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Kimura et al.

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(54) **DISPLAY DEVICE**

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H01L 27/32 (2006.01)
G09G 3/30 (2006.01)

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

CPC ***H01L 51/5203*** (2013.01); ***G09G 3/30*** (2013.01); ***H01L 27/3209*** (2013.01); ***H01L 27/3248*** (2013.01); ***H01L 27/3258*** (2013.01); ***H01L 27/3276*** (2013.01); *G09G 2310/0264* (2013.01); *H01L 27/3265* (2013.01); *H01L 51/5237* (2013.01); *H01L 2251/303* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

A display device includes a thin film transistor; a first organic insulating film covering the thin film transistor and containing a resin material; an inorganic insulating film on the first organic insulating film; a pixel electrode electrically connected with the thin film transistor; a second organic insulating film covering an end of the pixel electrode and exposing a top surface of the pixel electrode; and an organic layer provided on the top surface of the pixel electrode and including a light emitting layer. As seen in a plan view, the inorganic insulating film has an opening, overlapping the second organic insulating film, at a position not overlapping an opening provided in the first organic insulating film. The first and second organic insulating films face each other in the opening in the inorganic insulating film, with an oxide conductive film being between the first and second organic insulating films.

10 Claims, 16 Drawing Sheets

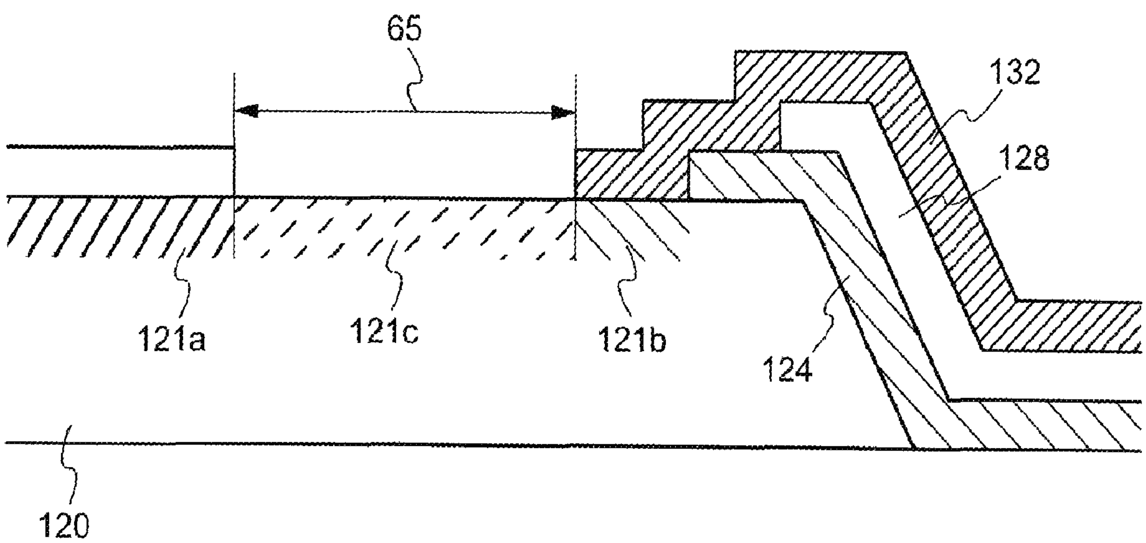


FIG.1

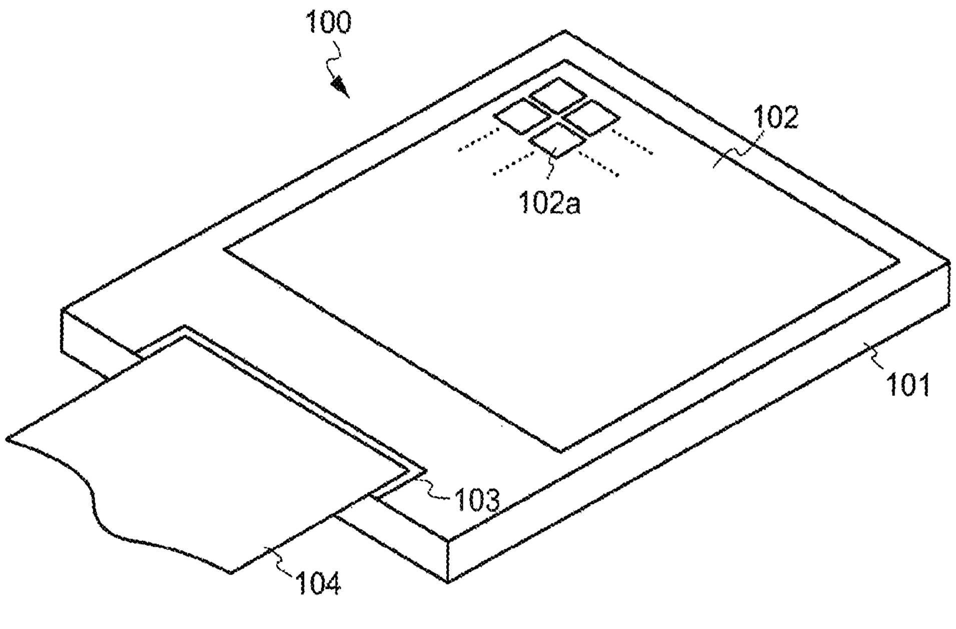


FIG.2

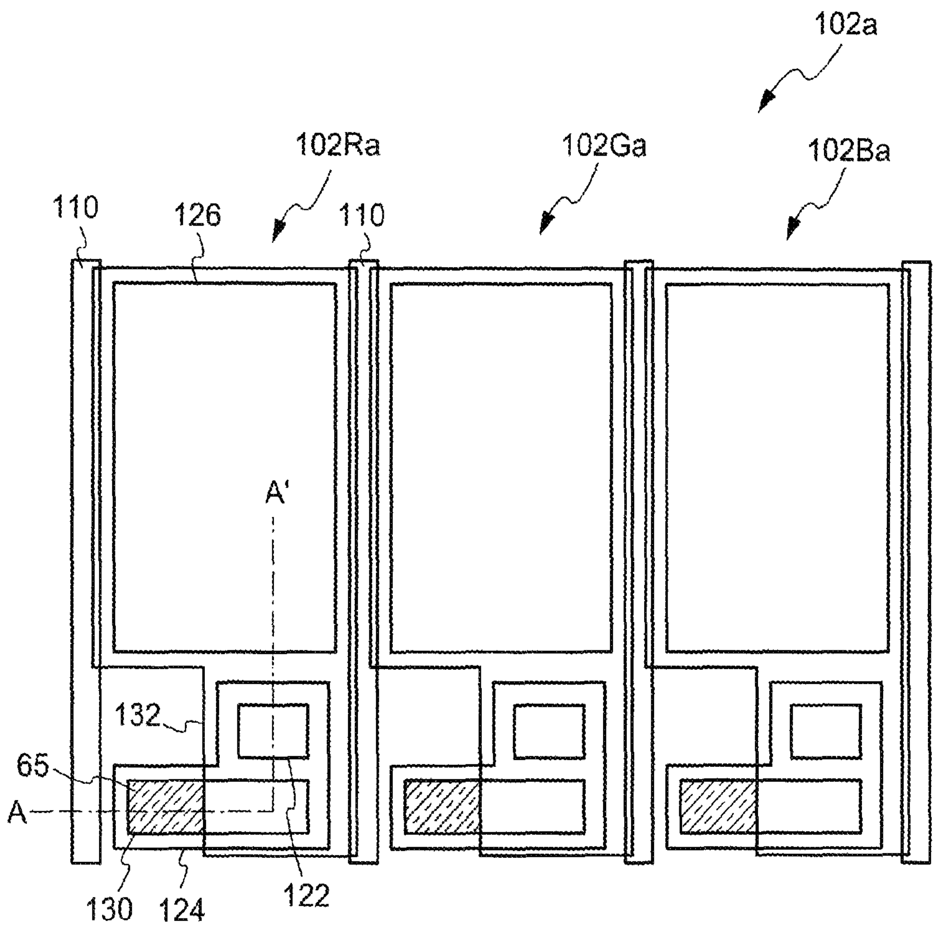


FIG.3

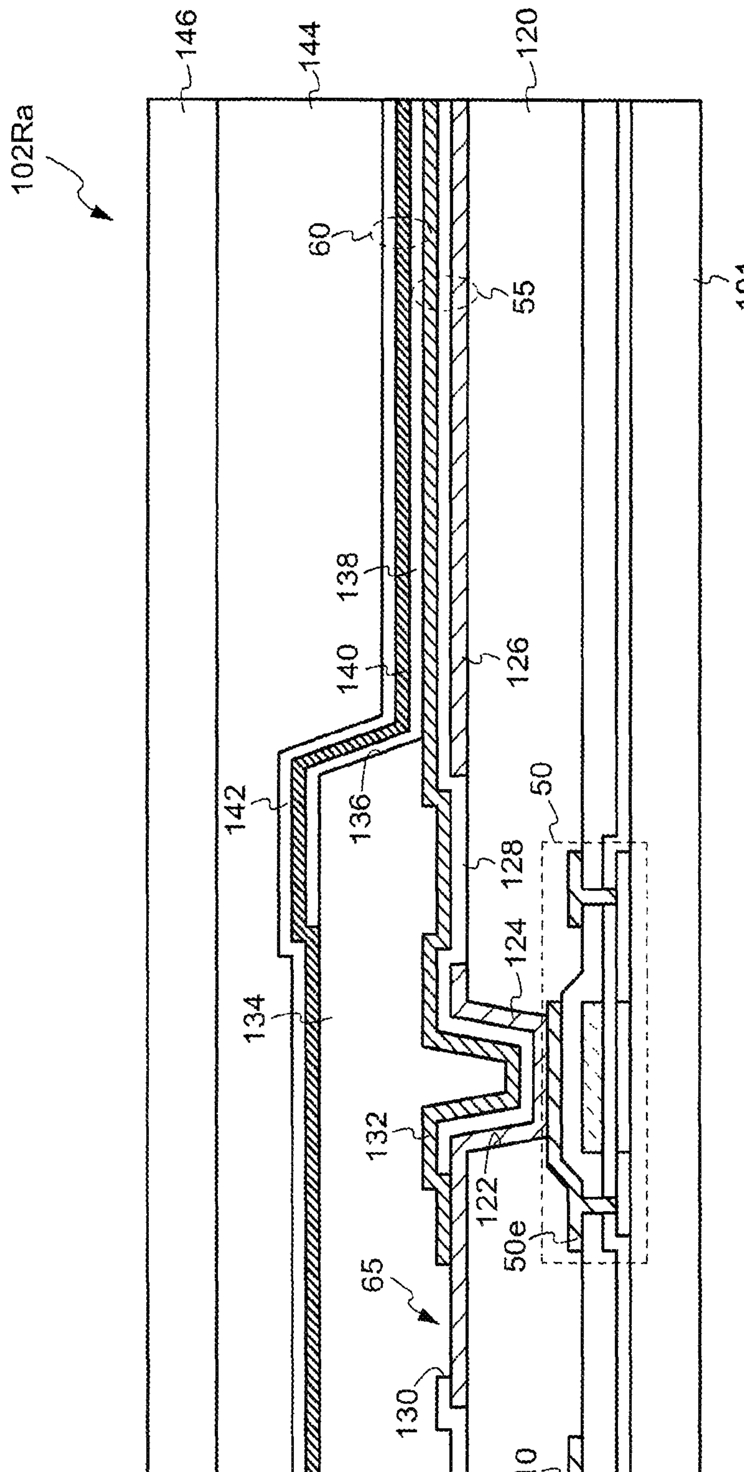

102Ra
146
144
120
60
55
101
138
140
126
142
136
50
128
124
134
132
122
50e
65
130
110

