



(11) **EP 1 818 997 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**15.08.2007 Bulletin 2007/33**

(51) Int Cl.:  
**H01L 51/52<sup>(2006.01)</sup> H01L 27/32<sup>(2006.01)</sup>**

(21) Application number: **07101707.3**

(22) Date of filing: **05.02.2007**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR**

Designated Extension States:  
**AL BA HR MK YU**

(30) Priority: **14.02.2006 KR 20060014324**  
**02.03.2006 KR 20060020108**

(71) Applicant: **Samsung SDI Co., Ltd.**  
**Suwon-si**  
**Gyeonggi-do (KR)**

(72) Inventors:  
• **Kim, Deuk Jong,**  
**Samsung SDI Co., Ltd.**  
**Yongin-si,**  
**Gyeonggi-do (KR)**  
• **Song, Seung Yong,**  
**Samsung SDI Co., Ltd.**  
**Yongin-si,**  
**Gyeonggi-do (KR)**

(74) Representative: **Hengelhaupt, Jürgen et al**  
**Gulde Hengelhaupt Ziebig & Schneider**  
**Wallstrasse 58/59**  
**10179 Berlin (DE)**

(54) **Organic electroluminescence display device**

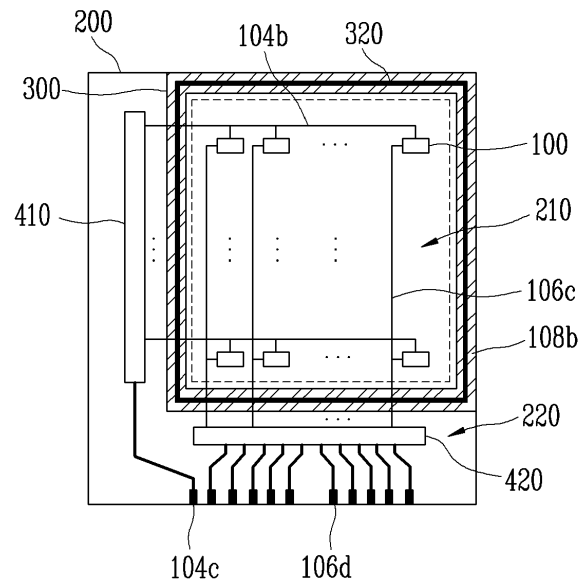
(57) The invention relates to an organic electroluminescence display comprising:

a first substrate (200, 600) formed with organic electroluminescence elements (100, 500) each comprising a first electrode (108a, 509a), an organic thin film layer (110, 511) and a second electrode (111, 512) and metal wiring for transmitting signals to the organic electroluminescence elements (100, 500),  
a second substrate (300, 700) arranged in a upper side of the first substrate (200, 600),  
a frit (320, 720) provided between the first substrate (200, 600) and the second substrate (300, 700), and

(i) a protective film (108b) formed of the same material as the first electrode (108a) and arranged between the metal wiring and the frit (320); or

(ii) a first protective film (507) and a second protective film (509b) provided as a stacking structure between the metal wiring and the frit (720), wherein the second protective film (509b) is formed of the same material as the first electrode (509a).

FIG. 4



**EP 1 818 997 A2**

## Description

**[0001]** The invention relates to an organic electroluminescence display device, more specifically, to an organic electroluminescence display device encapsulated by a frit.

### Discussion of the Related Technology

**[0002]** In general, organic electroluminescence display devices comprise a substrate on which a pixel region and a non-pixel region are provided, and a vessel or another substrate arranged to be opposite to the substrate and attached to the substrate by a sealant such as epoxy for its encapsulation.

**[0003]** On the pixel region of the substrate are formed multiple light-emitting elements connected in a matrix form between a scan line and a data line, the light-emitting elements comprising an anode electrode and cathode electrode, and an organic thin film layer formed between the anode electrode and cathode electrode, the organic thin film layer comprising a hole transport layer, an organic light-emitting layer and an electron transport layer.

**[0004]** The light-emitting elements configured as described above are susceptible to oxygen exposure because of they contain organic materials. They are also easily oxidized by moisture in the air since the cathode electrode is made of metal materials and can suffer deterioration to electrical and light-emitting properties. To mitigate the above problems, a powder-type moisture absorbent or a film-type moisture absorbent on a vessel manufactured in the form of a metal material can or cup, or a substrate made of glass, plastic, etc. is provided to take up moisture, oxygen and hydrogen penetrated from the exterior.

**[0005]** However, such a method of coating the powder-type moisture absorbent requires complicated processes and raises cost for materials and the processes. In addition, the method results in an increase of the thickness of the display device and further it is difficult to be applied to a screen light-emitting type. In addition, the method of attaching the film-type moisture absorbent has limited ability to eliminate all the moisture and also has low durability and reliability, thus limiting application in the production in large quantities. The above discussion is simply to describe the general field of organic light emitting displays and is not a discussion of the prior art.

**[0006]** Methods have been employed which encapsulates light-emitting elements by forming side walls with frits to overcome the afore-mentioned problems.

**[0007]** International patent application No. PCT/KR2002/000994 (5. 24. 2002) discloses an encapsulation container formed with side walls using a glass frit and a manufacturing method thereof.

**[0008]** U. S. Patent application No. 10/414,794 (2003. 4. 16) discloses a glass package encapsulated by attaching a first and a second glass plates through a frit and a

manufacturing method thereof.

**[0009]** Korean patent laying-open gazette No. 2001-0084380(9. 6. 2001) discloses a frit frame encapsulation method using a laser.

**[0010]** Korean patent laying-open gazette No. 2002-0051153(6. 28. 2002) discloses a packaging method of encapsulating an upper substrate and a lower substrate with a frit layer using a laser.

## 10 SUMMARY OF THE INVENTION

**[0011]** According to the invention there is provided an organic electroluminescence display device comprising:

15 a first substrate formed with organic electroluminescence elements each comprising a first electrode, an organic thin film layer and a second electrode and metal wiring for transmitting signals to the organic electroluminescence elements,

20 a second substrate arranged in a upper side of the first substrate,

25 a frit provided between the first substrate and the second substrate, and

(i) a protective film formed of the same material as the first electrode and arranged between the metal wiring and the frit; or

30 (ii) a first protective film and a second protective film provided as a stacking structure between the metal wiring and the frit, wherein the second protective film is formed of the same material as the first electrode.

**[0012]** Preferably, at least one of the first substrate and the second substrate consists of a transparent material.

**[0013]** The metal wiring may comprise a scan line, a data line, and a power supply line.

**[0014]** A pixel region on the first substrate is defined by the presence of the organic electroluminescence elements and a non-pixel region on the first substrate is defined by the presence of the metal wiring and the protective films may be formed on the surface of the non-pixel region.

**[0015]** The first electrode material may be selected from a group consisting of ACX, Ag, and Au or the first electrode material may be selected from the group consisting of ITO, IZO, and ITZO.

**[0016]** The frit may comprise at least one dopant made of transition metal.

**[0017]** The organic electroluminescence display device may further comprise transistors for controlling the operation of the organic electroluminescence elements.

**[0018]** The frit may comprise one or more materials selected from the group consisting of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium

oxide ( $\text{Li}_2\text{O}$ ), sodium oxide ( $\text{Na}_2\text{O}$ ), potassium oxide ( $\text{K}_2\text{O}$ ), boron oxide ( $\text{B}_2\text{O}_3$ ), vanadium oxide ( $\text{V}_2\text{O}_5$ ), zinc oxide ( $\text{ZnO}$ ), tellurium oxide ( $\text{TeO}_2$ ), aluminum oxide ( $\text{Al}_2\text{O}_3$ ), silicon dioxide ( $\text{SiO}_2$ ), lead oxide ( $\text{PbO}$ ), tin oxide ( $\text{SnO}$ ), phosphorous oxide ( $\text{P}_2\text{O}_5$ ), ruthenium oxide ( $\text{Ru}_2\text{O}$ ), rubidium oxide ( $\text{Rb}_2\text{O}$ ), rhodium oxide ( $\text{Rh}_2\text{O}$ ), ferrite oxide ( $\text{Fe}_2\text{O}_3$ ), copper oxide ( $\text{CuO}$ ), titanium oxide ( $\text{TiO}_2$ ), tungsten oxide ( $\text{WO}_3$ ), bismuth oxide ( $\text{Bi}_2\text{O}_3$ ), antimony oxide ( $\text{Sb}_2\text{O}_3$ ), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate.

