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(54) METHOD OF FABRICATING ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE

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USPC **438/46**

(57) **ABSTRACT**

A method of fabricating an organic light emitting diode display device includes forming a first electrode over a 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 first bank and a second bank, the first bank formed on edges of the first electrode and having a first width and a first thickness, and the second bank formed on the first bank and having a second width smaller than the first width; forming an organic emitting layer on the first electrode and a portion of the first bank; and forming a second electrode on the organic emitting layer and covering an entire of the display region.

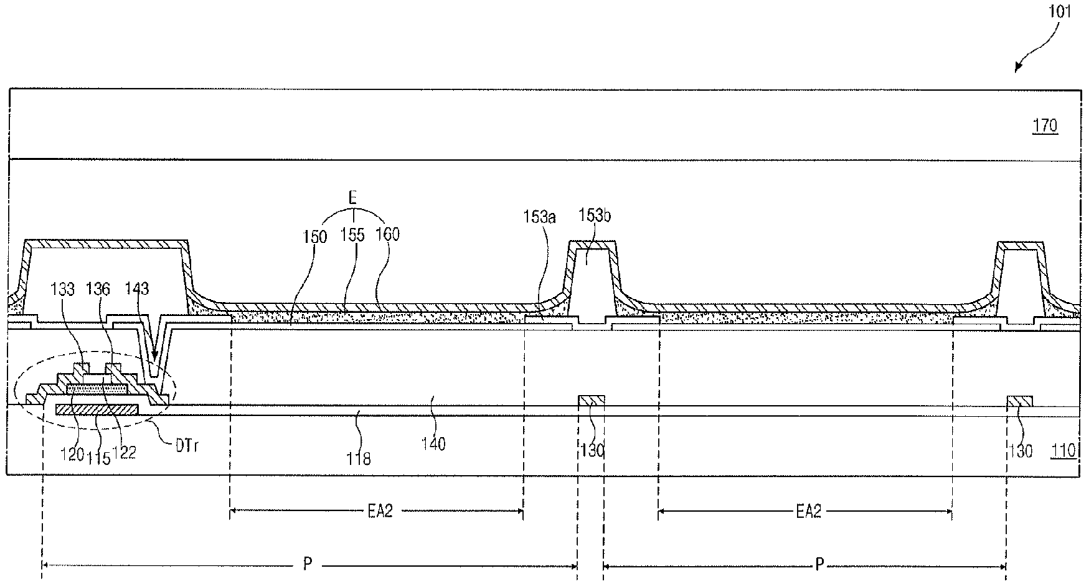


FIG. 1

Related Art

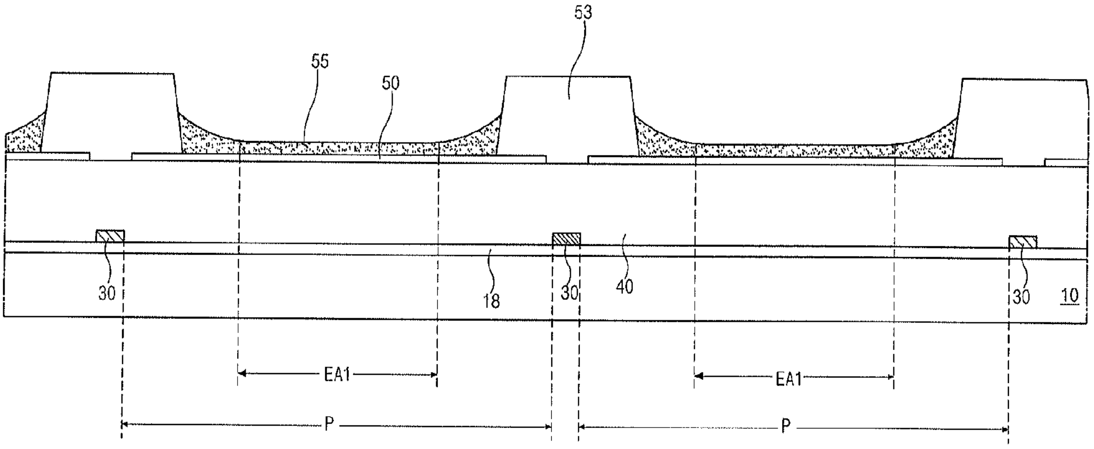


FIG. 2

Related Art

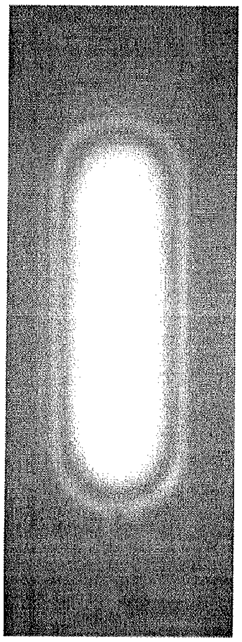


FIG. 3

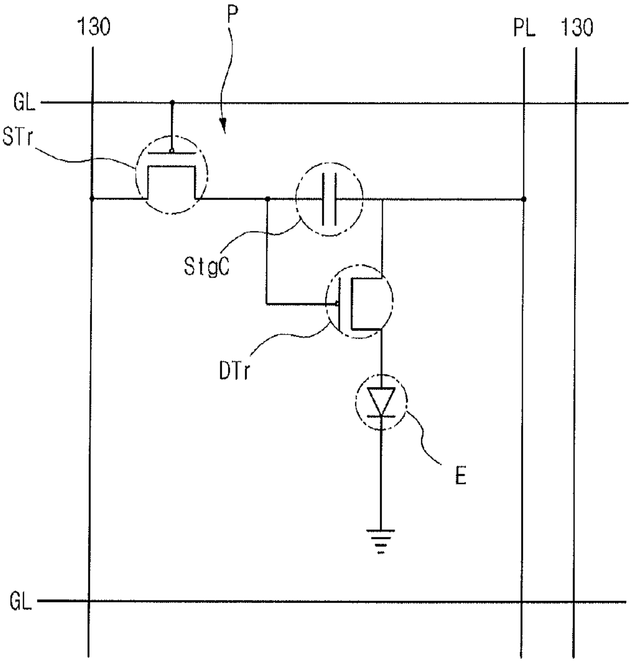

130
P
PL
130
GL
STr
StgC
DTr
E
GL

FIG. 4

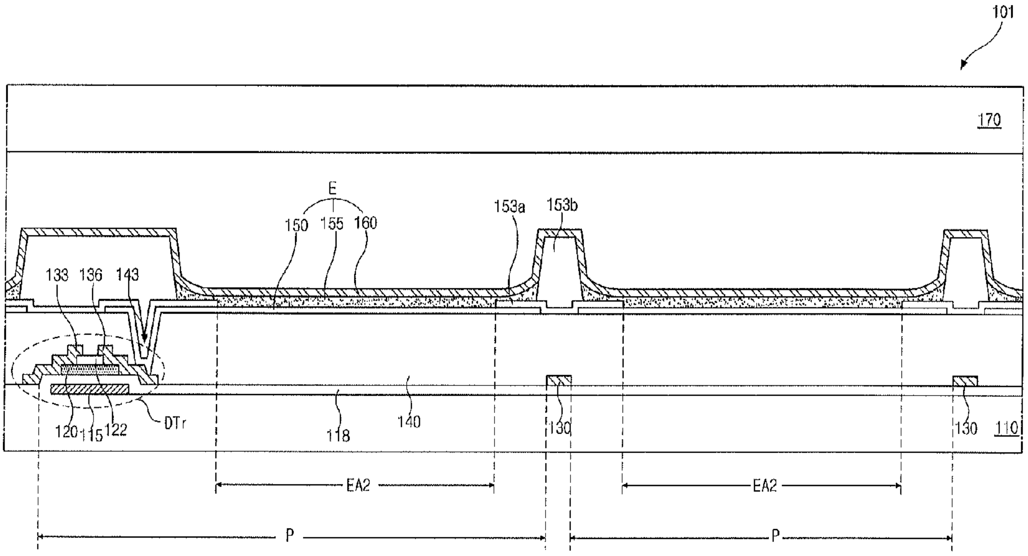

101
170
E
150
155
160
153a
153b
133
136
143
120
115
122
DTr
118
140
130
130
110
EA2
EA2
P
P