FIG. 4A

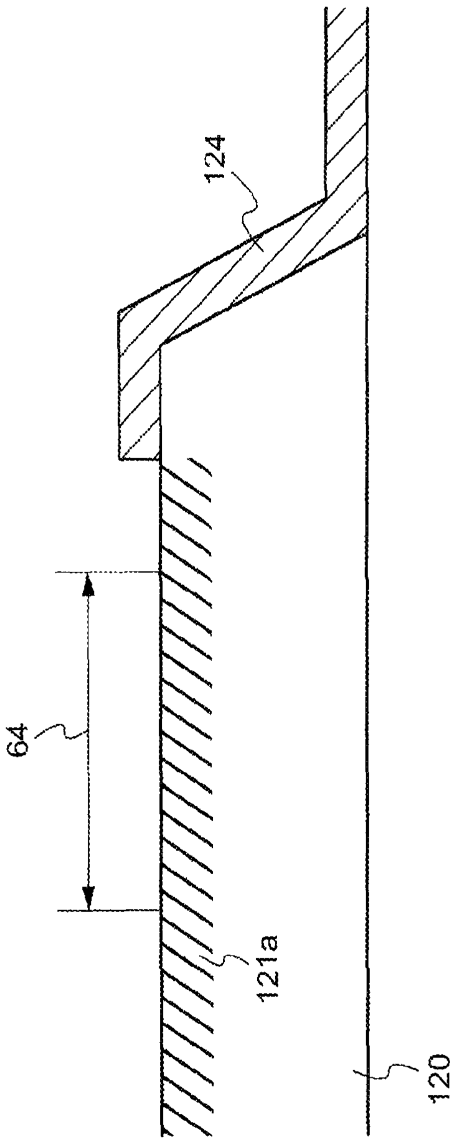


FIG. 4B

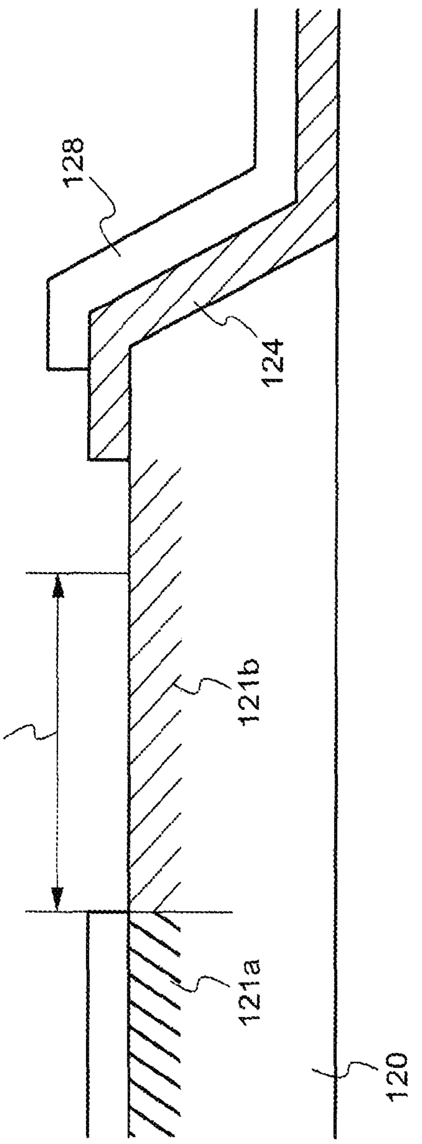


FIG.4C

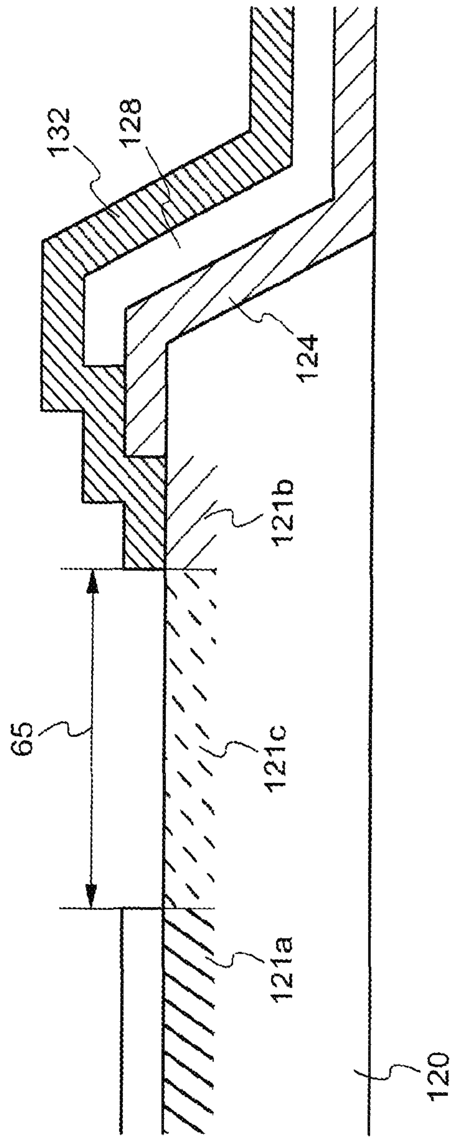


FIG.5A

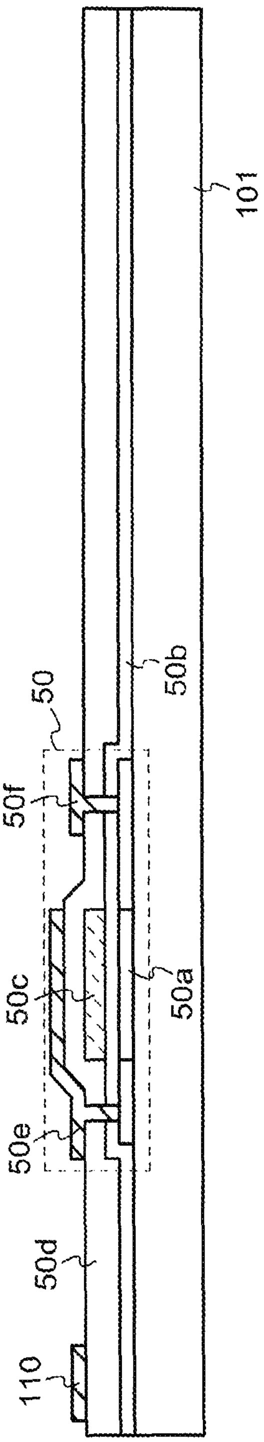
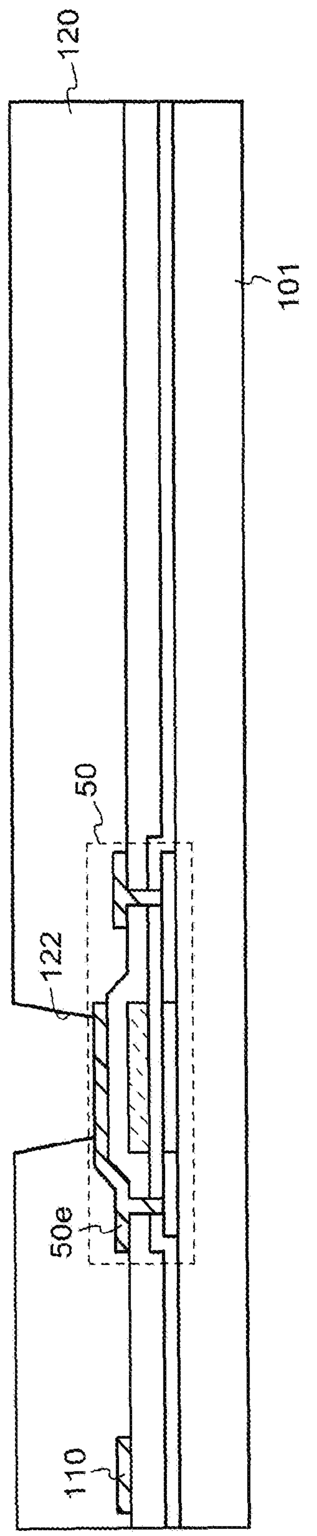


FIG.5B



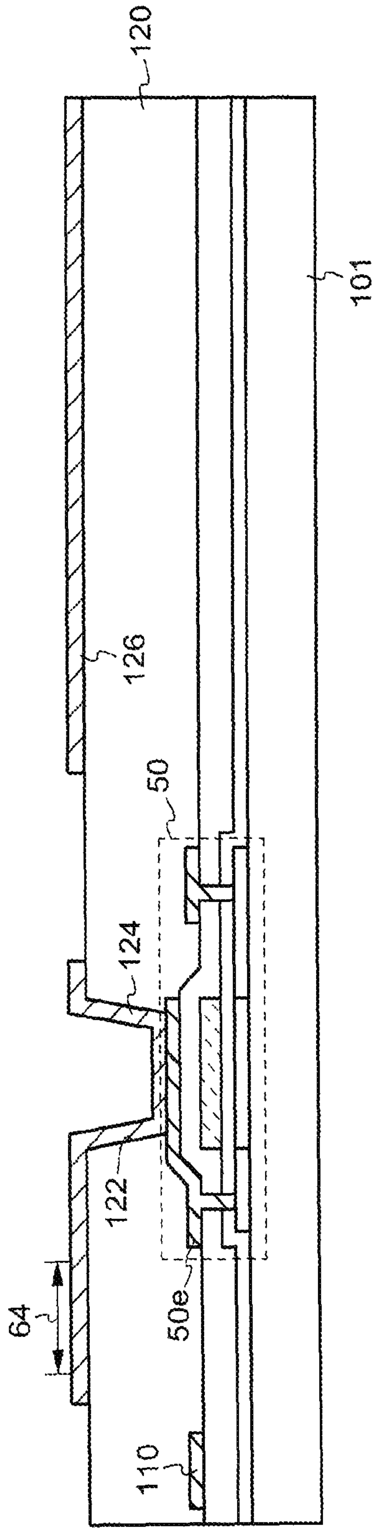
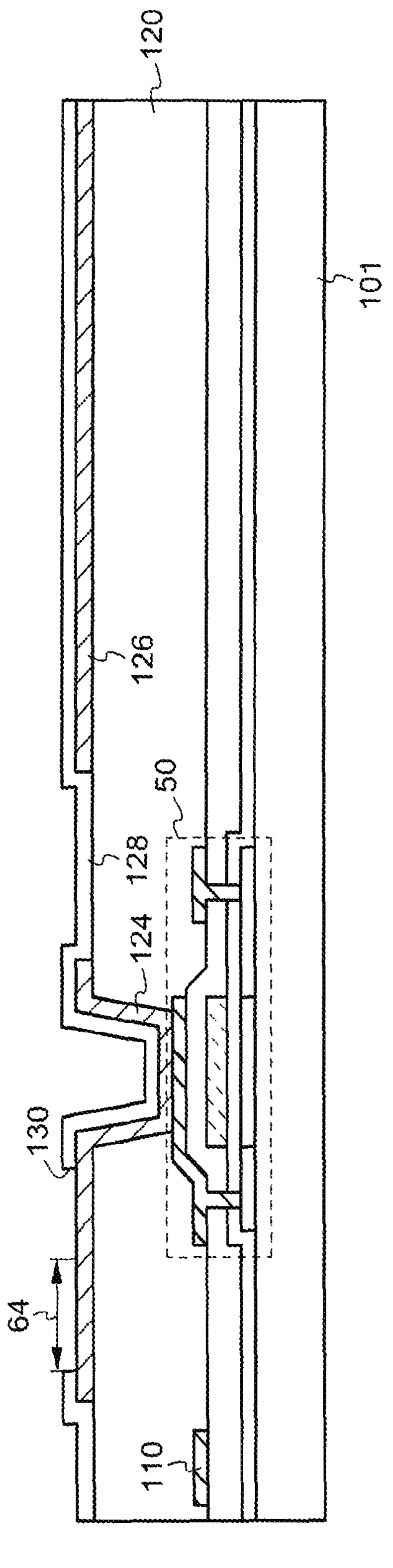