**[0019]** The first protective film may be formed of a silicon compound selected from a group consisting of  $\text{SiO}_x$ ,  $\text{SiN}_x$ , and  $\text{SiO}_x\text{N}_y$ .

**[0020]** A representative manufacturing method of an organic electroluminescence display device comprises the steps of forming a buffer layer on a first substrate of a pixel region and a non-pixel region, forming a semiconductor layer on the buffer layer of the pixel region and then forming a gate insulating film on the upper surface of the pixel region and the non-pixel region, forming a gate electrode and a first metal wiring on the gate insulating film of the pixel region and forming on the gate insulating film of the non-pixel region the first metal wiring and a pad extended from the first metal wiring of the pixel region, forming a between-layer insulating film on the upper surface of the pixel region and then forming a contact hole so that a portion of the semiconductor layer is exposed, forming on the between-layer insulating film of the pixel region a source and drain electrodes and a second metal wiring connected through the contact hole to the semiconductor layer and forming on the gate insulating film of the non-pixel region the second metal wiring and pad extended from the second metal wiring of the pixel region, forming a first protective film on the upper surface of the non-pixel region including the first and second metal wirings, forming a flattened layer on the upper surface of the pixel region and then forming a via hole so that the source and drain electrodes are exposed, forming an inorganic electrode layer on the upper surface of the pixel region and non-pixel region and then patterning the inorganic electrode layer, with a first electrode formed on the pixel region, the first electrode connected through the via hole to the source or drain electrode, and with a second protective film formed on the non-pixel region, forming an organic thin film layer and a second electrode on the first electrode to form an organic electroluminescence element, preparing a second substrate formed with the frit along a surrounding of the second substrate, and arranging the second substrate on an upper surface of the first substrate and then attaching the frit to the first substrate.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0021]** These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying

drawings of which:

FIG. 1 is a picture for illustrating damage to a metal wiring by irradiating a laser beam.

FIGS. 2a, 3a and 4 are plan views of illustrating an organic electroluminescence display device according to a first embodiment of the invention.

FIGS. 2b and 3b are sectional views for illustrating FIGS. 2a and 3a.

FIGS. 5a through 5g and FIG. 7 are sectional views of illustrating a manufacturing method of an organic electroluminescence display device according to a first embodiment of the invention.

FIGS. 6a and 6b are plan views for illustrating FIGS. 5a and 5e.

FIGS. 8a and 8b are an enlarged sectional view and a plan view of region 'A' circled in FIG. 7.

FIGS. 9a, 10a and 11 are plan views of illustrating an organic electroluminescence display device according to a second embodiment of the invention.

FIGS. 9b and 10b are sectional views for illustrating FIGS. 9a and 10a.

FIGS. 12a through 12h and FIG. 14 are sectional views of illustrating a manufacturing method of an organic electroluminescence display device according to a second embodiment of the invention.

FIGS. 13a and 13b are plan views for illustrating FIGS. 12a and 12g.

FIGS. 15a and 15b are an enlarged sectional view and a plan view of region 'B' circled in FIG. 14.

FIG. 16 is a schematic exploded view of a passive matrix type organic light emitting display device in accordance with one embodiment.

FIG. 17 is a schematic exploded view of an active matrix type organic light emitting display device in accordance with one embodiment.

FIG. 18 is a schematic top plan view of an organic light emitting display in accordance with one embodiment.

FIG. 19 is a cross-sectional view of the organic light emitting display of FIG. 18, taken along the line 19-19.

FIG. 20 is a schematic perspective view illustrating

mass production of organic light emitting devices in accordance with one embodiment.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

**[0022]** A method for encapsulating a light emitting element using a frit, which attaches a substrate on which the frit is coated to another substrate on which light emitting elements are formed, and then causes the frit to be fused and attached to the substrates by illuminating a laser beam, has a limitation in that when the laser beam is irradiated to the frit, metal wirings 10 of a lower part of the frit 20 and a part (region 'A') intersecting the frit may be directly exposed to heat due to the laser beam, which can possibly result in heat damage (see FIG. 1). Heat damaged metal wirings may develop cracks, and/or their self resistance and electrical properties can be changed, thus affecting the electrical property and reliability of elements.

**[0023]** An organic light emitting display (OLED) is a display device comprising an array of organic light emitting diodes. Organic light emitting diodes are solid state devices which include an organic material and are adapted to generate and emit light when appropriate electrical potentials are applied.

**[0024]** OLEDs can be generally grouped into two basic types dependent on the arrangement with which the stimulating electrical current is provided. Fig. 16 schematically illustrates an exploded view of a simplified structure of a passive matrix type OLED 1000. Fig. 17 schematically illustrates a simplified structure of an active matrix type OLED 1001. In both configurations, the OLED 1000, 1001 includes OLED pixels built over a substrate 1002, and the OLED pixels include an anode 1004, a cathode 1006 and an organic layer 1010. When an appropriate electrical current is applied to the anode 1004, electric current flows through the pixels and visible light is emitted from the organic layer.

**[0025]** Referring to Fig. 16, the passive matrix OLED (PMOLED) design includes elongate strips of anode 1004 arranged generally perpendicular to elongate strips of cathode 1006 with organic layers interposed therebetween. The intersections of the strips of cathode 1006 and anode 1004 define individual OLED pixels where light is generated and emitted upon appropriate excitation of the corresponding strips of anode 1004 and cathode 1006. PMOLEDs provide the advantage of relatively simple fabrication.

**[0026]** Referring to Fig. 17, the active matrix OLED (AMOLED) includes local driving circuits 1012 arranged between the substrate 1002 and an array of OLED pixels. An individual pixel of AMOLEDs is defined between the common cathode 1006 and an anode 1004, which is electrically isolated from other anodes. Each driving circuit 1012 is coupled with an anode 1004 of the OLED pixels and further coupled with a data line 1016 and a scan line 1018. In embodiments, the scan lines 1018 supply scan

signals that select rows of the driving circuits, and the data lines 1016 supply data signals for particular driving circuits. The data signals and scan signals stimulate the local driving circuits 1012, which excite the anodes 1004 so as to emit light from their corresponding pixels.

**[0027]** In the illustrated AMOLED, the local driving circuits 1012, the data lines 1016 and scan lines 1018 are buried in a planarization layer 1014, which is interposed between the pixel array and the substrate 1002. The planarization layer 1014 provides a planar top surface on which the organic light emitting pixel array is formed. The planarization layer 1014 may be formed of organic or inorganic materials, and formed of two or more layers although shown as a single layer. The local driving circuits 1012 are typically formed with thin film transistors (TFT) and arranged in a grid or array under the OLED pixel array. The local driving circuits 1012 may be at least partly made of organic materials, including organic TFT. AMOLEDs have the advantage of fast response time improving their desirability for use in displaying data signals. Also, AMOLEDs have the advantages of consuming less power than passive matrix OLEDs.

**[0028]** Referring to common features of the PMOLED and AMOLED designs, the substrate 1002 provides structural support for the OLED pixels and circuits. In various embodiments, the substrate 1002 can comprise rigid or flexible materials as well as opaque or transparent materials, such as plastic, glass, and/or foil. As noted above, each OLED pixel or diode is formed with the anode 1004, cathode 1006 and organic layer 1010 interposed therebetween. When an appropriate electrical current is applied to the anode 1004, the cathode 1006 injects electrons and the anode 1004 injects holes. In certain embodiments, the anode 1004 and cathode 1006 are inverted; i.e., the cathode is formed on the substrate 1002 and the anode is opposingly arranged.

