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(54) **ORGANIC LIGHT EMITTING DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME**

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H01L 29/04	(2006.01)
H01L 29/15	(2006.01)
H01L 31/036	(2006.01)

(52) **U.S. Cl.** **257/72**; 257/59; 257/99; 438/158; 438/687; 349/39; 349/42; 349/43; 349/46; 349/139

(58) **Field of Classification Search** 257/59, 257/72, 99; 438/158, 687; 349/39, 42, 43, 349/46, 139
See application file for complete search history.

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(57) **ABSTRACT**

An organic light emitting display apparatus and a method of manufacturing the organic light emitting display apparatus, whereby the manufacturing process is simplified and the electric characteristics of the organic light emitting display apparatus are improved. The organic light emitting display apparatus includes: a gate electrode that includes a first conductive layer including ITO, a second conductive layer on the first conductive layer, a third conductive layer on the second conductive layer and including ITO, and a fourth conductive layer on the third conductive layer and including IZO or AZO; and a pixel electrode formed in the same layer level as the gate electrode and including a first electrode layer that includes ITO, a second electrode layer on the first electrode layer, a third electrode layer on the second electrode layer and including ITO, and a fourth electrode layer on the third electrode layer and including IZO or AZO.

23 Claims, 5 Drawing Sheets

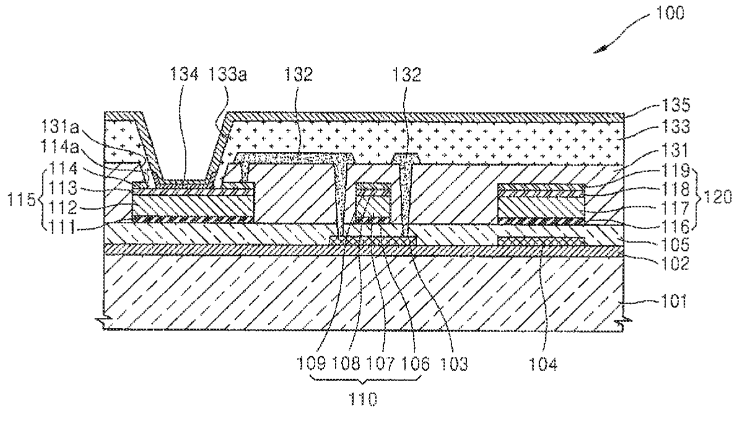
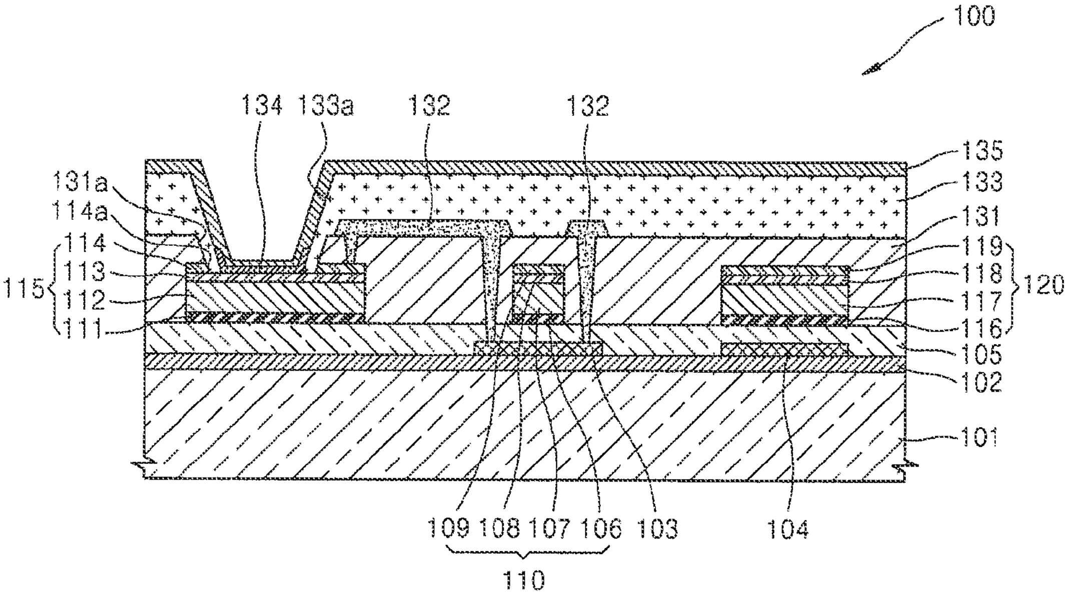


FIG. 1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105
102
101
109
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107
106
103
104
110

FIG. 2A

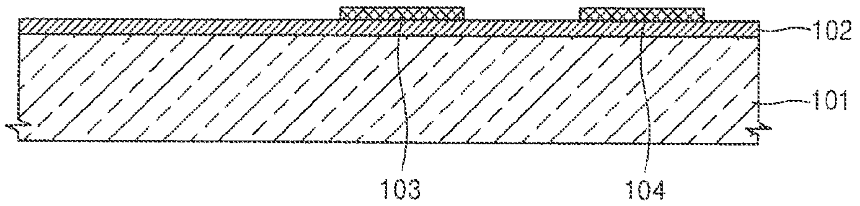
102
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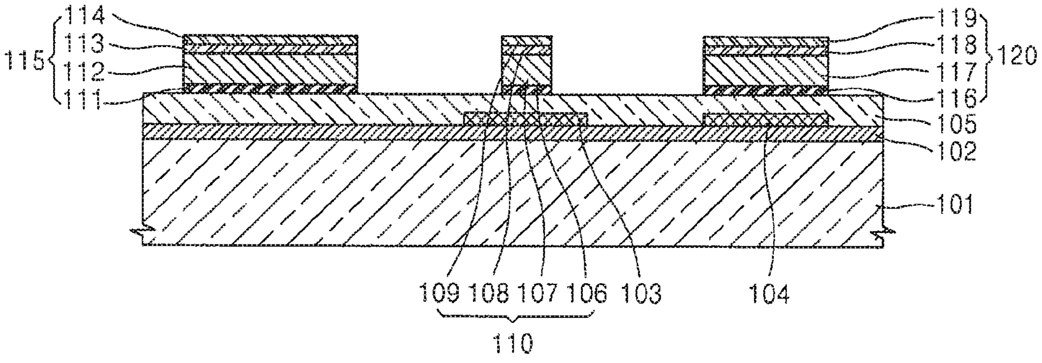
FIG. 2B


