the hole transporting layer, the emitting material layer and the electron transporting layer.

Next, as shown in FIG. **7**G, the second electrode **160** is formed on the organic emitting layer **155** by depositing a metallic material having a relatively low work function. The second electrode **160** is formed on an entire surface of the display region. The metallic material includes at least one of Al, Al alloy such as AlNd, Ag, Mg, Au and AlMg.

As explained above, the first electrode **150**, the organic emitting layer **155** and the second electrode **160** constitute the emitting diode E.

Next, as shown in FIG. **7**H, after forming a seal pattern (not shown) on edges of the first substrate **110** or the second substrate **170**, the first and second substrates **110** and **170** are attached under a vacuum condition or an inert gas condition such that the OLED display device is fabricated. Alternatively, a paste seal (not shown), which is formed of a fit material, an organic insulating material or a polymer material having transparent and adhesive properties is formed over an entire surface of the first substrate **110**, and then the first and second substrates **110** and **170** are attached. As explained above, instead of the second substrate **170**, an inorganic insulating film or an organic insulating film may be used for an encapsulation and may be attached by an adhesive layer.

In the OLED display device of the invention, since the bank has the double-layered structure of the hydrophilic lower layer and the hydrophobic upper layer, the hydrophobic residues hardly remain on the first electrode after forming the bank by patterning the bank layer. Therefore, the liquid phase organic emitting material is spread well in the pixel region surrounded by the bank when it is sprayed or dropped.

Moreover, the organic emitting material is spread better due to the force drawing the organic emitting material from the lower layer of the bank because the lower layer of the bank has the hydrophilic property, and the organic emitting layer is formed in the boundaries of the pixel region P adjacent to the bank.

Accordingly, the organic emitting layer has a uniform thickness in the pixel region, and the organic emitting layer is prevented from being degraded, thereby lengthening lifetime of the device.

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

What is claimed is:

1. An organic light emitting diode display device, comprising:

a first substrate including first and second pixel regions adjacent to each other;

first and second thin film transistors on the first substrate, within respective first and second driving areas;

- a passivation layer on the first and second thin film transistors;
- first electrodes in the first and second pixel regions on the passivation layer and connected to the first and second thin film transistors, respectively, wherein the first electrode in the first pixel region is adjacent to the first electrode in the second pixel region and a portion of the passivation layer is exposed between the first electrodes in the first and second pixel regions; and
- respective first and second banks overlying the first and second driving areas, the first and second banks covering the exposed portion of the passivation layer and respective edges of the first electrodes in the first and second pixel regions, wherein the banks include a first portion having a first molecular weight and a second portion having a second molecular weight different from the first portion, and the second portion contacts the exposed portion of the passivation layer,
- wherein the second molecular weight is greater than the first molecular weight;
- wherein the first portion is stacked on the second portion; and
- wherein the first electrode extending from the first driving area partially overlaps the second driving area.

2. The device according to claim **1**, wherein the bank overlaps one of the first and second thin film transistors.

3. The device according to claim **1**, wherein a side surface of the second portion has a same slope as a side surface of the first portion.

4. The device according to claim **1**, wherein a thickness of the first portion is different from a thickness of the second portion.

5. The device according to claim **4**, wherein the thickness of the first portion is larger than the thickness of the second portion.

6. The device according to claim **1**, wherein the second portion includes a high molecular substance having a molecular weight of more than 15,000.

7. The device according to claim **6**, wherein the first portion includes a low molecular substance having a molecular weight under 10,000.

8. The device according to claim **7**, wherein the first portion and the second portion are formed through phase separation of a bank material including the high molecular substance and the low molecular substance.

9. The device according to claim **7**, wherein the high molecular substance includes polyimide or acryl, and the low molecular substance includes fluorine.

10. The device according to claim **7**, wherein the high molecular substance has a hydrophilic property and the low molecular substance has a hydrophobic property.

11. The device according to claim **1**, wherein the first portion and the second portion are formed of a photosensitive material having a hydrophobic property and a photosensitive material having a hydrophilic property, respectively.

12. The device according to claim **11**, wherein the photosensitive material having a hydrophobic property includes acryl including fluorine and the photosensitive material having a hydrophilic property includes polyimide or acryl.

13. The device according to claim **1**, further comprising an organic emitting layer formed on the first electrode in each of the first and second pixel regions.

14. The device according to claim **13**, wherein the organic emitting layer has a single-layered structure or a multi-layered structure.

15. The device according to claim **14**, wherein the organic emitting layer has a triple-layered structure of a hole transporting layer, an emitting material layer and an electron transporting layer.

16. The device according to claim **14**, wherein the organic emitting layer includes a hole injecting layer, a hole transporting layer, an emitting material layer, an electron transporting layer and an electron injecting layer.

17. The device according to claim **14**, wherein at least one layer of the organic emitting layer is formed on the first electrode in each of the first and second pixel regions and is surrounded by the bank by spraying or dropping a liquid phase organic material.

