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

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(57) **ABSTRACT**

An organic light emitting diode display device and a method of manufacturing the same are disclosed. The organic light emitting diode display device includes a substrate having an emission section and anon-emission section, a semiconductor layer located on the substrate, a gate dielectric layer located over an entire front surface of the substrate, a gate electrode located in correspondence to the semiconductor layer, a dielectric layer located over the entire front surface of the substrate, source and drain electrodes and a first electrode located on the dielectric layer and electrically connected to the semiconductor layer, a pixel definition layer exposing a part of the first electrode, a spacer located on the pixel definition layer and located on the non-emission section of the substrate, an organic film layer located on the first electrode, and a second electrode located over the entire front surface of the substrate.

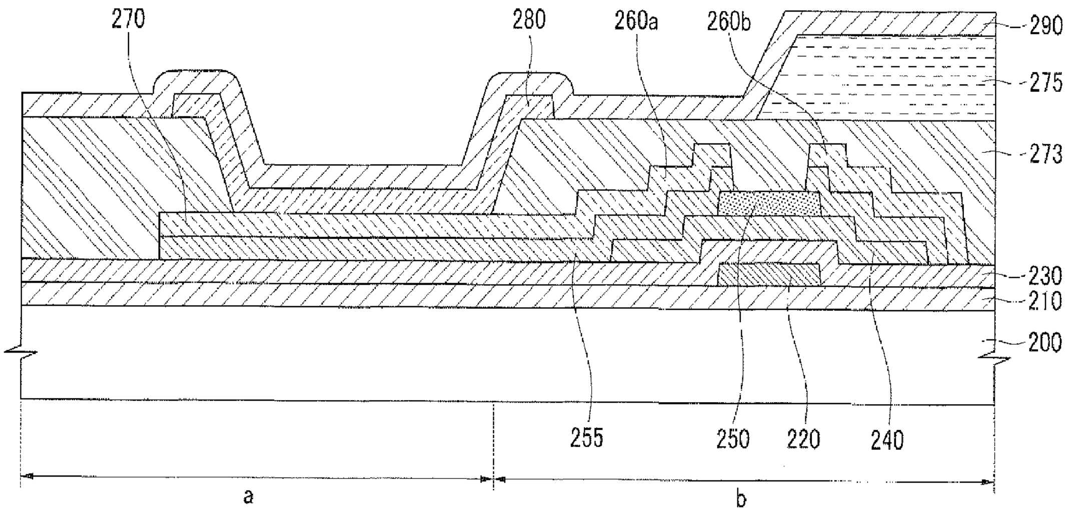


FIG.1A

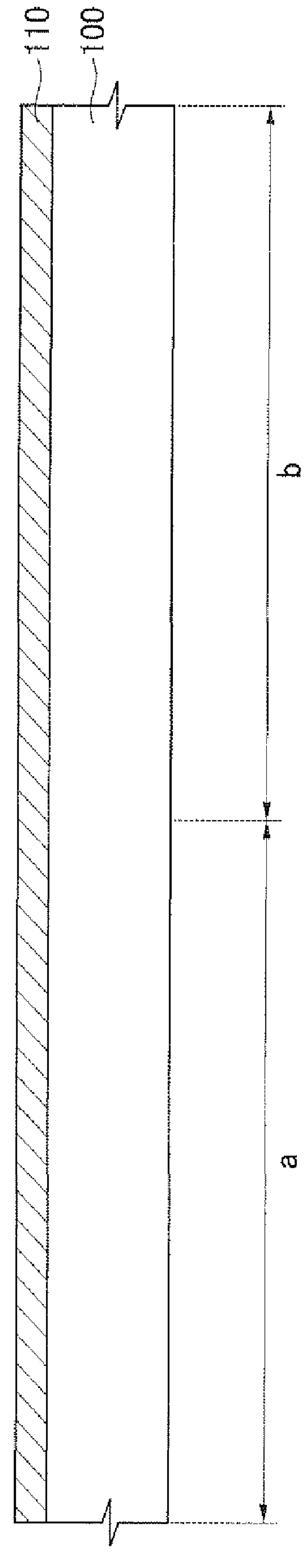


FIG.1B

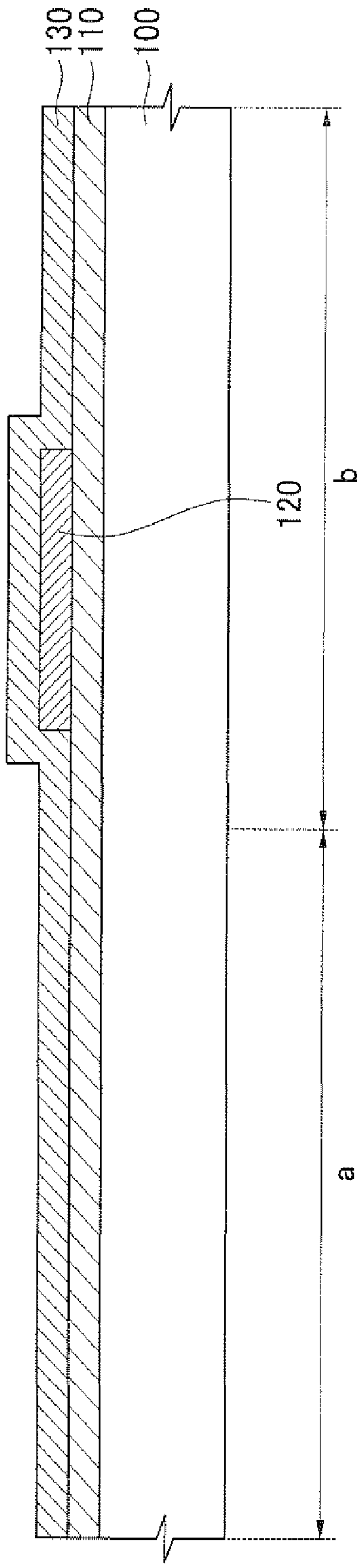


FIG.1C

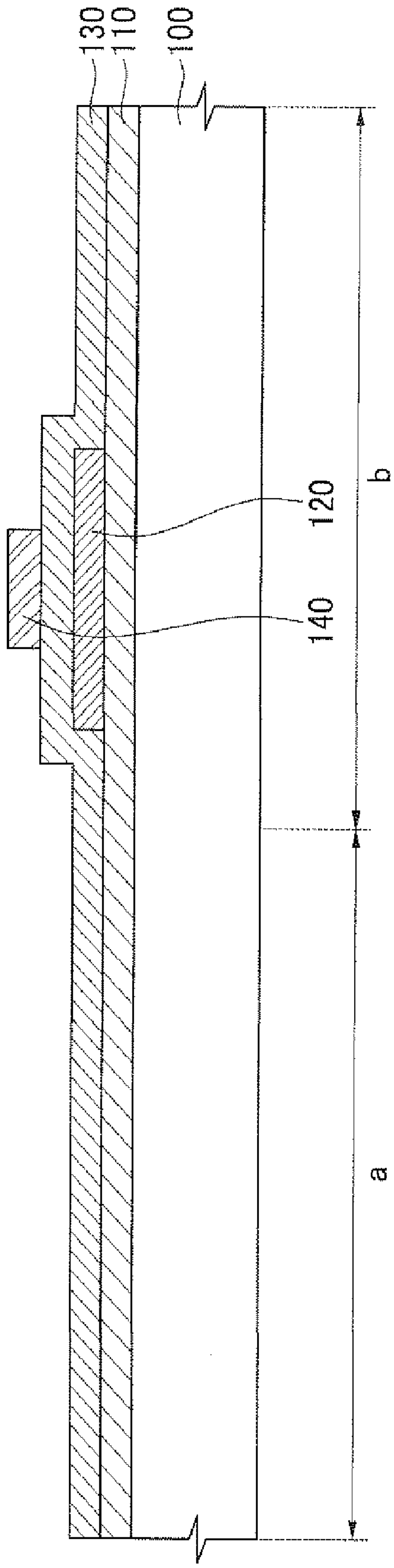


FIG.1D

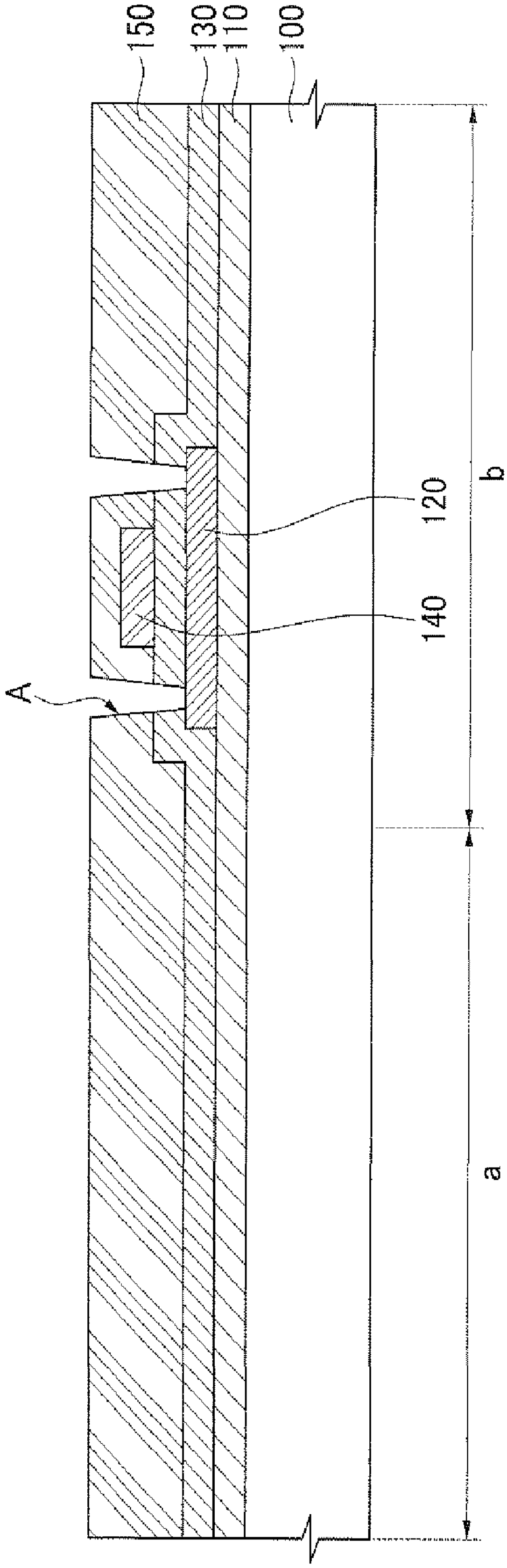


FIG.1E

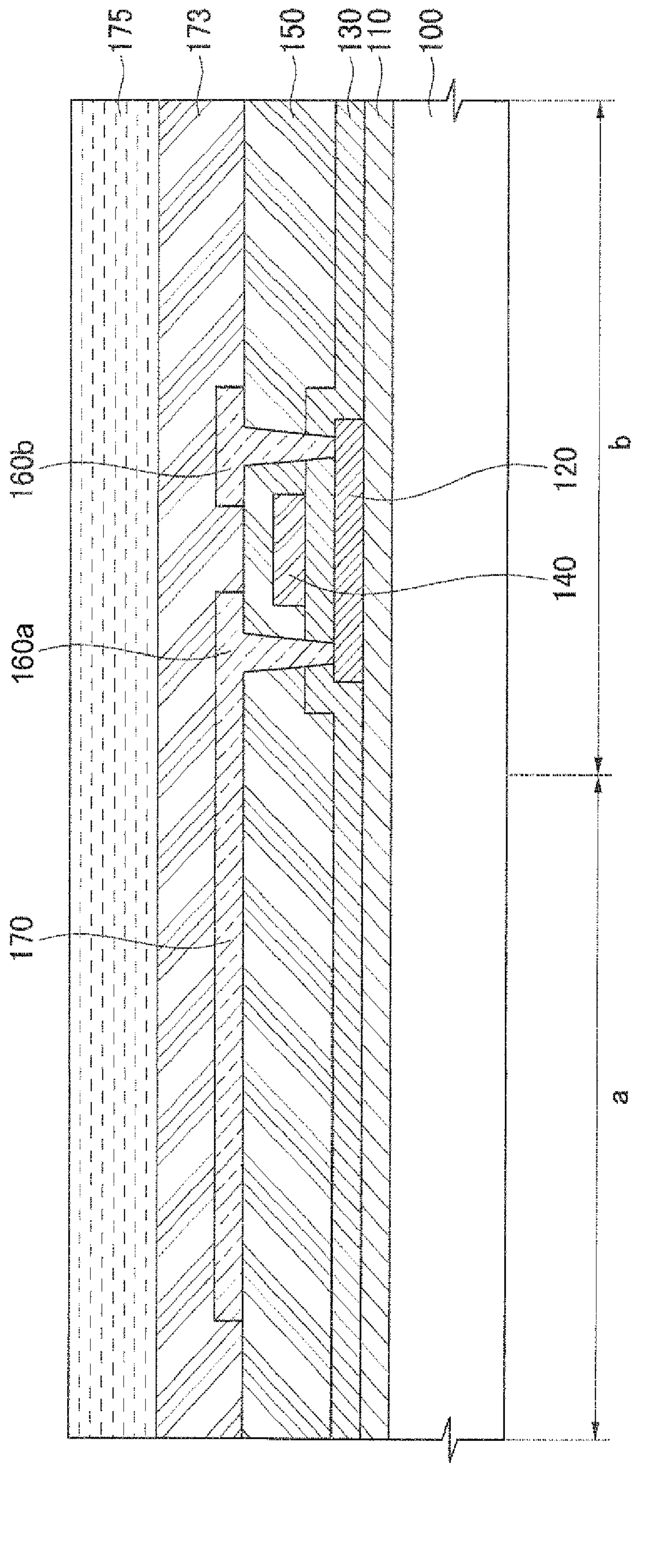


FIG. 1F

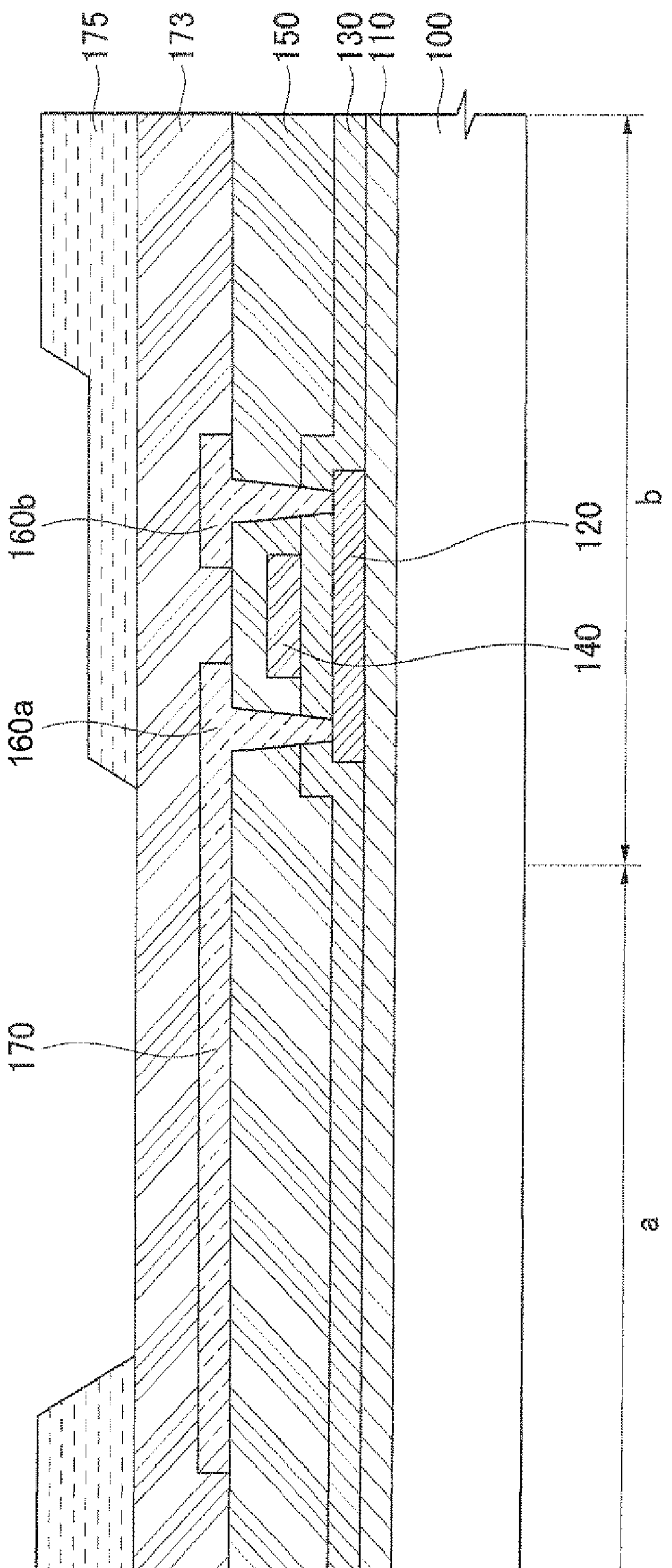


FIG.1G

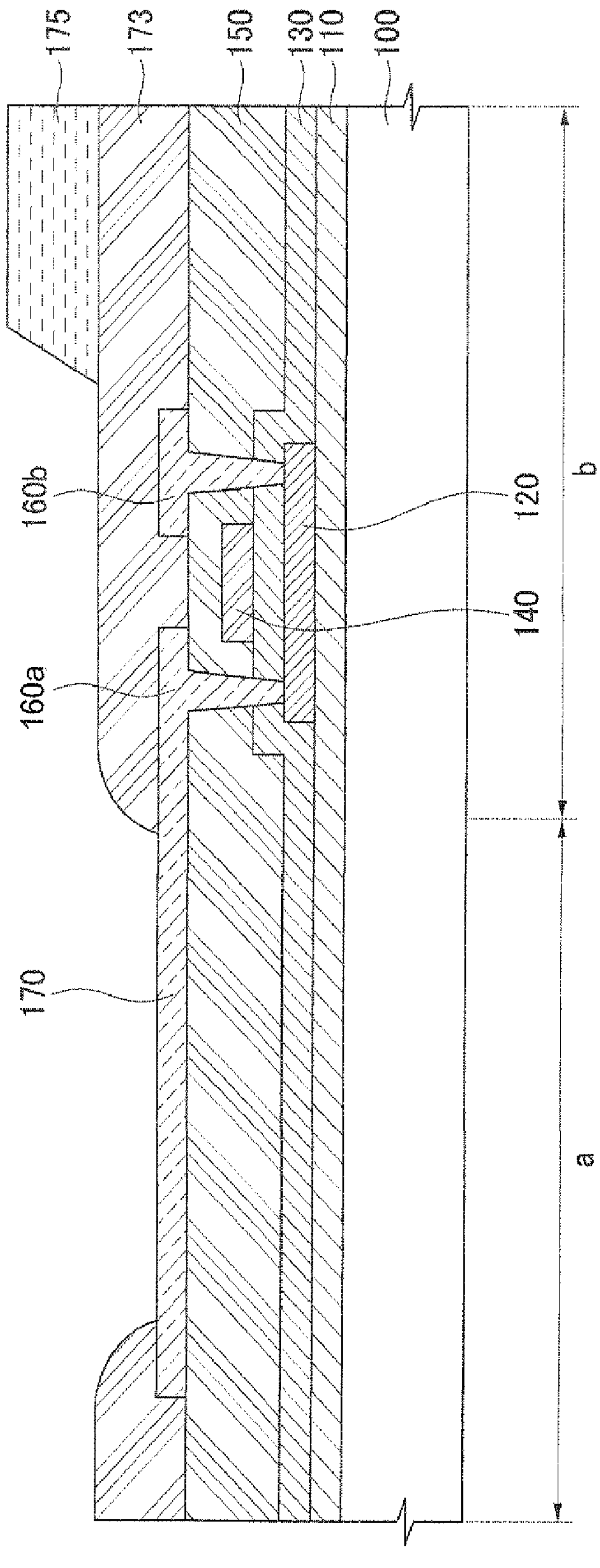


FIG. 1H

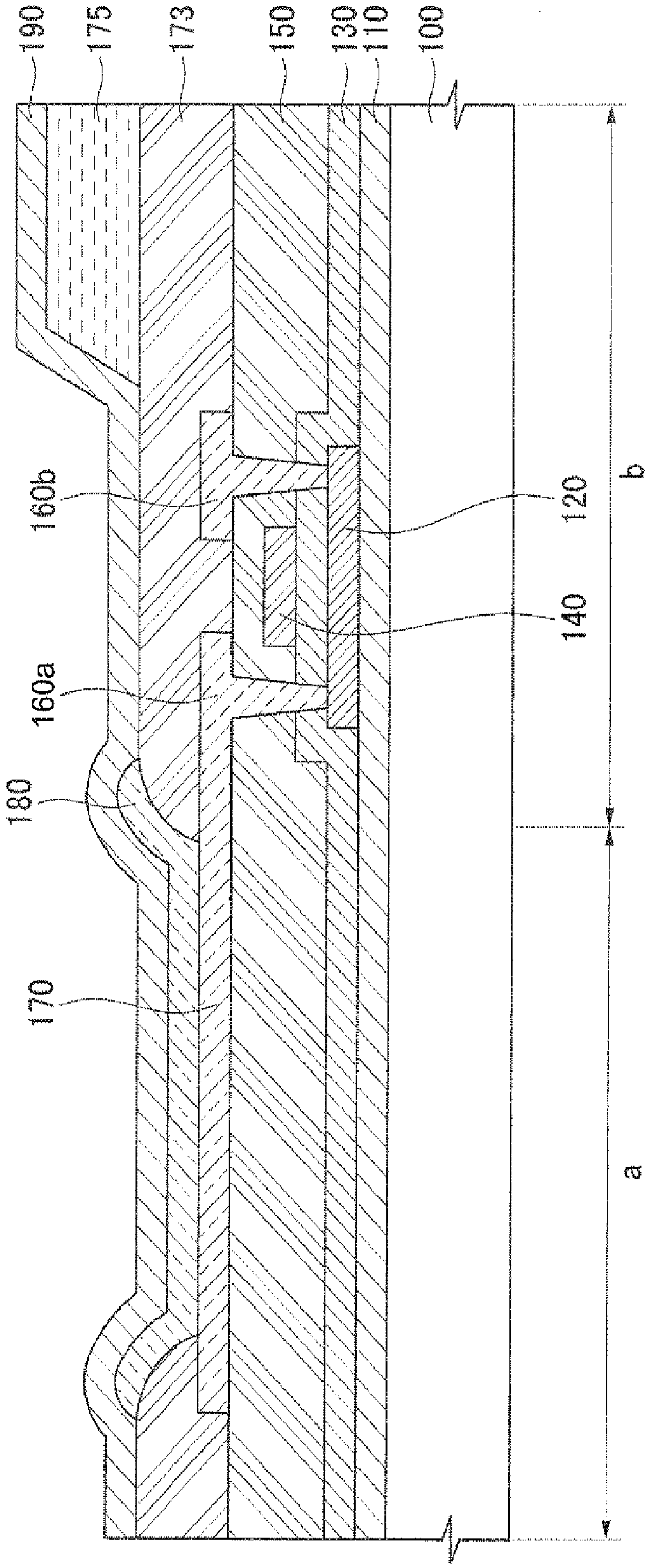


FIG.1I

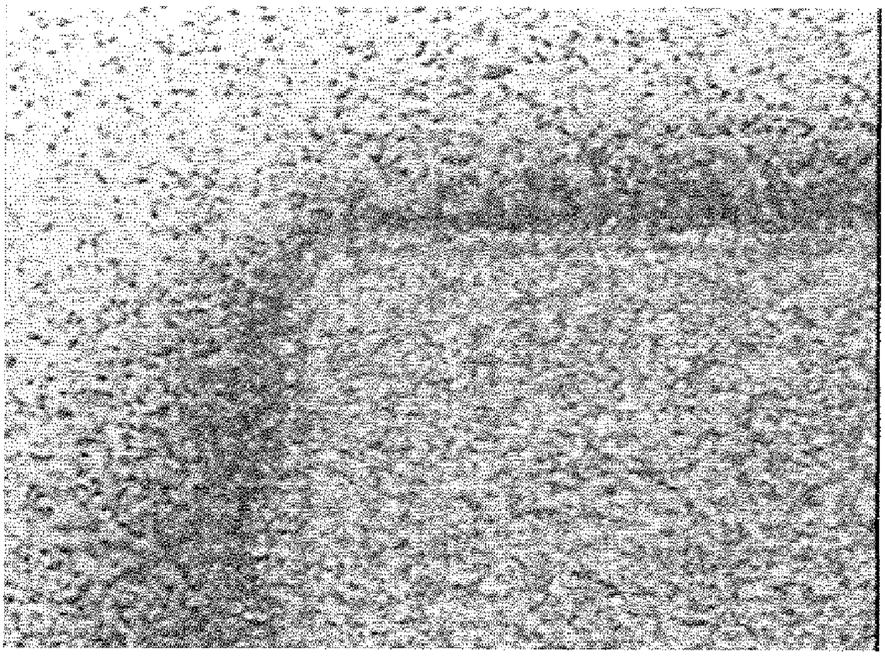


FIG.1J

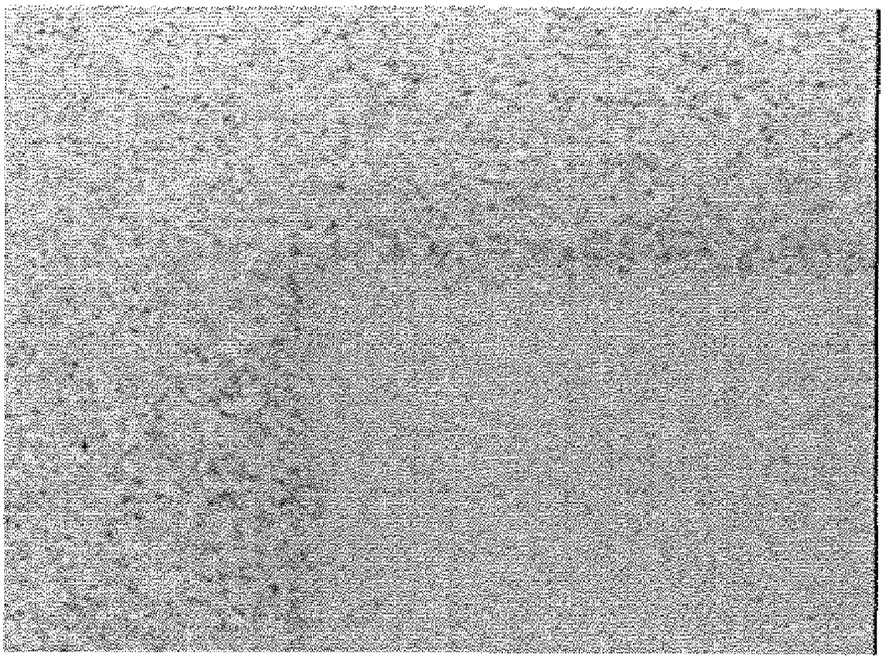


FIG.1K

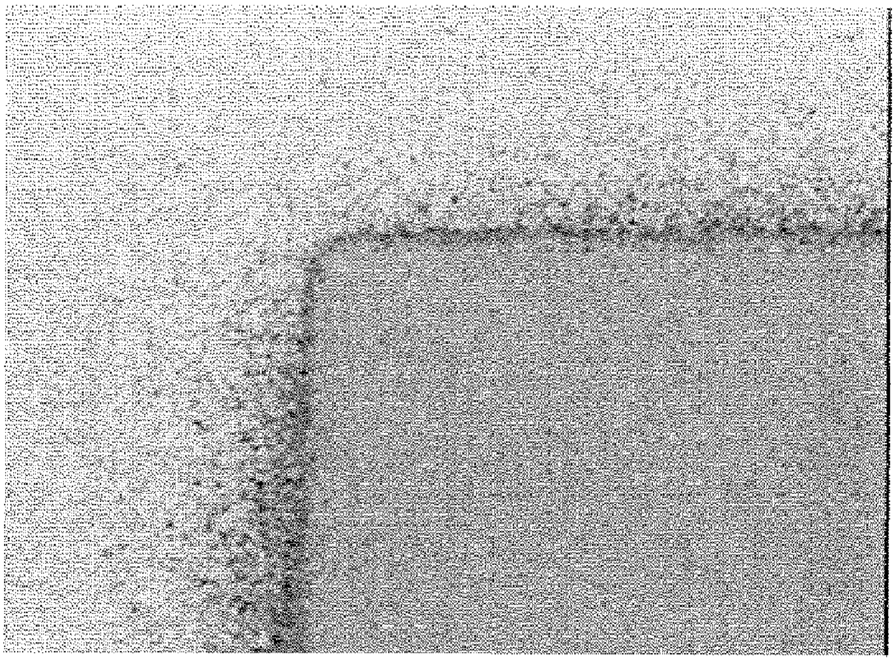


FIG.1L

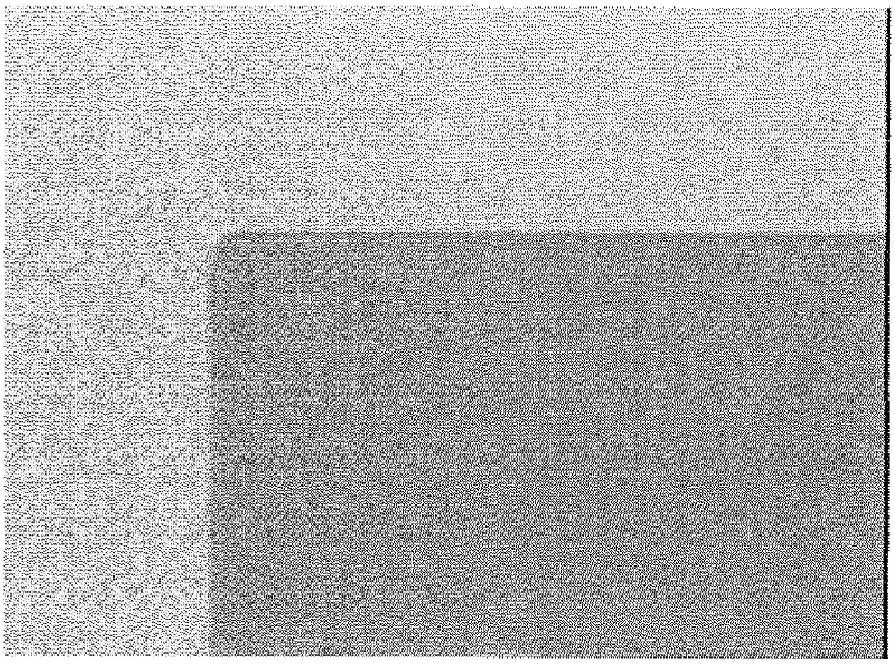


FIG.2A

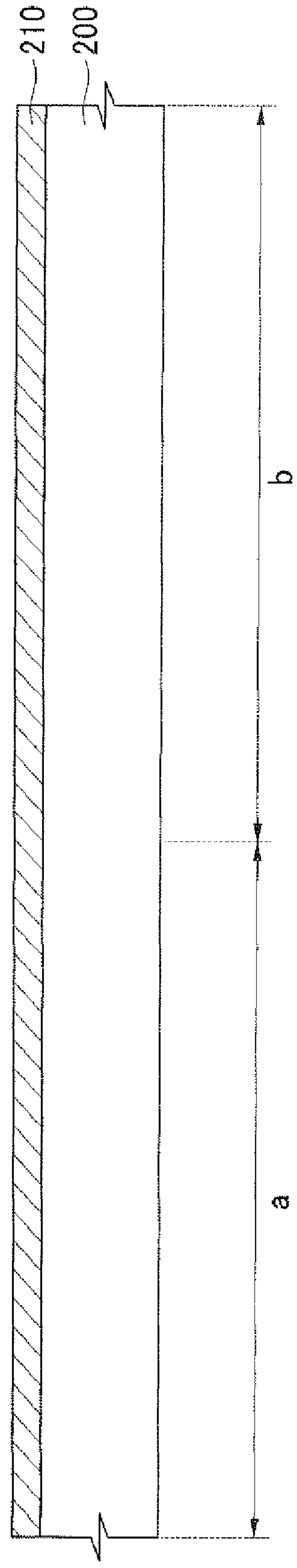


FIG.2B

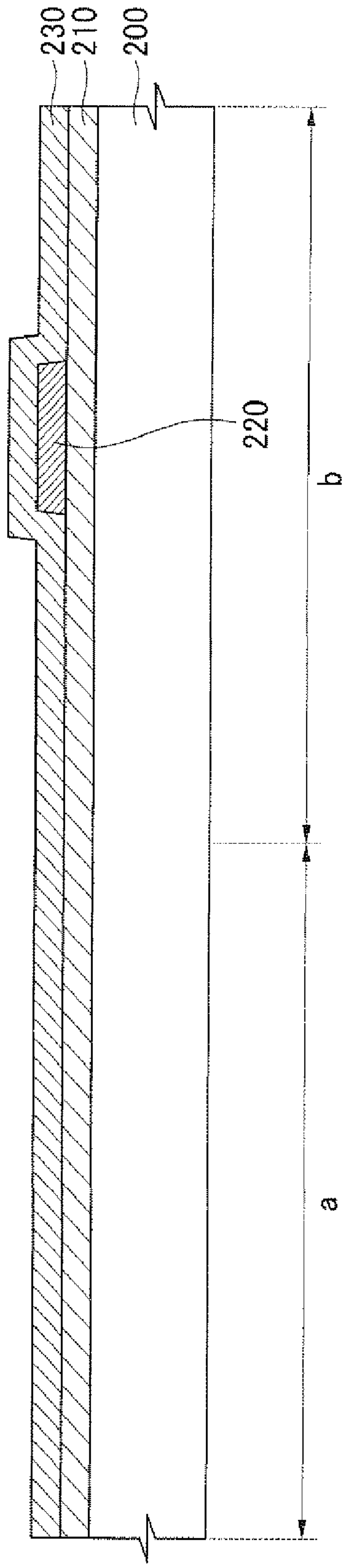


FIG.2C

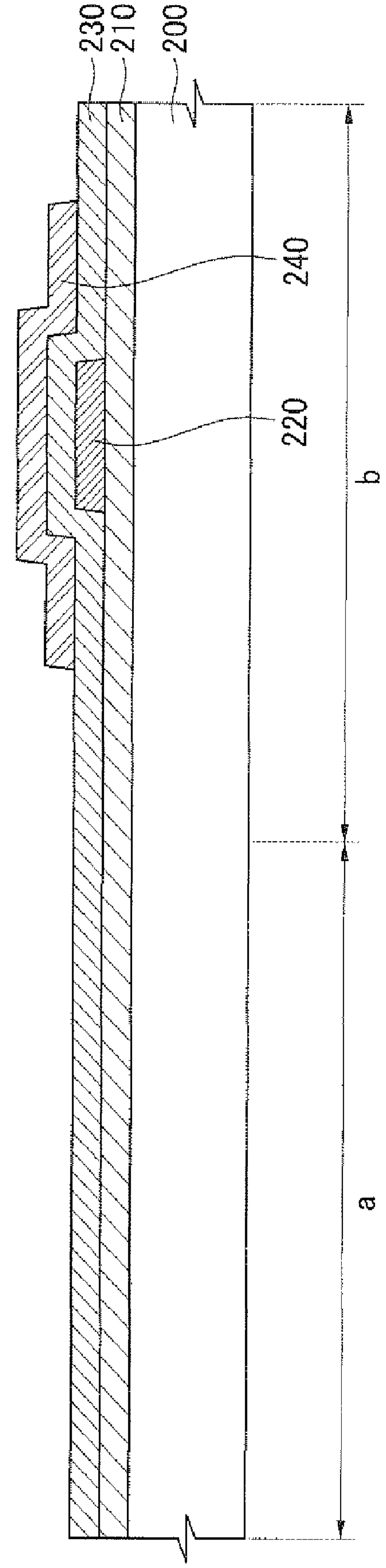