114
113
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102
101
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108
107
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104
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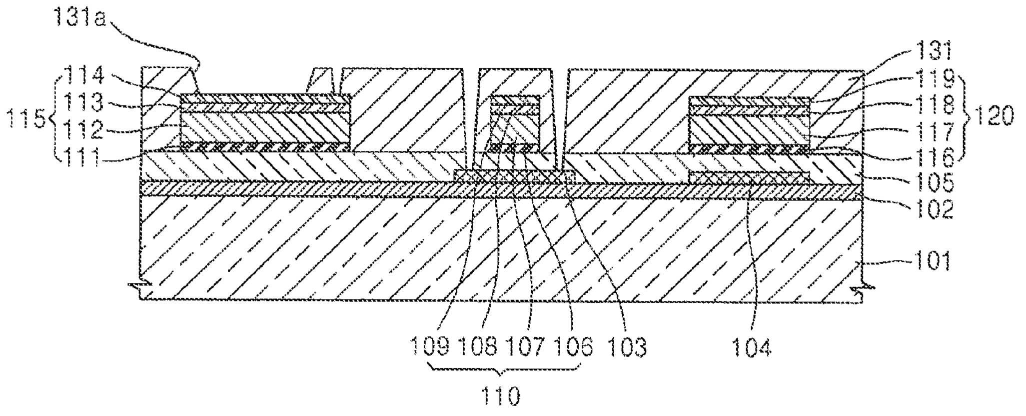
FIG. 2C


131a
114
113
115
112
111
131
119
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120
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116
105
102
101
109
108
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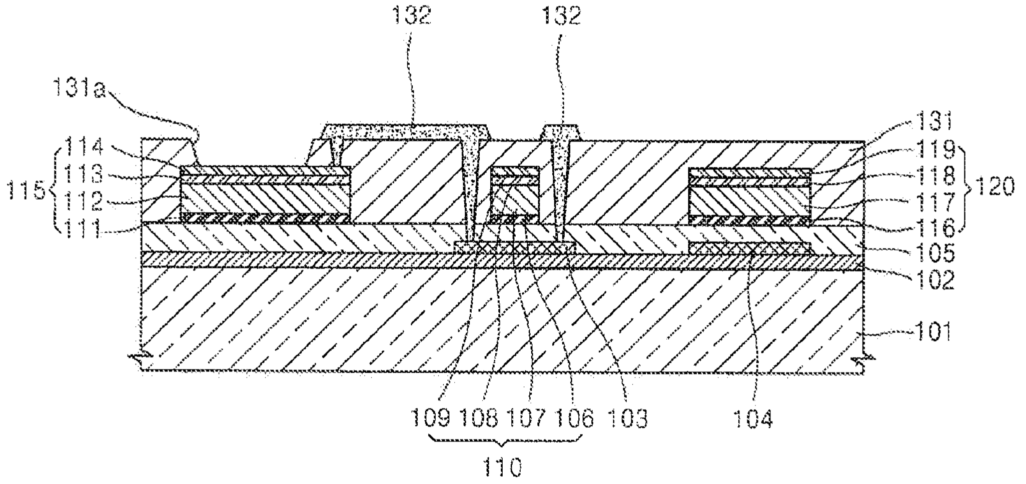
103
104
110

FIG. 2D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114
113
115
112
111
131
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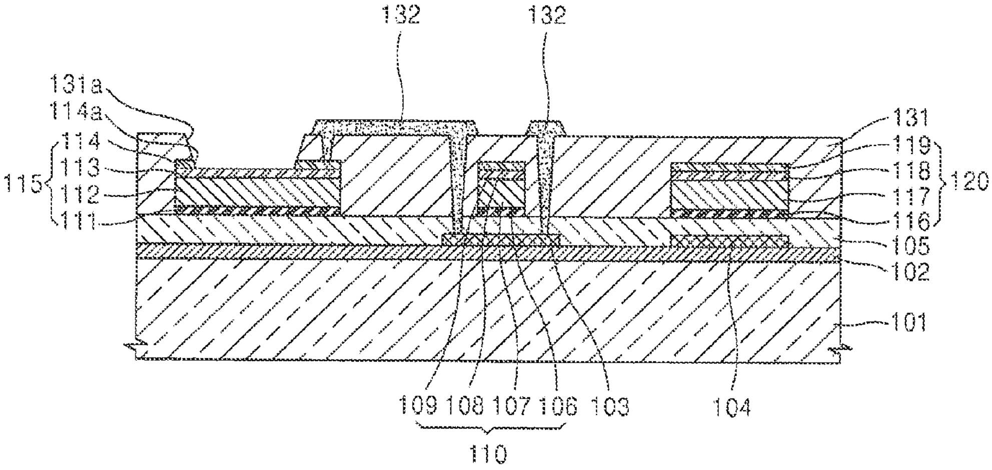
107
106
103
104
110

FIG. 2E


132
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114
113
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131
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120
105
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101
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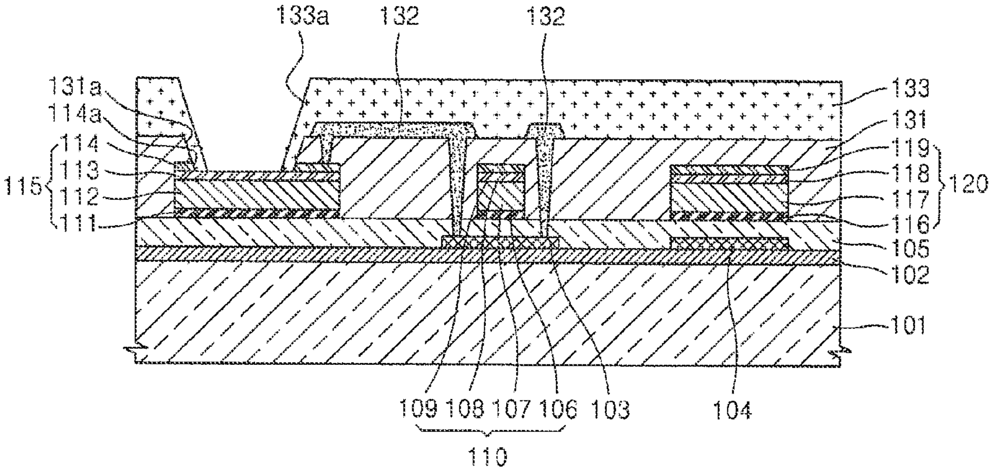
106
103
104
110