18. The device according to claim **17**, wherein at least one layer of the organic emitting layer is formed in an entire surface of a display region of the first substrate by a deposition method.

19. The device according to claim **13**, wherein the organic emitting layer contacts a side of the second portion.

20. The device according to claim **13**, further comprising a second electrode on the organic emitting layer and covering an entire surface of a display region of the first substrate.

21. The device according to claim **20**, further comprising a second substrate for encapsulation and facing the first substrate.

22. The device according to claim **21**, wherein the second substrate is a flexible plastic substrate or a glass substrate.

23. The device according to claim **21**, wherein the second substrate is a film type and is attached to the second electrode by an adhesive layer.

24. The device according to claim **21**, further comprising a seal of an organic insulating material or a polymer material formed over an entire surface of the first substrate, wherein the first and second substrates are attached with the seal interposed therebetween.

25. The device according to claim **21**, further comprising a seal pattern of a sealant or a frit material on edges of the first substrate or the second substrate.

26. The device according to claim **20**, further comprising a capping layer of an organic insulating film or an inorganic insulating film on the second electrode and serving as an encapsulation film.

27. The device according to claim **1**, further comprising:

- gate lines and data lines crossing each other to define the first and second pixel regions;
- power lines parallel to the data lines; and
- switching thin film transistors connected to the gate and data lines,
- wherein the first and second thin film transistors are driving thin film transistors connected to the switching thin film transistors, respectively.

28. The device according to claim **27**, wherein each of the switching thin film transistors and the driving thin film transistors includes an oxide semiconductor layer, an amorphous silicon semiconductor layer including an active layer and an ohmic contact layer, or a poly-silicon semiconductor layer.

29. The device according to claim **1**, wherein the passivation layer is formed of photo-acryl and has a flat top surface.

30. The device according to claim **1**, further comprising a reflection layer between each of the first electrodes and the passivation layer.

31. An organic light emitting diode display device, comprising:

a first substrate including first and second pixel regions adjacent to each other;

first and second thin film transistors on the first substrate, within respective first and second driving areas;

first electrodes in the first and second pixel regions and connected to the first and second thin film transistors, respectively, wherein the first electrode in the first pixel region overlaps the first thin film transistor and is adjacent to the first electrode in the second pixel region;

first and second banks on the first electrodes, respectively, wherein each of the first and second banks includes a first portion and a second portion having a different molecular weight from the first portion, a molecular weight of the second portion is greater than a molecular weight of the first portion, and the second portion is disposed between the first portion and each of the first electrodes, respective first and second banks overlying the first and second driving areas;

wherein a distance between the first and second banks is smaller than a distance between the first and second thin film transistors; and

wherein the first electrode extending from the first driving area overlaps the second driving area.

32. The device according to claim **31**, wherein the first electrodes in the first and second pixel regions are connected to drain electrodes of the first and second thin film transistors, respectively, and

wherein the distance between the first and second banks is smaller than a distance between the drain electrode of the first thin film transistor and a source electrode or the drain electrode of the second thin film transistor.

33. The device according to claim **32**, wherein each of the first and second thin film transistors further includes a gate electrode and an active layer.

34. The device according to claim **31**, wherein the first and second banks overlap the first and second thin film transistors, respectively.

35. The device according to claim **31**, wherein a side surface of the second portion has a same slope as a side surface of the first portion.

36. The device according to claim **31**, wherein a thickness of the first portion is different from a thickness of the second portion.

37. The device according to claim **36**, wherein the thickness of the first portion is larger than the thickness of the second portion.

38. The device according to claim **31**, wherein the second portion includes a high molecular substance having a molecular weight of more than 15,000.

39. The device according to claim **38**, wherein the first portion includes a low molecular substance having a molecular weight under 10,000.

40. The device according to claim **39**, wherein the first portion and the second portion are formed through phase separation of a bank material including the high molecular substance and the low molecular substance.

41. The device according to claim **39**, wherein the high molecular substance includes polyimide or acryl, and the low molecular substance includes fluorine.

42. The device according to claim **39**, wherein the high molecular substance has a hydrophilic property and the low molecular substance has a hydrophobic property.

43. The device according to claim **31**, wherein the first portion and the second portion are formed of a photosensitive material having a hydrophobic property and a photosensitive material having a hydrophilic property, respectively.

44. The device according to claim **43**, wherein the photosensitive material having a hydrophobic property includes acryl including fluorine and the photosensitive material having a hydrophilic property includes polyimide or acryl.

45. The device according to claim **31**, further comprising an organic emitting layer formed on the first electrode in each of the first and second pixel regions.

46. The device according to claim **45**, wherein the organic emitting layer has a single-layered structure or a multi-layered structure.

47. The device according to claim **46**, wherein the organic emitting layer has a triple-layered structure of a hole transporting layer, an emitting material layer and an electron transporting layer.

48. The device according to claim **46**, wherein the organic emitting layer includes a hole injecting layer, a hole transporting layer, an emitting material layer, an electron transporting layer and an electron injecting layer.