FIG.5C

FIG.5D



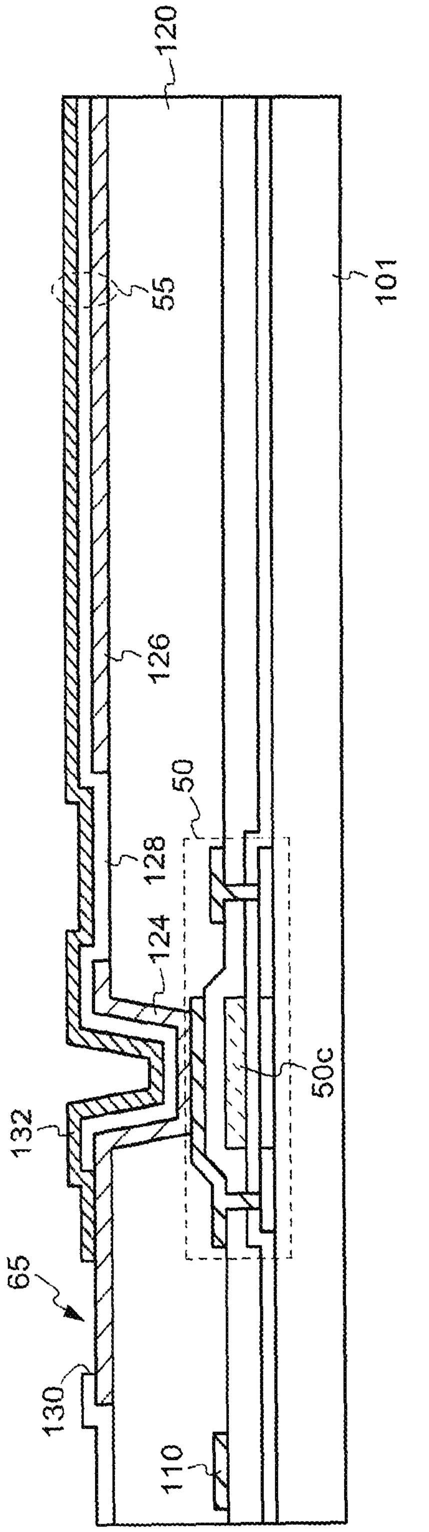


FIG.5E

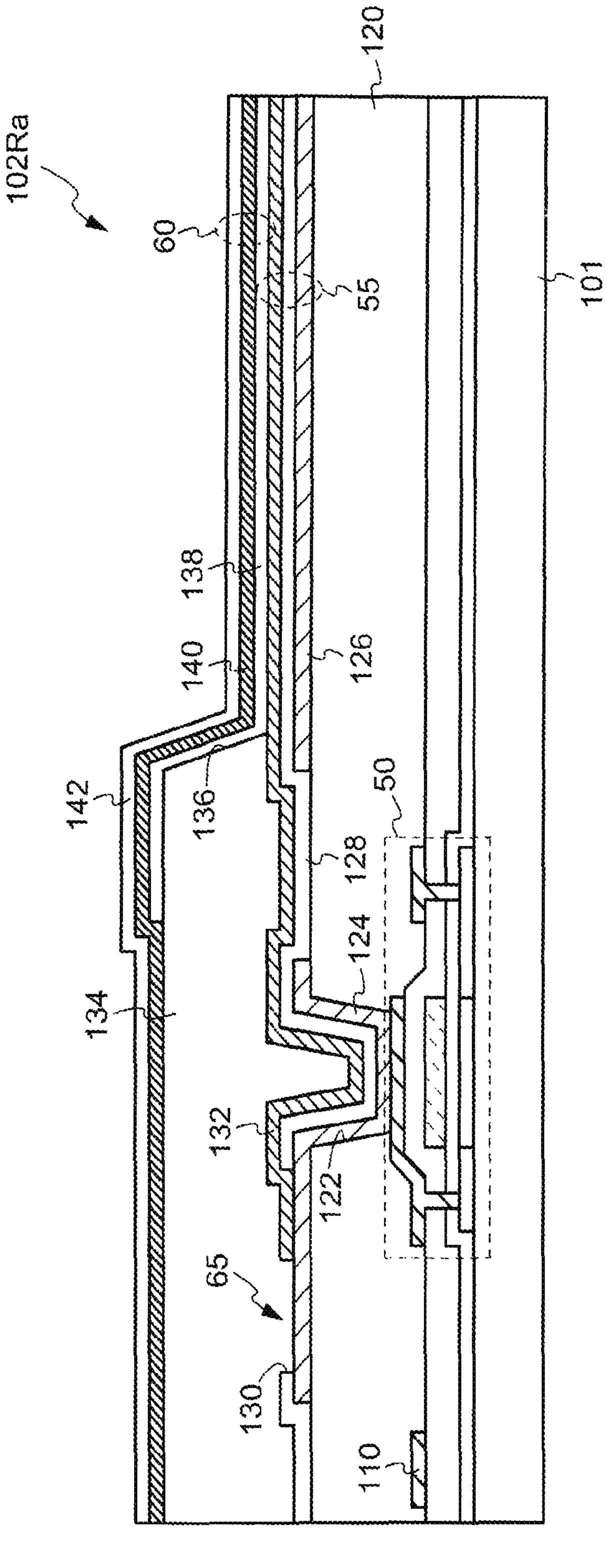

120
102Ra
60
55
101
138
140
126
142
136
50
128
124
134
132
122
65
130
110

FIG.5F

FIG.6

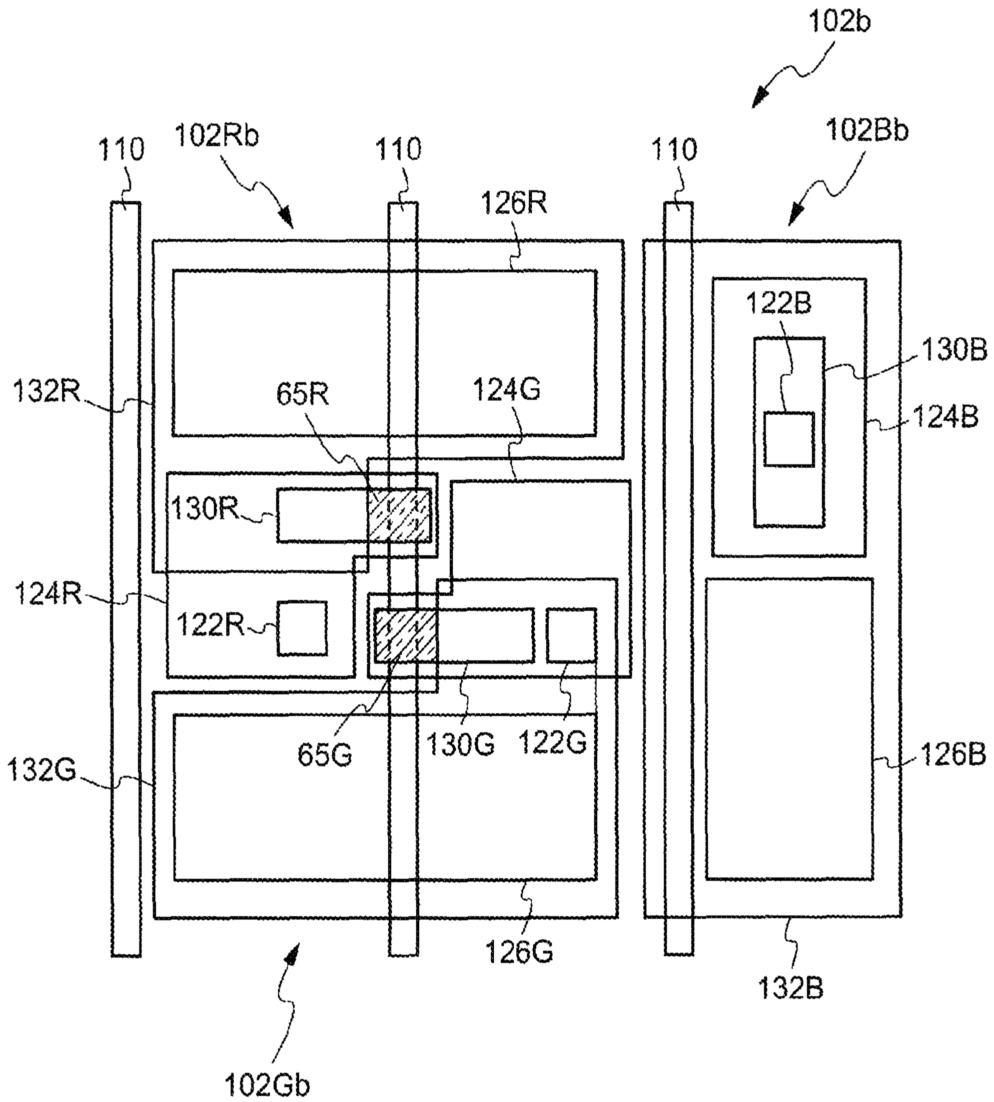

102b
110
102Rb
110
110
102Bb
126R
122B
130B
132R
65R
124G
124B
130R
124R
122R
65G
130G
122G
132G
126B
126G
132B
102Gb

FIG. 7

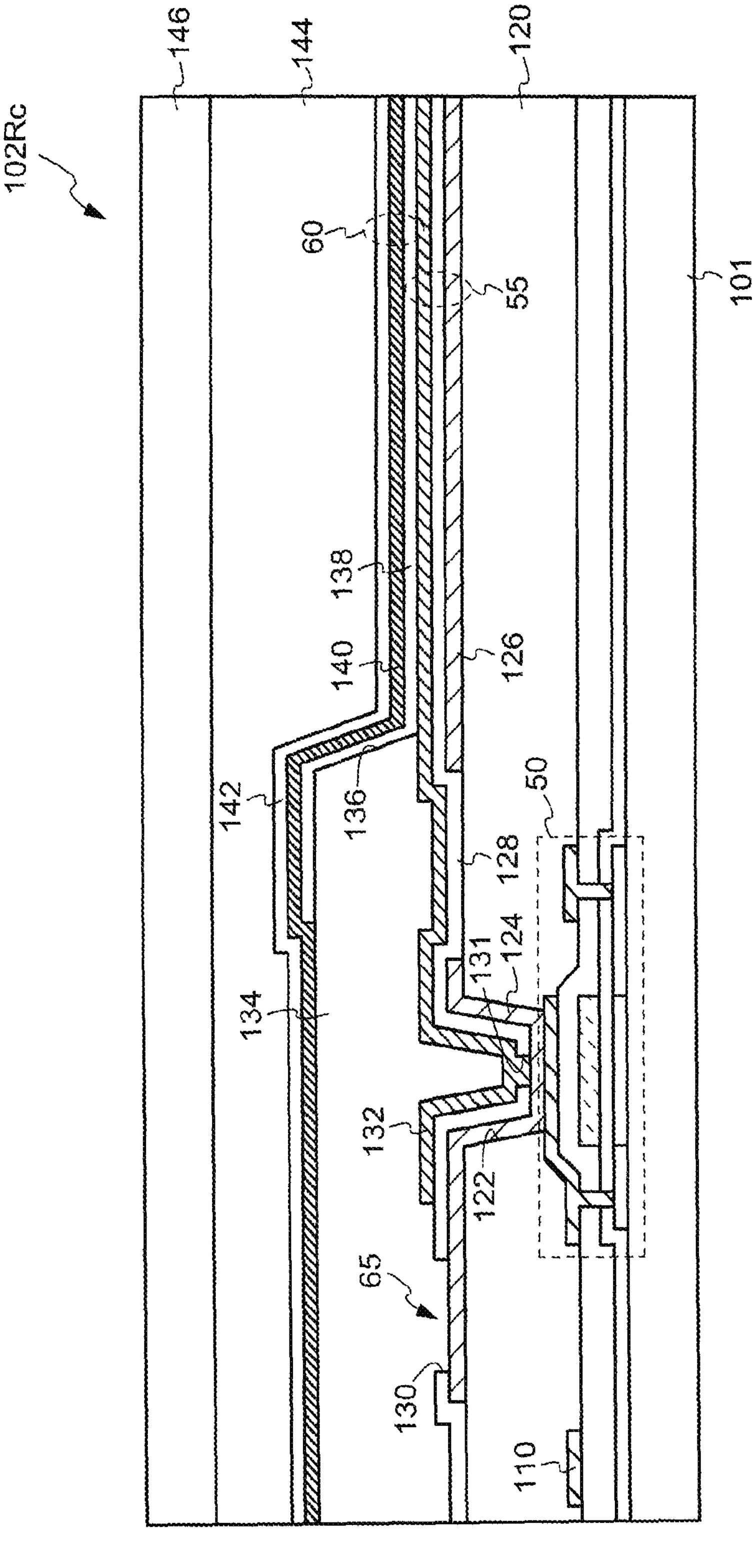
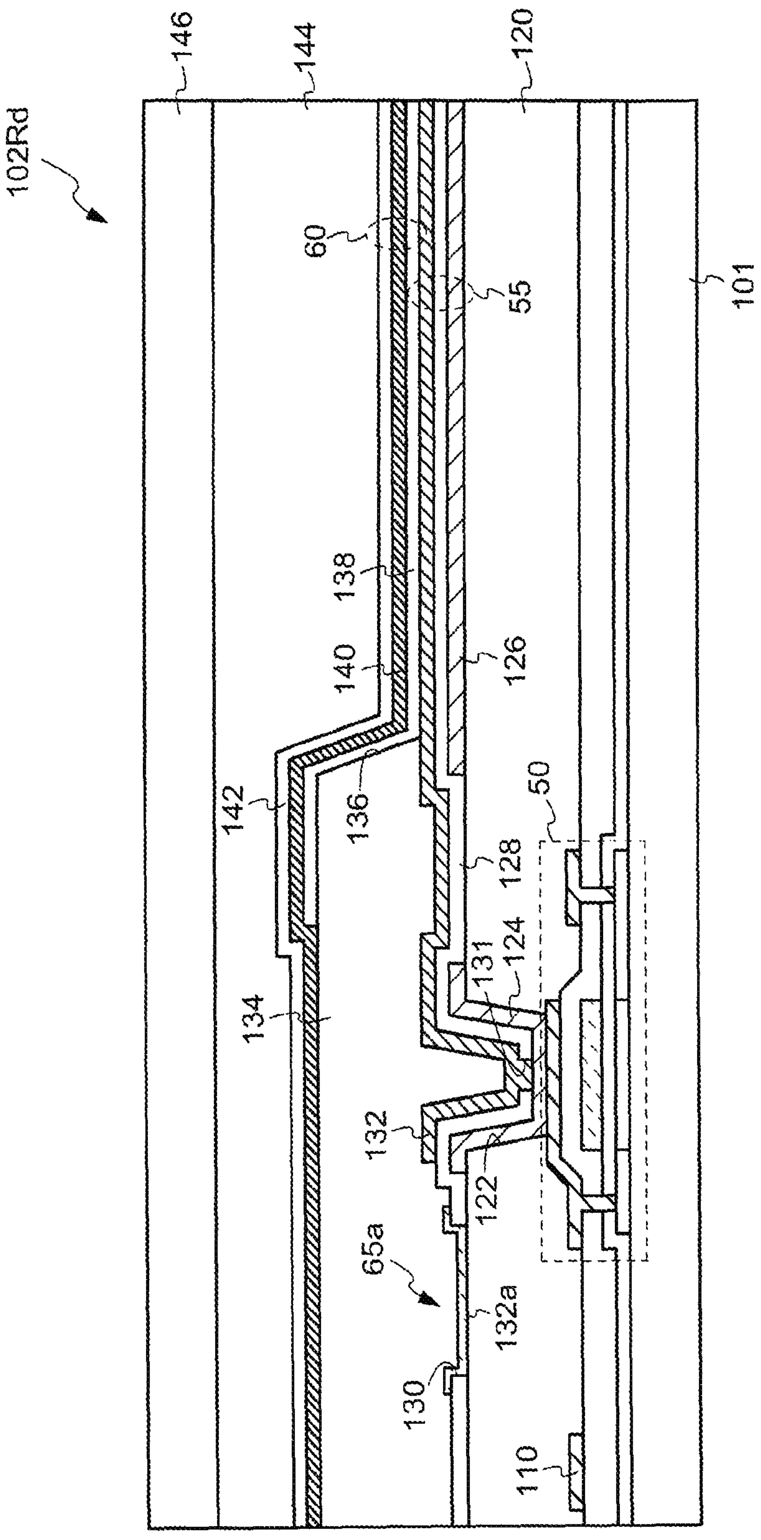
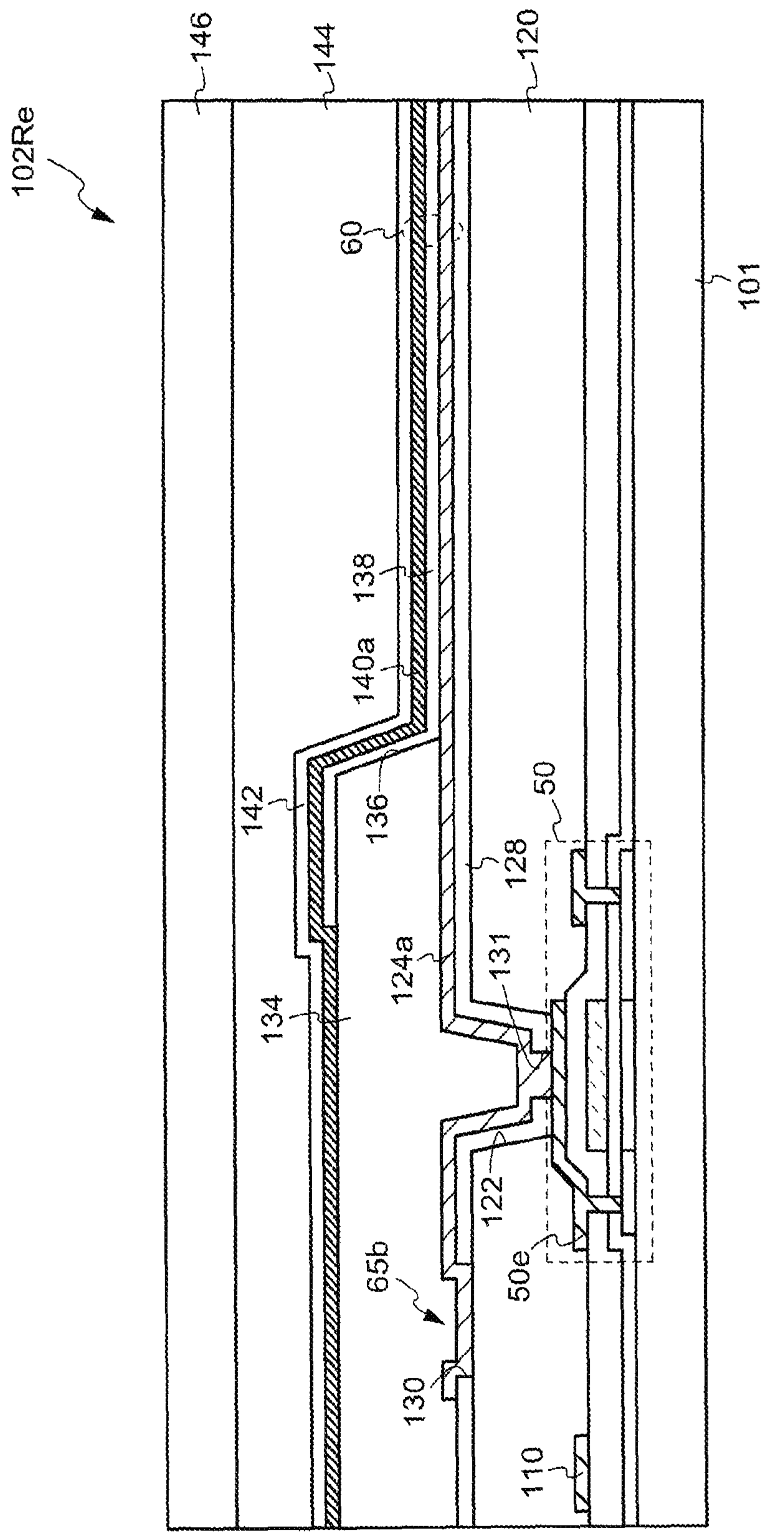

102Rc
146
144
120
60
55
101
138
140
126
142
136
50
128
124
131
134
132
122
65
130
110

FIG.8



146
144
120
102Rd
60
55
101
138
140
126
142
136
50
128
124
131
134
132
122
65a
132a
130
110

FIG.9


146
144
120
102Re
60
101
138
140a
142
136
50
128
124a
131
134
122
65b
50e
130
110

DISPLAY DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based on and claims the benefit of priority from the prior Japanese Patent Application No. 2017-002282, filed on Jan. 11, 2017, the entire contents of which are incorporated herein by reference.