**[0029]** Interposed between the cathode 1006 and anode 1004 are one or more organic layers. More specifically, at least one emissive or light emitting layer is interposed between the cathode 1006 and anode 1004. The light emitting layer may comprise one or more light emitting organic compounds. Typically, the light emitting layer is configured to emit visible light in a single color such as blue, green, red or white. In the illustrated embodiment, one organic layer 1010 is formed between the cathode 1006 and anode 1004 and acts as a light emitting layer. Additional layers, which can be formed between the anode 1004 and cathode 1006, can include a hole transporting layer, a hole injection layer, an electron transporting layer and an electron injection layer.

**[0030]** Hole transporting and/or injection layers can be interposed between the light emitting layer 1010 and the anode 1004. Electron transporting and/or injecting layers can be interposed between the cathode 1006 and the light emitting layer 1010. The electron injection layer facilitates injection of electrons from the cathode 1006 toward the light emitting layer 1010 by reducing the work function for injecting electrons from the cathode 1006.

Similarly, the hole injection layer facilitates injection of holes from the anode 1004 toward the light emitting layer 1010. The hole and electron transporting layers facilitate movement of the carriers injected from the respective electrodes toward the light emitting layer.

**[0031]** In some embodiments, a single layer may serve both electron injection and transportation functions or both hole injection and transportation functions. In some embodiments, one or more of these layers are lacking. In some embodiments, one or more organic layers are doped with one or more materials that help injection and/or transportation of the carriers. In embodiments where only one organic layer is formed between the cathode and anode, the organic layer may include not only an organic light emitting compound but also certain functional materials that help injection or transportation of carriers within that layer.

**[0032]** There are numerous organic materials that have been developed for use in these layers including the light emitting layer. Also, numerous other organic materials for use in these layers are being developed. In some embodiments, these organic materials may be macromolecules including oligomers and polymers. In some embodiments, the organic materials for these layers may be relatively small molecules. The skilled artisan will be able to select appropriate materials for each of these layers in view of the desired functions of the individual layers and the materials for the neighboring layers in particular designs.

**[0033]** In operation, an electrical circuit provides appropriate potential between the cathode 1006 and anode 1004. This results in an electrical current flowing from the anode 1004 to the cathode 1006 via the interposed organic layer(s). In one embodiment, the cathode 1006 provides electrons to the adjacent organic layer 1010. The anode 1004 injects holes to the organic layer 1010. The holes and electrons recombine in the organic layer 1010 and generate energy particles called "excitons." The excitons transfer their energy to the organic light emitting material in the organic layer 1010, and the energy is used to emit visible light from the organic light emitting material. The spectral characteristics of light generated and emitted by the OLED 1000, 1001 depend on the nature and composition of organic molecules in the organic layer(s). The composition of the one or more organic layers can be selected to suit the needs of a particular application by one of ordinary skill in the art.

**[0034]** OLED devices can also be categorized based on the direction of the light emission. In one type referred to as "top emission" type, OLED devices emit light and display images through the cathode or top electrode 1006. In these embodiments, the cathode 1006 is made of a material transparent or at least partially transparent with respect to visible light. In certain embodiments, to avoid losing any light that can pass through the anode or bottom electrode 1004, the anode may be made of a material substantially reflective of the visible light. A second type of OLED devices emits light through the anode

or bottom electrode 1004 and is called "bottom emission" type. In the bottom emission type OLED devices, the anode 1004 is made of a material which is at least partially transparent with respect to visible light. Often, in bottom emission type OLED devices, the cathode 1006 is made of a material substantially reflective of the visible light. A third type of OLED devices emits light in two directions, e.g. through both anode 1004 and cathode 1006.

**[0035]** Depending upon the direction(s) of the light emission, the substrate may be formed of a material which is transparent, opaque or reflective of visible light.

**[0036]** In many embodiments, an OLED pixel array 1021 comprising a plurality of organic light emitting pixels is arranged over a substrate 1002 as shown in Fig. 18. In embodiments, the pixels in the array 1021 are controlled to be turned on and off by a driving circuit (not shown), and the plurality of the pixels as a whole displays information or image on the array 1021. In certain embodiments, the OLED pixel array 1021 is arranged with respect to other components, such as drive and control electronics to define a display region and a non-display region. In these embodiments, the display region refers to the area of the substrate 1002 where OLED pixel array 1021 is formed. The non-display region refers to the remaining areas of the substrate 1002. In embodiments, the non-display region can contain logic and/or power supply circuitry. It will be understood that there will be at least portions of control/drive circuit elements arranged within the display region. For example, in PMOLEDs, conductive components will extend into the display region to provide appropriate potential to the anode and cathodes. In AMOLEDs, local driving circuits and data/scan lines coupled with the driving circuits will extend into the display region to drive and control the individual pixels of the AMOLEDs.

**[0037]** One design and fabrication consideration in OLED devices is that certain organic material layers of OLED devices can suffer damage or accelerated deterioration from exposure to water, oxygen or other harmful gases. Accordingly, it is generally understood that OLED devices be sealed or encapsulated to inhibit exposure to moisture and oxygen or other harmful gases found in a manufacturing or operational environment. Fig. 19 schematically illustrates a cross-section of an encapsulated OLED device 1011 having a layout of Fig. 18 and taken along the line 19-19 of Fig. 18. In this embodiment, a generally planar top plate or substrate 1061 engages with a seal 1071 which further engages with a bottom plate or substrate 1002 to enclose or encapsulate the OLED pixel array 1021. In other embodiments, one or more layers are formed on the top plate 1061 or bottom plate 1002, and the seal 1071 is coupled with the bottom or top substrate 1002, 1061 via such a layer. In the illustrated embodiment, the seal 1071 extends along the periphery of the OLED pixel array 1021 or the bottom or top plate 1002, 1061.

**[0038]** In embodiments, the seal 1071 is made of a frit material as will be further discussed below. In various

embodiments, the top and bottom plates 1061, 1002 comprise materials such as plastics, glass and/or metal foils which can provide a barrier to passage of oxygen and/or water to thereby protect the OLED pixel array 1021 from exposure to these substances. In embodiments, at least one of the top plate 1061 and the bottom plate 1002 are formed of a substantially transparent material.

**[0039]** To lengthen the life time of OLED devices 1011, it is generally desired that seal 1071 and the top and bottom plates 1061, 1002 provide a substantially non-permeable seal to oxygen and water vapor and provide a substantially hermetically enclosed space 1081. In certain applications, it is indicated that the seal 1071 of a frit material in combination with the top and bottom plates 1061, 1002 provide a barrier to oxygen of less than approximately  $10^{-3}$  cc/m<sup>2</sup>-day and to water of less than  $10^{-6}$  g/m<sup>2</sup>-day. Given that some oxygen and moisture can permeate into the enclosed space 1081, in some embodiments, a material that can take up oxygen and/or moisture is formed within the enclosed space 1081.

**[0040]** The seal 1071 has a width W, which is its thickness in a direction parallel to a surface of the top or bottom substrate 1061, 1002 as shown in Fig. 19. The width varies among embodiments and ranges from about 300  $\mu$ m to about 3000  $\mu$ m, optionally from about 500  $\mu$ m to about 1500  $\mu$ m. Also, the width may vary at different positions of the seal 1071. In some embodiments, the width of the seal 1071 may be the largest where the seal 1071 contacts one of the bottom and top substrate 1002, 1061 or a layer formed thereon. The width may be the smallest where the seal 1071 contacts the other. The width variation in a single cross-section of the seal 1071 relates to the cross-sectional shape of the seal 1071 and other design parameters.