49. The device according to claim **46**, wherein at least one layer of the organic emitting layer is formed on the first electrode in each of the first and second pixel regions and is surrounded by the bank by spraying or dropping a liquid phase organic material.

50. The device according to claim **49**, wherein at least one layer of the organic emitting layer is formed in an entire surface of a display region of the first substrate by a deposition method.

51. The device according to claim **45**, wherein the organic emitting layer contacts a side of the second portion.

52. The device according to claim **45**, further comprising a second electrode on the organic emitting layer and covering an entire surface of a display region of the first substrate.

53. The device according to claim **52**, further comprising a second substrate for encapsulation and facing the first substrate.

54. The device according to claim **53**, wherein the second substrate is a flexible plastic substrate or a glass substrate.

55. The device according to claim **53**, wherein the second substrate is a film type and is attached to the second electrode by an adhesive layer.

56. The device according to claim **53**, further comprising a seal of an organic insulating material or a polymer material formed over an entire surface of the first substrate, wherein the first and second substrates are attached with the seal interposed therebetween.

57. The device according to claim **53**, further comprising a seal pattern of a sealant or a frit material on edges of the first substrate or the second substrate.

58. The device according to claim **52**, further comprising a capping layer of an organic insulating film or an inorganic insulating film on the second electrode and serving as an encapsulation film.

59. The device according to claim **31**, further comprising:

gate lines and data lines crossing each other to define the first and second pixel regions;

power lines parallel to the data lines; and

switching thin film transistors connected to the gate and data lines,

wherein the first and second thin film transistors are driving thin film transistors connected to the switching thin film transistors, respectively.

60. The device according to claim **59**, wherein each of the switching thin film transistors and the driving thin film transistors includes an oxide semiconductor layer, an amorphous silicon semiconductor layer including an active layer and an ohmic contact layer, or a poly-silicon semiconductor layer.

61. The device according to claim **31**, further comprising a passivation layer between the first and second thin film transistors and the first electrodes.

62. The device according to claim **61**, wherein the passivation layer is formed of photo-acryl and has a flat top surface.

63. The device according to claim **61**, further comprising a reflection layer between each of the first electrodes and the passivation layer.

64. An organic light emitting diode display device, comprising:

a first substrate including first and second pixel regions adjacent to each other;

first and second thin film transistors on the first substrate;

a passivation layer on the first and second thin film transistors;

first electrodes in the first and second pixel regions on the passivation layer and connected to the first and second thin film transistors, respectively, wherein the first electrode in the first pixel region is adjacent to the first electrode in the second pixel region and a portion of the passivation layer is exposed between the first electrodes in the first and second pixel regions; and

a bank covering the exposed portion of the passivation layer and respective edges of the first electrodes in the first and second pixel regions, wherein the bank includes a first portion having a first molecular weight and a second portion having a second molecular weight different from the first portion, and the second portion contacts the exposed portion of the passivation layer;

wherein the second molecular weight is greater than the first molecular weight; and

wherein the first portion is stacked on the second portion, wherein the first electrode of the first pixel region is spaced apart from a gate electrode of the second thin film transistor of the second pixel region and overlaps a source electrode of the second thin film transistor of the second pixel region.

65. An organic light emitting diode display device, comprising:

a first substrate including first and second pixel regions adjacent to each other;

first and second thin film transistors on the first substrate;

first electrodes in the first and second pixel regions and connected to the first and second thin film transistors, respectively, wherein the first electrode in the first pixel region overlaps the first thin film transistor and is adjacent to the first electrode in the second pixel region;

first and second banks on the first electrodes, respectively, wherein each of the first and second banks includes a first portion and a second portion having a different molecular weight from the first portion, a molecular weight of the second portion is greater than a molecular weight of the first portion, and the second portion is disposed between the first portion and each of the first electrodes;

wherein the first and second banks are disposed over the first and second thin film transistors, respectively, and a distance between the first and second banks is smaller than a distance between the first and second thin film transistors; and

wherein the first electrode of the first pixel region is spaced apart from a gate electrode of the second thin film transistor of the second pixel region and overlaps a source electrode of the second thin film transistor of the second pixel region.

66. The device according to claim **1**, wherein the first electrode in the first pixel region partially overlaps a gate electrode of the first thin film transistor.

67. The device according to claim **31**, wherein the first electrode in the first pixel region partially overlaps a gate electrode of the first thin film transistor.

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外部链接	Espacenet		

摘要(译)

一种有机发光二极管显示装置，包括：第一基板，其包括显示区域；其中，在所述显示区域中限定多个像素区域；以及 在衬底上方和多个像素区域中的每个像素区域中的第一电极； 在第一电极的边缘上的堤岸并且围绕多个像素区域中的每个，堤岸包括具有亲水性的下层和具有疏水性的上层； 在第一电极上以及由堤围住的多个像素区域的每一个中的有机发光层； 第二电极在有机发射层上并覆盖显示区域的整个表面。