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(57) **ABSTRACT**

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A display device comprising including a plurality of pixels arranged in the shape of a matrix above a substrate, and a plurality of thin film transistors arranged corresponding to each of the plurality of pixel having an organic EL layer, the device comprising; a planarized film covering the thin film transistor and a wire connected with the thin film transistor; a reflecting layer formed above the planarized film; a light path length expanded layer covering the reflecting layer; and a pixel transparent electrode formed above the light path length expanded layer.

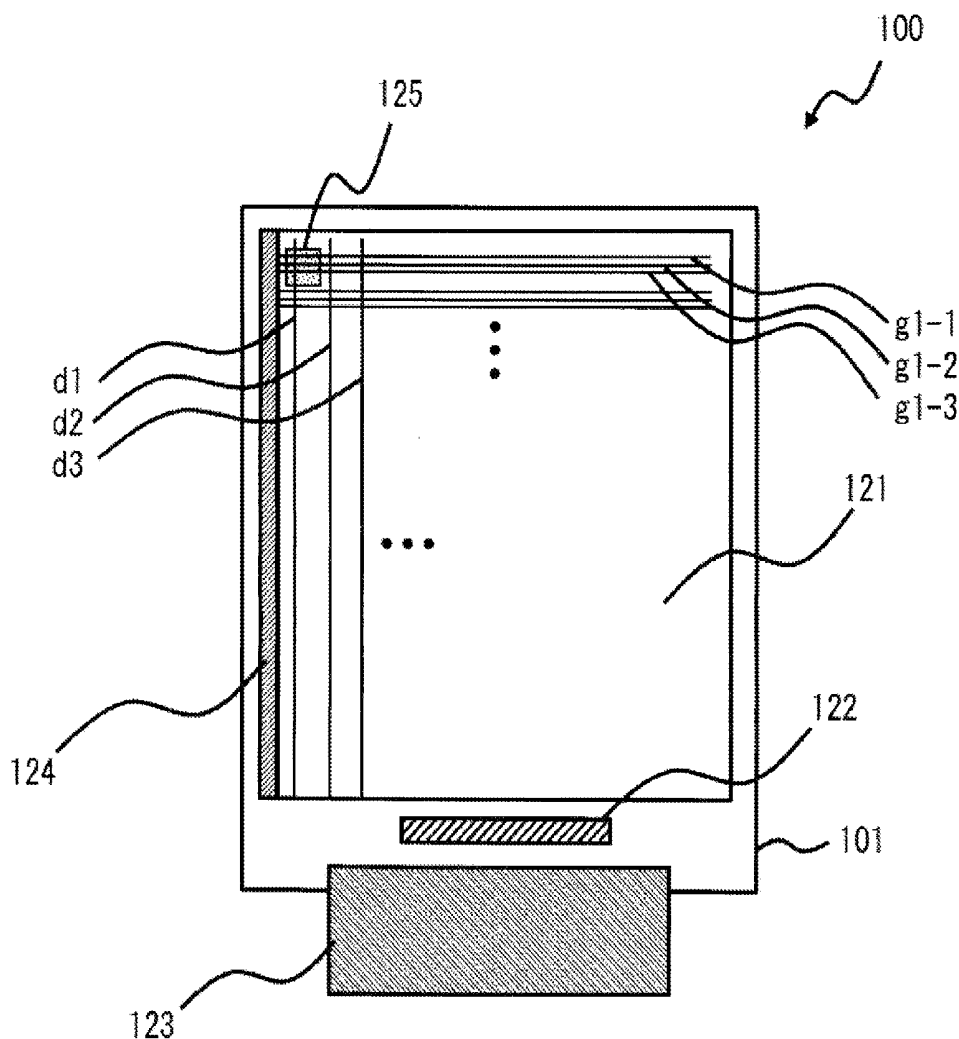


FIG.1

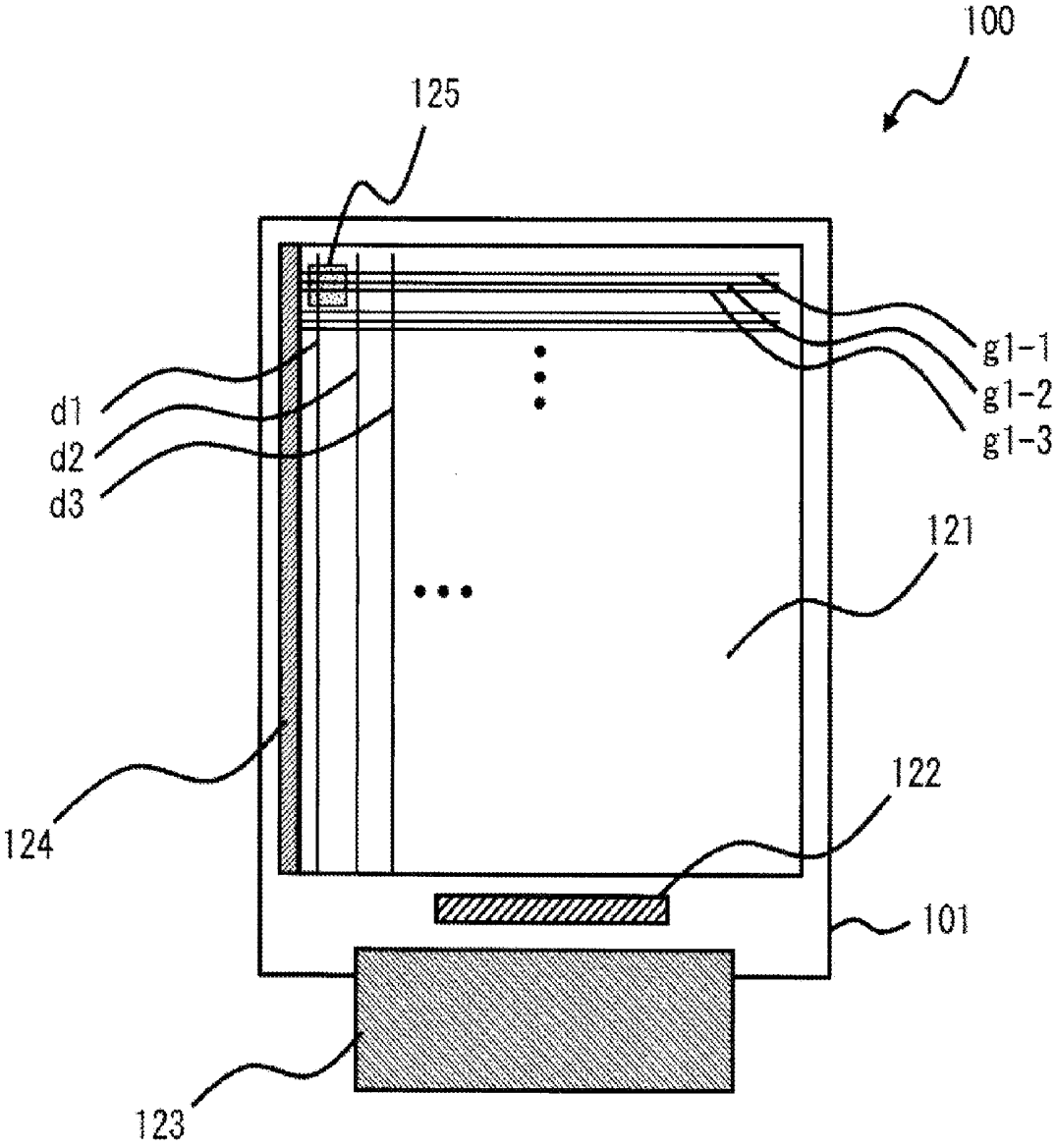


FIG. 2

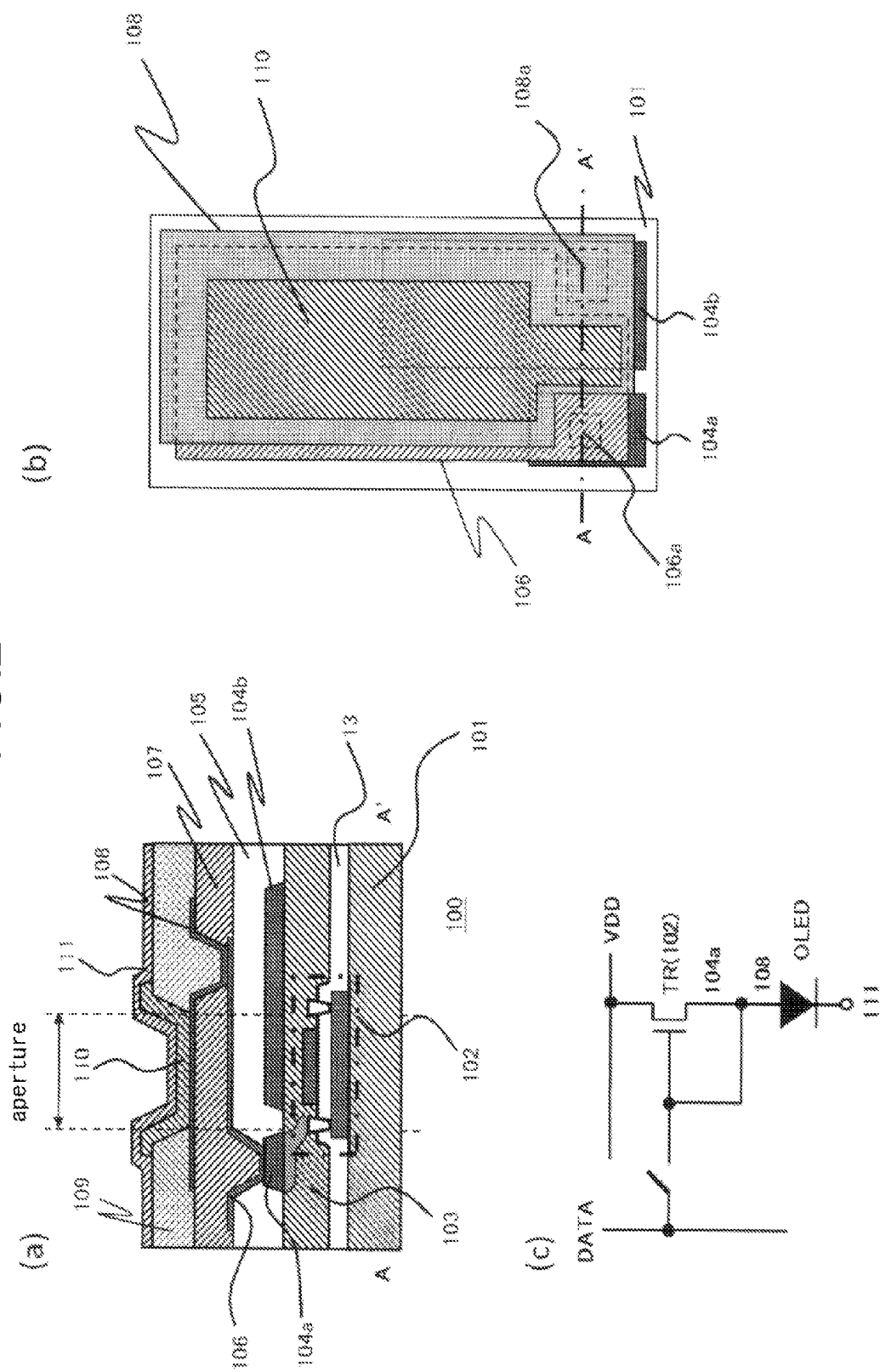


FIG.3

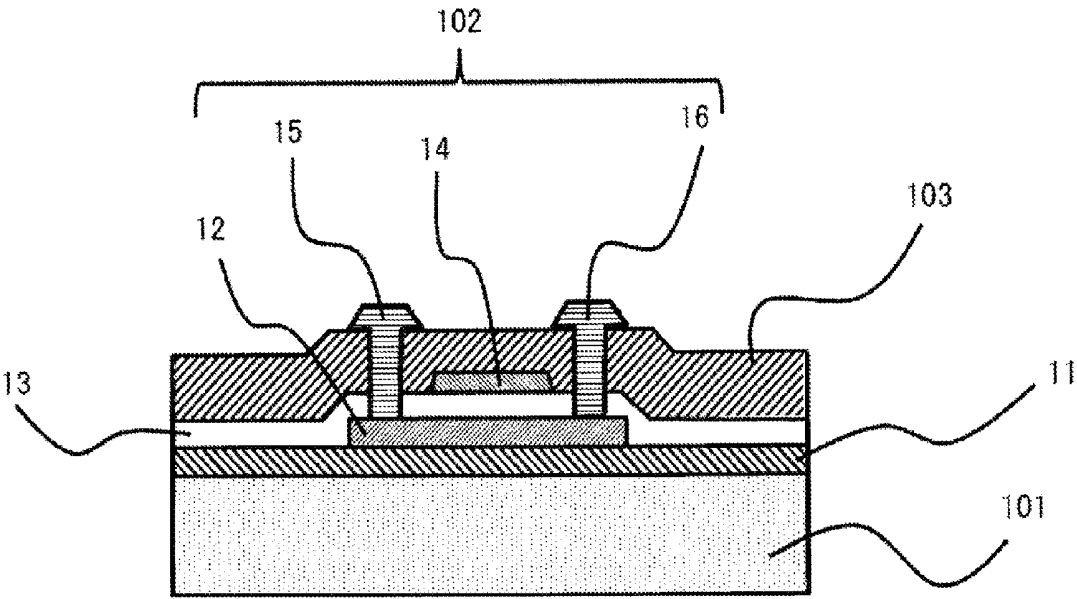


FIG. 4