FIG. 2F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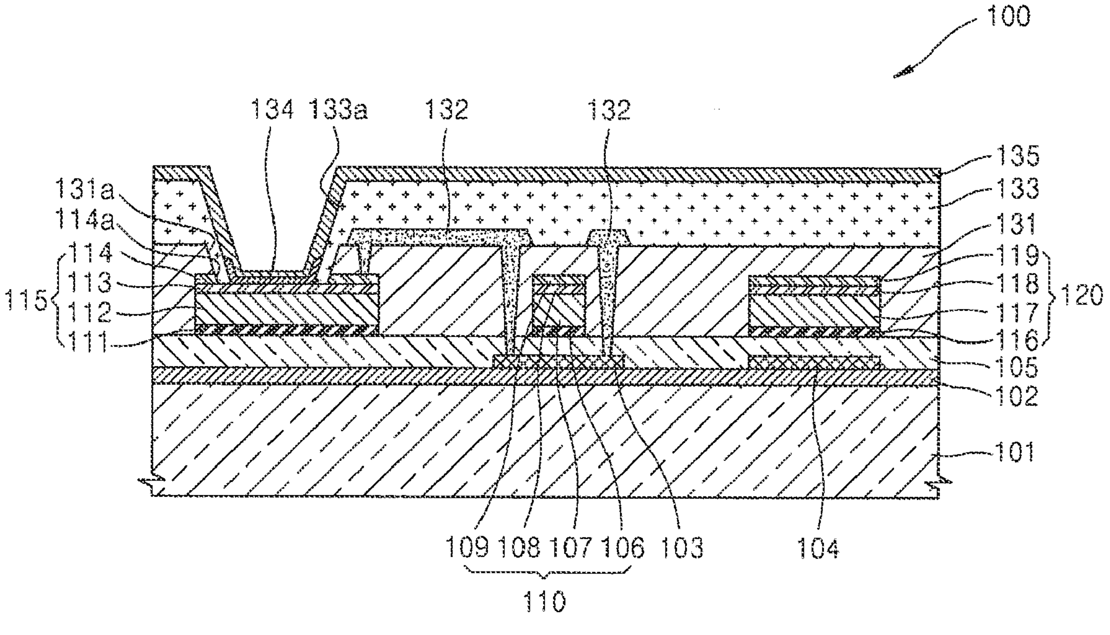
106
103
104
110

FIG. 2G


100
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135
131a
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114a
131
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115
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116
105
102
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108
107
106
103
104
110

ORGANIC LIGHT EMITTING DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2009-0109706, filed on Nov. 13, 2009, in the Korean Intellectual Property Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

One or more embodiments of the present invention relate to an organic light emitting display apparatus and a method of manufacturing the same, and more particularly, to an organic light emitting display apparatus and a method of manufacturing the same, in which manufacturing processes may be simplified and electric characteristics of the organic light emitting display apparatus may be improved.

2. Description of the Related Art

Developments in display technology have led to the replacement of conventional display apparatus with portable, thin flat panel display apparatuses. From among the flat panel apparatuses, an electroluminescent display apparatus, which is a self-emissive display apparatus, has a wide viewing angle, high contrast ratio, and high response speed, and thus has been considered as the next-generation display apparatus. In addition, in comparison to an inorganic light emitting display apparatus, an organic light-emitting display apparatus having a light emitting layer formed of an organic material has better properties in terms of brightness, driving voltage, and response speed: and can realize multiple colors.

The organic light emitting display apparatus includes a cathode electrode, an anode electrode, and an organic light emitting layer between the cathode and anode electrodes; and as a voltage is applied to the cathode and anode electrodes, visible light is emitted from the organic light emitting layer connected to the cathode and anode electrodes.

The organic light emitting display apparatus includes a plurality of thin films, and in each thin film, a minute pattern of a desired form is formed. To form the minute pattern, various suitable processes are performed. The pattern may be formed by using various suitable methods, but usually, a photolithography method using a mask is used.

The photolithography method requires precise controlling. Also, when forming a pattern using a mask, various suitable operations such as forming a photoresist, exposure, development, etching, or the like are required. Thus, the frequency that the photolithography method using a mask is used is increased, the manufacturing process of the organic light emitting display apparatus is complicated, and the manufacturing time thereof is increased. Also, it is difficult to control the manufacturing process and thus many defects may occur.

In addition, the organic light emitting display apparatus includes various suitable electrodes which are formed of conductive thin films. The electric characteristics and light emitting characteristics of the organic light emitting display apparatus are likely to vary according to the electric characteristics of these electrodes.

SUMMARY

Aspects of embodiments of the present invention are directed toward an organic light emitting display apparatus and a method of manufacturing the organic light emitting apparatus, wherein the manufacturing process of the organic light emitting display apparatus may be simplified and the electric characteristics of the organic light emitting display apparatus may be improved.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

According to an embodiment of the present invention, an organic light emitting display apparatus includes: a substrate; an active layer on the substrate; a gate electrode insulated from the active layer and composed of a first conductive layer including ITO, a second conductive layer on the first conductive layer, a third conductive layer on the second conductive layer and including ITO, and a fourth conductive layer on the third conductive layer and including IZO or AZO; a pixel electrode formed in the same layer level as the gate electrode and composed of a first electrode layer including ITO, a second electrode layer on the first electrode layer, a third electrode layer on the second electrode layer and including ITO, and a fourth electrode layer on the third electrode layer and including IZO or AZO; a source electrode and a drain electrode, the source and drain electrodes being insulated from the gate electrode and electrically coupled to the active layer; an intermediate layer on the pixel electrode and including an organic light emitting layer; and a counter electrode on the intermediate layer, wherein the pixel electrode is electrically coupled to the source electrode or the drain electrode.

In one embodiment, the third electrode layer includes crystallized ITO.

In one embodiment, the intermediate layer contacts the third electrode layer of the pixel electrode.

In one embodiment, the source electrode or the drain electrode contacts the fourth electrode layer of the pixel electrode.

In one embodiment, the fourth electrode layer of the pixel electrode includes a first opening portion to expose the third electrode layer disposed below the fourth electrode layer. Here, the organic light emitting display apparatus may further include a planarization layer for insulating the gate electrode from the source electrode and the drain electrode, the source electrode and the drain electrode may be on the planarization layer, and the planarization layer may include a second opening portion corresponding to the first opening portion. The organic light emitting display apparatus may further include a pixel define layer on the planarization layer, and covering the source electrode and the drain electrode, the pixel define layer may include a third opening portion contacting the first opening portion or formed in the first opening portion, and the intermediate layer may contact the third electrode layer through the third opening portion.