FIELD

The present invention relates to a display device including a plurality of pixels, and specifically, to a display device including a light emitting element in each of the pixels.

BACKGROUND

Conventionally, as a display device usable for a display of a mobile terminal, a TV or the like, an organic EL (electroluminescence) display device including an organic EL element is known. An organic EL display device has advantages of emitting bright light, having superb viewing angle characteristics, and the like, and thus rapid development thereof is desired to provide a display device replacing a liquid crystal display device.

Usually, an organic EL display device includes a flattening film covering a thin film transistor and a light emitting element provided on the flattening film. For example, Japanese Laid-Open Patent Publication No. 2009-016231 and Japanese Laid-Open Patent Publication No. 2012-22787 discloses an organic EL display device including a pixel electrode provided on a flattening film containing an organic material, an inorganic insulating film exposing a part of a top surface of the pixel electrode, and an organic layer provided on the exposed part of the pixel electrode.

SUMMARY

A display device in an embodiment according to the present invention includes a thin film transistor; a first organic insulating film covering the thin film transistor, the first organic insulating film containing a resin material; an inorganic insulating film provided on the first organic insulating film; a pixel electrode electrically connected with the thin film transistor; a second organic insulating film covering an end of the pixel electrode and exposing a top surface of the pixel electrode, the second organic insulating film containing a resin material; and an organic layer provided on the top surface of the pixel electrode, the organic layer including a light emitting layer. As seen in a plan view, the inorganic insulating film has an opening, overlapping the second organic insulating film, provided therein, the opening being located at a position not overlapping an opening provided in the first organic insulating film; and the first organic insulating film and the second organic insulating film face each other in the opening provided in the inorganic insulating film, with an oxide conductive film being located between the first organic insulating film and the second organic insulating film.

A display device in an embodiment according to the present invention includes a thin film transistor; a first organic insulating film covering the thin film transistor, the first organic insulating film containing a resin material; an inorganic insulating film provided on the first organic insulating film; a pixel electrode electrically connected with the thin film transistor; a second organic insulating film covering an end of the pixel electrode and exposing a top surface of the pixel electrode, the second organic insulating film containing a resin material; and an organic layer provided on the top surface of the pixel electrode, the organic layer including a light emitting layer. As seen in a plan view, the inorganic insulating film has an opening, overlapping the second organic insulating film, provided therein, the opening being located at a position not overlapping an opening provided in the first organic insulating film; and the first organic insulating film and the second organic insulating film face each other in the opening provided in the inorganic insulating film, with the pixel electrode being located between the first organic insulating film and the second organic insulating film.

A display device in an embodiment according to the present invention includes a thin film transistor; a first organic insulating film covering the thin film transistor, the first organic insulating film containing a resin material; an inorganic insulating film provided on the first organic insulating film; and an oxide conductive film electrically connected with the thin film transistor via an opening provided in the first organic insulating film. As seen in a plan view, the inorganic insulating film has an opening, overlapping the oxide conductive film, provided therein, the opening being located at a position not overlapping the opening provided in the first organic insulating film.

BRIEF EXPLANATION OF DRAWINGS

FIG. **1** is a perspective view schematically showing a structure of an organic EL display device in embodiment 1;

FIG. **2** is a plan view showing a structure of a pixel of the organic EL display device in embodiment 1;

FIG. **3** is a cross-sectional view showing a structure of a sub pixel of the organic EL display device in embodiment 1;

FIG. **4**A shows an example in which an oxide conductive film is not provided in an opening in an inorganic insulating film as opposed to embodiment 1;

FIG. **4**B shows the example in which the oxide conductive film is not provided in the opening in the inorganic insulating film as opposed to embodiment 1;

FIG. **4**C shows the example in which the oxide conductive film is not provided in the opening in the inorganic insulating film as opposed to embodiment 1;

FIG. **5**A is a cross-sectional view showing an example of step in a method for producing the organic EL display device in embodiment 1;

FIG. **5**B is a cross-sectional view showing the example of step in the method for producing the organic EL display device in embodiment 1;

FIG. **5**C is a cross-sectional view showing the example of step in the method for producing the organic EL display device in embodiment 1;

FIG. **5**D is a cross-sectional view showing the example of step in the method for producing the organic EL display device in embodiment 1;

FIG. **5**E is a cross-sectional view showing the example of step in the method for producing the organic EL display device in embodiment 1;

FIG. **5**F is a cross-sectional view showing the example of step in the method for producing the organic EL display device in embodiment 1;

FIG. **6** is a plan view showing a layout of a pixel of an organic EL display device in embodiment 2;

FIG. **7** is a cross-sectional view showing a structure of a pixel of an organic EL display device in embodiment 3;

FIG. **8** is a cross-sectional view showing a structure of a pixel of an organic EL display device in embodiment 4; and

FIG. **9** is a cross-sectional view showing a structure of a pixel of an organic EL display device in embodiment 5.

DESCRIPTION OF EMBODIMENTS

A flattening film containing an organic material contains moisture incorporated during the formation of the flattening film, or moisture absorbed in a washing step after the formation of the flattening film. When the flattening film is subjected to a heating process in this state, the moisture contained in the flattening film is evaporated. In the organic EL display device described in each of Japanese Laid-Open Patent Publication No. 2009-016231 and Japanese Laid-Open Patent Publication No. 2012-22787, the flattening film is covered with an inorganic insulating film or the like having a high airtightness, and therefore, the evaporated moisture is confined in the flattening film.

When the inorganic insulating film or a pixel electrode does not withstand the pressure received from the evaporated moisture, the inorganic insulating film or the pixel electrode may be peeled off from the flattening film. In this case, inconveniences may occur such that the pixel electrode is partially missed and thus a display failure is caused, or that an organic layer is deteriorated by the moisture discharged from the part where the inorganic insulating film or the pixel electrode is peeled off.

An object of the present invention is to reduce the influence of the moisture contained in an organic insulating film containing a resin material.

Hereinafter, embodiments of the present invention will be described with reference to the drawings and the like. The present invention may be carried out in various forms without departing from the gist thereof, and is not to be construed as being limited to any of the following embodiments.

In the drawings, components may be shown schematically regarding the width, thickness, shape and the like, instead of being shown in accordance with the actual sizes, for the sake of clearer illustration. The schematic drawings are merely examples and do not limit the interpretations of the present invention in any way. In the specification and the drawings, components that have substantially the same functions as those described before with reference to a previous drawing(s) bear the identical reference signs thereto, and detailed descriptions thereof may be omitted.

In the specification and the claims, an expression that a component is "on" other component encompasses a case where such a component is in contact with the other component and also a case where such a component is above or below the other component, namely, a case where still another component is provided between such a component and the other component, unless otherwise specified.

In this specification and the claims, the terms "up", "down", "above", "below" and the like represent a positional relationship with respect to a face of a substrate on which light emitting elements are provided (hereinafter, this face will be referred to simply as a "surface"). For example, in this specification, a direction away from the surface of the substrate is defined as "upward", and a direction toward the surface of the substrate is defined as "downward".

Embodiment 1

<Structure of the Organic EL Display Device>

FIG. **1** is a perspective view schematically showing a structure of an organic EL display device **100** in embodiment 1. The organic EL (electroluminescence) display device **100** in this embodiment includes a substrate **101**, and also includes a display portion **102** including a plurality of pixels **102***a*, a terminal portion **103** supplying an external signal to the display portion **102**, and a flexible printed circuit **104** transmitting an external signal to the terminal portion **103**. The display portion **102**, the terminal portion **103**, and the flexible printed circuit **104** are provided on the substrate **101**.

The display portion **102** is a portion that displays an image. The pixels **102***a* located in the display portion **102** each include an organic EL element **60** (FIG. **3**) as a light emitting element. Namely, the assembly of the plurality of pixels **102***a* acts as the display portion **102**. The pixels **102***a* each include a thin film transistor **50** (FIG. **3**) described below as a driving element. In this embodiment, the thin film transistor **50** included in each pixel **102***a* is controlled to control light emission of the organic EL element **60** included in each pixel **102***a*.

The terminal portion **103** includes a line group including lines connected to the display portion **102**, and acts as a terminal supplying an external signal. The external signal is transmitted from the flexible printed circuit **104** connected with the terminal portion **103**. The terminal portion **103** and the flexible printed circuit **104** may be connected with each other by a known method using an anisotropic conductive film.

The flexible printed circuit **104** is a circuit board usable to transmit or receive a signal to or from an external circuit (not shown). The flexible printed circuit **104** includes a flexible resin substrate and a plurality of lines provided thereon, and is bonded to the terminal portion **103** with an anisotropic conductive film or the like.

In this embodiment, various signals are input to the display portion **102** from the external circuit (not shown). Nonetheless, although not shown, a scanning line driving circuit supplying a scanning signal to a scanning line (gate line) and/or a video signal driving circuit supplying a video signal to a video signal line (data line) may be formed on the substrate **101** by use of the thin film transistor **50**. Although not shown, an IC chip acting as a driving circuit outputting such a scanning signal and/or such a video signal may be located on the substrate **101** or the flexible printed circuit **104**.

Now, a structure of the pixel **102***a* of the organic EL display device **100** in this embodiment will be described. The pixel **102***a* shown in FIG. **1** actually includes three sub pixels respectively corresponding to three primary colors of RGB. Specifically, in this embodiment, one pixel **102***a* includes a sub pixel **102**Ra corresponding to red, a sub pixel **102**Ga corresponding to green, and a sub pixel **102**Ba corresponding to blue. In this embodiment, the sub pixel **102**Ra, the sub pixel **102**Ga and the sub pixel **102**Ba have the same structure. Therefore, the sub pixel **102**Ra will be described below, and the descriptions of the sub pixel **102**Ga and the sub pixel **102**Ba will be omitted.

FIG. **2** is a plan view of showing a structure of the pixel **102***a* of the organic EL display device **100** in embodiment 1. FIG. **3** is a cross-sectional view showing a structure of the sub pixel **102**Ra of the organic EL display device **100** in embodiment 1. The cross-sectional view of the sub pixel **102**Ra in FIG. **3** is taken along one-dot chain line A-A' in FIG. **2**.

As shown in FIG. **3**, the thin film transistor **50** is provided on the substrate **101**. The thin film transistor **50** is a so-called top gate-type thin film transistor. The thin film transistor **50** is not limited to being of this type, and any type of thin film transistor may be provided. The thin film transistor **50** shown in FIG. **3** acts as a driving transistor supplying an electric current to the organic EL element **60**. In this embodiment, the thin film transistor **50** is an N-channel transistor. Therefore, the organic EL element **60** is connected with a source electrode **50***e* of the thin film transistor **50**.

The structure of the thin film transistor **50** is known, and thus will not be described in detail. Although not shown in FIG. **3**, a storage capacitance may be formed in the process of forming the thin film transistor **50**. In this case, the storage capacitance may include any two of conductive films included in the thin film transistor **50** and an insulating film provided between the two conductive films. Such a storage capacitance may have any known structure.