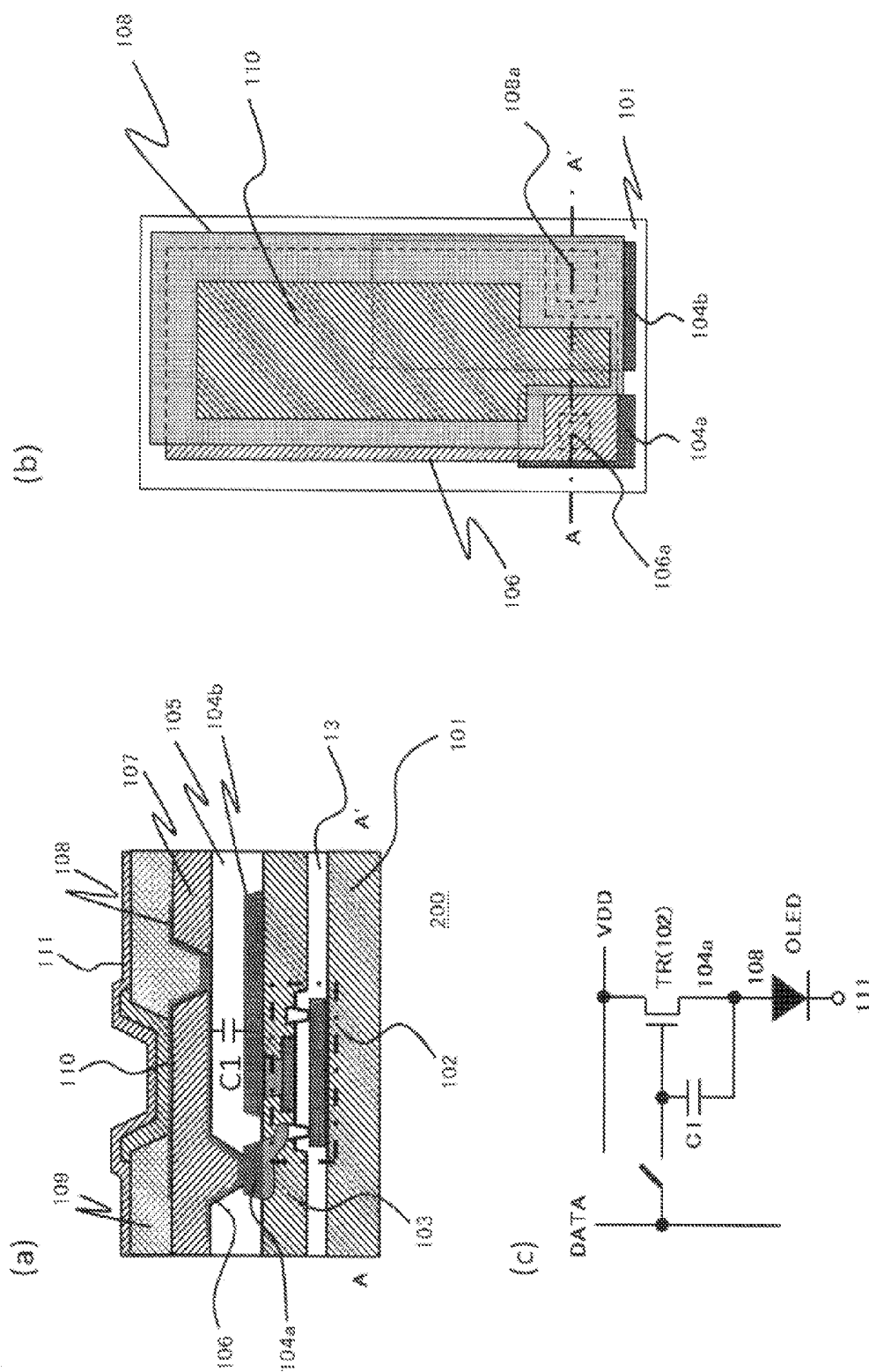


FIG. 5

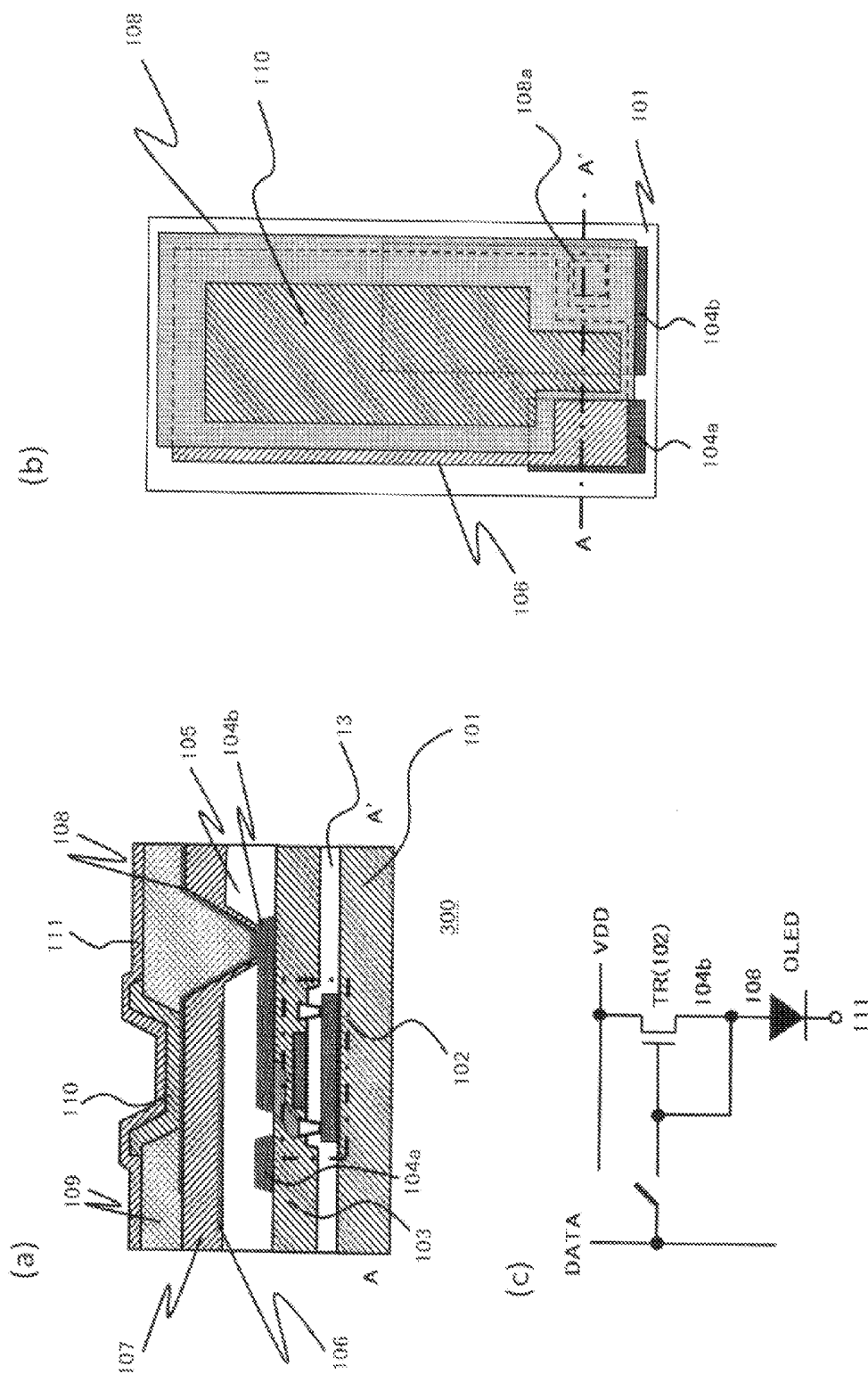


FIG. 6

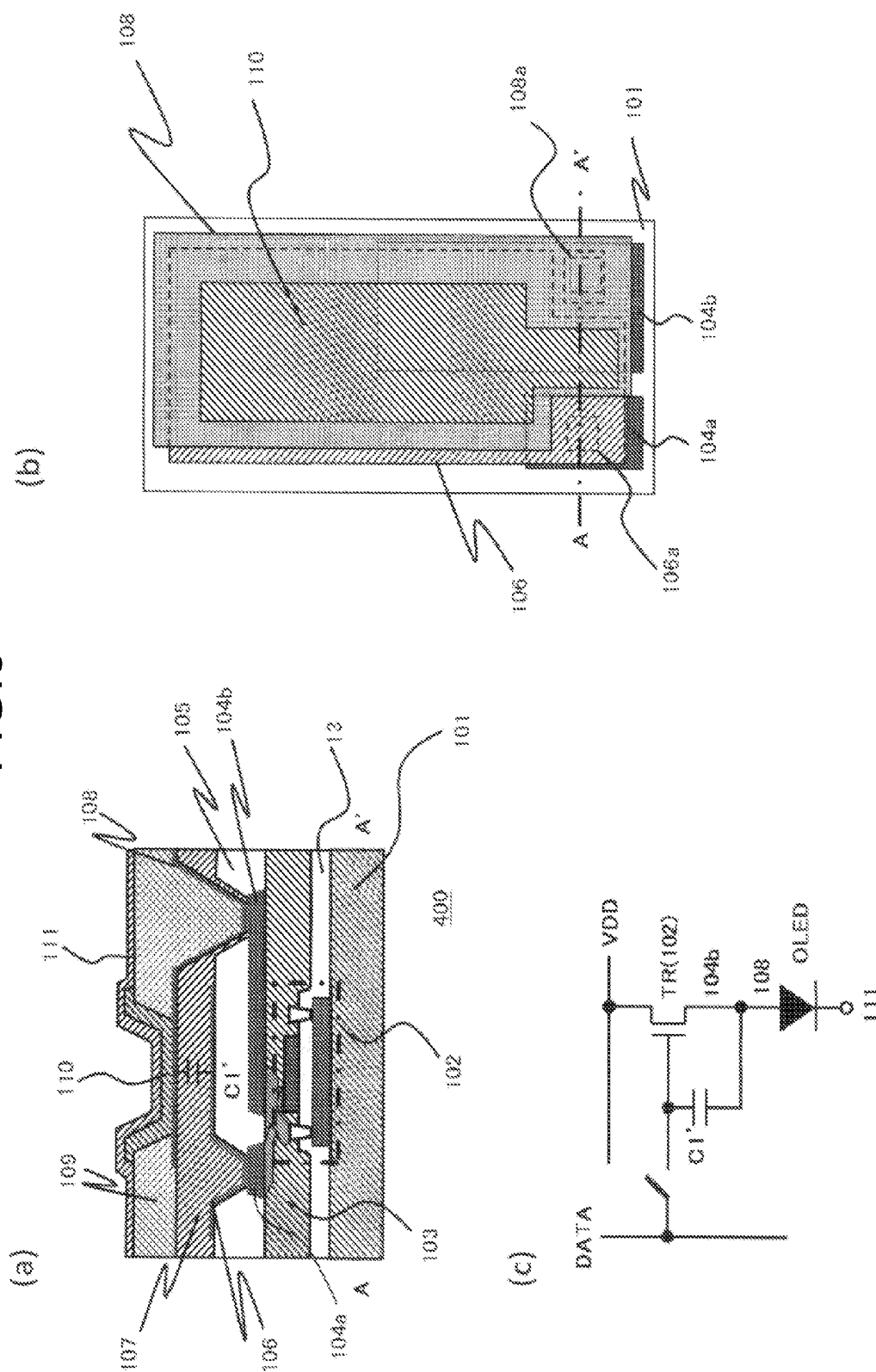


FIG. 7

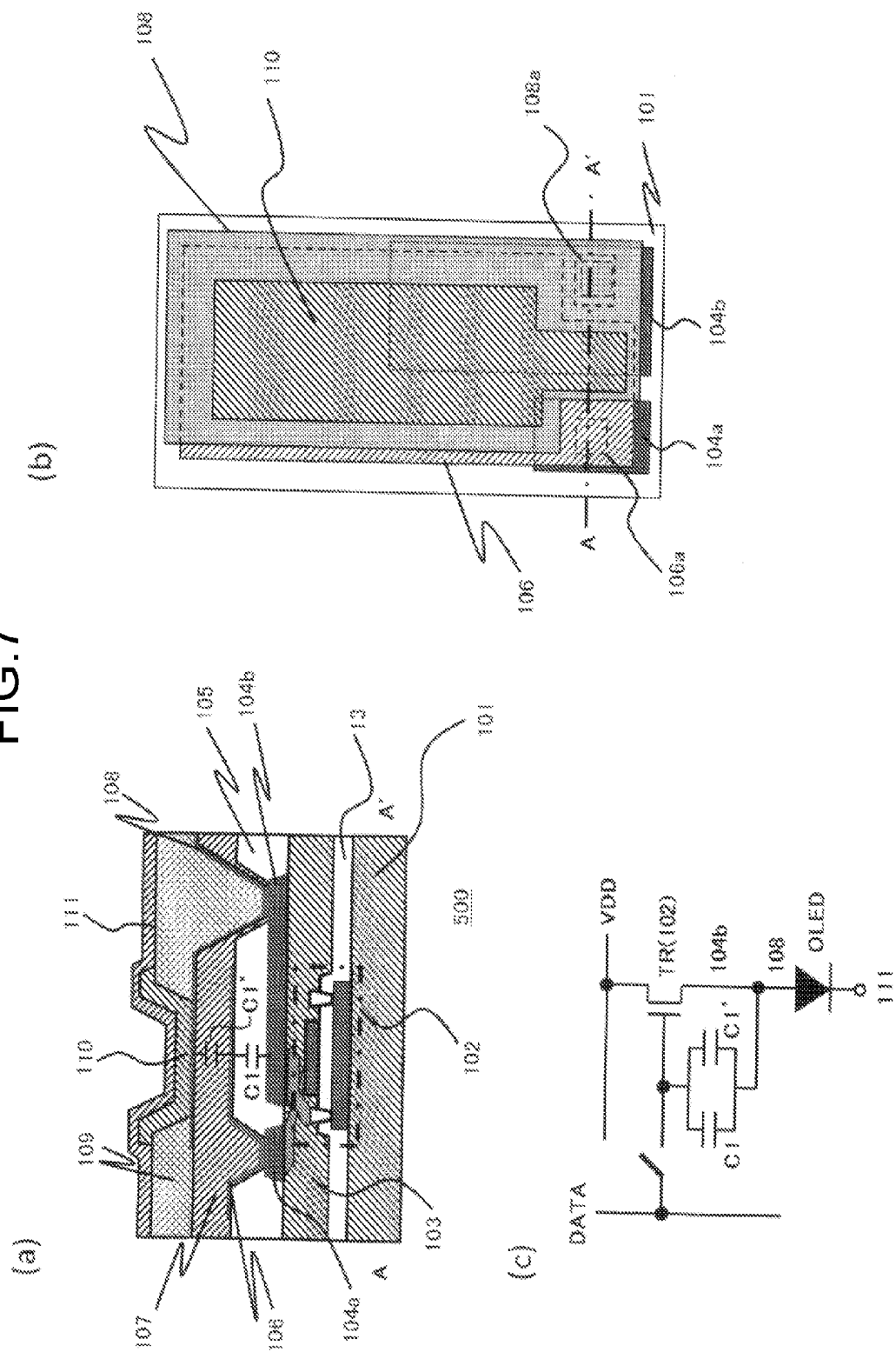
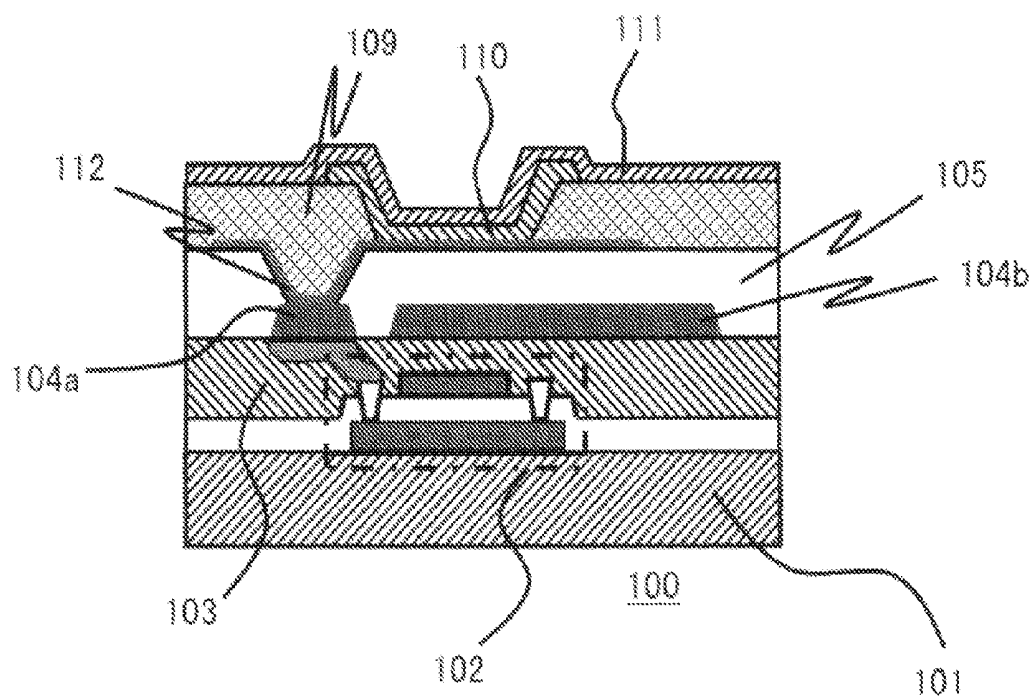


FIG.8



DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2013-101459, filed on 13 May 2013, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The present invention is related to a display device, in particular an organic EL display device with improved visual angle characteristics.

BACKGROUND

[0003] In recent years, various organic EL (electroluminescence) display devices are being actively developed (For example, refer to patent document 1 [Japanese Laid Open Patent 2006-32327]), patent document 2 [Japanese Laid Open Patent 2002-343555]).

[0004] In an organic EL display device which uses a thin film transistor (TFT), a top emission type organic EL element is widely used for extracting light from the cathode electrode side in order to increase the light emitting area.