FIG. 5

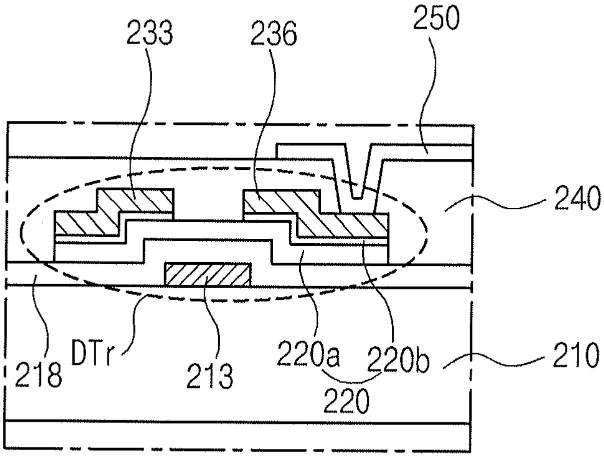

233
236
250
240
218
DTr
213
220a
220b
220
210

FIG. 6

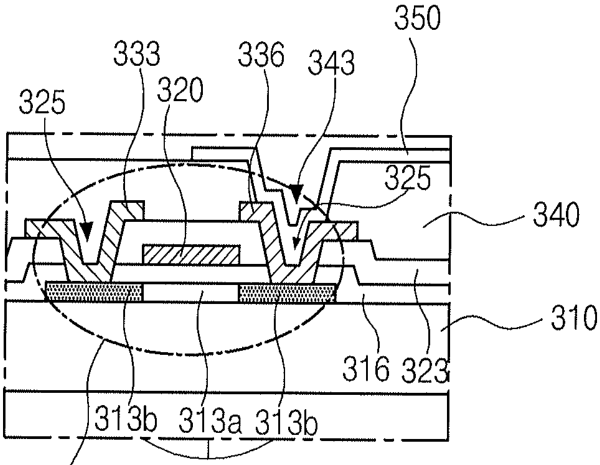

350
333
336
343
320
325
325
340
310
316
323
313b
313a
313b
313
DTr

FIG. 7

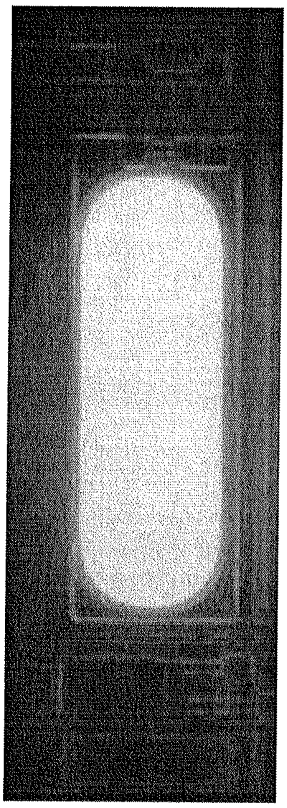


FIG. 8

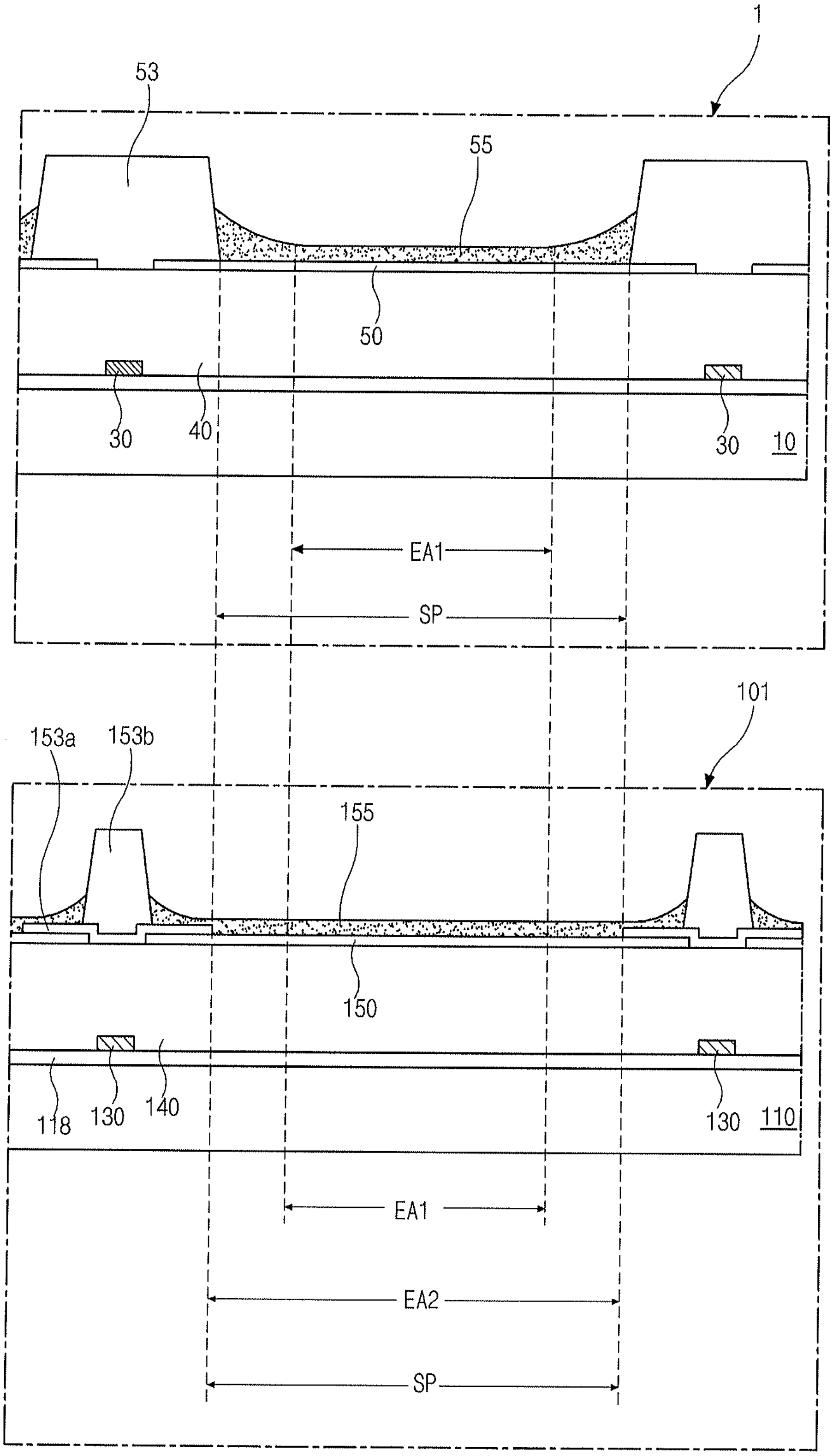

1
53
55
50
30
40
30
10
EA1
SP
101
153a
153b
155
150
118
130
140
130
110
EA1
EA2
SP

FIG. 9A

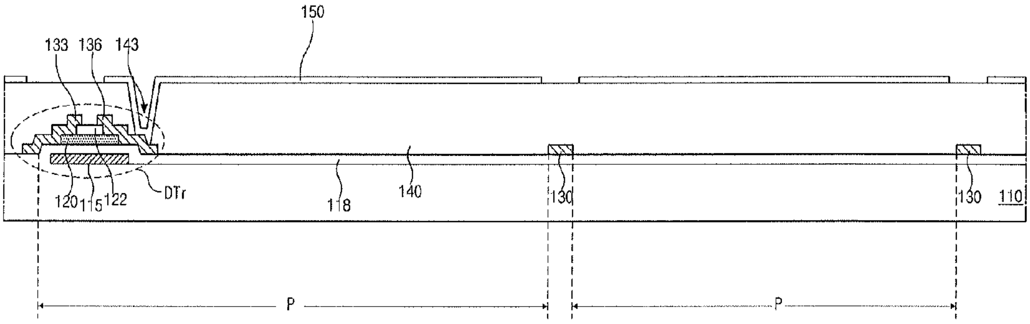


FIG. 9B

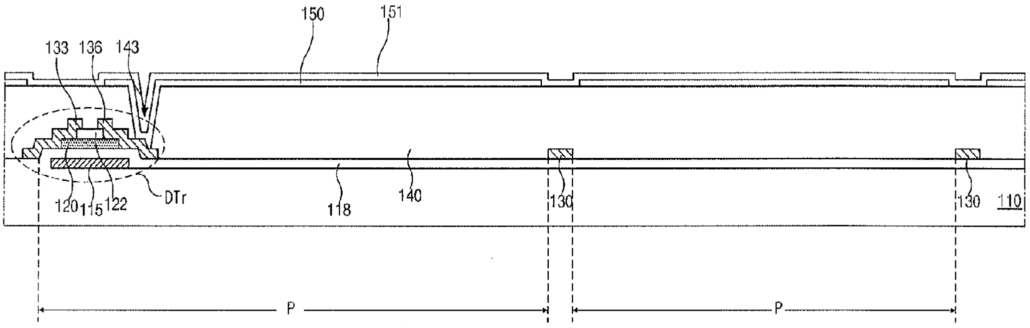


FIG. 9C

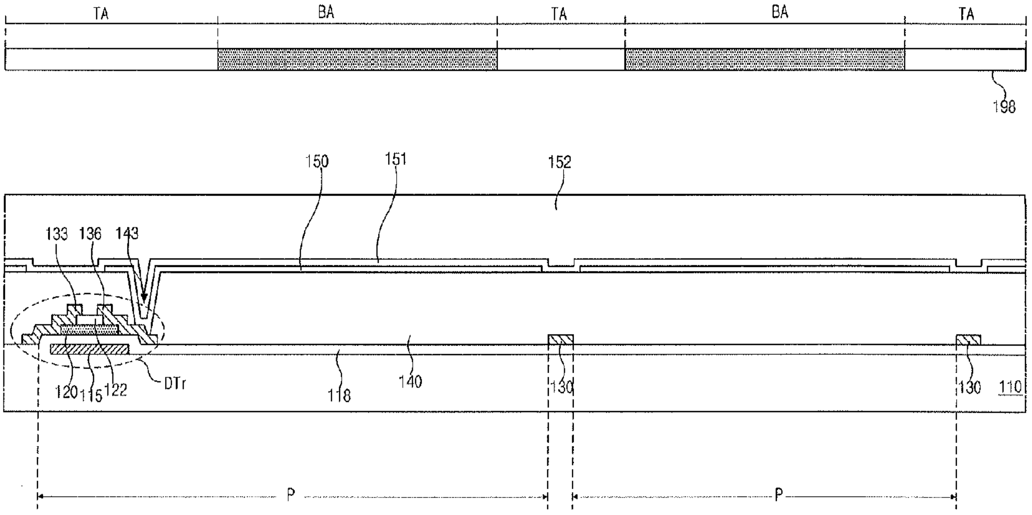


FIG. 9D

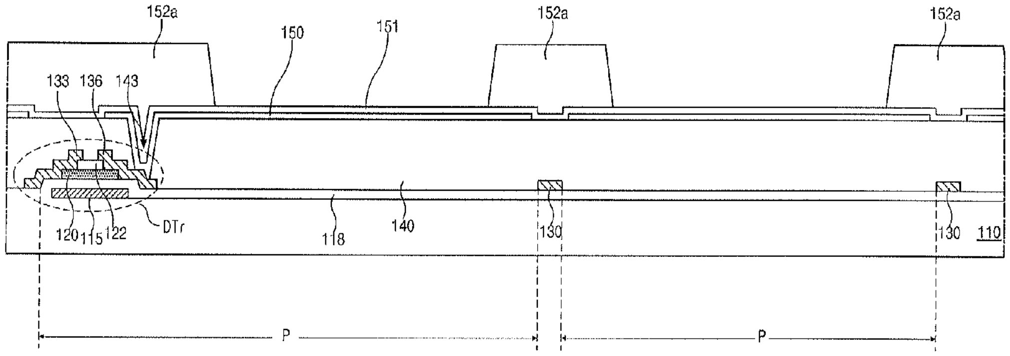


FIG. 9E

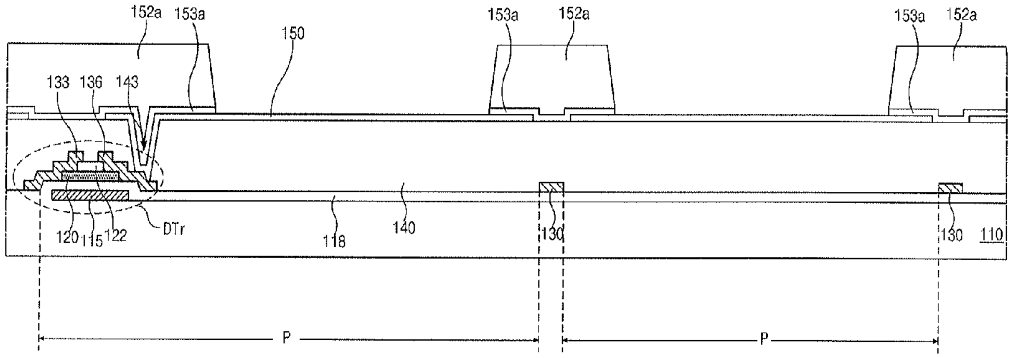


FIG. 9F

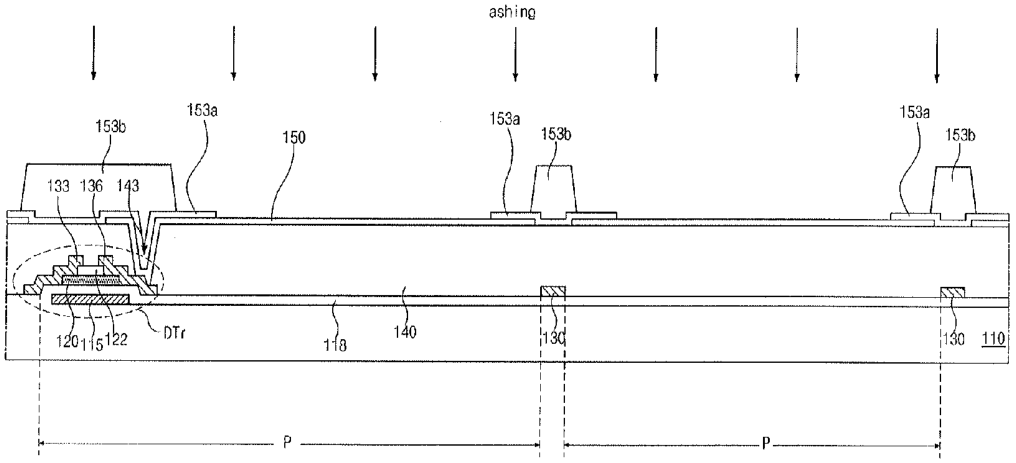


FIG. 9G

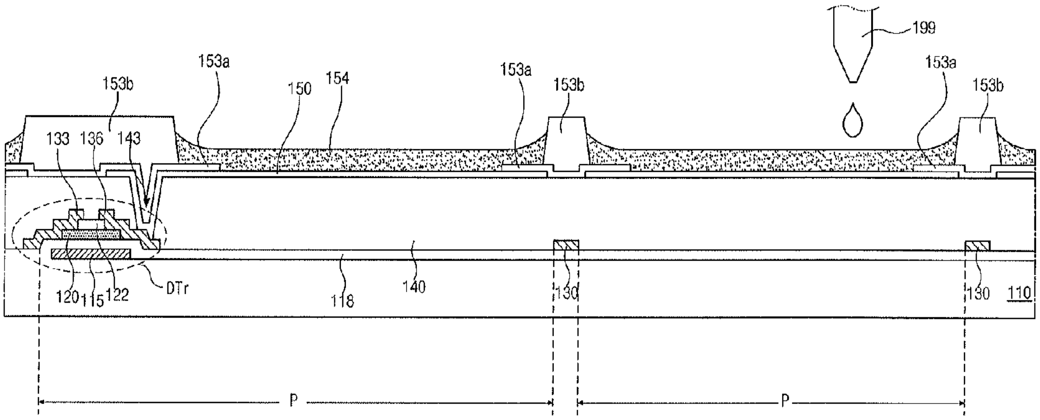


FIG. 9H

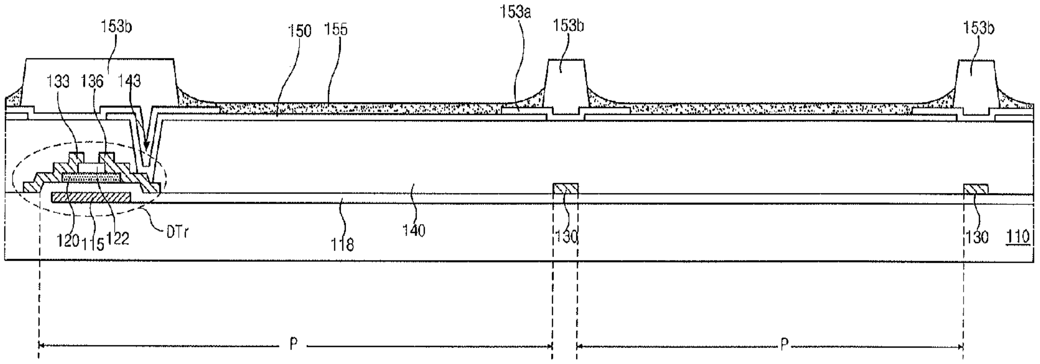


FIG. 9I

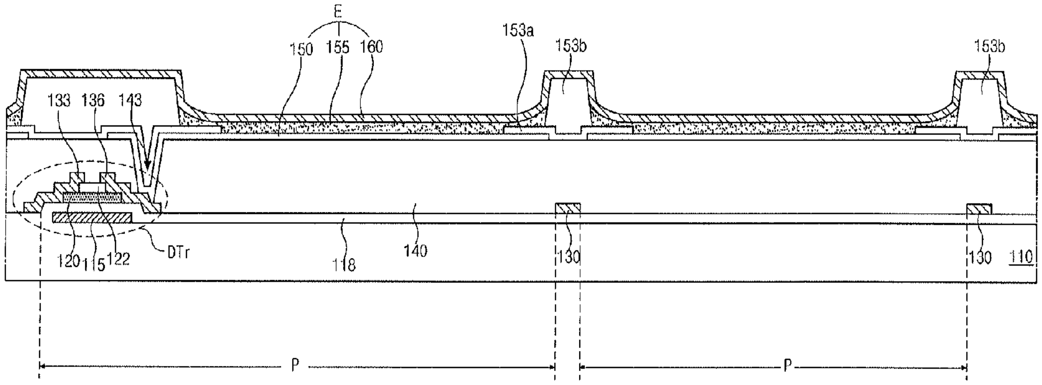
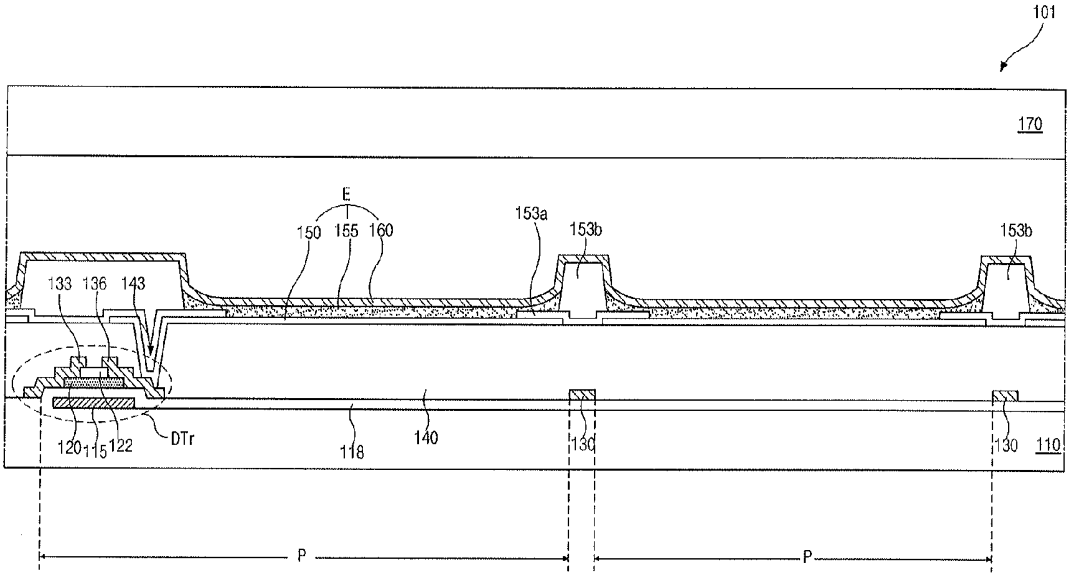


FIG. 9J


101
170
E
150
155
160
153a
153b
153b
133
136
143
120
115
122
DTr
118
140
130
130
110
P
P

METHOD OF FABRICATING ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE

[0001] The present application claims the benefit of Korean Patent Application No. 10-2012-0135163 filed in Korea on Nov. 27, 2012, which is herein incorporated by reference in its entirety.