In one embodiment, the second conductive layer includes Ag or Al.

In one embodiment, the organic light emitting display apparatus further includes a capacitor composed of a capacitor first electrode layer formed in the same layer level as the active layer and physically separated from the active layer, and a capacitor second electrode layer insulated from the capacitor first electrode layer and formed in the same layer level as the gate electrode to correspond to the capacitor first electrode layer. The capacitor second electrode layer may include a first layer including ITO, a second layer on the first layer, a third layer on the second layer and including ITO, and a fourth layer on the third layer and including IZO or AZO. The second layer may include Ag or Al.

According to an embodiment of the present invention, a method of manufacturing an organic light emitting display apparatus, includes: forming an active layer on a substrate; forming a gate electrode insulated from the active layer and composed of a first conductive layer including ITO, a second conductive layer on the first conductive layer, a third conductive layer on the second conductive layer and including ITO, and a fourth conductive layer on the third conductive layer and including IZO or AZO; forming a pixel electrode in the same layer level as the gate electrode and composed of a first electrode layer including ITO, a second electrode layer on the first electrode layer, a third electrode layer on the second electrode layer and including ITO, and a fourth electrode layer on the third electrode layer and including IZO or AZO; forming a source electrode and a drain electrode to be insulated from the gate electrode and electrically coupled to the active layer; forming an intermediate layer on the pixel electrode and including an organic light emitting layer; and forming a counter electrode on the intermediate layer, wherein the pixel electrode is electrically coupled to the source electrode or the drain electrode.

In one embodiment, the forming of the gate electrode and the forming of the pixel electrode are performed at the same time.

In one embodiment, the forming of the pixel electrode includes crystallizing the third electrode layer.

In one embodiment, the intermediate layer is formed to contact the third electrode layer of the pixel electrode.

In one embodiment, the source electrode or the drain electrode is formed to contact the fourth electrode layer of the pixel electrode.

In one embodiment, the method further includes forming a first opening portion in the fourth electrode layer to expose the third electrode layer before the forming of the intermediate layer. In one embodiment, the method may further include forming a planarizing layer on the gate electrode and the pixel electrode to insulate the gate electrode from the source electrode and the drain electrode, wherein the planarization layer may include a second opening portion corresponding to the first opening portion. The first opening portion may be formed by removing the fourth electrode layer exposed through the second opening portion after forming the second opening portion. The method may further include forming a pixel define layer on the planarizing layer, covering the source electrode and the drain electrode, wherein the pixel define layer may include a third opening portion contacting the first opening portion or formed in the first opening portion, and wherein the intermediate layer may be formed to contact the third electrode layer through the third opening portion.

In one embodiment, the method may further include: forming a capacitor first electrode layer in the same layer level as the active layer and physically separated from the active layer; and forming a capacitor second electrode layer to be insulated from the capacitor first electrode layer and to correspond to the capacitor first electrode layer and in the same layer level as the gate electrode. The forming of the capacitor second electrode layer may include forming a first layer including ITO, a second layer on the first layer, a third layer on the second layer and including ITO, and a fourth layer on the third layer and including IZO or AZO. The second layer may include Ag or Al.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, together with the specification, illustrate exemplary embodiments of the present invention, and, together with the description, serve to explain the principles of the present invention.

FIG. **1** is a cross-sectional view of an organic light emitting display apparatus according to an embodiment of the present invention.

FIGS. **2**A through **2**G are cross-sectional views illustrating a method of manufacturing the organic light emitting display apparatus of FIG. **1**, according to an embodiment of the present invention.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description.

FIG. **1** is a cross-sectional view of an organic light emitting display apparatus **100** according to an embodiment of the present invention.

The organic light emitting display apparatus **100** includes a substrate **101**, an active layer **103**, a gate electrode **110**, a pixel electrode **115**, a source/drain electrode **132**, an intermediate layer **134**, and a counter electrode **135**.

The substrate **101** may be formed of transparent glass containing SiO_2 as a main component, but is not limited thereto. For example, the substrate **101** may also be formed of a transparent plastic material that may be an insulating organic material selected from the group consisting of polyethersulphone (PES), polyacrylate (PAR), polyetherimide (PEI), polyethyelene napthalate (PEN), polyethyelene terephthalate (PET), polyphenylene sulfide (PPS), polyallylate, polyimide, polycarbonate (PC), triacetate cellulose (TAC), and cellulose acetate propionate (CAP).

In a bottom emission type organic light-emitting display apparatus in which an image is directed toward and/or realized through the substrate **101**, the substrate **101** is, in one embodiment, formed of a transparent material. However, in a top emission type organic light-emitting display apparatus in which an image is directed and/or realized away from the substrate **101**, the substrate **101** does not have to be formed of a transparent material, and, in this case, the substrate **101** may be formed of metal. When the substrate **101** is formed of metal, the substrate **101** may include at least one metal selected from the group consisting of carbon (C), iron (Fe), chromium (Cr), manganese (Mg), nickel (Ni), titanium (Ti), molybdenum (Mo), stainless steel (SUS), Invar alloys, Inconel alloys, and Kovar alloys. However, the embodiment of the present invention is not limited to the above examples. In one embodiment, the substrate **101** is formed of a metal foil.

In order to form a planarized surface on the substrate **101** and to prevent impurity elements from penetrating into the substrate **101**, a buffer layer **102** may be formed on the substrate **101**. The buffer layer **102** may be formed of SiO_2 and/or SIN_X.

The active layer **103** having a set or predetermined pattern is formed on the buffer layer **102**. The active layer **103** may be formed of an inorganic semiconductor such as amorphous silicon or polysilicon, or an organic semiconductor, and includes a source region, a drain region, and a channel region. The source and drain regions may be formed by doping the active layer **103**, which is formed of amorphous silicon or polysilicon, with impurities. When the source and drain regions are doped with a Group III element such as Boron (B), a p-type semiconductor may be formed. When the source and drain regions are doped with a Group V element such as nitrogen (N), an n-type semiconductor may be formed.

A capacitor first electrode **104** may be formed on the buffer layer **102** to be separated from the active layer **103**. The capacitor first electrode **104** may be formed of an inorganic semiconductor such as amorphous silicon or polysilicon, or an organic semiconductor.

A gate insulation layer **105** is formed on the buffer layer **102** and covers the active layer **103** and the capacitor first electrode **104**. The gate insulation layer **105** is for insulating the active layer **103** and the gate electrode **110** from each other, and may be formed of an inorganic material such as SiN_x and SiO_2.