**[0041]** The seal 1071 has a height H, which is its thickness in a direction perpendicular to a surface of the top or bottom substrate 1061, 1002 as shown in Fig. 19. The height varies among embodiments and ranges from about 2  $\mu$ m to about 30  $\mu$ m, optionally from about 10  $\mu$ m to about 15  $\mu$ m. Generally, the height does not significantly vary at different positions of the seal 1071. However, in certain embodiments, the height of the seal 1071 may vary at different positions thereof.

**[0042]** In the illustrated embodiment, the seal 1071 has a generally rectangular cross-section. In other embodiments, however, the seal 1071 can have other various cross-sectional shapes such as a generally square cross-section, a generally trapezoidal cross-section, a cross-section with one or more rounded edges, or other configuration as indicated by the needs of a given application. To improve hermeticity, it is generally desired to increase the interfacial area where the seal 1071 directly contacts the bottom or top substrate 1002, 1061 or a layer formed thereon. In some embodiments, the shape of the seal can be designed such that the interfacial area can be increased.

**[0043]** The seal 1071 can be arranged immediately adjacent the OLED array 1021, and in other embodiments,

the seal 1071 is spaced some distance from the OLED array 1021. In certain embodiment, the seal 1071 comprises generally linear segments that are connected together to surround the OLED array 1021. Such linear segments of the seal 1071 can extend, in certain embodiments, generally parallel to respective boundaries of the OLED array 1021. In other embodiment, one or more of the linear segments of the seal 1071 are arranged in a non-parallel relationship with respective boundaries of the OLED array 1021. In yet other embodiments, at least part of the seal 1071 extends between the top plate 1061 and bottom plate 1002 in a curvilinear manner.

**[0044]** As noted above, in certain embodiments, the seal 1071 is formed using a frit material or simply "frit" or glass frit," which includes fine glass particles. The frit particles includes one or more of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium oxide (Li<sub>2</sub>O), sodium oxide (Na<sub>2</sub>O), potassium oxide (K<sub>2</sub>O), boron oxide (B<sub>2</sub>O<sub>3</sub>), vanadium oxide (V<sub>2</sub>O<sub>5</sub>), zinc oxide (ZnO), tellurium oxide (TeO<sub>2</sub>), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), silicon dioxide (SiO<sub>2</sub>), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P<sub>2</sub>O<sub>5</sub>), ruthenium oxide (Ru<sub>2</sub>O), rubidium oxide (Rb<sub>2</sub>O), rhodium oxide (Rh<sub>2</sub>O), ferrite oxide (Fe<sub>2</sub>O<sub>3</sub>), copper oxide (CuO), titanium oxide (TiO<sub>2</sub>), tungsten oxide (WO<sub>3</sub>), bismuth oxide (Bi<sub>2</sub>O<sub>3</sub>), antimony oxide (Sb<sub>2</sub>O<sub>3</sub>), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate, etc. In embodiments, these particles range in size from about 2  $\mu$ m to about 30  $\mu$ m, optionally about 5  $\mu$ m to about 10  $\mu$ m, although not limited only thereto. The particles can be as large as about the distance between the top and bottom substrates 1061, 1002 or any layers formed on these substrates where the frit seal 1071 contacts.

**[0045]** The frit material used to form the seal 1071 can also include one or more filler or additive materials. The filler or additive materials can be provided to adjust an overall thermal expansion characteristic of the seal 1071 and/or to adjust the absorption characteristics of the seal 1071 for selected frequencies of incident radiant energy. The filler or additive material(s) can also include inversion and/or additive fillers to adjust a coefficient of thermal expansion of the frit. For example, the filler or additive materials can include transition metals, such as chromium (Cr), iron (Fe), manganese (Mn), cobalt (Co), copper (Cu), and/or vanadium. Additional materials for the filler or additives include ZnSiO<sub>4</sub>, PbTiO<sub>3</sub>, ZrO<sub>2</sub>, eucryptite.

**[0046]** In embodiments, a frit material as a dry composition contains glass particles from about 20 to 90 about wt%, and the remaining includes fillers and/or additives. In some embodiments, the frit paste contains about 10-30 wt% organic materials and about 70-90% inorganic materials. In some embodiments, the frit paste contains about 20 wt% organic materials and about 80 wt% inorganic materials. In some embodiments, the organic materials may include about 0-30 wt% binder(s) and about 70-100 wt% solvent(s). In some embodiments, about 10 wt% is binder(s) and about 90 wt% is solvent(s) among the organic materials. In some embodiments, the inor-

ganic materials may include about 0-10 wt% additives, about 20-40 wt% fillers and about 50-80 wt% glass powder. In some embodiments, about 0-5 wt% is additive(s), about 25-30 wt% is filler(s) and about 65-75 wt% is the glass powder among the inorganic materials.

**[0047]** In forming a frit seal, a liquid material is added to the dry frit material to form a frit paste. Any organic or inorganic solvent with or without additives can be used as the liquid material. In embodiments, the solvent includes one or more organic compounds. For example, applicable organic compounds are ethyl cellulose, nitro cellulose, hydroxyl propyl cellulose, butyl carbitol acetate, terpineol, butyl cellulose, acrylate compounds. Then, the thus formed frit paste can be applied to form a shape of the seal 1071 on the top and/or bottom plate 1061, 1002.

**[0048]** In one exemplary embodiment, a shape of the seal 1071 is initially formed from the frit paste and interposed between the top plate 1061 and the bottom plate 1002. The seal 1071 can in certain embodiments be pre-cured or pre-sintered to one of the top plate and bottom plate 1061, 1002. Following assembly of the top plate 1061 and the bottom plate 1002 with the seal 1071 interposed therebetween, portions of the seal 1071 are selectively heated such that the frit material forming the seal 1071 at least partially melts. The seal 1071 is then allowed to resolidify to form a secure joint between the top plate 1061 and the bottom plate 1002 to thereby inhibit exposure of the enclosed OLED pixel array 1021 to oxygen or water.

**[0049]** In embodiments, the selective heating of the frit seal is carried out by irradiation of light, such as a laser or directed infrared lamp. As previously noted, the frit material forming the seal 1071 can be combined with one or more additives or filler such as species selected for improved absorption of the irradiated light to facilitate heating and melting of the frit material to form the seal 1071.

**[0050]** In some embodiments, OLED devices 1011 are mass produced. In an embodiment illustrated in Fig. 20, a plurality of separate OLED arrays 1021 is formed on a common bottom substrate 1101. In the illustrated embodiment, each OLED array 1021 is surrounded by a shaped frit to form the seal 1071. In embodiments, common top substrate (not shown) is placed over the common bottom substrate 1101 and the structures formed thereon such that the OLED arrays 1021 and the shaped frit paste are interposed between the common bottom substrate 1101 and the common top substrate. The OLED arrays 1021 are encapsulated and sealed, such as via the previously described enclosure process for a single OLED display device. The resulting product includes a plurality of OLED devices kept together by the common bottom and top substrates. Then, the resulting product is cut into a plurality of pieces, each of which constitutes an OLED device 1011 of Fig. 19. In certain embodiments, the individual OLED devices 1011 then further undergo additional packaging operations to fur-

ther improve the sealing formed by the frit seal 1071 and the top and bottom substrates 1061, 1002.

**[0051]** FIGS. 2a, 3a and 4 are plan views illustrating an organic electroluminescence display device according to one embodiment of the invention. FIGS. 2b and 3b are sectional views for illustrating FIGS. 2a and 3a.

**[0052]** Referring to FIG. 2a, a substrate 200 defines a pixel region 210 and a non-pixel region 220. The non-pixel region 220 may be a region surrounding the pixel region 210 or a peripheral region of the pixel region 210. Multiple organic electroluminescence elements 100 are formed between a scan line 104b and a data line 106c on the pixel region 210 of the substrate 200, and on the non-pixel region 220 of the substrate 200 are formed a scan line 104b and a data line 106c extended from the scan line 104b and the data line 106c, respectively, of the pixel region 210, a power supply line (not shown) for generating the organic electroluminescence elements 100, and a scan driver 410 and a data driver 420 for processing signals from the exterior through pads 104c and 106d and supplying them to the scan line 104b and data line 106c.