[0005] In this top emission type organic EL element, micro cavity effects are produced by reflecting and interfering light emitted multiple times by a light emitting layer between an anode electrode (reflecting electrode) and cathode electrode. Due to micro cavity effects the emitted light spectrum width (full width half maximum) becomes steep and luminosity and color intensity increase (for example, refer to patent document 1 [Japanese Laid Open Patent 2006-32327]).

[0006] By making the light emitting spectrum width (full width half maximum) steep due to micro cavity effects and improving luminosity when seen from the front, the wavelength changes are large due to changes in the light path length which includes multiple reflected light rays when viewed from a diagonal direction. As a result, color variation increases with changes in the visual angle and visual angle characteristics deteriorate.

[0007] Therefore, the present invention aims to reduce micro cavity effects and reduce the visual angle variation in color by increasing the distance between a reflecting portion of the anode electrode side and the cathode side. Alternatively, the present invention aims to provide a display device in which a pixel capacitor can be formed which can store a necessary charge without securing a separate area by increasing the distance between a reflecting portion of an anode electrode and a cathode electrode.

SUMMARY

[0008] A display device according to one embodiment of the present invention including a plurality of pixels arranged in the shape of a matrix above a substrate, and a plurality of thin film transistors arranged corresponding to each of the plurality of pixel, the device including a planarized film covering the thin film transistor and a wire connected with the thin film transistor, a reflecting layer formed above the planarized film, a light path length expanded layer covering the reflecting layer, and a pixel transparent electrode formed above the light path length expanded layer, wherein the pixel includes an organic EL layer.

[0009] The reflecting layer may be connected to the wire and the pixel transparent electrode.

[0010] The reflecting layer may be connected to the wire and forms a capacitance.

[0011] The reflecting layer may be a floating electrode.

[0012] The reflecting layer and the pixel transparent electrode may be connected and form a capacitance.

[0013] The reflecting layer and the pixel transparent electrode may be connected and form a first capacitance, and the reflecting layer and the wire may be connected and form a second capacitance.