The thin film transistor **50** is covered with an organic insulating film **120**. The organic insulating film **120** acts as a flattening film flattening the unevenness caused by the formation of the thin film transistor **50**. In this embodiment, the organic insulating film **120** may be formed of an insulating film containing a resin material such as an acrylic resin, a polyimide resin or the like.

The organic insulating film **120** has an opening **122** provided therein. The opening **122** is formed by removing a part of the organic insulating film **120**. At this point, the opening **122** is formed to expose a part of the source electrode **50***e* of the thin film transistor **50**. As described below, the thin film transistor **50** and a pixel electrode **132** are electrically connected with each other via the opening **122**.

The opening **122** formed in the organic insulating film **120** is covered with an oxide conductive film **124**. In this embodiment, the oxide conductive film **124** may be formed by patterning a thin film formed of a metal oxide material such as ITO (Indium Tin Oxide) or the like. The oxide conductive film **124** is not limited to being formed of such a material and may be formed of any other oxide conductive film. The oxide conductive film **124** is connected with the source electrode **50***e* exposed by the opening **122**.

A lower electrode **126** of a storage capacitance **55** is provided on a top surface of the organic insulating film **120**. The lower electrode **126** is formed of an oxide conductive film that is different from the oxide conductive film **124** but is formed at the same time as the oxide conductive film **124**. The lower electrode **126** is provided below the organic EL element **60**. As described below, the organic EL element **60** in this embodiment is of a structure that emits light upward. Therefore, a space below the light emitting element **60** may be utilized to form the storage capacitance **55**.

Although shown in neither FIG. **2** nor FIG. **3**, the oxide conductive films used for forming the oxide conductive film **124** and the lower electrode **126** of the storage capacitance **55** may be used for another use (e.g., as a line). In this case, a metal film may be located on the oxide conductive film used as the line, so that the line resistance is decreased. An oxide conductive film formed of a metal oxide has a line resistance higher than that of a metal film. Therefore, in the case where the oxide conductive film is used as the line, it is preferred that the metal film is provided thereon to decrease the entire line resistance. In this case, the oxide conductive film **124** also acts as a protective film protecting the source electrode **50***e* of the thin film transistor **50** against etching gas in the step of forming the metal film.

An inorganic insulating film **128** is provided on the organic conductive film **124** and the lower electrode **126**. In this embodiment, the inorganic insulating film **128** is formed of a silicon nitride film. The inorganic insulating film **128** is not limited to being formed of silicon nitride, and may be formed of another inorganic insulating film such as a silicon oxide film or the like. The inorganic insulating film **128** has an opening **130** provided therein exposing a part of the organic conductive film **124**.

The pixel electrode **132** is provided on the inorganic insulating film **128**. The pixel electrode **132** is connected with the oxide conductive film **124** via the opening **130** formed in the inorganic insulating film **128**. Namely, the pixel electrode **132** is connected with the thin film transistor **50** via the oxide conductive film **124**. The pixel electrode **132** also acts as an upper electrode of the storage capacitance **55**, and also as an anode electrode of the organic EL element **60**.

The pixel electrode **132** covers a part of the opening **130**. Therefore, in regions represented by hatching in FIG. **2** (hereinafter, referred to as "water drawing regions") **65**, the organic insulating film **120** and an organic insulating film **134** acting as a bank face each other with the oxide conductive film **124** being provided between the organic insulating film **120** and the organic insulating film **134**. A reason why such a structure is adopted will be described below.

In this embodiment, the pixel electrode **132** is formed of a conductive film having a stack structure including oxide conductive films of ITO or the like and a silver-containing thin film provided between the oxide conductive films. The pixel electrode **132** is not limited to having such a structure. It is desirable that the pixel electrode **132** includes a reflective conductive film to allow light emitted from the organic EL element **60** to be output upward.

In this embodiment, a dielectric film included in the storage capacitance **55** is a silicon nitride film, which has a dielectric constant higher than that of other insulating films. This provides an advantage that a high capacitance is easily provided. In addition, the space below the organic EL element **60** may be effectively utilized to provide the storage capacitance **55**. This provides an advantage that the area size occupied by the storage capacitance **55** is easily made large.

The pixel electrode **132** is partially covered with the organic insulating film **134**. Specifically, the organic insulating film **134** covers an end of the pixel electrode **132** and has an opening **136** provided therein exposing a part of a top surface of the pixel electrode **132**. The organic insulating film **134** having such a structure is generally referred to as a "bank" or a "rib", and has a role of defining a light emitting region. The organic insulating film **134** may be formed of a resin material such as a photosensitive acrylic resin, a polyimide resin or the like, but is not limited to being formed of such a material.

On a region of the top surface of the pixel electrode **132** that does not overlap the organic insulating film **134** (i.e., region in the opening **136**), an organic EL layer **138** is provided. In this embodiment, the organic EL layer **138** is formed of an organic EL material by vapor deposition. The organic EL layer **138** includes at least a light emitting layer, and may also include an electron injection layer, an electron transfer layer, an electron blocking layer, a hole injection layer, a hole transfer layer, and/or a hole blocking layer. The organic EL layer **138** shown in FIG. **3** includes a light emitting layer containing an organic EL material emitting red light.

In this embodiment, light emitting layers that emit light of different colors are provided in different pixels. The light emitting layers are not limited to having such a structure. For example, although not shown, an organic EL layer emitting white light may be provided in the plurality of pixels **102***a*, and the while light may be colored red, green or blue by use of a color filter provided in each of the pixels **102***a*. The functional layers such as the electron injection layer, the electron transfer layer, the electron blocking layer, the hole injection layer, the hole transfer layer, and the hole blocking layer may be provided commonly for the plurality of pixels **102***a*.

A common electrode **140** formed of a conductive film containing an alkaline metal material or an alkaline earth-metal material is provided on the organic EL layer **138**. The alkaline metal material or alkaline earth-metal material may be, for example, magnesium (Mg), lithium (Li) or the like. In this embodiment, an MgAg film formed of an alloy of magnesium and silver is used as the conductive film containing an alkaline earth-metal material. The common electrode **140** acts as a cathode electrode of the organic EL element **60**. The common electrode **140** is provided commonly for the plurality of pixels **102***a*.

In the case where the display device **100** is of a top emission-type, in which the light from the organic EL layer **138** is output upward, namely, is output toward the common electrode **140**, the common electrode **140** needs to be light-transmissive. Therefore, in the case of being formed of the above-described conductive film containing an alkaline metal material, the common electrode **140** is made sufficiently thin to transmit light and thus is made light-transmissive. Specifically, the common electrode **140** has a thickness of 10 nm or greater and 30 nm or less to be light-transmissive.

A sealing film **142** is provided on the common electrode **140**. The sealing film **140** has a role of preventing entrance of moisture from outside and thus preventing deterioration of the organic EL layer **138** and the common electrode **140**. Although not shown in detail in FIG. **3**, in this embodiment, the sealing film **142** has a three-layer stack structure including silicon nitride films and a resin film provided between the silicon nitride films. The sealing film **142** is not limited to having such a structure. Silicon oxide films may be used instead of, or in addition to, the silicon nitride films.

A cover member **146** is provided on the sealing film **142** with a filler member **144** being located between the cover member **146** and the sealing film **142**. The filler member **144** also acts as an adhesive bonding the cover member **146**. The filler member **144** is formed of an acrylic resin in this embodiment, but is not limited to being formed of an acrylic resin. In this embodiment, the cover member **146** is provided. The filler member **144** and the cover member **146** may be omitted.

As shown in FIG. **2** and FIG. **3**, in this embodiment, the opening **130** is formed in a part of the inorganic insulating film **128**, and the oxide conductive film **124** and the pixel electrode **132** are in contact with each other in a part of the opening **130**. Specifically, as seen in a plan view, the inorganic insulating film **128** has the opening **130**, overlapping the organic insulating film **134**, at a position not overlapping the opening **122** provided in the organic insulating film **120**.

As described above, in the organic EL display device **100** in this embodiment, the opening **130** acts as a region providing the electric connection between the oxide conductive film **124** and the pixel electrode **132** with certainty (i.e., as a contact hole), and also acts as a region allowing moisture generated in the organic insulating film **120** formed of a resin material to escape outside.

In the case where an insulating film is formed of a resin material, moisture remaining in the insulating film may be discharged from inside in a heating process performed after the formation of the insulating film. Therefore, in this embodiment, the opening **130** is provided in the inorganic insulating film **128** in order to allow the moisture discharged from the inside of the organic insulating film **120** to escape outside. In FIG. **2**, the opening **130** is provided in each of the sub pixels **102**Ra, **102**Ga and **102**Ba. The opening **130** may be provided at any position. For example, the opening **130** may not be provided in any of the sub pixels **102**Ra, **102**Ga and **102**Ba. Alternatively, the opening **130** may be provided at a rate of one per a plurality of sub pixels.

As described above, in this embodiment, the opening **130** is provided in the inorganic insulating film **128** to form the water drawing region **65**, so that the moisture discharged from the organic insulating film **120** is not prevented by the inorganic insulating film **128** from escaping outside. In addition, in this embodiment, in the opening **130**, the organic insulating film **120** is covered with the oxide conductive film **124**. A reason why such a structure is adopted will be described with reference to FIG. **4**A, FIG. **4**B and FIG. **4**C.

FIG. **4**A, FIG. **4**B and FIG. **4**C show an example in which the oxide conductive film **124** is not located in the opening **130** in the inorganic insulating film **128**. A region **64** is to be the water drawing region **65** in a later step.

As shown in FIG. **4**A, the oxide conductive film **124** is formed on the organic insulating film **120**. In the step of forming the oxide conductive film **124**, a surface and the vicinity thereof (region **121***a*) of the exposed part of the organic insulating film **120** may be damaged. For example, in the case where the oxide conductive film **124** is etched by dry etching, the oxide insulating film **120** may be damaged by plasma. In the case where the oxide conductive film **124** is etched by wet etching, the composition of the oxide insulating film **120** may be denatured by the influence of an etchant and thus damaged.

As shown in FIG. **4**B, the inorganic insulating film **128** is formed on the organic insulating film **120** and the oxide conductive film **124**. In this embodiment, the inorganic insulating film **128** is formed of a silicon nitride film, and thus the etching is usually performed by dry etching. Therefore, in the step of forming the opening **130** in the inorganic insulating film **128**, the organic insulating film **120** may be damaged by plasma in a region **121***b*.

As shown in FIG. **4**C, the pixel electrode **132** is formed on the organic insulating film **120**, the oxide conductive film **124** and the inorganic insulating film **128**. In the step of forming the pixel electrode **132** also, the surface and the vicinity thereof (region **121***c*) of the organic insulating film **120** may be damaged by the etching.

As described above, in the case where the oxide conductive film **124** is not located in the opening **130** in the inorganic insulating film **128**, the surface and the vicinity thereof of the organic insulating film **120** may be damaged at least three times before the pixel electrode **132** is formed. According to the knowledge of the present inventors, a resin film damaged as described above may have a moisture absorbing property thereof increased. Therefore, in the case where the pixel electrode **132** is formed in the process shown in FIG. **4**A, FIG. **4**B and FIG. **4**C, the moisture may be gradually discharged from the damaged resin film after the organic EL layer **138** and the common electrode **140** are formed.