**[0053]** Referring to FIG. 2b, the organic electroluminescence element 100 comprises an anode electrode 108a and cathode electrode 111, and an organic thin film layer 110 formed between the anode electrode 108a and cathode electrode 111. The organic thin film layer 110 is formed as a structure in which a hole transport layer, an organic light-emitting layer and an electron transport layer are deposited, and may further comprise an hole injection layer and an electron injection layer.

**[0054]** In a passive matrix type display, the organic electroluminescence element 100 as configured above is connected in a matrix form between a scan line 104b and a data line 106c, and in an active matrix type, the organic electroluminescence element 100 is connected in a matrix form between the scan line 104b and data line 106c, the active matrix type further comprising a thin film transistor (TFT) for controlling the organic electroluminescence element 100 and a capacitor for sustaining a signal. The thin film transistor comprises a source, a drain and a gate. A semiconductor layer 102 provides a source and drain regions, to which a source and drain electrodes 106a and 106b, and a channel region, on an upper side of which is a gate electrode 104a electrically insulated from the semiconductor layer 102 by a gate insulation film 103.

**[0055]** Referring to FIGS. 3a and 3b, on an encapsulation substrate 300 is formed a frit 320 along the surrounding of the encapsulation substrate 300. The frit 320 encapsulates the pixel region 210 to inhibit oxygen or moisture from penetrating therein, which is formed to surround at least a part of the non-pixel region 220 including the pixel region 210 and may be formed of a material, for example, such as a glass frit doped with at least one kind of transition metal, which may be fused by laser beam or infrared ray.

**[0056]** Referring to FIG. 4, the encapsulation substrate

300 is arranged on the upper side of the substrate 200. The encapsulation substrate 300 is arranged on the upper side of the substrate 200 so as to be superposed to the pixel region 210 and a part of the non-pixel region 220. A protective film 108b, which in one embodiment is made of the same inorganic material as an anode electrode 108a and is separated from the anode electrode 108a, is provided between the frit 320 and a scan line 104b, a data line 106c and a power supply line. The anode electrode 108a and protective film 108b may be made of an opaque inorganic electrode material in the case of front surface light emitting type, and a transparent inorganic electrode material in the case of back surface light emitting type. The opaque inorganic electrode material may be an inorganic material selected from a group comprising, for example, ACX(alloy of Al), Ag, and Au, or a mixture thereof, and the transparent inorganic electrode material may be an inorganic material selected from a group comprising, for example, ITO, IZO, and ITZO, or a mixture thereof. A laser beam and/or infrared ray is irradiated under a condition where the encapsulation substrate 300 is attached onto the substrate 200, such that the frit 320 is fused and bonded to the substrate 200.

**[0057]** A manufacturing method of an organic electroluminescence display device configured as above will be described below with reference to FIGS. 5a through 5g and FIGS. 6a and 6b in accordance with one embodiment. Referring to FIGS. 5a and 6a, a substrate 200 is prepared, on which a pixel region 210 and a non-pixel region 220 are defined. The non-pixel region 220 may be defined as a region surrounding the pixel region 210 or a peripheral region of the pixel region 210. A buffer layer 101 is formed on the pixel region 210 and non-pixel region 220 of the substrate 200. The buffer layer 101, which serves to inhibit the damage to the substrate 200 due to heat and isolate diffusion of ions from the substrate 200 to the outside, is formed as an insulating film such as silicon oxide film  $\text{SiO}_2$  and/or silicon nitride film  $\text{SiN}_x$ .

**[0058]** Referring to FIG. 5b, a semiconductor layer 102, which provides an active layer, is formed on the buffer layer 101 of the pixel region 210, and a gate insulating film 103 is formed on the upper surface of the pixel region 210 and non-pixel region 220 including the semiconductor layer 102. The semiconductor layer 102 provides a source and drain regions and a channel region for a thin film transistor.

**[0059]** Referring to FIG. 5c, a gate electrode 104a is formed on the gate insulating film 103 placed on the upper side of the semiconductor layer 102. On the pixel region 210 is formed a scan line connected to the gate electrode 104a and on the non-pixel region 220 are formed a scan line 104b extended from the scan line 104a of the pixel region 210 and a pad 104c to receive signals from the exterior. The gate electrode 104a, scan line 104b and pad 104c are made of metals such as Mo, W, Ti, Al, and/or alloys thereof, and can be formed as a stacking structure. The non-pixel region 220 of FIG. 5c is a sectional surface of a part formed with the scan line 104b.

**[0060]** Referring to FIG. 5d, a between-layer insulating film 105 is formed on the upper surface of the pixel region 210 and non-pixel region 220 including the gate electrode 104a. Contact holes are formed through which parts of the semiconductor layer 102 are exposed by patterning the between-layer insulating film 105 and gate insulating film 103, and a source electrode 106a and a drain electrode 106b are formed to be connected through the contact holes to the semiconductor layer 102. On the pixel region 210 is formed a scan line connected to the gate electrode 106a and on the non-pixel region 220 are formed a scan line 106 extended from the scan line 106 of the pixel region 210 and a pad 104c to receive signals from the exterior. The source and drain electrodes 106a and 106b, data line 106c and pad 106d are made of metals such as Mo, W, Ti, Al, and/or alloy thereof, and formed as a stacking structure. The non-pixel region 220 of FIG. 5d is a sectional surface of a part formed with the data line 106c.

**[0061]** Referring to FIGS. 5e and 5f and FIG. 6b, a flattened layer 107 is formed on the upper surface of the pixel region 210 to flatten the surface. A via hole is formed through which parts of the source or drain electrode 106a or 106b are exposed by patterning the flattened layer 107 of the pixel region 210. An electrode material layer made of an inorganic material is formed on the upper side of the pixel region 210 and non-pixel region 220. The patterning is made so that on the pixel region 210 is formed the anode electrode 108a, which is connected through the via hole to the source or drain electrode 106a or 106b, and on the non-pixel region 220 is formed the protective film 108b. The patterning is performed so that the anode electrode 108 and protective film 108b have a separated structure for electrical isolation between the scan electrode 104b and data line 106c and the anode electrode 108a. The non-pixel region 220 of FIG. 5e is a sectional surface of a part formed with the scan line 104b, and the non-pixel region 220 of FIG. 5f is a sectional surface of a part formed with the data line 106c.

**[0062]** The electrode material layer made of an inorganic material may be made of an opaque inorganic material or a mixture of inorganic materials in the case of front surface light emitting type, and a transparent inorganic material or a mixture of inorganic materials in the case of back surface light emitting type. The opaque inorganic material or mixture of inorganic materials may be selected from a group comprising, for example, ACX (alloy of Al), Ag, and Au, and the transparent inorganic or mixture of inorganic materials may be selected from a group comprising, for example, ITO, IZO, and ITZO.

**[0063]** In one embodiment, the flattened layer 107 is formed on the upper side of the pixel region 210 and non-pixel region 220 and then to pattern the flattened layer 107 such that the pad 106d connected to the data line 106c is exposed. In another embodiment, the flattened layer 107 is formed only on the pixel region 210 since the attachment to the data line 106 may be less secure in a case where the flattened layer 107 is made of an organic

material.

**[0064]** Referring to FIG. 5g, a pixel definition film 109 is formed on the flattened layer 107 so that a part of the anode electrode 108a is exposed, and then an organic thin film 110 is formed on the exposed anode electrode 108a and a cathode electrode 111 is formed on the pixel definition film 109 including the organic thin film layer 110.

**[0065]** This embodiment suggests a construction where the scan line 104b, data line 106c and power supply line are not exposed by the protective film 108b made of an inorganic material. Although a construction is suggested where the protective film 108b is formed on the surface of the non-pixel region 220 including the scan line 104b, data line 106c and power supply line, it is also possible to implement a construction where the protective film 108b is formed only on the scan line 104b, data line 106c and power supply line of the non-pixel region 220.