BACKGROUND

[0002] 1. Technical Field

[0003] The present disclosure relates to an organic light emitting diode (OLED) display device, and more particularly, to a method of fabricating an OLED display device having improved aperture ratio and lifetime.

[0004] 2. RELATED ART

[0005] An OLED display device used in new flat panel display devices has a high brightness and low driving voltage. The OLED display device is a self-emitting type and has excellent characteristics of a view angle, a contrast ratio, a response time, etc.

[0006] Accordingly, the OLED display device is being widely used for a television, a monitor, a mobile phone, etc.

[0007] 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 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.

[0008] Generally, the organic emitting layer is formed by a thermal deposition using a shadow mask. However, the shadow mask sags because the shadow mask becomes larger with larger 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 using the shadow mask, it is very difficult to fabricate a high resolution OLED display device, e.g., above 250 PPI (pixels per inch).

[0009] Accordingly, new method instead of the thermal deposition using the shadow mask is introduced.

[0010] 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.

[0011] FIG. **1** is a schematic cross-sectional view showing a step of forming an organic emitting layer by spraying or dropping a liquid phase organic emitting material.

[0012] 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 adjacent pixel region P. Accordingly, as shown in FIG. **1**, the bank **53** is formed on edges of the first electrode **50** before forming the organic emitting layer **55**.

[0013] The bank **53** is formed of an organic material having 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 adjacent pixel region P.

[0014] 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 a heat to form the organic emitting layer **55**.

[0015] However, the organic emitting layer **55** has a difference in a thickness. Namely, the organic emitting layer **55** has a thickness in edges being larger than a thickness in a center.

[0016] If the organic emitting layer **55** has a thickness difference, the OLED display device has a difference in emitting efficiency. Accordingly, as shown in FIG. **2**, which is a picture showing one pixel region in the related art OLED display device, dark images are displayed in edges of the pixel region. In this instance, since the dark edges are perceived as an image defect by the viewer, the edges of the pixel region should be shielded such that the edges of the pixel region do not serve as an effective emitting area.

[0017] Referring again to FIG. **1**, an effective emitting area EA**1** is a portion of the pixel region P where the organic emitting layer **55** has a flat top surface. Namely, the aperture ratio of the OLED display device is decreased.

SUMMARY

[0018] A method of fabricating an organic light emitting diode display device includes forming a first electrode over a 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 first bank and a second bank, the first bank formed on edges of the first electrode and having a first width and a first thickness, and the second bank formed on the first bank and having a second width smaller than the first width; forming an organic emitting layer on the first electrode and a portion of the first bank; and forming a second electrode on the organic emitting layer and covering an entire surface of the display region.