The gate electrode **110** is formed on the gate insulation layer **104**. The gate electrode **110** is connected to a gate line via which a TFT on/off signal is applied.

The gate electrode **110** includes a first conductive layer **106** including ITO, a second conductive layer **107**, a third conductive layer **108** containing ITO, and a fourth conductive layer **109** containing ISO or AZO. The second conductive layer **107** may contain Ag or Al. However, since Al and ITO have large potential differences, Al may be abruptly damaged due to the Galvanic effect. Thus when the second conductive layer **107** contains Al, the thickness of the third conductive layer **108** may be increased and the third conductive layer **108** may cover an upper surface of the second conductive layer **107** sufficiently so that the upper surface of the second conductive layer **107** is not exposed or is completely covered by the third conductive layer **108**.

The gate electrode **110** according to the current embodiment includes the second conductive layer **107** including Ag or Al to reduce resistance of the gate electrode **110**, and the first conductive layer **106** including ITO is disposed under the second conductive layer **107** to increase bonding characteristics between the first conductive layer **106** and the gate insulation layer **105**. Also, the third conductive layer **108** and the fourth conductive layer **109** are sequentially stacked on the second conductive layer **107**, thereby increasing a resistance reduction effect of the gate electrode **110**. Also, the fourth conductive layer **109** including IZO or AZO may protect the third conductive layer **108**. The third conductive layer **108** of the gate electrode **110** may include crystallized ITO, specifically, polycrystalline ITO. The polycrystalline ITO is denser than amorphous ITO and has high durability; and due to the third conductive layer **108** including crystallized ITO, the durability of the gate electrode **110** is improved.

The pixel electrode **115** is formed on the gate insulation layer **105** separately from the gate electrode **110**. The pixel electrode **115** includes a first electrode layer **111** including ITO, a second electrode layer **112**, a third electrode layer **113** including ITO, and a fourth electrode layer **114** including IZO or AZO. The second electrode layer **112** may include Ag or Al.

However, since Al and ITO have large potential differences, Al may be abruptly damaged due to the Galvanic effect. Thus when the second electrode layer **112** contains Al, the thickness of the third electrode layer **113** may be increased and the third electrode layer **113** may cover an upper surface of the second electrode layer **112** sufficiently so that the upper surface of the second electrode layer **112** is not exposed or is completely covered by the third electrode layer **113**.

The fourth electrode layer **114** includes a first opening portion **114***a* that exposes the third electrode layer **113**. Accordingly, the intermediate layer **134** contacts the third electrode layer **113**. The third electrode layer **113** including ITO includes crystallized ITO, specifically, polycrystalline ITO. The polycrystalline ITO is denser than amorphous ITO and has high durability.

The pixel electrode **115** is formed of the same materials as the gate electrode **110**. The pixel electrode **115** includes the second electrode layer **112** that includes Ag or Al, thereby reducing resistance of the pixel electrode **115**. The first electrode layer **111** including ITO is disposed below the first electrode layer **111**, thereby increasing the bonding characteristics between the second electrode layer **112** and the gate insulation layer **105**. Also, the third electrode layer **113** and the fourth electrode layer **114** are sequentially stacked on the second electrode layer **112** to further increase the resistance reducing effect of the pixel electrode **115**.

Also, the pixel electrode **115** is bonded to the intermediate layer **134**, and the electrical characteristics and the light emitting characteristics of the organic light emitting display apparatus **100** are influenced by the bonding characteristics between the pixel electrode **115** and the intermediate layer **134**. Accordingly, the surface characteristics of a portion of the pixel electrode **115** contacting the intermediate layer **134** are important. The third electrode layer **113** of the pixel electrode **115** contacts the intermediate layer **134**, includes polycrystalline ITO, and has high durability. Thus, the surface of the pixel electrode **115** is prevented or protected from damaging even when undergoing a subsequent process, particularly, an etching process. As a result, the bonding characteristics between the third electrode layer **113** and the intermediate layer **134** are improved.

In addition, a capacitor second electrode **120** may be formed on the gate insulation layer **105** to correspond to the capacitor first electrode **104**. The capacitor second electrode **120** may be formed of the same materials as the gate electrode **110**. That is, the capacitor second electrode **120** includes a first layer **116** including ITO, a second layer **117**, a third layer **118** including ITO, and a fourth layer **119** including IZO or AZO. The second layer **117** may include Ag or Al. However, since Al and ITO have large potential differences, Al may be abruptly damaged due to the Galvanic effect. Thus when the second layer **117** contains Al, the thickness of the third layer **118** may be increased and the third layer **118** may cover an upper surface of the second layer **117** sufficiently so that the upper surface of the second layer **117** is not exposed or is completely covered by the third layer **118**.

The capacitor first electrode **104** and the capacitor second electrode **120** that are respectively formed on and below the gate insulation layer **105** to form one capacitor are formed in the same layer level as the active layer **103** and the gate electrode **110**, respectively. Accordingly, the thickness of the organic light emitting display apparatus **100** may be efficiently reduced.

The capacitor second electrode **120** according to the current embodiment includes the second layer **117** including Ag or Al to reduce resistance of the capacitor second electrode **120**, and the first layer **116** including ITO is disposed under the second layer **117** to increase bonding characteristics between the first layer **116** and the gate insulation layer **105** therebelow. Also, the third layer **118** and the fourth layer **119** are sequentially stacked on the second layer **117**, thereby increasing a resistance reduction effect of the capacitor second electrode **120**. Also, the fourth layer **119** including IZO or AZO may protect the third layer **118**. The third layer **118** of the capacitor second electrode **120** may include crystallized ITO, specifically, polycrystalline ITO. The polycrystalline ITO is denser than amorphous ITO and has high durability, and due to the third layer **118** including crystallized ITO, the durability of the capacitor second electrode **120** is improved.

A planarization layer **131** is formed on the gate insulating layer and covers the gate electrode **110**, the pixel electrode **115**, and the capacitor second electrode **120**. The planarization layer **131** may be formed of various suitable insulation materials. For example, the planarization layer **131** may be formed of an inorganic material such as an oxide or a nitride, or an organic material.

In one embodiment, an inorganic insulation layer for forming the planarization layer **131** includes SiO_2, SiN_x, $SiON_x$, Al_2O_3, TiO_2, Ta_2O_5, HfO_2, ZrO_2, BST, and/or PZT. In one embodiment, an organic insulation layer for forming the planarization layer **131** includes a general-use polymer (PMMA, PS), a polymer derivative having a phenol group, an acrylic polymer, an imide-based polymer, an arylether-based polymer, an amide-based polymer, a fluorine polymer, a p-xylene-based polymer, and/or a vinyl alcohol-based polymer. The planarization layer **131** may be formed of a composite stack of an organic insulation layer and an organic insulation layer.