**[0066]** Turning again to FIGS. 3a and 3b, a encapsulation substrate 300 is provided whose size is such an extent that a part of the pixel region 210 is superposed to a part of the non-pixel region 220. A substrate made of a transparent material such as glass is employed as the encapsulation substrate 300, and in one embodiment a substrate made of silicon oxide  $\text{SiO}_2$  is employed.

**[0067]** The frit 320 is formed along the surrounding of the encapsulation substrate 300. The frit 320 encapsulates the pixel region 210 to inhibit oxygen or moisture from penetrating therein, which is formed to surround a part of the non-pixel region 220 including the pixel region 210. The frit is in certain embodiments a powder-type glass material. In other embodiments, a paste state of frit wherein a laser or infrared light absorber, an organic binder, a filler for reducing the thermal expansion coefficient, etc., are included to facilitate curing after a firing process. For example, a frit may be doped with at least one kind of transition metal.

**[0068]** Referring to FIG. 7, the encapsulation substrate 300 is arranged on the upper side of the substrate 200 manufactured through processes shown in FIGS. 5a through 5g. The frit 320 is attached to the substrate 200 by an irradiating laser beam or infrared ray along the frit 320 under a condition where the encapsulation substrate 300 is arranged on the upper side of the substrate 200 to be superposed to the pixel region 210 and a part of the non-pixel region 220. The laser beam or infrared ray is at least partially absorbed by the frit, which in turn generates heat. Thereby the frit 320 is fused and attached to the substrate 200.

**[0069]** In one embodiment using the laser, the laser beam is irradiated on the order of power of 36W to 38W, and is moved in a substantially constant speed along the frit 320 so as to sustain a more uniform fusion temperature and adhesive strength. In one embodiment, movement speed of the laser or infrared ray is on the order of 10 to 30mm/sec, and preferably, 20mm/sec.

**[0070]** In one embodiment with respect to a case where the gate insulating film 103 and between-layer in-

ulating film 105 are formed on the pixel region 210 and non-pixel region 220, it is also possible to form them only on the pixel region 210. An embodiment has been described with respect to a case where the frit 320 is formed to seal only the pixel region 210, it is not limited thereto, but may be formed to include the scan driver 410. In that embodiment, the size of the encapsulation substrate 300 should also be appropriately changed. In addition, an embodiment has been described where the frit 320 is formed on the encapsulation substrate 300, it is not limited thereto, but may also be formed on the substrate 200.

**[0071]** The organic electroluminescence display device according to one embodiment allows the protective film 108b to be made of an inorganic electrode material to be formed on the upper side of metal wiring such as the scan line 104b, data line 106c and power supply line in the procedure that the anode electrode 108a of the pixel region 210 is formed. Therefore, when a laser beam is irradiated to fuse and attach the frit 320 to the substrate 200, metal wirings such as the scan line 104b, data line 106c and power supply line placed in a lower side of the frit 320 and a part intersecting the frit 320 fail to be directly exposed to heat due to the laser beam as shown in FIGS. 8a and 8b.

**[0072]** Reflectivity of the metals generally used as electrodes or wirings is Cr(0.632), Mo(0.550), Ti(0.557), and W(0.500), but reflectivity of the opaque inorganic electrode materials used for this embodiment is relatively high such as Al(0.868), Ag(0.969), Au(0.986), etc. Accordingly, since heat absorption ratio is low due to the high reflectivity, heat transfer to the metal wirings of the lower side may be decreased.

**[0073]** In addition, the transparent inorganic electrode materials (ITO, IZO, ITZO, etc.) used for this embodiment, which are metal oxide, have even lower heat conductivity compared to metallic materials, and thus may serve to isolate heat transferred to the metal wirings of the lower side and may serve as a buffer layer, thus making it possible to inhibit damage to the metal wiring due to heat. Heat transfer is insulated by the protective film 108b and thus possible damage to the metal wirings due to heat is inhibited, which in turn inhibits the cracking of the metal wirings or substantial variation of self resistance and electrical properties, thereby making it possible to sustain electrical property and reliability of elements.

**[0074]** As mentioned above, one embodiment allows the protective film made of an inorganic material to be formed on the upper side of metal wiring such as the scan line, data line and power supply line in the procedure that the anode electrode is formed. The metal wirings of the lower side of the frit and the part intersecting the frit are not directly exposed to heat due to laser beam or infrared ray, and heat transfer is insulated, thus inhibiting any damage to the metal wirings due to heat. Therefore, cracks of the metal wirings or substantial variation of self resistance and electrical properties are inhibited, thereby making it possible to sustain electrical property and reliability of elements.

**[0075]** In addition, since a protective film is formed by an inorganic material having an outstanding adhesive strength with the frit on the metal wirings of the non-pixel region without addition of separate processes or mask, it is possible to give even more prominent adhesive strength than the case where the frit is attached directly to the metal wirings. Thus, the adhesive strength is enhanced between the frit and substrate, which in turn inhibits the penetration of oxygen or moisture effectively, thereby improving reliability of the display device.

**[0076]** FIGS. 9a, 10a and 11 are plan views of illustrating an organic electroluminescence display device according to another embodiment FIGS. 9b and 10b are sectional views for illustrating FIGS. 9a and 10a. Referring to FIG. 9a, a substrate 600 defines into a pixel region 610 and a non-pixel region 620. The non-pixel region 620 may be a region surrounding the pixel region 610 or a peripheral region of the pixel region 610. Multiple organic electroluminescence elements 500 are formed between a scan line 504b and a data line 506c on the pixel region 610 of the substrate 600, and on the non-pixel region 620 of the substrate 600 are formed a scan line 504b and a data line 506c extended from the scan line 504b and the data line 506c, respectively, of the pixel region 610, a power supply line (not shown) for generating the organic electroluminescence elements 500, and a scan driver 810 and a data driver 820 for processing signals from the exterior through pads 504c and 506d and supplying them to the scan line 504b and data line 506c.

**[0077]** Referring to FIG. 9b, the organic electroluminescence element 500 comprises an anode electrode 509a and cathode electrode 512, and an organic thin film layer 512 formed between the anode electrode 509a and cathode electrode 511. The organic thin film layer 511 is formed as a structure in which a hole transport layer, an organic light-emitting layer and an electron transport layer are deposited, and may further comprise a hole injection layer and an electron injection layer.

**[0078]** In a passive matrix type display, the organic electroluminescence element 500 as configured above is connected in a matrix form between a scan line 504b and a data line 506c, and in an active matrix type display, the organic electroluminescence element 500 is connected in a matrix form between the scan line 504b and data line 506c, the active matrix type further comprising a thin film transistor TFT for controlling the organic electroluminescence element 500 and a capacitor for sustaining a signal. The thin film transistor comprises a source, a drain and a gate. A semiconductor layer 502 provides a source and drain regions, to which a source and drain electrodes 506a and 506b, and a channel region, on an upper side of which is a gate electrode 504a electrically insulated from the semiconductor layer 503 by a gate insulation film 502.

**[0079]** Referring to FIGS. 10a and 10b, on the encapsulation substrate 700 is formed a frit 720 along the surrounding of the encapsulation substrate 300. The frit 720 encapsulates the pixel region 610 to inhibit oxygen or

moisture from penetrating therein, and is formed to surround at least a part of the non-pixel region 620 including the pixel region 610 and may be formed of a material, for example, such as a glass frit doped with at least one kind of transition metal, which may be fused by laser beam or infrared ray.