In consideration of the above, the organic EL display device **100** in this embodiment has a structure in which the organic insulating film **120** is covered with the oxide conductive film **124** in the opening **130** formed in the inorganic insulating film **128**. Specifically, in the organic EL display device **100** in this embodiment, as shown in FIG. **3**, the organic insulating film **120** and the organic insulating film **134** face each other in the opening **130** provided in the inorganic insulating film **128**, with the oxide conductive film **124** being located between the organic insulating film **120** and the organic insulating film **134**.

Such a structure prevents the organic insulating film **120** from being damaged as described above with reference to FIG. **4**A, FIG. **4**B and FIG. **4**C. Namely, in this embodiment, the oxide conductive film **124** acts as an electrode connecting the pixel electrode **132** and the thin film transistor **50** to each other and also acts as a protective film protecting the organic insulating film **120** against the etching process.

Since the inorganic insulating film **128** has the opening **130** provided therein, the moisture generated in the organic insulating film **120** is discharged outside via the water drawing region **65**. In the organic EL display device **100** in this embodiment, the water drawing region **65** is covered with the oxide conductive film **124**. However, the oxide conductive film **124** has a moisture permeation property higher than that of the inorganic insulating film **128** formed of a silicon nitride film, and therefore, permeates the moisture.

As described above, the organic EL display device **100** in this embodiment decreases the influence of the moisture contained in the insulating film containing a resin material.

<Method for Producing the Organic EL Display Device>

Now, a method for producing the organic EL display device **100** in this embodiment will be described with reference to FIG. **5**A to FIG. **5**F. FIG. **5**A to FIG. **5**F are each a cross-sectional view showing a step of the method for producing the organic EL display device **100** in this embodiment.

First, as shown in FIG. **5**A, the thin film transistor **50** and a vide signal line **110** are formed on the substrate **101**. The thin film transistor **50** may be formed by any known method with no specific limitation. The substrate **101** is a glass substrate in this embodiment, but may be any other insulating substrate.

In the case where the substrate **101** is a flexible substrate formed of a resin material, a resin film of polyimide or the like is formed on a support substrate, and the thin film transistor **50** and the video signal line **110** are formed on the resin film. After the sealing film **142** shown in FIG. **3** is formed, the support substrate may be peeled off.

In this embodiment, the thin film transistor **50** and the video signal line **110** are formed as follows. An underlying insulating film (not shown) is formed on the substrate **101**, and a semiconductor film **50***a* is formed on the underlying insulating film. Next, a gate insulating film **50***b* covering the semiconductor film **50***a* is formed. After the gate insulating film **50***b* is formed, a gate electrode **50***c* is formed on a region of the gate insulating film **50***b* that overlaps the semiconductor film **50***a*. Next, an insulating film **50***d* covering the gate electrode **50***c* is formed. After this, the source electrode **50***e* and a drain electrode **50***f* to be connected with the semiconductor film **50***a* via a contact hole formed in the insulating film **50***d* are formed. At the same time, the video signal line **110** is formed. In this manner, the thin film transistor **50** and the video signal line **110** are formed on the substrate **101**.

After the thin film transistor **50** and the video signal line **110** are formed, as shown in FIG. **5**B, the organic insulating film **120** is formed. In this embodiment, a positive photosensitive acrylic resin material is used to form the organic insulating film **120**. In more detail, an acrylic resin material for forming the organic insulating film **120** is applied to form a film, and the film of the acrylic resin material is patterned by photolithography, by selectively exposing, to light, a region thereof where the opening **122** is to be formed, so that the unnecessary part of the acrylic resin material is removed. In this manner, the organic insulating film **120** having the opening **122** provided therein is formed without etching. As shown in FIG. **5**B, the opening **122** is formed to expose a part of the source electrode **50***e* of the thin film transistor **50**.

After the opening **122** is formed, as shown in FIG. **5**C, the oxide conductive film **124** and the lower electrode **126** of the storage capacitance **55** are formed of a metal oxide material such as ITO or the like to cover the opening **122**.

The oxide conductive film **124** and the lower electrode **126** are formed by patterning an oxide conductive film of ITO or the like, formed to cover the organic insulating film **120**, by photolithography. The oxide conductive film **124** covers the exposed part of the source electrode **50***e* of the thin film transistor **50**. The lower electrode **126** is formed in a region where the organic EL element **60** is to be formed in a later step.

The oxide conductive film **124** is extended to overlap the region **64**, of the surface of the organic insulating film **120**, which corresponds to the water drawing region **65** shown in FIG. **2** and FIG. **3**. Therefore, in the region **64** corresponding to the water drawing region **65**, the organic insulating film **120** is not damaged by the etching process for the formation of the oxide conductive film **124**.

In a region that does not need to be light-transmissive, a metal film may be directly formed on a conductive film containing a metal oxide material to form a stack-structured conductive film. Such a stack-structured conductive film decreases the resistance by the metal film and thus is effectively usable as a line or an electrode.

After the oxide conductive film **124** and the lower electrode **126** are formed, as shown in FIG. **5**D, the inorganic insulating film **128** is formed. In this embodiment, a silicon nitride film is formed as the inorganic insulating film **128**. In a region of the inorganic insulating film **128** that overlaps the oxide conductive film **124** (this region includes the above-described region **64**), the opening **130** is formed. In the step of forming the opening **130**, the oxide conductive film **124** acts as a protective film. Therefore, the organic insulating film **120** is not damaged by the formation of the opening **130**. The inorganic insulating film **128** acts as a dielectric film included in the storage capacitance **55**.

After the opening **130** is formed in the inorganic insulating film **128**, as shown in FIG. **5**E, the pixel electrode **132** is formed. The pixel electrode **132** is formed to overlap a part of the opening **130**. Therefore, the pixel electrode **132** is connected with the oxide conductive film **124** in the opening **130**. In other words, the pixel electrode **132** is connected with the thin film transistor **50** via the oxide conductive film **124**.

In this step, a region of the oxide conductive film **124** exposed to the opening **130** acts as the region **65**.

As a result of the formation of the pixel electrode **132**, the storage capacitance **55** including the lower electrode **126**, the inorganic insulating film **128** and the pixel electrode **132** is formed below the organic EL element **60**. In this embodiment, although not shown, the storage capacitance **55** is located between the gate electrode **50***c* and the source electrode **50***e* of the thin film transistor **50**, which is an N-channel transistor. Namely, the lower electrode **126**, which is one of two electrodes of the storage capacitance **55**, is connected with the gate electrode **50***c*. The pixel electrode **132**, which is the other electrode of the storage capacitance **55**, is connected with the source electrode **50***e*.

After the pixel electrode **132** is formed, as shown in FIG. **5**F, the organic insulating film **134** acting as the bank is formed. In this embodiment, a photosensitive acrylic resin material is used to form the organic insulating film **134**. The organic insulating film **134** is formed by patterning to cover an outer periphery of the pixel electrode **132** and to expose the top surface of the pixel electrode **132**. The opening **136**, which is formed by the patterning, defines a region acting as a light emitting element (light emitting region) on the top surface of the pixel electrode **132**.

In this embodiment, the organic insulating film **134** and the oxide conductive film **124** contact each other in the water drawing region **65**. In other words, the organic insulating film **120** as the flattening film, and the organic insulating film **134** as the bank, face each other in the opening **130** with the oxide conductive film **124** being located between the organic insulating film **120** and the organic insulating film **134**. In such a structure, even if being discharged from the organic insulating film **120**, the moisture is discharged outside via the oxide conductive film **124** and the organic insulating film **134**.

In this embodiment, the organic insulating film **120**, after being formed, is subjected to a heating process accompanying the formation of the oxide conductive film **124**, the inorganic insulating film **128** and the pixel electrode **132**. Therefore, moisture is discharged from the organic insulating film **120** during the heating process. During a baking process performed to form the organic insulating film **134**, moisture is discharged from the organic insulating film **120**.

As described above, in this embodiment, the moisture remaining in the organic insulating film **120** is mostly discharged before the organic insulating film **134** is formed. In addition, there is no such damage as described above with reference to FIG. **4**A to FIG. **4**C on the organic insulating film **120**. Therefore, it does not occur that the organic insulating film **120** has the moisture absorbing property increased to keep on discharging moisture for a long time. For this reason, extra moisture is removed from the organic insulating film **120** before the organic EL layer **138** and the common electrode **140** are formed.

After the organic insulating film **134** acting as the bank is formed, the organic EL layer **138** and the common electrode **140** are formed. In this embodiment, the organic EL layer **138** and the common electrode **140** are formed by vapor deposition pixel by pixel. The organic EL layer **138** and the common electrode **140** are not limited to being formed in this manner. For example, the functional layers other than the light emitting layer, for example, the electron transfer layer or the hole transfer layer, may be commonly provided for a plurality of pixels **102***a*. The organic EL layer **138** usable in this embodiment may be formed of any known material with no specific limitation. In FIG. **5**F, the sub pixel **102**Ra emitting red light is shown as an example. Therefore, the light emitting layer included in the organic EL layer **138** is formed of a light emitting material emitting red light.

In this embodiment, an MgAg film is used as the common electrode **140**. Like the organic EL layer **138**, a conductive film containing an alkaline earth-metal material is vulnerable against moisture or the like. Therefore, it is desirable that the vapor deposition to form the organic EL layer **138** and the vapor deposition to form the common electrode **140** are performed without exposing the materials to the atmosphere. In this case, it is preferable that the vapor deposition to form the organic EL layer **138** and the vapor deposition to form the common electrode **140** are performed continuously while a vacuum state is maintained. The present invention is not limited to this, and such continuous vapor deposition may be performed while an inert atmosphere such as a nitrogen atmosphere or the like is maintained.

At this point, the organic EL element **60** including the pixel electrode **132**, the organic EL layer **138** and the common electrode **140** is formed in the opening **130** provided in the organic insulating film **134**.

Next, a silicon nitride film, a resin film formed of an acrylic resin material, and a silicon nitride film are stacked in this order to form the sealing film **142**. In this step, the resin film forming a part of the sealing film **142** flattens the unevenness caused by the organic EL layer **138** and the common electrode **140**. Since the resin film flattens the unevenness, even if foreign objects such as particles or the like are on the common electrode **140**, the possibility that the silicon nitride film formed on the resin film is peeled off by the influence of the foreign objects or that a coverage fault is caused is decreased.

After the state shown in FIG. **5**F is obtained, the cover member **146** such as a glass substrate or the like is formed on the substrate **101** with the filler member **144** formed of a resin material being located between the cover member **146** and the substrate **101**. In such a process, the organic EL display device **100** shown in FIG. **3** is produced.

Embodiment 2

In embodiment 2, an example in which an organic EL display device has a layout different from that in embodiment 1 will be described. In this embodiment, structural differences from the organic EL display device **100** in embodiment 1 will be mainly described. Components that are same as those in embodiment 1 will bear the identical reference signs thereto and descriptions thereof may be omitted.