The planarization layer **131** includes a second opening portion **131***a* that corresponds to the first opening portion **114***a*.

The planarization layer **131** includes a contact hole exposing the source/drain region of the active layer **103**. A source/drain electrode **132** may be formed to respectively contact the source/drain region of the active layer **103** via the contact hole. The source/drain electrode **132** is connected to the pixel electrode **115**; in more detail, the source/drain electrode **132** is connected to the fourth electrode layer **114** of the pixel electrode **115**.

The source/drain electrode **132** may have a three-layer structure, for example, a Ti/Al/Ti structure.

A pixel define layer **133** is formed on the planarization layer **131** and covers the source/drain electrode **132**. The pixel define layer **133** includes a third opening portion **133***a* that exposes the third electrode layer **113** of the pixel electrode **115**. The third opening portion **133***a* is formed to contact the first opening portion **114***a* or is formed in the first opening portion **114***a*. The pixel define layer **133** may be formed of an organic material or an inorganic material.

The intermediate layer **134** is formed in the third opening portion **133***a* to contact the third electrode layer **113** of the pixel electrode **115**. The intermediate layer **134** includes an organic light emitting layer.

The intermediate layer **134** emits light by the electric driving of the pixel electrode **115** and the counter electrode **135**.

The intermediate layer **134** is formed of an organic material. When the organic light emitting layer included in the intermediate layer **134** is formed of a small molecule organic material, a hole injection layer (HIL) and a hole transport layer (HTL) are disposed between the organic light emitting layer and the pixel electrode **115**, and an electron transport layer (ETL) and an electron injection layer (EIL) are disposed between the organic light emitting layer and the counter electrode **135**. Other suitable layers may also be stacked according to necessity. Examples of the organic material for forming the intermediate layer **134** include copper phthalocyanine (CuPc), N,N'-Di(naphthalene-1-yl)-N,N'-diphenyl-benzidine (NPB), tris-8-hydroxyquinoline aluminum (Alq3), etc.

When the organic light emitting layer is formed of a polymer organic material, the intermediate layer **134** may include only an HTL that is disposed between the organic light emitting layer and the pixel electrode **115**. The HTL may be formed of, for example, poly(2,4-ethylenedioxythiophene) (PEDOT) or polyaniline, on the pixel electrode **115** by using an inkjet printing method or a spin coating method. The polymer organic light emitting layer may be formed of PPV, soluble PPV's, cyano-PPV, polyfluorene, etc.; and a color pattern may be formed in the organic light emitting layer by using an inkjet printing method, a spin coating method, and/or a thermal transfer method using laser.

The counter electrode **135** may be formed on the intermediate layer **134**. The counter electrode **135** may be formed by depositing a metal having a low work function, such as Ag, Mg, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, and a compound of these, and depositing a transparent conductive material such as ITO, IZO, ZnO, or In_2O_3 thereon.

A sealing member may be formed on the counter electrode **135**. The sealing member is formed to protect the intermediate layer **134** or other layers from external water and/or oxygen, and is formed of a transparent material. To this end, the sealing member may be formed of glass, plastic, or a multi-layer structure of organic and inorganic materials.

FIGS. **2**A through **2**G are cross-sectional views illustrating a method of manufacturing the organic light emitting display apparatus **100** of FIG. **1**, according to an embodiment of the present invention.

Operations of the method will be described sequentially in manufacturing order with reference to FIGS. **2**A through **2**G.

First, referring to FIG. **2**A, a buffer layer **102** is formed on a substrate **101**, and an active layer **103** and a capacitor first electrode **104** are formed on the buffer layer **102**. The active layer **103** and the capacitor first electrode **104** each have a set or predetermined pattern so as to be physically separated from each other. The active layer **103** and the capacitor first electrode **104** may be formed at the same time by using a photolithography method using one mask.

Next, referring to FIG. **2**B, a gate insulation layer **105** is formed on the substrate **101**, and covers the active layer **103** and the capacitor first electrode **104**, and then a gate electrode **110**, a pixel electrode **115**, and a capacitor second electrode **120** are formed on the gate insulation layer **105**. The gate electrode **110**, the pixel electrode **115**, and the capacitor second electrode **120** are formed by stacking the same materials and using a photolithography method using one mask.

In more detail, the gate electrode **110**, the pixel electrode **115**, and the capacitor second electrode **120** are formed by forming an ITO/Ag/ITO/IZO(AZO) structure or a ITO/Al/ITO/IZO(AZO) structure and then patterning the structure to desired patterns by using a photolithography method. As a result, the gate electrode **110** is formed by sequentially forming a first conductive layer **106** including ITO, a second conductive layer **107** including Ag or Al, a third conductive layer **108** including ITO, and a fourth conductive layer **109** including IZO or AZO. Also, the pixel electrode **115** is formed by sequentially stacking a first electrode layer **111** including ITO, a second electrode layer **112** including Ag or Al, a third electrode layer **113** including ITO, and a fourth electrode layer **114** including IZO or AZO. The capacitor second electrode **120** is formed by sequentially stacking a first layer **116** including ITO, a second layer **117** including Ag or Al, a third layer **118** including ITO, and a fourth layer **119** including IZO or AZO.

The third electrode layer **113** of the pixel electrode **115** is crystallized. That is, the third electrode layer **113** includes crystallized ITO. To this end, the third electrode layer **113** is crystallized by using a thermal process before forming the fourth electrode layer **114**. In more detail, the third electrode layer **113** may include polycrystalline ITO.

The third conductive layer **108** of the gate electrode **110** formed in the same layer level as the third electrode layer **113** of the pixel electrode **115** and the third layer **118** of the capacitor second electrode **120** are also crystallized, thereby including crystallized ITO.

The crystallized ITO is denser and has high durability, and thus a surface thereof is not damaged during subsequent processes. In addition, as the surface of the crystallized ITO is not damaged, the bonding characteristics between the crystallized ITO and other layers may be improved.