**[0080]** Referring to FIG. 11, the encapsulation substrate 700 is arranged on the upper side of the substrate 600. The encapsulation substrate 700 is arranged on the upper side of the substrate 600 so as to be superposed to the pixel region 610 and a part of the non-pixel region 620. A first protective film 507 and a second protective film 509b are provided in a stacking structure between the frit 720 and the scan line 504b, data line 506c and the power supply line formed on the non-pixel region 620. The first protective film 507 is formed of a silicon compound selected from a group comprising  $\text{SiO}_x$ ,  $\text{SiN}_x$ ,  $\text{Si-O}_x\text{N}_y$ , and the second protective film 509b is formed of an opaque inorganic electrode material in a front surface light emitting type, and a transparent inorganic electrode material in a back surface light emitting type. The opaque inorganic electrode material may be an inorganic material selected from a group comprising, for example, ACX (alloy of Al), Ag, and Au, or a mixture thereof, and the transparent inorganic electrode may be an inorganic material selected from a group comprising, for example, ITO, IZO, and ITZO, or a mixture thereof.

**[0081]** The first protective film 507 and the second protective film 509b may be formed on the surface of the non-pixel region 620, and the second protective film 509b may be formed of the same inorganic electrode material as the anode electrode 509a. In a case where the second protective film 509b is formed of the same inorganic electrode material as the anode electrode 509a, it should be separated from the anode electrode 509a for the electrical isolation between the scan line 504b and data line 506c and the anode electrode 509a. A laser beam or infrared ray is irradiated under a condition where the encapsulation substrate 700 is attached onto the substrate 600, such that the frit 720 is fused and bonded to the substrate 600.

**[0082]** A manufacturing method of an organic electroluminescence display device configured as above will be described below with reference to FIGS. 12a through 12h and FIGS. 13a and 13b in accordance with another embodiment. Referring to FIGS. 12a and 13a, a substrate 600 is prepared, on which a pixel region 610 and a non-pixel region 620 are defined. The non-pixel region 620 may be defined as a region surrounding the pixel region 610 or a peripheral region of the pixel region 610. A buffer layer 501 is formed on the pixel region 610 and non-pixel region 620 of the substrate 600. The buffer layer 501, which serves to inhibit the damage to the substrate 600 due to heat and isolate diffusion of ions from the substrate 600 to the outside, is formed as an insulating film such as silicon oxide film  $\text{SiO}_2$  and/or silicon nitride film  $\text{SiN}_x$ .

**[0083]** Referring to FIG. 12b, a semiconductor layer 501, which provides an active layer, is formed on the

buffer layer 502 of the pixel region 610, and a gate insulating film 502 is formed on the upper surface of the pixel region 610 and non-pixel region 620 including the semiconductor layer 503. The semiconductor layer 502 provides a source and drain regions and a channel region for a thin film transistor.

**[0084]** Referring to FIG. 12c, a gate electrode 504a is formed on the gate insulating film 502 placed on the upper side of the semiconductor layer 503. On the pixel region 610 is formed a scan line connected to the gate electrode 504a and on the non-pixel region 620 are formed a scan line 504b extended from the scan line 504b of the pixel region 610 and a pad 504c to receive signals from the exterior. The gate electrode 504a, scan line 504b and pad 504c are made of metals such as Mo, W, Ti, Al, or alloy thereof, and can be formed as a stacking structure. The non-pixel region 620 of FIG. 12c is a sectional surface of a part formed with the scan line 504b.

**[0085]** Referring to FIG. 12d, a between-layer insulating film 505 is formed on the upper surface of the pixel region 610 including the gate electrode 504a. Contact holes are formed through which parts of the semiconductor layer 503 are exposed by patterning the between-layer insulating film 505 and gate insulating film 502, and a source electrode 506a and a drain electrode 506b are formed to be connected through the contact holes to the semiconductor layer 502. At this time, on the pixel region 610 is formed a data line 506c connected to the source and drain electrodes 506a, 506b and on the non-pixel region 620 are formed a data line 506c extended from the data line 506c of the pixel region 610 and a pad 506d to receive signals from the exterior. The source and drain electrodes 506a and 506b, data line 506c and pad 506d are made of metals such as Mo, W, Ti, Al, or alloy thereof, and formed as a stacking structure. The non-pixel region 620 of FIG. 12d is a sectional surface of a part formed with the data line 506c.

**[0086]** Referring to FIGS. 12e and 12f, the first protective film 507 is formed on the upper surface of the non-pixel region 620 including the scan line 504b and data line 506c. The first protective film 507 is formed of a material including Si, selected from a group comprising SiOx, SiNx, SiOxNy, etc., e.g., a silicon compound. The non-pixel region 620 of FIG. 12e is a sectional surface of a part formed with the scan line 504b, and the non-pixel region 620 of FIG. 12f is a sectional surface of a part formed with the data line 506c.

**[0087]** Referring to FIGS. 12g and 13b, a flattened layer 508 is formed on the upper surface of the pixel region 610 to flatten the surface. A via hole is formed through which parts of the source or drain electrode 506a or 506b are exposed by patterning the flattened layer 508 of the pixel region 610. An electrode material layer made of an inorganic material is formed on the upper side of the pixel region 610 and non-pixel region 620. Patterning is made so that on the pixel region 610 is formed the anode electrode 509a, which is connected through the via hole to the source or drain electrode 506a or 506b, and on the

non-pixel region 620 is formed the second protective film 509b.

**[0088]** The electrode material layer made of an inorganic material may be made of an opaque inorganic material or a mixture of inorganic materials in the case of front surface light emitting type, and a transparent inorganic material or a mixture of inorganic materials in the case of back surface light emitting type. The opaque inorganic material or mixture of inorganic materials may be selected from a group comprising, for example, ACX (alloy of Al), Ag, and Au, and the transparent inorganic or mixture of inorganic materials may be selected from a group comprising, for example, ITO, IZO, and ITZO.

**[0089]** In one embodiment, the second protective film 509b is formed during the procedure when the anode electrode 509a is formed, so that additional processes and mask will not be required. In other embodiments, it is also possible to form the anode electrode 509a and the second protective film 509b through separate processes. In a case where the anode electrode 509a and the second protective film 509b are formed as inorganic electrode material layers in the same process steps, the anode electrode 509a and the second protective film 509b have the separated structure for the electrical isolation between the scan line 504b and data line 506c and the anode electrode 509a.

**[0090]** Referring to FIG. 12h, a pixel definition film 510 is formed on the flattened layer 508 so that a part of the anode electrode 509a is exposed, and then an organic thin film 511 is formed on the exposed anode electrode 509a and a cathode electrode 511 is formed on the pixel definition film 510 including the organic thin film layer 512. This embodiment suggests a construction where the scan line 504b, data line 506c and power supply line are not exposed by the first protective film 507 and the second protective film 509b. Although a construction is suggested where the first protective film 507 and the second protective film 509b are formed to have a stacking structure on the surface of the non-pixel region 620 including the scan line 504b, data line 506c and power supply line, it is also possible to implement a construction where the first protective film 507 and the second protective film 509b are formed only on the scan line 504b, data line 506c and power supply line of the non-pixel region 620.

**[0091]** Turning again to FIGS. 10a and 10b, an encapsulation substrate 700 is provided whose size is such an extent that at least a part of the pixel region 610 is superposed to a part of the non-pixel region 620. A substrate made of a transparent material such as glass is employed as the encapsulation substrate 700. In one embodiment, a substrate made of silicon oxide SiO<sub>2</sub> is employed.

**[0092]** The frit 720 is formed along the surrounding of the encapsulation substrate 700. The frit 720 encapsulates the pixel region 610 to inhibit oxygen or moisture from penetrating therein, which is formed to surround at least a part of the non-pixel region 620 including the pixel

region 610. In one embodiment, the frit is generally a powder-type glass material. Another embodiment provides a paste state of frit, wherein a laser or infrared light absorber, an organic binder, a filler for reducing the thermal expansion coefficient, etc., can be included to facilitate curing after a firing process. For example, a frit may be doped with at least one kind of transition metal.