FIG.2D

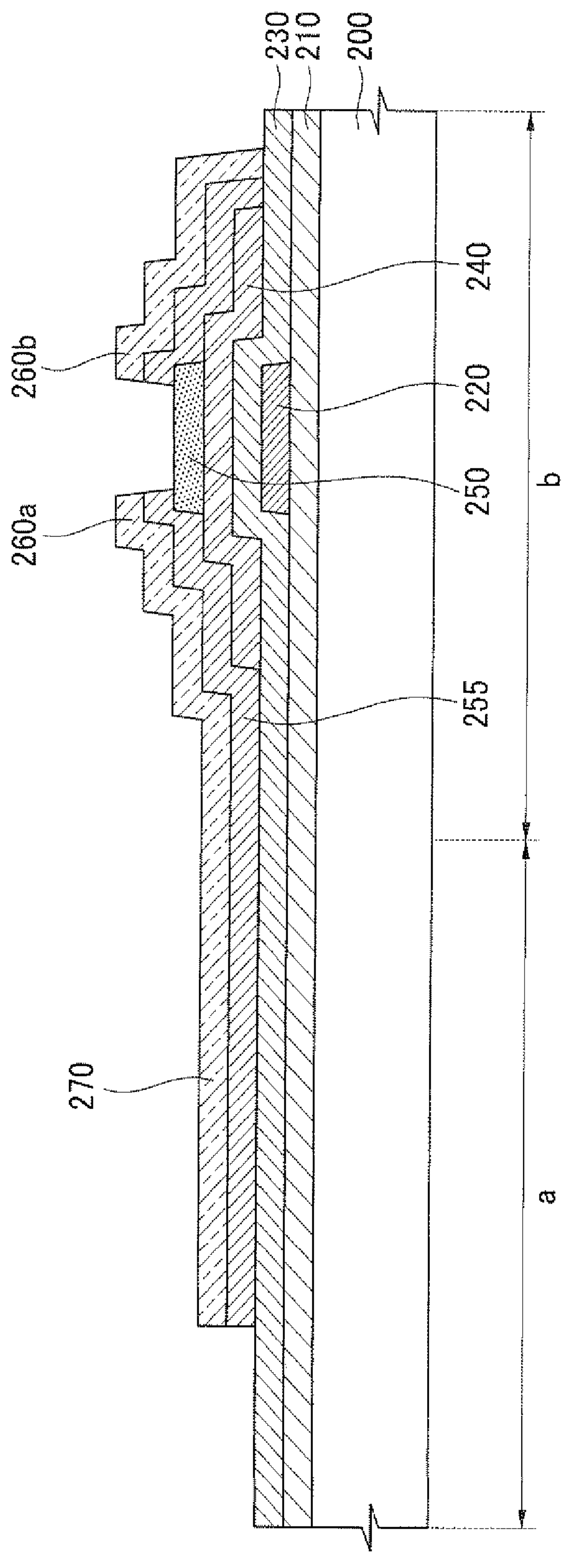


FIG.2E

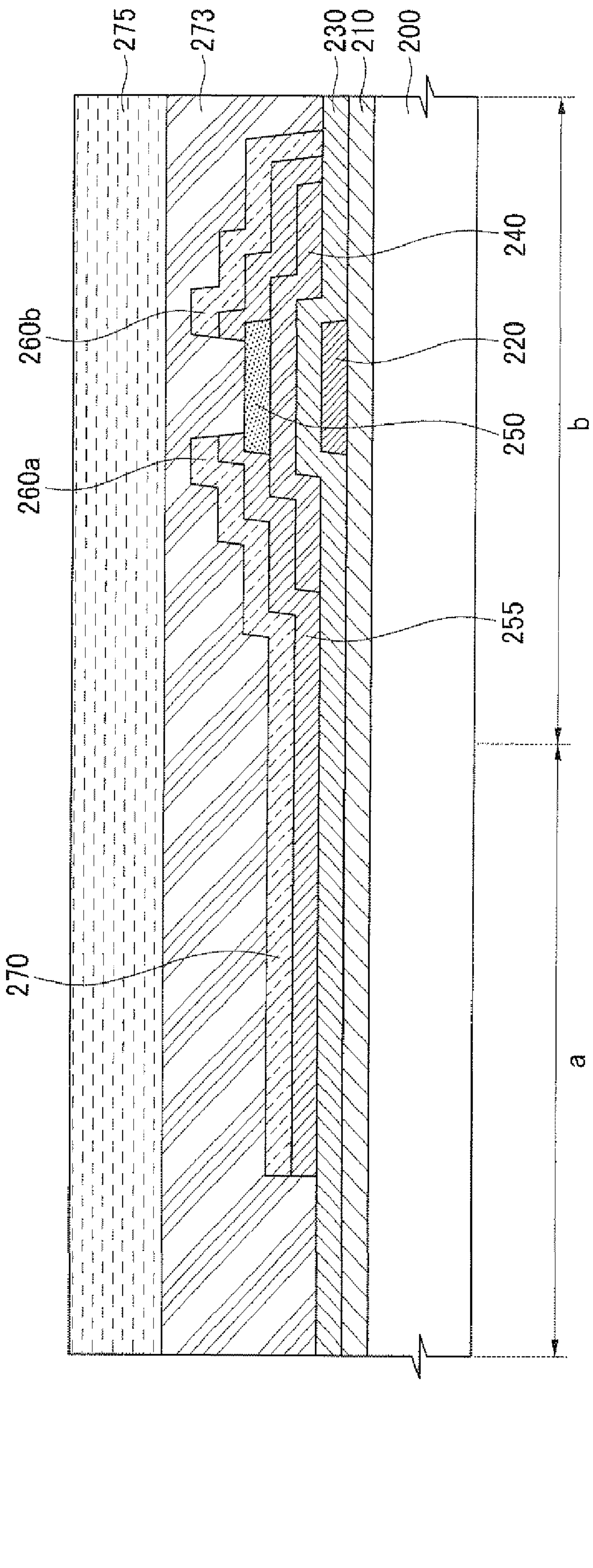


FIG.2F

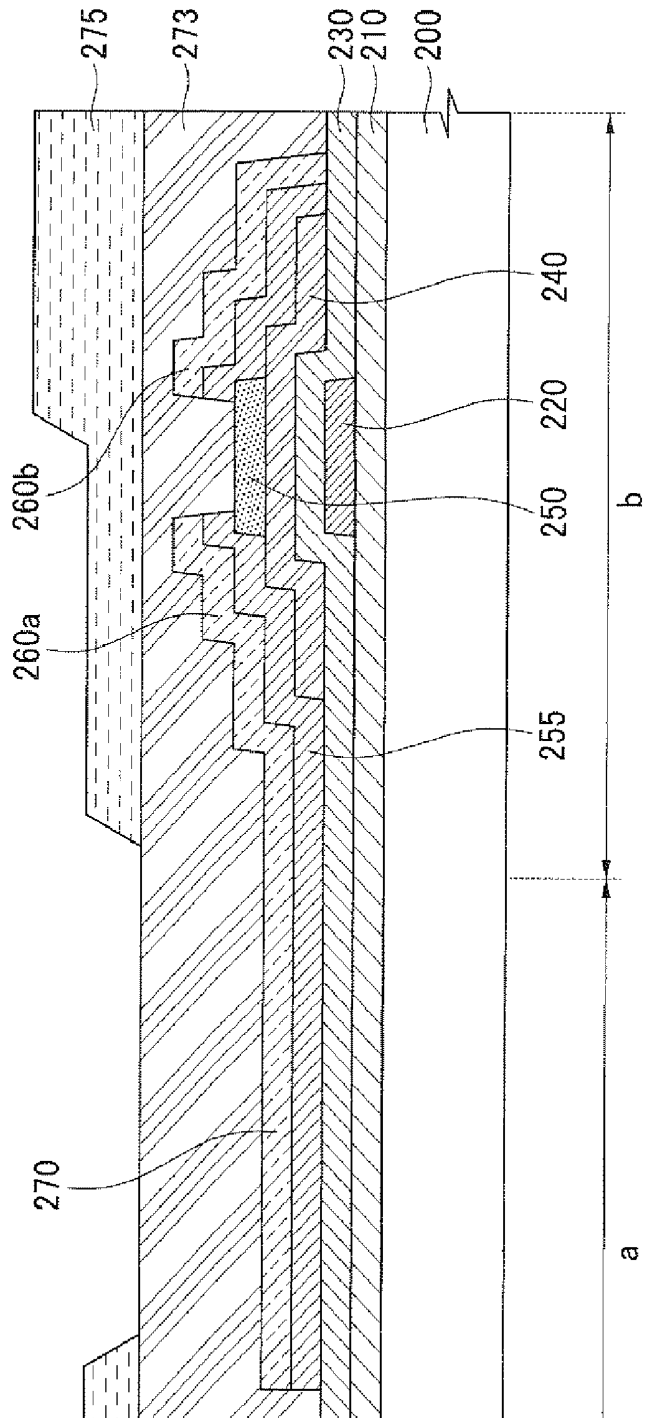


FIG.2G

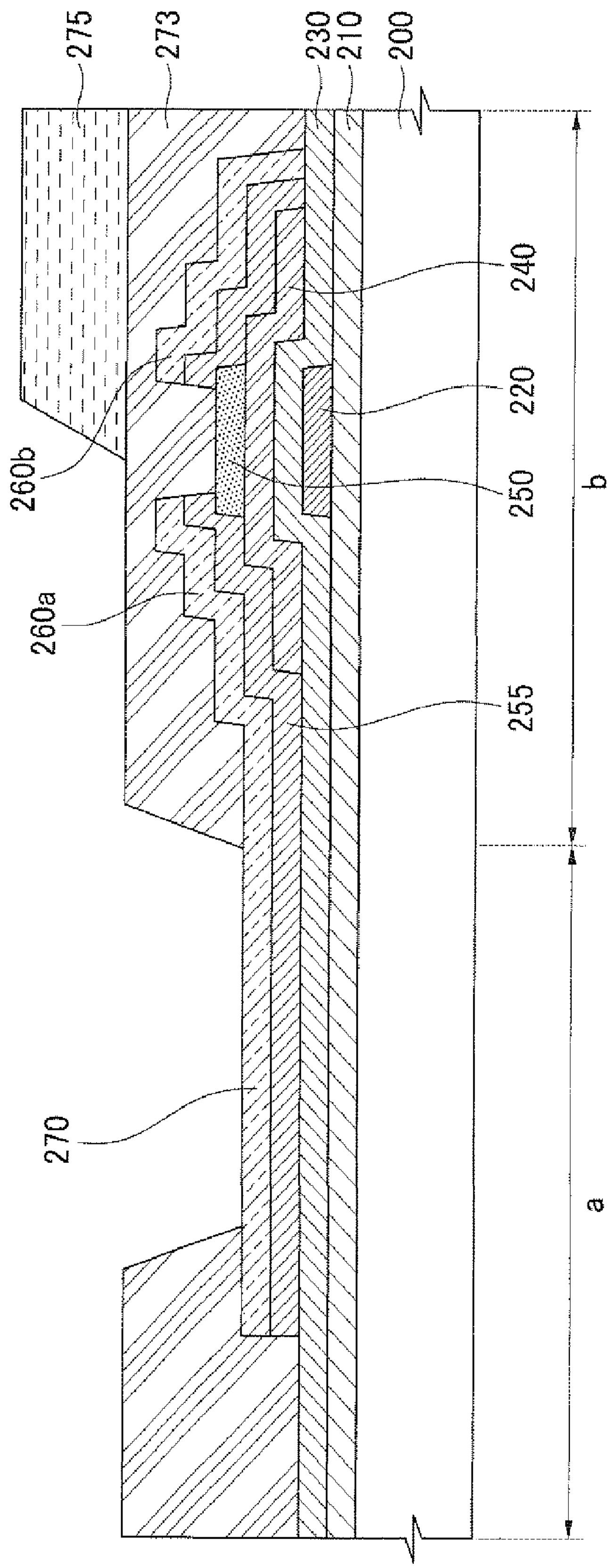
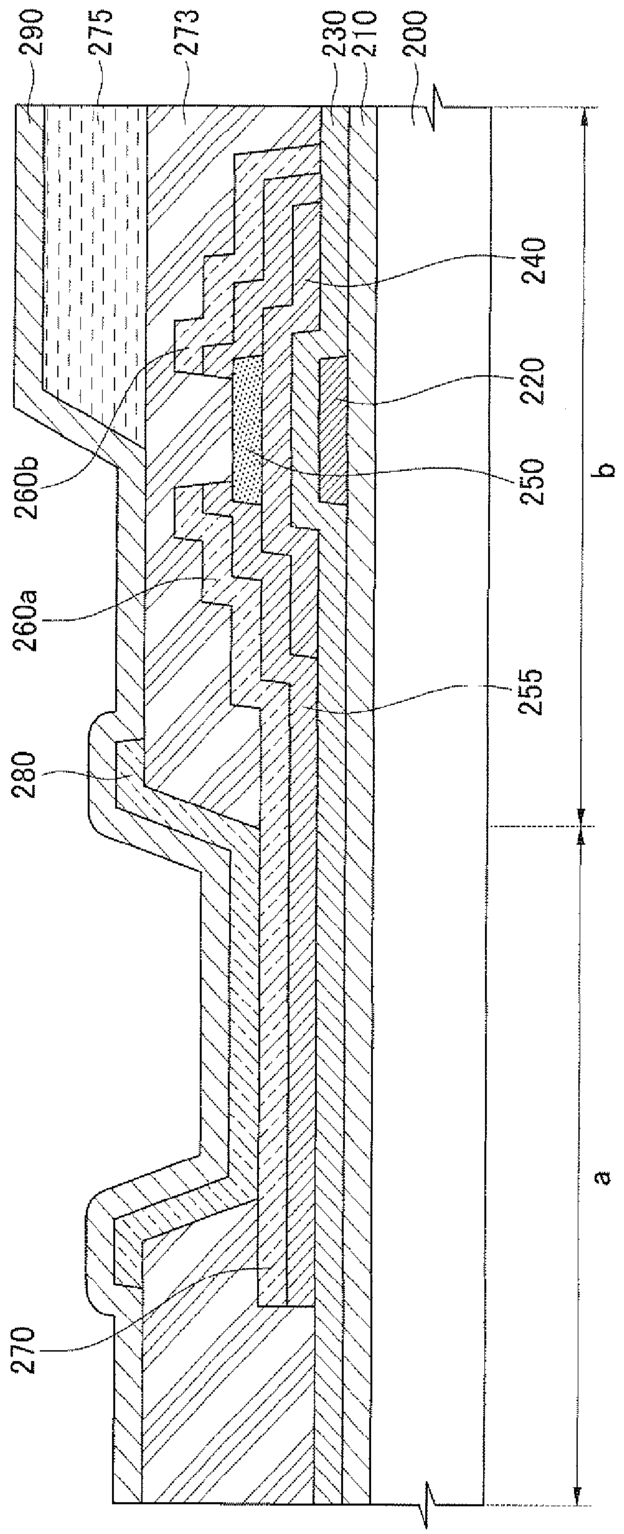


FIG.2H



# ORGANIC LIGHT EMITTING DIODE DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

## CLAIM OF PRIORITY

**[0001]** This application makes reference to, incorporates the same herein, and claims all benefits accruing under 35 U.S.C. §119 from an application earlier filed in the Korean Intellectual Property Office on Jan. 8, 2010 and there duly assigned Serial No. No. 2010-0001723.

## BACKGROUND OF THE INVENTION

**[0002]** 1. Field of the Invention

**[0003]** The present invention relates generally to an organic light emitting diode display device and a method of manufacturing the same, to which a 5-mask process can be applied, thereby making it possible to reduce the number of masks, cut down the cost of production, and simplify a process to enhance a yield.