[0019] 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

[0020] 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.

[0021] FIG. **1** is a schematic cross-sectional view showing a step of forming an organic emitting layer by spraying or dropping a liquid phase organic emitting material.

[0022] FIG. **2** is a picture showing one pixel region in the related art OLED display device.

[0023] FIG. **3** is a circuit diagram of one sub-pixel region of an OLED device.

[0024] FIG. **4** is a schematic cross-sectional view of an OLED display device according to an embodiment of the present invention.

[0025] FIG. **5** is a schematic cross-sectional view of an OLED display device according to one modified embodiment of the present invention.

[0026] FIG. **6** is a schematic cross-sectional view of an OLED display device according to another modified embodiment of the present invention.

[0027] FIG. **7** is a picture showing one pixel region in an OLED display device according to the present invention.

[0028] FIG. **8** is a schematic cross-sectional view explaining effective emitting areas of the related art OLED display device and an OLED display device according to the present invention.

[0029] FIGS. **9**A to **9**J are cross-sectional views showing a fabricating process of an OLED display device according to the present invention.

DETAILED DESCRIPTION

[0030] Reference will now be made in detail to the exemplary embodiments, examples of which are illustrated in the accompanying drawings.

[0031] FIG. **3** is a circuit diagram of one sub-pixel region of an OLED device.

[0032] 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.

[0033] On a substrate (not shown), a gate line GL along a first direction and a data line **130** along a second direction are formed. The gate line GL and the data line **130** cross each other to define the pixel region P. A power line PL for providing a voltage to the emitting diode E is formed to be parallel to and spaced apart from the data line **130**.

[0034] The switching TFT STr is connected to the gate and data lines GL and **130**, 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.

[0035] 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.

[0036] 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 **130** 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 next frame.

[0037] FIG. **4** is a schematic cross-sectional view of an OLED display device according to an embodiment of the present invention. FIG. **4** shows one driving TFT DTr in one pixel region P. However, the driving TFT DTr is formed in each pixel region P.

[0038] As shown in FIG. **4**, an OLED display device **101** of the present invention includes a first substrate **110**, where a driving TFT DTr, a switching TFT (not shown) and an organic 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.

[0039] A gate line (not shown) and a data line **130** are formed on the first substrate **110**. The gate line and the data line **130** 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 **130**.

[0040] In each pixel region P, the switching TFT is connected to the gate line and the data line **130**, and the driving TFT DTr and the storage capacitor StgC are connected to the switching TFT and the power line.

[0041] 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.

[0042] 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**.

[0043] In addition, 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 poly-silicon 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**.

[0044] The top gate structure TFT requires the interlayer insulating layer **323** in comparison to a bottom gate structure TFT. In the top gate structure TFT, the gate line is formed on the gate insulating layer **316**, and the data line is formed on the interlayer insulating layer **323**.

[0045] 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.

[0046] 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.

[0047] The first electrode **150** is formed of a conductive material having a relatively high work function, e.g., about 4.8 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.

[0048] 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 (AlNd), having a relatively high reflectivity.

[0049] With the reflection layer, the light from the 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.

[0050] A first bank **153***a* having a first width is formed along boundaries of the pixel region P. Namely, the first bank **153***a* is formed on edges of the first electrode **150** such that a center of the first electrode **150** is exposed by the first bank **153***a*. The first bank **153***a* includes a hydrophilic material. For example, the first bank **153***a* may be formed of an inorganic insulating material. Particularly, the first bank **153***a* may be formed of at least one of silicon oxide or silicon nitride. A thickness of the first bank **153***a* is smaller than that of the organic emitting layer **155**.

[0051] In addition, a second bank **153***b* is formed on the first bank **153***a*. The second bank **153***b* has a second width smaller than the first width of the first bank **153***a* and completely overlaps the first bank **153***a*. The first width of the first bank **153***a* is substantially the same as the bank **53** in the related art OLED display device. The second bank **153***b* includes an organic insulating material having a hydrophobic property. Namely, the second bank **153***b* is formed of an organic insulating material having a hydrophobic property or an organic insulating material containing a hydrophobic material.

[0052] In the OLED display device **101** including the first bank **153***a*, which has the first width and the thickness being smaller than the organic emitting layer **155**, and the second bank **153***b* having the second width being smaller than the first width of the first bank **153***a*, the organic emitting layer **155** is formed on the first bank **153***a* and the organic emitting material is concentrated into a center of the pixel region P by the first bank **153***a*. As a result, a problem of increase of a thickness of the organic emitting layer **155** in a region adjacent to the first bank **153***a* is reduced.

[0053] In addition, since the first bank **153***a* has substantially the same width as the bank **53** (of FIG. **1**), a region surrounded by the second bank **153***b*, which has a second width smaller than the first bank **153***a*, is larger than that surrounded by the bank **53**.

[0054] Moreover, since the first bank **153***a* has the thickness smaller than the organic emitting layer **155**, the organic emitting layer **155** is formed on the first bank **153***a*.

[0055] Furthermore, since the organic emitting layer **155** on the first bank **153***a* has a portion forming substantially flat top surface with the center of the pixel region P, the organic emitting layer **155** has the flat top surface in a region surrounded by the first bank **153***a*.

[0056] Accordingly, an emitting region EA2, which is defined as a region of the organic emitting layer having the flat top surface, is increased in comparison to the emitting area EA**1** (of FIG. **1**) in the related art OLED display device such that the OLED display device of the present invention has improved aperture ratio.

[0057] Referring to FIG. **7**, which is a picture showing one pixel region in an OLED display device according to the present invention, the emitting area EA**2** (of FIG. **4**) in the OLED display device of the present invention is increased in comparison to the emitting area EA**1** (of FIG. **1**) in the related art OLED display device. In addition, brightness uniformity of the OLED display device of the present invention is improved.

[0058] FIG. **8** is a schematic cross-sectional view explaining effective emitting areas of the related art OLED display device and an OLED display device according to the present invention.

[0059] With the size pixel region, an effective pixel region SP is defined as a region surrounded by the bank. In this instance, referring to FIG. **8**, the effective pixel region SP in the related art OLED display device is a region surrounded by the bank **53**, while the effective pixel region SP in the OLED display device of the present invention is a region surrounded by the first bank **153***a*. The area of the effective pixel regions SP in the related art OLED display device and the OLED display device of the present invention is equal.

[0060] However, an area of the effective emitting area EA**2** in the effective pixel region SP of the OLED display device of the present invention is larger than that of the effective emitting area EA**1** in the effective pixel region SP of the related art OLED display device.