[0014] The light path length expanded layer may be formed from a resin such as acryl resin, polyimide resin or an Inorganic insulation film such as SiO₂, SiN.

[0015] The display device further includes an upper portion electrode, a distance between the upper portion electrode and the reflecting layer being 500 nm or more.

[0016] According to the present invention it is possible to reduce changes in a visual angle of colors by relieving micro cavity effects without adding any changes to an organic EL layer and cathode electrode in a conventional organic EL element and provide a display device in which a pixel capacitor can be formed which can store a charge necessary for stable image display without securing a separate area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a planar view diagram showing an approximate structure of a display device related to one embodiment of the present invention;

[0018] FIG. 2 is a diagram showing an approximate structure of a display device 100 related to one embodiment of the present invention;

[0019] FIG. 3 is a diagram showing an approximate structure of a display device 200 related to another embodiment of the present invention;

[0020] FIG. 4 is a diagram showing an approximate structure of a display device 300 related to another embodiment of the present invention;

[0021] FIG. 5 is a diagram showing an approximate structure of a display device 400 related to another embodiment of the present invention;

[0022] FIG. 6 is a diagram showing an approximate structure of a display device 500 related to another embodiment of the present invention;

[0023] FIG. 7 is a diagram showing an approximate structure of a thin film transistor 101b of the display device 100 related to one embodiment of the present invention; and

[0024] FIG. 8 is a diagram showing an approximate structure of a conventional display device.

DESCRIPTION OF THE EMBODIMENTS

[0025] The embodiments of the display device of the present invention are explained below while referring to the diagrams. Furthermore, the display device of the present invention can be realized by various modifications without limitation to the embodiments described below.

[0026] An approximate structure of a display device 100 related to one embodiment of the present invention is shown in FIG. 1. The display device 100 related to the present embodiment includes a display area 121, a driver IC 122, a FPC (Flexible Printer Circuit) 123 and a scanning line driver circuit 124 formed above a substrate 101. A plurality of control signal lines g1-1~g1-3 which run in a horizontal direction

in the diagram and a plurality of data signal lines d1~d3 which run in a vertical direction are arranged to alternately intersect each other in the display area 121, and a plurality of pixels 125 are arranged in the shape of a matrix at a position corresponding to a portion where the control signal lines g1-1~g1-3 and data signal lines d1~d3 intersect. Although, a structure whereby 3 control signal lines g1-1~g1-3 and 1 data signal line are arranged intersecting each other per single pixel 125 is shown in FIG. 1, the present invention is not limited to this structure. In addition, although not shown in the diagram, a line which supplies a fixed voltage such as a power supply line may also be arranged within the display area 121. By controlling programming of a data voltage supplied to each pixel 125 in response to a control signal supplied from the control signal lines g1-1~g1-3 to each pixel 125, a pixel circuit is arranged including a thin film transistor 102 which controls the light emitting from a pixel 125 and a condenser which stores a data voltage supplied from the data signal lines d1~d3.

[0027] Various embodiments with respect to a pixel circuit, a pixel 125 and layers there between in the display device of the present invention are explained below.

Embodiment One

[0028] FIG. 2 is a diagram shows an approximate structure of a display device 100 related to one embodiment of the present invention. FIG. 2 (b) is a planar view diagram of the display device 100 and FIG. 2 (a) is a cross sectional diagram along the line A-A' in FIG. 2 (b). FIG. 2 (c) is a circuit diagram of the display device 100.

[0029] The display device 100 is arranged with a thin film transistor 102 (inside the dotted line in the diagram), an interlayer insulation film 103, wires 104a and 104b, a planarized film 105, a reflecting layer 106, a light path length expanded layer 107, a pixel transparent electrode 108, a bank layer 109, an organic EL layer 110 and a cathode electrode 111 above a substrate 101.

[0030] The substrate 101 is formed from an insulation material such as glass for example but may also be formed from silicon. A passivation film (not shown in the diagram) which blocks impurities from the substrate 101 is formed above the substrate 101. The passivation film is formed from a silicon oxide film or silicon nitride film using a known technique (sputtering method, PCVD method, vacuum deposition method etc).

[0031] A semiconductor layer for forming the thin film transistor 102 is formed above the passivation film. The thin film transistor 102 is shown abbreviated in FIG. 2(a). One example of the structure of the thin film transistor is explained while referring to FIG. 3. The thin film transistor 102 described in FIG. 3 is a top-gate type thin film transistor. A passivation film 11 is formed above the substrate 101. A gate insulation film 13 is formed covering the semiconductor layer 12. A gate electrode 14 is formed above the gate insulation film 13. A contact hole is formed to reach the semiconductor layer 12, and a drain electrode 15 which is connected with a drain region of the semiconductor layer 12, and a source electrode 16 which is connected with a source region of the semiconductor layer are formed. Furthermore, the thin film transistor 102 may have a different structure than that shown in FIG. 3, for example, the thin film transistor 102 may also be a bottom-gate type thin film transistor.

[0032] An interlayer insulation film 103 is formed covering the gate electrode of the thin film transistor 102 and wires 104a and 104b are formed above the interlayer insulation film

103. In this specification, the wires 104a and 104b are referred to as a source wire which is connected with the source region of the semiconductor layer 12 of the thin film transistor 102, and a drain wire which is connected with the drain region of the semiconductor layer 12. In FIG. 2, the wire 104a is connected with a drain region via the drain electrode 15.

[0033] Furthermore, although not shown in the diagram, a passivation film for protecting the entire thin film transistor 102 may be formed covering the wires 104a, 104b.

[0034] The planarized film 105 is formed covering all of the wires 104a, 104b and the thin film transistor 102. The planarized film 105 is formed from acryl resin or polyimide resin to a thickness of several hundreds of nm to several μm .

[0035] The reflecting film 106 is formed above the planarized film 105. The reflecting film 106 reflects light and may be formed from gold or Ag, Al or an alloy of these. The reflecting film 106 is connected with the wire 104a via the contact hole 106a.

[0036] The light path length expanded film 107 is formed covering the reflecting film 106. The material of the light path length expanded film 107 may be acryl resin or polyimide resin the same as the planarized film 105 or a non-organic insulation film such as SiO or SiN. By adjusting the thickness of the light path length expanded film 107, it is possible to adjust the distance between the reflecting layer 106 and each structure above the reflecting layer 106. In this way, as described below, it is possible to adjust the distance between the reflecting layer 106 and the cathode electrode 111 and relieve micro cavity effects.

[0037] The pixel transparent electrode 108 is formed above the light path length expanded film 107. The pixel transparent electrode 108 is formed from an inorganic transparent oxide such as ITO and is transparent. The pixel transparent electrode 108 is connected with the reflecting film 106 via the contact hole 108a. The bank layer 109 is formed at a position which separates the pixel electrode transparent electrode 108 of adjacent pixels.