Next, referring to FIG. 2C, a planarization layer **131** is formed of an insulation material on the gate insulation layer **105**, and covers the gate electrode **110**, the pixel electrode **115**, and the capacitor second electrode **120**. A contact hole is formed in the planarization layer **131**. A source/drain region of the active layer **103** may be exposed through the contact hole formed in the planarization layer **131**. To form the contact hole, a photolithography method may be used. Also, a second opening portion **131***a* may be formed in the planarization layer **131**. The fourth electrode layer **114** of the pixel electrode **115** is exposed through the second opening portion **131***a*. Also, a hole that exposes the fourth electrode layer **114** of the pixel electrode **115** is further formed in the planarization layer **131** so as to connect the pixel electrode **115** and a source/drain electrode to be formed later.

Next, referring to FIG. 2D, a source/drain electrode **132** is formed, The source/drain electrode **132** contacts a source/drain region of the active layer **103**. Also, the source/drain electrode **132** contacts the pixel electrode **115**, specifically, the fourth electrode layer **114** of the pixel electrode **115**.

The source/drain electrode **132** may each be formed of a multi-layer structure including various suitable conductive layers, specifically, a Ti/Al/Ti structure.

Next, referring to FIG. 2E, a first opening portion **114***a* is formed in the fourth electrode layer **114** of the pixel electrode **115**. The first opening portion **114***a* is formed in the fourth electrode layer **114** by etching the fourth electrode layer **114** that is exposed through the second opening portion **131***a* formed in the planarization layer **131**. The first opening portion **114***a* is formed to correspond to the second opening portion **131***a*.

A wet etching process (in which an etching solution such as an oxalic acid solution, a nitric acid solution, a sulfuric acid solution, and/or a cerium ammonium nitride (CAN) solution is used) may be utilized to etch the fourth electrode layer **114**. However, the embodiment of the present invention is not limited thereto. Alternatively, various other suitable etching solutions for etching IZO or AZO, such as a phosphoric acid solution or an acetic acid solution, may be used.

While forming the first opening portion **114***a* by etching the fourth electrode layer **114**, the third electrode layer **113** is not substantially affected by the etching solution and thus is not etched. This is because the third electrode layer **113** includes crystallized ITO and thus has increased durability and higher resistance to etching. As such, while etching the fourth electrode layer **114** including IZO or AZO, the third electrode layer **113** is not etched (or not substantially etched). Accordingly, a surface of a portion of the pixel electrode **115** that is not covered by the planarization layer **131** and thus is exposed, is not damaged, thereby increasing the bonding characteristics between the pixel electrode **115** and an intermediate layer to be formed in a subsequent process.

Next, referring to FIG. 2F, a pixel define layer **133** is formed on the planarization layer **131**, and covers the source/drain electrode **132**. The pixel define layer **133** may be formed of an organic material.

A third opening portion **133***a* is formed in the pixel define layer **133** to contact the first opening portion **114***a* or in the first opening portion **114***a*. The third electrode layer **113** of the pixel electrode **115** is exposed through the third opening portion **133***a*. In order to form the third opening portion **133***a*, an etching process for removing a set or predetermined region of the pixel define layer **133** is used, and during this etching process, a surface of the pixel electrode **115** may be damaged.

However, according to the current embodiment of the present invention, since the third electrode layer **113** includes crystallized ITO, the durability thereof increased. Thus the third electrode layer **113** is not affected by the etching solution.

Next, referring to FIG. 2G, an intermediate layer **134** and a counter electrode **135** are sequentially formed on the third electrode layer **113** of the pixel electrode **115** exposed through the third opening portion **133***a* of the pixel define layer **133**, and on the pixel define layer **133**. The intermediate layer **134** includes an organic light emitting layer. Materials for forming the intermediate layer **134** and the counter electrode **135** are the same as described above and thus descriptions thereof will not be provided again.

Although not shown in FIG. 2G, a sealing member may be disposed on the counter electrode **135** to face a surface of the substrate **101**. The sealing member is formed to protect the intermediate layer **134** from external water and/or oxygen, and is formed of a transparent material. To this end, the sealing member may be formed of glass, plastic, or a multi-layer structure of organic and inorganic materials.

According to the current embodiment of the present invention, the gate electrode **110** and the pixel electrode **115** are formed of the same materials in the same layer level. Accordingly, the manufacturing process may be simplified. Also, according to the current embodiment, the capacitor first electrode **104** is formed of the same material as and in the same layer level as the active layer **103** at the same time with the active layer **103**, and the capacitor second electrode **120** is formed at the same time with the gate electrode **110**, thereby further simplifying the manufacturing process.

The gate electrode **110** may have a four-layer structure in order to obtain a resistance reduction effect. Also, the third conductive layer **108** of the gate electrode **110** includes crystallized ITO and thus has increased durability, and the fourth conductive layer **109** is formed on the third conductive layer **108**, thereby further protecting the third conductive layer **108**. In addition, the capacitor second electrode **120** and the pixel electrode **115** have a four-layer structure, and thus the same effect in terms of reducing resistance may be obtained.

Also, the third electrode layer **113** in the portion of the pixel electrode **115** contacting the intermediate layer **134** includes crystallized ITO and thus has high durability, thereby preventing or protecting from surface damage of the third electrode layer **113** in subsequent processes. Also, the fourth electrode layer **114** is formed on the third electrode layer **113**, and thus the fourth electrode layer **114** protects the third electrode layer **113** when the second opening portion **131***a* is formed in the planarization layer **131**, thereby further preventing or protecting damage to the surface of the third electrode layer **113**.

As described above, according to the one or more of the above embodiments of the present invention, the characteristics of a contact interface between the third electrode layer **113** and the intermediate layer **134** is improved, and the electric characteristics and the light emitting characteristics of the organic light emitting display apparatus **100** are improved.

According to the organic light emitting display apparatus and the method of manufacturing the same, the manufacturing process of the organic light emitting display apparatus may be simplified and the electric characteristics of the organic light emitting display apparatus may be easily improved.

While the present invention has been described in connection with certain exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, and equivalents thereof.

What is claimed is:

1. An organic light emitting display apparatus comprising:

a substrate;

an active layer on the substrate;

a gate electrode insulated from the active layer and composed of a first conductive layer comprising ITO, a second conductive layer on the first conductive layer, a third conductive layer on the second conductive layer and comprising ITO, and a fourth conductive layer on the third conductive layer and comprising IZO or AZO;

a pixel electrode formed in the same layer level as the gate electrode and composed of a first electrode layer comprising ITO, a second electrode layer on the first electrode layer, a third electrode layer on the second electrode layer and comprising ITO, and a fourth electrode layer on the third electrode layer and comprising IZO or AZO;

a source electrode and a drain electrode, the source and drain electrodes being insulated from the gate electrode and electrically coupled to the active layer;

an intermediate layer on the pixel electrode and comprising an organic light emitting layer; and

a counter electrode on the intermediate layer,

wherein the pixel electrode is electrically coupled to the source electrode or the drain electrode.