[0061] Since the organic emitting layer **55** has a thickness difference in the edges of the effective pixel region SP, the effective emitting area EA**1** is smaller than the effective pixel region SP. However, since the organic emitting layer **155** has a thickness uniformity in an entire surface of the effective pixel region SP, the effective emitting area EA**2** is equal to the effective pixel region SP. Namely, an area of the effective emitting area EA**2** in the effective pixel region SP of the OLED display device of the present invention is larger than that of the effective emitting area EA**1** in the effective pixel region SP of the related art OLED display device such that the aperture ration of the OLED display device is increased.

[0062] Referring again to FIG. **4**, the organic emitting layer **155** is formed on the first electrode **150** and in an opening of the second bank **153***b*. The organic emitting layer **155** includes red, green and blue emitting material in each pixel region P.

[0063] 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 material by an ink-jet apparatus or a nozzle-coating apparatus.

[0064] 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 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.

[0065] 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, silver (Ag), magnesium (Mg), gold (Au), Al—Mg alloy (AlMg). The second electrode **160** serves as a cathode. In the top emission type OLED display device, the second electrode **160** has a transparent property. On the other hand, in a bottom emission type OLED display device, the second electrode **160** has a reflective property.

[0066] The first electrode **150**, the organic emitting layer **155** and the second electrode **160** constitute the emitting diode E.

[0067] A seal pattern (not shown) of a sealant or a fit 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.

[0068] 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.

[0069] 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**.

[0070] In the OLED display device **101** including the first bank **153***a*, which has the thickness being smaller than the organic emitting layer **155**, and the second bank **153***b* having the second width being smaller than the first width of the first bank **153***a*, the organic emitting layer **155** is formed on the first bank **153***a* and the organic emitting material is concentrated into a center of the pixel region P by the first bank **153***a*. As a result, a problem of increase of a thickness of the organic emitting layer **155** in a region adjacent to the first bank **153***a* is reduced.

[0071] In addition, since the organic emitting layer **155** on the first bank **153***a* has a portion forming substantially flat top surface with the center of the pixel region P, the organic emitting layer **155** has a uniform thickness in a region surrounded by the first bank **153***a*. As a result, an emitting area EA2 is increased in comparison to the emitting area EA1 (of FIG. **1**) in the related art OLED display device such that the OLED display device of the present invention has improved aperture ratio.

[0072] Moreover, since an area having thickness uniformity of the organic emitting layer **155** is increased, brightness uniformity of the OLED display device of the present invention is improved. Furthermore, due to the thickness uniformity of the organic emitting layer **155**, a thermal degradation problem of the organic emitting layer is prevented such that the OLED display device has an improved lifetime.

[0073] Hereinafter, a method of fabricating the OLED display device is explained with reference to FIGS. **9**A to **9**J. FIGS. **9**A to **9**J are cross-sectional views showing a fabricating process of an OLED display device according to the present invention. The explanation is focused on the first and second banks.

[0074] As shown in FIG. **9**A, on the first substrate **110**, the gate line (not shown), the data line (not shown) and the power line (not shown) are formed. 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.

[0075] As explained above, each of the switching TFT and the driving TFT DTr has a bottom gate type TFT including the gate electrode **115** or **213** as a lowest layer or a top gate type TFT including the semiconductor layer **313** as a lowest layer. The bottom gate type TFT includes the oxide semiconductor layer **120** or the amorphous silicon semiconductor layer **220** 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**.

[0076] 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**.

[0077] 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 and is separated in each pixel region P. For example, the transparent conductive material may be ITO.

[0078] On the other hand, as explained above, the reflection layer (not shown), which includes Al or Al alloy, 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 with the first electrode **150**.

[0079] Next, as shown in FIG. **9**B, a first bank material layer **151** is formed on the first electrode **150** and the passivation layer **140**. For example, the first bank material layer **151** may be formed by depositing an inorganic insulating material such as silicon oxide or silicon nitride. The first bank material layer **151** has a thickness smaller than an organic emitting material layer **154** (of FIG. **9**G). For example, the thickness of the first bank material layer **151** may have a range of about 0.2 to 1.5 micrometer.

[0080] Next, as shown in FIG. **9**C, a second bank material layer **152** is formed on the first bank material layer **151** by coating a polymer material having a hydrophobic property and a photosensitive property. The polymer material may include at least one of polyimide containing fluorine (F), styrene, methylmethacrylate, polytetrafluoroethylene, such as Teflon.

[0081] An exposing mask **198** including a transmitting region TA and a blocking region BA is disposed over the second bank material layer **152**, and an exposing process to the second bank material layer **152** is performed using the exposing mask **198**.

[0082] Next, as shown in FIG. **9**D, a bank pattern **152***a* is formed by developing the second bank material layer **152** (of FIG. **9**C). In this instance, an exposed portion of the second bank material layer **152** corresponding to the transmitting region TA of the exposing mask **198** remains to form the bank pattern **152***a*, while a non-exposed portion of the second bank material layer **152** corresponding to the blocking region BA of the exposing mask **198** is removed by the developing process. As a result, the first bank material layer **151** in a center of the pixel region P is exposed by the bank pattern **152***a*.

[0083] In FIGS. **9**C and **9**D, the second bank material layer **152** is shown to have a negative type photosensitive property where an exposed portion of the second bank material layer **152** remains to form the bank pattern **152***a*. Alternatively, the second bank material layer **152** may have a positive type photosensitive property. In this instance, a position of the transmitting region TA and the blocking region BA is replaced.

[0084] Next, as shown in FIG. **9**E, the second bank material layer **152** (of FIG. **9**D) is etched using the bank pattern **152***a* as an etching mask to form the first bank **153***a* under the bank pattern **152***a*. The etching process may be a dry-etching process using an etching gas or a wet-etching process using an etchant. Each of the etching gas and the etchant reacts with the material of the first bank material layer **151** except the material of the second bank material layer **152**.

[0085] Next, as shown in FIG. **9**F, an isotropic dry-etching process or an isotropic ashing process using a gas, which reacts with the material of the first bank pattern **152***a* (of FIG. **9**E) except the material of the first bank **153***a*, is performed to the bank pattern **152***a* to reduce a volume of the bank pattern **152***a* by a pre-determined ratio. Namely, by the dry-etching or ashing process, a thickness and a width of the bank pattern **152***a* is reduced to form the second bank **153***b*. The second bank **153***b* completely overlaps the first bank **153***a* and has a width smaller than the first bank **153***a*.