[0038] The organic EL layer 110 and the cathode electrode 111 as an upper part electrode are formed above the pixel transparent electrode 108. In the present embodiment, an organic EL element of the pixel 125 is formed including the pixel transparent electrode 108, organic EL layer 110 and cathode electrode 111. The pixel transparent electrode 108 is an anode electrode in an organic EL element. An inorganic transparent oxide of Ag or ITO sufficiently thin to allow light to pass through is used in the cathode electrode 111 and the cathode electrode 111 allows light to pass through.

[0039] A current path for an organic EL element in the present embodiment flows to the pixel transparent electrode 108 from the thin film transistor 102 via the wire 104a and reflecting layer 106 as shown in FIG. 2 (c). That is, a current is supplied from the thin film transistor 102 to the pixel transparent electrode 108 via the wire 104a and reflecting layer 106 in response to a data signal and by supplying the current to the organic EL layer 110, the organic layer 110 emits light and an image is formed.

[0040] An organic EL element in the present embodiment has a top-cathode structure comprised of an anode formed by the pixel transparent electrode 108 which is formed on the lower portion of the organic EL layer 110 and a cathode formed by the cathode electrode 111 which is formed on the upper portion of the organic EL layer 110. In the display device 100, the reflecting layer 106 reflects light from the

organic EL layer 110 and the light from the organic EL layer 110 is extracted from the direction of the cathode electrode 111. That is, the display device 100 is a top-emission type organic EL display device. Furthermore, the structure of the organic EL element can be formed using a known technology such as side-by-side RGB sub-pixel and a structure combining a color filter with a white light emitting layer may also be applied.

[0041] Light which is emitted towards the lower portion of the organic EL layer 110 passes through the pixel transparent electrode 108 and is reflected to the lower portion by the reflecting layer 106.

[0042] The light path length expanded layer 107 is arranged in the display device 100 in the present embodiment, the reflecting layer 110 and the pixel transparent electrode 108 are formed on different layers and an intermediate layer is formed between the reflecting layer 106 and the pixel transparent electrode 108, thereby the distance between the cathode electrode 111 and the reflecting layer 106 can be increased without changing the distance between the pixel transparent electrode 108, organic EL layer 110, cathode electrode 111 and the reflecting layer 106. It is possible to widen a light emitting region by arranging a contact hole 106a formed in the planarized film 105 and the contact hole 108a formed in the light path length expanded layer 107 at the same position seen from a planar view. In the present embodiment, the contact hole 106a formed in the planarized film 105 and the contact hole 108a formed in the light path length expanded layer 107 are arranged at different positions seen from a planar view as in FIG. 2 (b). By misaligning the arrangement of the contact hole 106a and the contact hole 108a, it is possible to easily planarize the upper layer portion of the stacked layers. In addition, manufacture becomes easy because it is unnecessary to align the contact hole 106a and contact hole 108a.

[0043] In a conventional display device, as is shown in FIG. 8, a structure corresponding to the reflecting layer 106 and pixel transparent electrode 108 forms a single reflecting electrode 112. As a result, there is no room for arranging a structure such as the light path length expanded layer 107 and it is necessary to change the thickness of the organic EL layer in order to change the distance between the reflecting electrode and cathode electrode which makes control of light emitting characteristics difficult.

[0044] In the present embodiment, the structure corresponding to the conventional reflecting electrode 112 shown in FIG. 8 is divided into two structures, the reflecting layer 106 and pixel transparent electrode 108. In the present embodiment, by increasing the distance between the cathode electrode 111 and the reflecting layer 106, it is possible to relieve micro cavity effects. Preferably, when the distance between the cathode electrode 111 and the reflecting layer 106 is increased to 500 nm or more, it is possible to relieve micro cavity effects in the visible light region (380 nm~780 nm). In the present embodiment, by arranging the light path length expanded layer 107 and adjusting its thickness, it is possible to increase the distance between the cathode electrode 111 and the reflecting layer 106 to 500 nm or more.

[0045] In this way, the display device 100 of the present embodiment which is a top emission type organic EL display device can be provided with excellent control of light emitting characteristics and improved visual angle characteristics without adding any changes to an organic EL layer or cathode electrode.

Embodiment Two

[0046] Next, the structure of a display device 200 related to another embodiment of the present invention is explained while referring to FIG. 4 (a), FIG. 4 (b) and FIG. 4 (c). FIG. 4 is a diagram showing an approximate structure of the display device related to another embodiment of the present invention. FIG. 4 (a) is a planar view diagram of the display device 200, FIG. 4 (b) is a cross sectional diagram along the line A-A' in FIG. 4 (b). FIG. 4 (c) is a circuit diagram in the display device 200.

[0047] Although the display device 200 in FIG. 4 (a) is almost the same structure as the display device 100 explained referring to FIG. 2 (a), the reflecting layer 106 is different by forming a capacitance C1 between the thin film transistor 102 and gate electrode 14. In the present embodiment the capacitance C1 is formed by thinning the planarized film 105.

[0048] That is, by applying a voltage to the reflecting layer 106 with the same potential as the pixel transparent electrode 108, it is possible to form the capacitance C1 between the reflecting layer 106 and the gate electrode 14 of the thin film transistor 102. In this way it is possible to form a pixel capacitor which can store a charge necessary for a stable pixel display without securing further area for formation a separate capacitor.

Embodiment Three

[0049] Next, the structure of a display device 300 related to another embodiment of the present invention is explained while referring to FIG. 5 (a), FIG. 5 (b) and FIG. 5 (c). FIG. 5 (a) is a diagram showing an approximate structure of the display device 300 related to another embodiment of the present invention. FIG. 5 (b) is a planar view diagram of the display device 300, FIG. 5 (a) is a cross sectional view along the line A-A' in FIG. 5 (b) and FIG. 5 (c) is a circuit diagram in the display device 300.

[0050] Although the display device 300 in FIG. 5 (a) has almost the same structure as the display device 100 explained while referring to FIG. 2 (a), in the present embodiment the reflecting layer 106 is made into a floating electrode without being connected to the wire 104a, and the pixel transparent electrode 108 is connected to the wire 104b via the contact hole 108a formed in the light path length expanded layer 107 and planarized film 105.

[0051] A current path for an organic EL element in the present embodiment becomes the pixel transparent electrode 108 from the thin film transistor 102 via the wire 104b as shown in FIG. 5 (c). That is, a current is supplied from the thin film transistor 102 to the pixel transparent electrode 108 via the wire 104b in response to a data signal and by supplying the current to the organic EL layer 110, the organic layer 110 emits light and an image is formed.

[0052] The material of the light path length expanded layer 107 in the display device 300 shown in FIG. 5 (a) is not limited to an insulator but may be a conductor unlike the display device 100 shown in FIG. 2 (a).