**[0004]** 2. Description of the Related Art

**[0005]** Among flat panel display devices, organic light emitting diode display devices exhibit characteristics such as self-emission, wide viewing angle, rapid response speed of 1 ms or less, thin thickness, low manufacturing cost, and high contrast.

**[0006]** The organic light emitting diode display devices includes an organic emission layer between a positive electrode (anode) and a negative electrode (cathode). Thus, holes supplied from the anode and electrons supplied from the cathode are combined in the organic emission layer, thereby forming hole-electron pairs, i.e. excitons. The excitons release energy while returning to a ground state so that light is emitted.

**[0007]** The organic light emitting diode display devices are generally configured to mount a thin film transistor on each pixel, and supply constant current regardless of the number of pixels, so that they can provide stable luminance and low power consumption, and thus they are advantageous for application to high-resolution and large displays.

**[0008]** However, the organic light emitting diode display devices require a considerable number of masks due to a complicated process, and the resultant enormous cost. Thus, to have price competitiveness, a technique capable of reducing the number of masks and processes is acutely required.

## SUMMARY OF THE INVENTION

**[0009]** The present invention provides an organic light emitting diode display device which is capable of reducing the number of masks so as to cut down the cost of production and enhance a yield, and a method of manufacturing the same.

**[0010]** The present invention also provides an organic light emitting diode display device including: a substrate having an emission section and a non-emission section; a semiconductor layer located on the substrate; a gate dielectric layer located on an entire front surface of the substrate; a gate electrode located in correspondence to the semiconductor layer; a dielectric layer located on an entire front surface of the substrate; source and drain electrodes and a first electrode located on the dielectric layer and electrically connected to the semiconductor layer, the first electrode being located on the emission section of the substrate; a pixel definition layer exposing a part of the first electrode; a spacer located on the pixel definition layer and located on the non-emission section of the substrate; an organic film layer located on the first electrode; and a second electrode located on an entire front surface of the substrate. The pixel definition layer includes an inorganic layer, and the spacer includes an organic layer.