[0086] In this instance, by controlling a dry-etching or ashing process time or an amount of the gas, the bank pattern **152***a* is removed by a range within about 1 to 9 micrometer. Namely, a width of the second bank **153***b* is smaller than that of the first bank **153***a*, and the first bank **153***a* is protruded from a side of the second bank **153***b* by a width of about 1 to 9 micrometer.

[0087] By the above-mentioned process, the first and second banks **153***a* and **153***b*, which are formed of different materials and have different widths, are formed.

[0088] In the present invention, the first and second banks **153***a* and **153***b* are formed in a single mask process with the exposing mask **198** including the transmitting region TA and the blocking region BA.

[0089] Alternatively, the first and second banks **153***a* and **153***b*, which are formed of different materials and have different widths, may be formed in different mask processes. However, by forming the first and second banks **153***a* and **153***b* in the single mask process, production costs are reduced.

[0090] In addition, by forming the first and second banks **153***a* and **153***b* in the single mask process, fine particle residues from the second bank material layer **152** onto the first electrode **150** is prevented. In more detail, when the first and second banks **153***a* and **153***b* are formed in different mask processes, the second bank material layer **152** of the polymer material should be formed directly on the first electrode **150** such that fine particle residues from the polymer material are generated on the first electrode **150** even if the second bank material layer **152** is removed. As a result, there are damages, e.g., dispersion of an organic emitting material, in a process of forming the organic emitting layer.

[0091] However, since the second bank material layer **152** is formed on the first bank material layer **151**, not directly on the first electrode **150**, there is no above problem.

[0092] Next, as shown in FIG. **9**G, an organic emitting material layer **154** is formed on the first electrode **150** and the first bank **153***a* by spraying or dropping a liquid phase organic emitting material with an ink jet apparatus or a nozzle-coating apparatus. Since the organic emitting material layer **154** has a thickness larger than the first bank **153***a*, the organic emitting material layer **154** is also formed on the first bank **153***a*.

[0093] Even if the organic emitting material is sprayed or dropped on the second bank **153***b* because of a mis-alignment of the ink jet apparatus or the nozzle-coating apparatus, the organic emitting material is concentrated into a center of the pixel region P because the material of the second bank **153***b* has a hydrophobic property. In addition, even if an excessive amount of the organic emitting material is sprayed or dropped, the organic emitting material dost not flood due to the second bank **153***b* having the hydrophobic property.

[0094] Next, as shown in FIG. **9**H, by performing a curing process, solvents and moisture in the organic emitting material layer **154** (of FIG. **9**G) are removed such that the organic emitting layer **155** is formed.

[0095] As mentioned above, since the organic emitting layer **155** has a thickness uniformity in an entire surface of the effective pixel region SP (of FIG. **8**), the OLED display device of the present invention has the improved aperture ratio. Namely, since the organic emitting layer on a portion of the first bank **153***a* has a flat top surface with the organic emitting layer in a center of the pixel region P, the effective emitting area EA**2** (of FIG. **8**) is enlarged in comparison to the effective emitting area EA**1** (of FIG. **8**) of the related are OLED display device.

[0096] FIG. **9**H 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 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.

[0097] Next, as shown in FIG. **91**, 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 a display region. The metallic material includes at least one of Al, Al alloy (AlNd), Ag, Mg, Au and AlMg.

[0098] As explained above, the first electrode **150**, the organic emitting layer **155** and the second electrode **160** constitute the emitting diode E.

[0099] Next, as shown in FIG. **9**J, 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 frit 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 is used for an encapsulation.

[0100] In the OLED display device, the effective emitting area, where the organic emitting layer has a flat top surface, i.e., a thickness uniformity, is increased due to the first and second banks having a difference in a width. As a result, the aperture ratio of the OLED display device is improved. In addition, since the first and second banks are formed in a single mask process, there are advantages in the production costs and the fabricating process. Moreover, since the polymer material of the second bank having the hydrophobic property does not contact the second electrode, a problem resulting from fine particle residues of the polymer material is prevented.

[0101] 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. A method of fabricating an organic light emitting diode display device, comprising:

forming a first electrode over a 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 first bank and a second bank, the first bank formed on edges of the first electrode and having a first width and a first thickness, and the second bank formed on the first bank and having a second width smaller than the first width;

forming an organic emitting layer on the first electrode and a portion of the first bank; and

forming a second electrode on the organic emitting layer and covering an entire surface of the display region.

2. The method according to claim **1**, wherein the first bank includes a material having a hydrophilic property, and the second bank includes a material having a hydrophobic property.

3. The method according **2**, wherein the first bank is formed of one of silicon oxide and silicon nitride.

4. The method according to claim **2**, wherein the second bank is formed of at least one of polyimide containing fluorine (F), styrene, methylmethacrylate, and polytetrafluoroethylene .

5. The method according to claim **1**, wherein the organic emitting layer on the portion of the first bank has a flat top surface with the organic emitting layer on a center of the pixel region.

6. The method according to claim **1**, wherein the organic emitting layer has a second thickness larger than the first thickness.

7. The method according to claim **6**, wherein the first thickness has a range within about 0.2 to 1.5 micrometer.

8. The method according to claim **1**, wherein the step of forming the first bank and the second bank includes:

forming a first bank material layer on the first electrode;

forming a second bank material layer on the first bank material layer;

patterning the second bank material layer to form a bank pattern;

patterning the first bank using the bank pattern as an etching mask to form the first bank; and

reducing a volume of the bank pattern to form the second bank such that the first bank protrudes from the second bank by a third width.

9. The method according to claim **8**, wherein the third width has a range within about 1 to 9 micrometer.

10. The method according to claim **1**, wherein the step of forming the organic emitting layer includes:

coating a liquid phase emitting material layer using an ink jet apparatus or a nozzle-coating apparatus; and

curing the organic emitting material to form the organic emitting layer.

* * * * *

专利名称(译)	制造有机发光二极管显示装置的方法		
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摘要(译)

一种制造有机发光二极管显示装置的方法，包括在包括显示区域的基板上形成第一电极，所述显示区域包括多个像素区域，所述第一电极形成在所述多个像素区域中的每一个中;形成第一堤岸和第二堤岸，第一堤岸形成在第一电极的边缘上并具有第一宽度和第一厚度，第二堤岸形成在第一堤岸上并具有小于第一宽度的第二宽度;在第一电极和第一隔堤的一部分上形成有机发光层;在有机发光层上形成第二电极并覆盖整个显示区域。