2. The organic light emitting display apparatus of claim **1**, wherein the third electrode layer comprises crystallized ITO.

3. The organic light emitting display apparatus of claim **1**, wherein the intermediate layer contacts the third electrode layer of the pixel electrode.

4. The organic light emitting display apparatus of claim **1**, wherein the source electrode or the drain electrode contacts the fourth electrode layer of the pixel electrode.

5. The organic light emitting display apparatus of claim **1**, wherein the fourth electrode layer of the pixel electrode comprises a first opening portion to expose the third electrode layer disposed below the fourth electrode layer.

6. The organic light emitting display apparatus of claim **5**, further comprising a planarization layer for insulating the gate electrode from the source electrode and the drain electrode,

wherein the source electrode and the drain electrode are on the planarization layer, and the planarization layer comprises a second opening portion corresponding to the first opening portion.

7. The organic light emitting display apparatus of claim **6**, further comprising a pixel define layer on the planarization layer, and covering the source electrode and the drain electrode, wherein the pixel define layer comprises a third opening portion contacting the first opening portion or formed in the first opening portion, and wherein the intermediate layer contacts the third electrode layer through the third opening portion.

8. The organic light emitting display apparatus of claim **1**, wherein the second conductive layer comprises Ag or Al.

9. The organic light emitting display apparatus of claim **1**, further comprising a capacitor comprising:

a capacitor first electrode layer formed in the same layer level as the active layer and physically separated from the active layer; and

a capacitor second electrode layer insulated from the capacitor first electrode layer and formed in the same layer level as the gate electrode to correspond to the capacitor first electrode layer.

10. The organic light emitting display apparatus of claim **9**, wherein the capacitor second electrode layer comprises a first layer comprising ITO, a second layer on the first layer, a third layer on the second layer and comprising ITO, and a fourth layer on the third layer and comprising IZO or AZO.

11. The organic light emitting display apparatus of claim **10**, wherein the second layer comprises Ag or Al.

12. A method of manufacturing an organic light emitting display apparatus, the method comprising:

forming an active layer on a substrate;

forming a gate electrode insulated from the active layer and composed of a first conductive layer comprising ITO, a second conductive layer on the first conductive layer, a third conductive layer on the second conductive layer and comprising ITO, and a fourth conductive layer on the third conductive layer and comprising IZO or AZO;

forming a pixel electrode in the same layer level as the gate electrode and composed of a first electrode layer comprising ITO, a second electrode layer on the first electrode layer, a third electrode layer on the second electrode layer and comprising ITO, and a fourth electrode layer on the third electrode layer and comprising IZO or AZO;

forming a source electrode and a drain electrode to be insulated from the gate electrode and electrically coupled to the active layer;

forming an intermediate layer on the pixel electrode and comprising an organic light emitting layer; and

forming a counter electrode on the intermediate layer,

wherein the pixel electrode is electrically coupled to the source electrode or the drain electrode.

13. The method of claim **12**, wherein the forming of the gate electrode and the forming of the pixel electrode are performed at the same time.

14. The method of claim **12**, wherein the forming of the pixel electrode comprises crystallizing the third electrode layer.

15. The method of claim **12**, wherein the intermediate layer is formed to contact the third electrode layer of the pixel electrode.

16. The method of claim **12**, wherein the source electrode or the drain electrode is formed to contact the fourth electrode layer of the pixel electrode.

17. The method of claim **12**, further comprising forming a first opening portion in the fourth electrode layer to expose the third electrode layer before the forming of the intermediate layer.

18. The method of claim **17**, further comprising forming a planarization layer on the gate electrode and the pixel electrode to insulate the gate electrode from the source electrode and the drain electrode, wherein the planarization layer comprises a second opening portion corresponding to the first opening portion.

19. The method of claim **18**, wherein the first opening portion is formed by removing the fourth electrode layer exposed through the second opening portion after forming the second opening portion.

20. The method of claim **18**, further comprising forming a pixel define layer on the planarization layer, covering the source electrode and the drain electrode, wherein the pixel define layer comprises a third opening portion contacting the first opening portion or formed in the first opening portion, and wherein the intermediate layer is formed to contact the third electrode layer through the third opening portion.

21. The method of claim **12**, further comprising:

forming a capacitor first electrode layer in the same layer level as the active layer and physically separated from the active layer; and

forming a capacitor second electrode layer to be insulated from the capacitor first electrode layer and to correspond to the capacitor first electrode layer and in the same layer level as the gate electrode.

22. The method of claim **21**, wherein the forming of the capacitor second electrode layer comprises forming a first layer comprising ITO, a second layer on the first layer, a third layer on the second layer and comprising ITO, and a fourth layer on the third layer and comprising IZO or AZO.

23. The method of claim **22**, wherein the second layer comprises Ag or Al.

* * * * *

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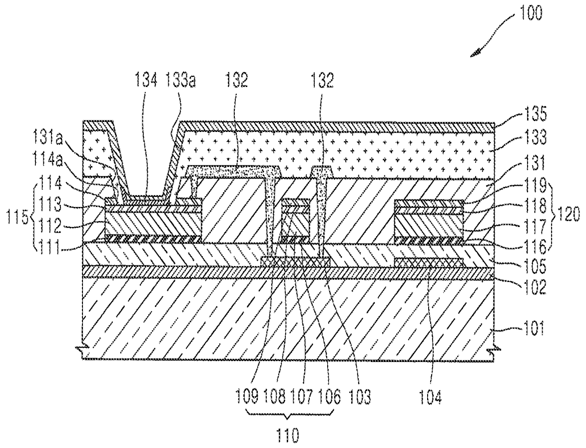
摘要(译)

有机发光显示装置和制造有机发光显示装置的方法，由此简化了制造工艺并且改善了有机发光显示装置的电特性。该有机发光显示装置包括：栅电极，包括：第一导电层，包括ITO;第二导电层，位于第一导电层上;第三导电层，位于第二导电层上，并且包括ITO;以及第四导电层，位于第一导电层上。第三导电层，包括IZO或AZO;像素电极形成在与栅电极相同的层级中，并且包括包括ITO的第一电极层，在第一电极层上的第二电极层，在第二电极层上的包括ITO的第三电极层，以及第四电极层第三电极层上的电极层包括IZO或AZO。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