**[0011]** Additional aspects and/or advantages of the invention will be set forth, in part, in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings, in which like reference symbols indicate the same or similar components, wherein:

**[0013]** FIGS. **1**A thru **1**H illustrate an organic light emitting diode display device according to a first embodiment of the invention;

**[0014]** FIGS. **1**I thru **1**L are microscopic photographs of a pixel electrode formed of a silicon nitride layer; and

**[0015]** FIGS. **2**A thru **2**H illustrate an organic light emitting diode display device according to a second embodiment of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

**[0016]** Reference will now be made in detail to the present embodiments, examples of which are shown in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

### First Embodiment

**[0017]** FIGS. **1**A thru **1**H illustrate an organic light emitting diode display device according to a first embodiment of the invention.

**[0018]** First, referring to FIG. **1**A, a substrate **100** having an emission section a and non-emission section b is provided. The substrate **100** is formed of a material such as glass or plastic. Then, a buffer layer **110** is formed on the substrate **100**. The buffer layer **110** is formed of at least one dielectric layer, for instance, a silicon oxide layer and a silicon nitride layer, using chemical or physical vapor deposition.

**[0019]** Referring to FIG. **1**B, a semiconductor layer **120** is formed on the buffer layer **110** using a first mask. Then, a gate dielectric layer **130** is formed over an entire front surface of the substrate **100**. The gate dielectric layer **130** may be formed of a silicon oxide layer, a silicon nitride layer or both of them.

**[0020]** Then, referring to FIG. **1**C, a gate electrode **140** is formed on the gate dielectric layer **130** so as to correspond to the semiconductor layer **120**. The gate electrode **140** is formed using a second mask. The gate electrode **140** is formed by forming a single layer of aluminum (Al) or an aluminum alloy such as aluminum-neodymium (Al—Nd), or a multiple layer in which an Al alloy is stacked on a chrome (Cr) or molybdenum (Mo) alloy as a metal layer (not shown) for the gate electrode, and etching the metal layer using a photolithography process.

**[0021]** Referring to FIG. **1**D, a dielectric layer **150** is formed above the substrate **100** so as to have contact holes A exposing parts of the semiconductor layer **120**. The dielectric layer **150** is formed using a third mask, and is formed using a mixture layer in which an inorganic layer such as a silicon nitride layer, a silicon oxide layer, or a multiple layer thereof is mixed with a planarization layer which is made of one selected from the group consisting of benzo cyclo butene (BCB), polyimide (PI), polyamide (PA), acrylic resin, and phenol resin, which are typically used as organic materials.

**[0022]** Subsequently, referring to FIG. **1**E, source and drain electrodes **160***a* and **160***b*, respectively, and a first electrode **170** are formed on the dielectric layer **150** so as to be electrically connected to the semiconductor layer **120**.

**[0023]** In this regard, the source and drain electrodes **160***a* and **160***b* and the first electrode **170** are simultaneously formed by stacking a metal layer (not shown) for the source and drain electrodes **160***a* and **160***b*, respectively, and a metal layer (not shown) for the first electrode **170** using a fourth mask.

**[0024]** The metal layer for the source and drain electrodes **160***a* and **160***b*, respectively, may be formed of one selected from molybdenum (Mo), tungsten (W), molybdenum tungsten (MoW), tungsten silicide ($WSi_2$), molybdenum silicide (MoSi2), and aluminum (Al). The metal layer for the first electrode **170** may be formed of one selected from layers including an indium tin oxide (ITO) layer, indium zinc oxide (IZO) layer, and a reflective layer. The reflective layer may be formed of Ag, Al or an alloy thereof.

**[0025]** Then, material layers for a pixel definition layer **173** and a spacer **175** are formed over an entire front surface of the substrate **100**. The material layer of the pixel definition layer **173** may be formed using an inorganic layer, preferably a silicon nitride (SiNx) layer. The material layer for the spacer **175** is formed of one selected from the group consisting of BCB, PI, PA, acrylic resin, and phenol resin, which are typical organic materials.

**[0026]** Referring to FIG. **1**F, the material layer, i.e. the organic layer, for the spacer **175** is ashed using a half-tone mask, a fifth mask, thereby removing a part of the organic layer located on the emission section a, so that an organic layer pattern is left on a part of the non-emission section b.

**[0027]** Then, as seen in FIG. **1**G, the material layer, i.e. the inorganic layer, for the pixel definition layer **173** is dry-etched to expose a part of the first electrode **170**. In this manner, a part of the material layer for the pixel definition layer **173** is removed by etching, and thus a part of the first electrode **170** located on the emission section is exposed, so that the pixel definition layer **173** defining a pixel is formed. The organic layer for the spacer **175** is ashed, so that the spacer **175**, i.e. the organic layer pattern, located on the non-emission section is formed.

**[0028]** In this regard, since the pixel definition layer **173** is formed of the inorganic layer, it is possible to prevent the source and drain electrodes **160***a* and **160***b*, respectively, from being damaged, which is a problem occurring when the pixel definition layer **173** is formed of an organic layer and when the source and drain electrodes **160***a* and **160***b*, respectively, are formed parallel to the first electrode **170**. The pixel definition layer **173** and the spacer **175** are formed using one mask process, so that it is possible to produce a reliable device, and cut down the cost of production.

**[0029]** Furthermore, when the pixel definition layer **173** is formed using the inorganic layer, i.e. the silicon nitride (SiNx) layer, amounts of silane gas and ammonium gas are adjusted so that the silicon nitride layer contains 18 wt % or less of Si. This is because, when the pixel definition layer **173** is formed on the ITO electrode using the silicon nitride layer, and when the content of Si of the silicon nitride layer is high, indium (In) of the ITO electrode migrates to the silicon nitride layer, thereby influencing the pixel definition layer **173**, and thus characteristics of the device.

**[0030]** FIGS. **1**I thru **1**L are microscopic photographs of a pixel region coated with a silicon nitride layer, wherein FIG. **1**I shows a case wherein the silicon nitride layer contains 47 wt % of Si, FIG. **1**J shows a case wherein the silicon nitride layer contains 40 wt % of Si, FIG. **1**K shows a case wherein the silicon nitride layer contains 31 wt % of Si, and FIG. **1**L shows a case wherein the silicon nitride layer contains 18 wt % of Si. Referring to FIGS. **1**I thru **1**L, it can be seen that an amount of indium absorbed into the silicon nitride layer containing 47 wt % of Si is maximum, and an amount of indium absorbed into the silicon nitride layer containing 18 wt % of Si is minimum, i.e. that, as the content of Si decreases, the amount of In decreases.

**[0031]** Finally, referring to FIG. **1**H, an organic film layer **180** including an organic emission layer is formed on the exposed first electrode **170**, and then a second electrode **190** is formed over the entire front surface of the substrate **100**. Thereby, the organic light emitting diode display device according to a first embodiment is finished.

## Second Embodiment

**[0032]** FIGS. **2**A thru **2**H illustrate an organic light emitting diode display device according to a second embodiment of the invention.

**[0033]** First, referring to FIG. **2**A, as in the first embodiment, a substrate **200** having an emission section a and non-emission section b is provided. The substrate **200** is formed of a material such as glass or plastic. Then, a buffer layer **210** is formed on the substrate **200**. The buffer layer **210** is formed of at least one of dielectric layers, for instance, a silicon oxide layer and a silicon nitride layer, using chemical or physical vapor deposition.

**[0034]** Referring to FIG. **2**B, a gate electrode **220** is formed on the substrate **200** using a first mask. Then, a gate dielectric layer **230** is formed over an entire front surface of the substrate **200**. The gate electrode **220** and the gate dielectric layer **230** are formed as in the first embodiment.

**[0035]** Then, referring to FIG. **2**C, a semiconductor layer **240** is formed on the gate dielectric layer **230** so as to correspond to the gate electrode **220**. The semiconductor layer **240** is formed using a second mask.

**[0036]** Referring to FIG. **2**D, an etch stop layer **250** is formed on the semiconductor layer **240** using a third mask so as to prevent damage to the semiconductor layer **240**. Then, source and drain electrodes **260***a* and **260***b*, respectively, and a first electrode **270** are formed using a fourth mask so as to be electrically connected to the semiconductor layer **240**.

**[0037]** In this regard, the source and drain electrodes **260***a* and **260***b*, respectively, and the first electrode **270** are formed by stacking and patterning a metal layer (not shown) for the source and drain electrodes **260***a* and **260***b*, respectively, and a metal layer (not shown) for the first electrode **270**, both of which are the same material, using the same mask at the same time. Further, a contact layer **255** is located under the source and drain electrodes **260***a* and **260***b*, respectively, and the first electrode **270**. Thus, the contact layer **255** is interposed between the semiconductor layer **240** and the source and drain electrodes **260***a* and **260***b*, respectively.