[0053] By making the reflecting layer in a floating state or an electrode with a different potential to a wire back layer, it is possible to cover parasitic capacitance coupling between pixel operation and ON/OFF of an organic EL element light emittance and stabilize operation of the display device 300. In addition, since positional restriction other than current extraction from the pixel transparent electrode 108 is not received,

each structure of the display device **300** has an increased level of arrangement freedom and increased aperture formation becomes possible.

Embodiment Four

[0054] Next, the structure of a display device **400** related to another embodiment of the present invention is explained while referring to FIG. **6 (a)**, FIG. **6 (b)** and FIG. **6 (c)**. FIG. **6 (a)** is a diagram showing an approximate structure of the display device **400** related to another embodiment of the present invention. FIG. **6 (a)** is a planar view diagram of the display device **400**, FIG. **6 (b)** is a cross sectional view along the line A-A' in FIG. **6 (a)** and FIG. **6 (c)** is a circuit diagram in the display device **400**.

[0055] Although the display device **400** in FIG. **6 (a)** has almost the same structure as the display device **100** explained while referring to FIG. **2 (a)**, the pixel transparent electrode **108** is connected with the wire **104b** via the contact hole **108a** formed in the light path length expanded layer **107** and planarized film **105**, capacitance **C1'** is formed between the reflecting layer **106** and pixel transparent electrode **108**, and the reflecting layer **106** and pixel transparent electrode **108** are combined.

[0056] That is, the reflecting layer **106** continues to be connected with the wire **104a**, made independent from the pixel transparent electrode **108**, and by applying a voltage it is possible to form capacitance **C1'** between the reflecting layer **106** and the pixel transparent electrode **108**. In this way, it is possible to form pixel capacitance which can store a charge necessary for stable image display without securing a separate area.

[0057] A current path for an organic EL element in the present embodiment becomes the pixel transparent electrode **108** from the thin film transistor **102** via the wire **104b** as shown in FIG. **6 (c)**. That is, a current is supplied from the thin film transistor **102** to the pixel transparent electrode **108** via the wire **104b** in response to a data signal and by supplying the current to the organic EL layer **110**, the organic layer **110** emits light and an image is formed.

Embodiment Five

[0058] Next, the structure of a display device **500** related to another embodiment of the present invention is explained while referring to FIG. **7 (a)**, FIG. **7 (b)** and FIG. **7 (c)**. FIG. **7 (a)** is a diagram showing an approximate structure of the display device **500** related to another embodiment of the present invention. FIG. **7 (a)** is a planar view diagram of the display device **500**, FIG. **7 (b)** is a cross sectional view along the line A-A' in FIG. **7 (a)** and FIG. **7 (c)** is a circuit diagram in the display device **500**.

[0059] Although the display device **500** in FIG. **7 (a)** has almost the same structure as the display device **400** explained while referring to FIG. **5 (a)**, a capacitance **C1'** is further formed between the reflecting layer **106** and the thin film transistor **102** which is a structure combining the second embodiment and fourth embodiment.

[0060] That is, the reflecting layer **106** continues to be connected with the wire **104a**, made independent from the pixel transparent electrode **108**, and by applying a voltage it is possible to form capacitance **C1'** between the reflecting layer **106** and the pixel transparent electrode **108**. That is, the

reflecting layer **106** and the pixel transparent electrode **107** are combined to form a capacitor electrode. Furthermore, a capacitance **C1** is formed between the reflecting layer **106** and an electrode of the thin film transistor **102**. In this way, it is possible to form pixel capacitance which can store a charge necessary for stable image display without securing a separate area. In addition, it is possible to secure a larger capacitance by combining the capacitance **C1** and **C1'**.

[0061] A current path for an organic EL element in the present embodiment becomes the pixel transparent electrode **108** from the thin film transistor **102** via the wire **104b** as shown in FIG. **7 (c)**. That is, a current is supplied from the thin film transistor **102** to the pixel transparent electrode **108** via the wire **104b** in response to a data signal and by supplying the current to the organic EL layer **110**, the organic layer **110** emits light and an image is formed.

[0062] As described above, in the present invention it is possible to reduce changes in a visual angle of colors by relieving micro cavity effects without adding any changes to an organic EL layer and cathode electrode in a conventional organic EL element and provide a display device in which a pixel capacitor can be formed which can store a charge necessary for stable image display without securing a separate area.

What is claimed is:

1. A display device comprising including a plurality of pixels arranged in the shape of a matrix above a substrate, and a plurality of thin film transistors arranged corresponding to each of the plurality of pixel having an organic EL layer, the device comprising;

- a planarized film covering the thin film transistor and a wire connected with the thin film transistor;
- a reflecting layer formed above the planarized film;
- a light path length expanded layer covering the reflecting layer; and
- a pixel transparent electrode formed above the light path length expanded layer.

2. The display device according to claim 1, wherein the reflecting layer is connected to the wire and the pixel transparent electrode.

3. The display device according to claim 2, wherein the reflecting layer is connected to the wire and forms a capacitance

4. The display device according to claim 1, wherein the reflecting layer is a floating electrode.

5. The display device according to claim 1, wherein the reflecting layer and the pixel transparent electrode are connected and form a capacitance.

6. The display device according to claim 1, wherein the reflecting layer and the pixel transparent electrode are connected and form a first capacitance, and the reflecting layer and the wire are connected and form a second capacitance.

7. The display device according to claim 1, wherein the light path length expanded layer is formed from a resin such as acryl resin, polyimide resin or an inorganic insulation film such as SiO₂, SiN.

8. The display device according to claim 1, further comprising:

- an upper portion electrode, a distance between the upper portion electrode and the reflecting layer being 500 nm or more.

* * * * *

专利名称(译)	显示设备		
公开(公告)号	US20140332781A1	公开(公告)日	2014-11-13
申请号	US14/275915	申请日	2014-05-13
[标]申请(专利权)人(译)	株式会社日本显示器		
申请(专利权)人(译)	日本展示INC.		
当前申请(专利权)人(译)	日本展示INC.		
[标]发明人	TOKUDA NAOKI MIYAMOTO MITSUhide		
发明人	TOKUDA, NAOKI MIYAMOTO, MITSUhide		
IPC分类号	H01L27/32 H01L51/50		
CPC分类号	H01L27/3265 H01L51/5012 H01L27/3258 H01L51/5265 H01L51/5271 H01L2251/5315		
优先权	2013101459 2013-05-13 JP		
其他公开文献	US9391129		
外部链接	Espacenet USPTO		

摘要(译)

一种显示装置，包括：多个像素，以矩阵形状排列在基板上方；以及多个薄膜晶体管，对应于所述多个像素中的每一个，具有有机EL层，所述装置包括：覆盖薄膜晶体管的平面化膜和与薄膜晶体管连接的导线；形成在平坦化膜上方的反射层；覆盖反射层的光程长度扩展层；形成在光路长度扩展层上方的像素透明电极。