FIG. **6** is a plan view showing a structure of a pixel **102***b* of an organic EL display device in this embodiment. In this embodiment also, the pixel **102***b* includes three sub pixels **102**Rb, **102**Gb and **102**Bb. In this embodiment, the sub pixels **102**Rb and **102**Gb are arrayed in a vertical direction (vertical direction in FIG. **6**), and the sub pixel **102**Bb is located adjacent to the sub pixels **102**Rb and **102**Gb in a horizontal direction (horizontal direction in FIG. **6**).

The sub pixel **102**Rb includes an opening **122**R provided in a flattening film (not shown), an oxide conductive film **124**R, a lower electrode **126**R of a storage capacitance, an opening **130**R provided in an insulating film (not shown), and a pixel electrode **132**R. The opening **130**R is provided to overlap the oxide conductive film **124**R. The oxide conductive film **124**R is connected to a thin film transistor (not shown) via the opening **122**R. The oxide conductive film **124**R is connected with the pixel electrode **132**R in the opening **130**R. A region of the opening **130**R that does not overlap the pixel electrode **132**R acts as a water drawing region **65**R.

The components of each of the sub pixels **102**Gb and **102**Bb are basically the same as those of the sub pixel **102**Rb described above. Thus, the components are represented by the same reference signs as those described above regarding the sub pixel **102**R, with “R” being replaced with “G” or “B”. These components will not be described.

In this embodiment, the sub pixel **102**Bb does not include a water drawing region. As can be seen, the water drawing region does not need to be provided in all the sub pixels. In accordance with the layout of the pixel, the water drawing region may be provided at any position. For example, one water drawing region may be provided in any one of the sub pixels for the RGB colors, or one water drawing region may be provided per a plurality of pixels. Needless to say, the sub pixel **102**Bb may include the water drawing region.

Embodiment 3

In embodiment 3, an example in which the pixel has a structure different from that in embodiment 1 will be described. In this embodiment, structural differences from the organic EL display device **100** in embodiment 1 will be mainly described. Components that are same as those in embodiment 1 will bear the identical reference signs thereto and descriptions thereof may be omitted.

FIG. **7** is a cross-sectional view showing a structure of a pixel **102**Rc of an organic EL display device in embodiment 3. In this embodiment, the inorganic insulating film **128** has an opening **131** provided therein in addition to the opening **130**. The opening **131** is located in the opening **122** provided in the organic insulating film **120**. Namely, the opening **131** is located at a position overlapping the opening **122**. Therefore, as shown in FIG. **7**, the pixel electrode **132** is connected with the oxide conductive film **124** via the opening **131**. Thus, the water drawing region **65** is defined by the opening **130** provided in the inorganic insulating film **128**.

In this embodiment also, in the water drawing region **65**, the organic insulating film **120** and the organic insulating film **134** face each other with the oxide conductive film **124** being located between the organic insulating film **120** and the organic insulating film **134**.

Embodiment 4

In embodiment 4, an example in which the pixel has a structure different from that in embodiment 1 will be described. In this embodiment, structural differences from the organic EL display device **100** in embodiment 1 will be mainly described. Components that are same as those in embodiment 1 will bear the identical reference signs thereto and descriptions thereof may be omitted.

FIG. **8** is a cross-sectional view showing a structure of a pixel **102**Rd of an organic EL display device in embodiment 4. In this embodiment, like in embodiment 3, the inorganic insulating film **128** has the opening **131** provided therein in addition to the opening **130**. The opening **131** is located in the opening **122** formed in the organic insulating film **120**. Therefore, as shown in FIG. **8**, the pixel electrode **132** is connected with the oxide conductive film **124** via the opening **131**.

In this embodiment, an oxide conductive film **132***a* is provided to cover the opening **130**. The oxide conductive film **132***a* acts as a protective film protecting the water drawing region **65**.

In this embodiment, the pixel **132** has a stack structure including oxide conductive films of ITO or the like and a silver-containing thin film provided between the oxide conductive films. Therefore, the upper or lower oxide conductive film is usable as the oxide conductive film **132***a*. Namely, in this embodiment, the oxide conductive film **132***a* is one layer included in the stack structure of the pixel electrode **132**. For example, the lower oxide conductive film may be used to form the oxide conductive film **132***a* and the lowermost layer of the pixel electrode **132**, and then the silver-containing thin film and the upper oxide conductive film may be formed in a region corresponding to the pixel electrode **132**. Needless to say, the upper oxide conductive film may be used as the oxide conductive film **132***a*, or a stack of the upper and lower oxide conductive films may be used as the oxide conductive film **132***a*.

In this embodiment, the oxide conductive film **132***a* and the pixel electrode **132** are physically insulated from each other. Alternatively, the oxide conductive film **132***a* and the pixel electrode **132** may be continuous and connected with each other.

In this embodiment, in the water drawing region **65**, the organic insulating film **120** and the organic insulating film **134** face each other with the oxide conductive film **132***a* (i.e., the conducive film forming a part of the pixel electrode **132**) being located between the organic insulating film **120** and the organic insulating film **134**.

Embodiment 5

In embodiment 5, an example in which the pixel has a structure different from that in embodiment 1 will be described. In this embodiment, structural differences from the organic EL display device **100** in embodiment 1 will be mainly described. Components that are same as those in embodiment 1 will bear the identical reference signs thereto and descriptions thereof may be omitted.

FIG. **9** is a cross-sectional view showing a structure of a pixel **102**Re of an organic EL display device in embodiment 5. In this embodiment, like in embodiment 3, the inorganic insulating film **128** has the opening **131** provided therein in addition to the opening **130**. The opening **131** is located in the opening **122** formed in the organic insulating film **120**.

In this embodiment, the inorganic insulating film **128** formed of a silicon nitride film is provided on the organic insulating film **120**, and an oxide conductive film **124***a* formed of a metal oxide material such as ITO or the like is provided on the inorganic insulating film **128**. Therefore, as shown in FIG. **9**, the oxide conductive film **124***a* is connected with the source electrode **50***e* of the thin film transistor **50** via the opening **131**. The oxide conductive film **124***a* also acts as a pixel electrode.

The oxide conductive film **124***a* also acts as an anode electrode of the organic EL element **60**. In this case, the oxide conductive film **124***a* is transparent and conductive. Therefore, light emitted from the organic EL element **60** passes the oxide conductive film **124***a* and is directed toward the substrate **101**. Thus, in this embodiment, it is preferred that a common electrode **140***a* formed of an MgAg film is thicker than the common electrode **140** in embodiment 1. With such a structure, the light directed toward the common electrode **140***a* from the organic EL element **60** is reflected by the common electrode **140***a* and directed toward the substrate **101**.

In this embodiment, in a water drawing region **65***b*, the organic insulating film **120** and the organic insulating film **134** face each other with the oxide conductive film **124***a* being located between the organic insulating film **120** and the organic insulating film **134**.

The above-described embodiments according to the present invention may be optionally combined as long as no contradiction occurs. The display devices described above in embodiments according to the present invention may have an element added thereto, or deleted therefrom, or may be changed in design optionally by a person of ordinary skill in the art. The methods described above in embodiments according to the present invention may have a step added thereto, or deleted therefrom, or may be changed in the condition optionally by a person of ordinary skill in the art. Such devices and methods are encompassed in the scope of the present invention as long as including the gist of the present invention.

Even functions and effects that are different from those provided by the above-described embodiments but are obvious from the description of this specification or are easily expectable by a person of ordinary skill in the art are naturally construed as being located by the present invention.

What is claimed is:

1. A display device, comprising:

a thin film transistor;

a first organic insulating film covering the thin film transistor, the first organic insulating film containing a resin material;

an inorganic insulating film provided on the first organic insulating film;

a pixel electrode electrically connected with the thin film transistor;

a second organic insulating film covering an end of the pixel electrode and exposing a top surface of the pixel electrode, the second organic insulating film containing a resin material; and

an organic layer provided on the top surface of the pixel electrode, the organic layer including a light emitting layer;

wherein:

as seen in a plan view, the inorganic insulating film has an opening, overlapping the second organic insulating film, provided therein, the opening being located at a position not overlapping an opening provided in the first organic insulating film;

the first organic insulating film and the second organic insulating film face each other in the opening provided in the inorganic insulating film, with the pixel electrode being located between the first organic insulating film and the second organic insulating film; and

the pixel electrode is in contact with the first organic insulating film in the opening provided in the inorganic insulating film.

2. The display device according to claim **1**, wherein the pixel electrode is electrically connected with the thin film transistor via the opening provided in the first organic insulating film.

3. The display device according to claim **1**, wherein:

as seen in a plan view, the inorganic insulating film has other opening provided therein, the other opening being located at a position overlapping the opening provided in the first organic insulating film; and

the pixel electrode is electrically connected with the thin film transistor via the other opening provided in the inorganic insulating film.

4. A display device, comprising:

a thin film transistor;

a first organic insulating film covering the thin film transistor, the first organic insulating film containing a resin material;

an inorganic insulating film provided on the first organic insulating film; and

an oxide conductive film electrically connected with the thin film transistor via an opening provided in the first organic insulating film;

wherein as seen in a plan view, the inorganic insulating film has an opening, overlapping the oxide conductive film, provided therein, the opening being located at a position not overlapping the opening provided in the first organic insulating film; and

the oxide conductive film is provided between the first organic insulating film and the inorganic insulating film.

5. The display device according to claim **4**, wherein the oxide conductive film is electrically connected with a pixel electrode via the opening provided in the inorganic insulating film.

6. The display device according to claim **4**, wherein:

as seen in a plan view, the inorganic insulating film has other opening provided therein, the other opening being located at a position overlapping the opening provided in the first organic insulating film; and

the oxide conductive film is electrically connected with a pixel electrode via the other opening provided in the inorganic insulating film.

7. The display device according to claim **4**, wherein the oxide conductive film is provided on the inorganic insulating film.

8. The display device according to claim **7**, wherein the oxide conductive film is electrically connected with the thin film transistor via the opening provided in the first organic insulating film.

9. The display device according to claim **7**, further comprising a pixel electrode electrically connected with the thin film transistor; wherein:

the pixel electrode has a stack structure; and

the oxide conductive film is a layer included in the stack structure.

10. The display device according to claim **9**, wherein the oxide conductive film is electrically connected with the pixel electrode.

* * * * *

patsnap

专利名称(译)	显示装置		
公开(公告)号	US10566567	公开(公告)日	2020-02-18
申请号	US15/848096	申请日	2017-12-20
[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	KIMURA YASUKAZU SAKAMOTO SHIGERU		
发明人	KIMURA, YASUKAZU SAKAMOTO, SHIGERU		
IPC分类号	H01L51/52 H01L27/32 G09G3/30		
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摘要(译)

显示装置包括薄膜晶体管； 第一有机绝缘膜，其覆盖薄膜晶体管并包含树脂材料； 在第一有机绝缘膜上的无机绝缘膜； 与薄膜晶体管电连接的像素电极； 第二有机绝缘膜，其覆盖像素电极的端部并暴露像素电极的顶表面； 有机层设置在像素电极的顶表面上并包括发光层。 俯视时，无机绝缘膜在与第一有机绝缘膜所具有的开口不重叠的位置具有与第二有机绝缘膜重叠的开口。 第一有机绝缘膜和第二有机绝缘膜在无机绝缘膜的开口中彼此面对，氧化物导电膜位于第一有机绝缘膜和第二有机绝缘膜之间。