[0038] Then, referring to FIG. 2E, material layers for a pixel definition layer **273** and a spacer **275** are formed over an entire front surface of the substrate **200**.

[0039] The material layer for the pixel definition layer **273** is formed of an inorganic layer, and the material layer for the spacer **275** is formed of an organic layer. In the same fashion as described in the first embodiment, the material layers for the pixel definition layer **273** and the spacer **275** are formed.

[0040] Referring to FIG. 2F, the material layer for the spacer **275** is ashed using a fifth mask, thereby exposing a part of the emission section a of the substrate **200**. The fifth mask is the same mask, i.e. the half-tone mask, as described in the first embodiment, so that it is possible to adjust a degree to which the organic layer is ashed.

[0041] Then, referring to FIG. 2G, the material layer, i.e. the inorganic layer, for the pixel definition layer **273** is etched to expose apart of the first electrode **270**. The pixel definition layer **273** defining a pixel and the spacer **275** located on the non-emission section b of the substrate **200** are formed.

[0042] Next, referring to FIG. 2H, an organic film layer **280** including an organic emission layer is formed on the exposed first electrode **270**, and then a second electrode **290** is formed over the entire front surface of the substrate **100**. Thereby, the organic light emitting diode display device according to a second embodiment is finished.

[0043] In comparison to the first embodiment, only the positions of the gate electrode and the semiconductor layer are different. The materials applied to the semiconductor layer, the gate electrode, the source and drain electrodes, the first electrode, and the second electrode are the same as in the first embodiment.

[0044] According to exemplary embodiments, the organic light emitting diode display device is configured such that a pixel definition layer is formed of an optimized inorganic layer, and is simultaneously formed along with a spacer. As a result, it is possible to reduce the mask process and production time so as to cut down the cost of production, and to enhance yield.

[0045] Although a few embodiments have been shown and described, it will be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

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

a substrate having an emission section and a non-emission section;

a semiconductor layer located on the substrate;

a gate dielectric layer located over an entire front surface of the substrate;

a gate electrode located in correspondence to the semiconductor layer;

a dielectric layer located over the entire front surface of the substrate;

source and drain electrodes and a first electrode located on the dielectric layer and electrically connected to the semiconductor layer, the first electrode being located on the emission section of the substrate;

a pixel definition layer exposing a part of the first electrode;

a spacer located on the pixel definition layer and located on the non-emission section of the substrate;

an organic film layer located on the first electrode; and

a second electrode located over the entire front surface of the substrate;

wherein the pixel definition layer includes an inorganic layer, and the spacer includes an organic layer.

**2**. The organic light emitting diode display device according to claim **1**, wherein the spacer includes one selected from the group consisting of benzo cyclo butene (BCB), polyimide (PI), polyamide (PA), acrylic resin, and phenol resin.

**3**. The organic light emitting diode display device according to claim **1**, wherein the pixel definition layer includes a silicon nitride layer.

**4**. The organic light emitting diode display device according to claim **3**, wherein the silicon nitride layer contains no greater than 18 wt % of silicon.

**5**. The organic light emitting diode display device according to claim **1**, wherein the source and drain electrodes are formed of a same material as the first electrode.

**6**. The organic light emitting diode display device according to claim **5**, wherein the source and drain electrodes have a multiple layer in which a metal layer for the source and drain electrodes and a metal layer for the first electrode are stacked.

**7**. The organic light emitting diode display device according to claim **1**, wherein the dielectric layer includes a mixture layer in which one of a silicon nitride layer, a silicon oxide layer, and a multiple layer thereof is mixed with a layer formed of one selected from the group consisting of BCB, PI, PA, acrylic resin, and phenol resin.

**8**. A method of manufacturing an organic light emitting diode display device, the method comprising the steps of:

preparing a substrate having an emission section and a non-emission section;

forming a semiconductor layer on the substrate;

forming a gate dielectric layer over an entire front surface of the substrate;

forming a gate electrode on the gate dielectric layer so as to correspond to the semiconductor layer;

forming a dielectric layer over the entire front surface of the substrate;

forming source and drain electrodes and a first electrode on the dielectric layer so as to be electrically connected to the semiconductor layer;

forming a pixel definition layer, which exposes a part of the first electrode, and a spacer;

forming an organic film layer on the exposed first electrode; and

forming a second electrode on an entire front surface of the substrate;

wherein the pixel definition layer is formed of an inorganic layer, and the spacer is formed of an organic layer.

**9**. The method according to claim **8**, wherein the pixel definition layer and the spacer are formed using a same mask.

**10**. The method according to claim **9**, wherein the mask is a half-tone mask.

**11**. The method according to claim **8**, wherein the source and drain electrodes are formed along with the first electrode simultaneously.

**12**. The method according to claim **8**, wherein the pixel definition layer is formed by dry etching.

**13**. The method according to claim **8**, wherein the first electrode and the source and drain electrodes are formed in a multiple layer by stacking a metal layer for the source and drain electrodes and a metal layer for the first electrode.

**14**. The method according to claim **8**, wherein the pixel definition layer is formed of a silicon nitride layer containing no greater than 18 wt % of silicon.

**15**. An organic light emitting diode display device, comprising:

a substrate having an emission section and a non-emission section;

a gate electrode located on the substrate;

a gate dielectric layer located over an entire front surface of the substrate;

a semiconductor layer located in correspondence to the gate electrode;

source and drain electrodes electrically connected to the semiconductor layer;

a first electrode located on the emission section of the substrate and connected to the source and drain electrodes;

a pixel definition layer exposing a part of the first electrode;

a spacer located on the pixel definition layer and located on the non-emission section of the substrate;

an organic film layer located on the first electrode; and

a second electrode located over the entire front surface of the substrate;

wherein the pixel definition layer includes an inorganic layer, and the spacer includes an organic layer.

**16**. The organic light emitting diode display device according to claim **15**, wherein the spacer includes one selected from the group consisting of benzo cyclo butene (BCB), polyimide (PI), polyamide (PA), acrylic resin, and phenol resin.

**17**. The organic light emitting diode display device according to claim **15**, wherein the pixel definition layer includes a silicon nitride layer.

**18**. The organic light emitting diode display device according to claim **17**, wherein the silicon nitride layer contains no greater than 18 wt % of silicon.

**19**. The organic light emitting diode display device according to claim **15**, wherein the source and drain electrodes are formed of a same material as the first electrode.

**20**. The organic light emitting diode display device according to claim **15**, wherein the source and drain electrodes have a multiple layer in which a metal layer for the source and drain electrodes and a metal layer for the first electrode are stacked.

**21**. The organic light emitting diode display device according to claim **15**, wherein the dielectric layer includes a mixture layer in which one of a silicon nitride layer, a silicon oxide layer, and a multiple layer thereof is mixed with a layer formed of one selected from the group consisting of BCB, PI, PA, acrylic resin, and phenol resin.

**22**. The organic light emitting diode display device according to claim **15**, further comprising a contact layer disposed between the semiconductor layer and the source and drain electrodes.

**23**. The organic light emitting diode display device according to claim **15**, further comprising an etch stop layer on the semiconductor layer.

**24**. A method of manufacturing an organic light emitting diode display device, the method comprising the steps of:

preparing a substrate having an emission section and a non-emission section;

forming a gate electrode on the non-emission section of the substrate

forming a gate dielectric layer over an entire front surface of the substrate;

forming a semiconductor layer on the gate dielectric layer so as to correspond to the gate electrode;

forming source and drain electrodes on the non-emission section and a first electrode on the emission section so as to be electrically connected to the semiconductor layer;

forming a pixel definition layer, which exposes a part of the first electrode, and a spacer;

forming an organic film layer on the exposed first electrode; and

forming a second electrode over the entire front surface of the substrate;

wherein the pixel definition layer is formed of an inorganic layer, and the spacer is formed of an organic layer.

**25**. The method according to claim **24**, wherein the pixel definition layer and the spacer are formed using the same mask.

**26**. The method according to claim **25**, wherein the mask is a half-tone mask.

**27**. The method according to claim **24**, wherein the source and drain electrodes are formed along with the first electrode simultaneously.

**28**. The method according to claim **24**, wherein the pixel definition layer is formed by dry etching.

**29**. The method according to claim **24**, wherein the first electrode and the source and drain electrodes are formed in a multiple layer by stacking a metal layer for the source and drain electrodes and a metal layer for the first electrode.

**30**. The method according to claim **24**, wherein the pixel definition layer is formed of a silicon nitride layer containing no greater than 18 wt % of silicon.

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摘要(译)

公开了一种有机发光二极管显示装置及其制造方法。有机发光二极管显示装置包括具有发光部分和非发光部分的基板，位于基板上的半导体层，位于基板的整个前表面上方的栅极介电层，与之对应的栅极电极。半导体层，位于基板的整个前表面上的介电层，源极和漏极以及位于介电层上并电连接到半导体层的第一电极，暴露第一电极的一部分的像素限定层，间隔物位于像素限定层上并位于基板的非发射部分上，有机膜层位于第一电极上，第二电极位于基板的整个前表面上。