**[0093]** Referring to FIG. 14, the encapsulation substrate 700 is arranged on the upper side of the substrate 600 manufactured through processes shown in FIGS. 12a through 12h. The frit 720 is attached to the substrate 700 by an irradiating laser beam or infrared ray along the frit 720 under a condition where the encapsulation substrate 700 is arranged on the upper side of the substrate 600 to be superposed to the pixel region 610 and a part of the non-pixel region 620. The laser beam or infrared ray is at least partially absorbed by the frit 720, which in turn generates heat, and thereby the frit 720 is fused and attached to the substrate 600.

**[0094]** In embodiments using the laser, the laser beam is irradiated on the order of power of 36W to 38W, and is moved in a generally constant speed along the frit 720 so as to sustain a more uniform fusion temperature and adhesive strength. In one embodiment, the movement speed of the laser or infrared ray is on the order of 10 to 30mm/sec, and preferably, 20mm/sec.

**[0095]** One the embodiment has been described where the frit 720 is formed to seal only the pixel region 610, it is not limited thereto, but may be formed to include the scan driver 810 in other embodiments. In these embodiments, the size of the encapsulation substrate 700 should also be appropriately changed. In addition, embodiments have been described where the frit 720 is formed on the encapsulation substrate 700, it is not limited thereto, but may also be formed on the substrate 600.

**[0096]** The organic electroluminescence display device according to one embodiment forms the first protective film 507 and the second protective film 509b to have a stacking structure on the metal wirings such as the scan line 504b, data line 506c and power supply line of the non-pixel region 620. When a laser beam is irradiated to fuse and attach the frit 720 to the substrate 600, the metal wirings 504b, 506c of a lower side of the frit 720 and a part intersecting the frit 720 fail to be directly exposed to heat due to the laser beam as shown in FIGS. 15a and 15b. The second protective film 509b made of an inorganic electrode material at least partially reflects laser beam out to inhibit heat from being absorbed. The first protective film 507 made of a silicon compound substantially insulates heat from being transferred from the second protective film 509b to the metal wirings 504b, 506c.

**[0097]** Reflectivity of the metals generally used as electrodes or wirings is approximately Cr(0.632), Mo(0.550), Ti(0.557), and W(0.500). Reflectivity of the opaque inorganic electrode materials used for embodiments is relatively high such as for Al(0.868), Ag(0.969), Au(0.986), etc. Accordingly, since heat absorption ratio is low due to the high reflectivity, the amount of heat trans-

ferred to the metal wirings of the lower side may be significantly lowered. In addition, the transparent inorganic electrode materials (ITO, IZO, ITZO, etc.) used for certain embodiments, which are metal oxide, have even lower heat conductivity compared to metallic materials, and thus may serve to isolate heat transferred to the metal wirings of the lower side and may serve as a buffer layer, thus making it possible to significantly reduce damage to the metal wiring due to heat. Accordingly, heat transfer is effectively insulated by the first protective film 507 and the second protective film 509b formed as a double structure and thus possible damage to the metal wirings 504b, 506c due to heat is reduced, which in turn inhibits cracking of the metal wirings or substantial variation of self resistance and electrical properties, thereby making it possible to sustain electrical properties and reliability of elements.

**[0098]** In addition, since the second protective film 509b is formed by an inorganic material having outstanding adhesive strength with the frit on the metal wirings 504b, 506c of the non-pixel region 620 without addition of separate processes or mask, it is possible to give even more prominent adhesive strength than the case where the frit is attached directly to the metal wirings 504b, 506c. Thus, the adhesive strength is enhanced between the frit 720 and substrate, which in turn inhibits the penetration of oxygen or moisture more effectively, thereby improving reliability of the display device.

**[0099]** One embodiment forms a protective film having a double structure on the metal wirings of the non-pixel region. Accordingly, the metal wirings of the lower side of the frit and the part intersecting the frit are not directly exposed to heat due to laser beam or infrared ray by an inorganic layer for reflecting laser beam to insulate heat from being absorbed and a silicon compound layer for insulating the heat transfer, and thus reducing possible damage to the metal wirings due to heat. This in turn inhibits cracking of the metal wirings or substantial variation of self resistance and electrical properties, thereby making it possible to sustain electrical properties and reliability of elements.

**[0100]** In addition, since a protective film is formed by an inorganic material having outstanding adhesive strength with the frit on the metal wirings of the non-pixel region during forming the anode electrode without addition of separate processes or mask, it is possible to give even more prominent adhesive strength than the case where the frit is attached directly to the metal wirings. Accordingly, the adhesive strength of the frit is enhanced to thus inhibit oxygen or moisture from penetrating, making it possible to improve reliability of the display device.

## Claims

1. An organic electroluminescence display device comprising:

- a first substrate (200, 600) formed with organic electroluminescence elements (100, 500) each comprising a first electrode (108a, 509a), an organic thin film layer (110, 511) and a second electrode (111, 512) and metal wiring for transmitting signals to the organic electroluminescence elements (100, 500),  
 a second substrate (300, 700) arranged in a upper side of the first substrate (200, 600),  
 a frit (320, 720) provided between the first substrate (200, 600) and the second substrate (300, 700), and
- (i) a protective film (108b) formed of the same material as the first electrode (108a) and arranged between the metal wiring and the frit (320); or  
 (ii) a first protective film (507) and a second protective film (509b) provided as a stacking structure between the metal wiring and the frit (720), wherein the second protective film (509b) is formed of the same material as the first electrode (509a).
2. The organic electroluminescence display device as claimed in claim 1, wherein at least one of the first substrate (200, 600) and the second substrate (300, 700) consists of a transparent material.
  3. The organic electroluminescence display device as claimed in claim 1, wherein the metal wiring comprises a scan line (104b, 504b), a data line (106c, 506c), and a power supply line.
  4. The organic electroluminescence display device as claimed in claim 1, wherein a pixel region (210, 610) on the first substrate (200, 600) is defined by the presence of the organic electroluminescence elements (100, 500) and a non-pixel region (220, 620) on the first substrate (200, 600) is defined by the presence of the metal wiring and wherein the protective films (108b, 507, 509b) are formed on the surface of the non-pixel region (220, 620).
  5. The organic electroluminescence display device as claimed in claim 1, wherein the first electrode material is selected from a group consisting of ACX, Ag, and Au.
  6. The organic electroluminescence display device as claimed in claim 1, wherein the first electrode material is selected from the group consisting of ITO, IZO, and ITZO.
  7. The organic electroluminescence display device as claimed in claim 1, wherein the frit (320, 720) comprises at least one dopant made of transition metal.
  8. The organic electroluminescence display device as claimed in claim 1, further comprising transistors for controlling the operation of the organic electroluminescence elements.
  9. The organic electroluminescence display device as claimed in claim 1, wherein the frit (320, 720) comprises one or more materials selected from the group consisting of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium oxide (Li<sub>2</sub>O), sodium oxide (Na<sub>2</sub>O), potassium oxide (K<sub>2</sub>O), boron oxide (B<sub>2</sub>O<sub>3</sub>), vanadium oxide (V<sub>2</sub>O<sub>5</sub>), zinc oxide (ZnO), tellurium oxide (TeO<sub>2</sub>), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), silicon dioxide (SiO<sub>2</sub>), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P<sub>2</sub>O<sub>5</sub>), ruthenium oxide (Ru<sub>2</sub>O), rubidium oxide (Rb<sub>2</sub>O), rhodium oxide (Rh<sub>2</sub>O), ferrite oxide (Fe<sub>2</sub>O<sub>3</sub>), copper oxide (CuO), titanium oxide (TiO<sub>2</sub>), tungsten oxide (WO<sub>3</sub>), bismuth oxide (Bi<sub>2</sub>O<sub>3</sub>), antimony oxide (Sb<sub>2</sub>O<sub>3</sub>), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate.
  10. The organic electroluminescence display device as claimed in claim 1, wherein the first protective film (507) is formed of a silicon compound selected from a group consisting of SiO<sub>x</sub>, SiN<sub>x</sub>, and SiO<sub>x</sub>N<sub>y</sub>.

FIG .1

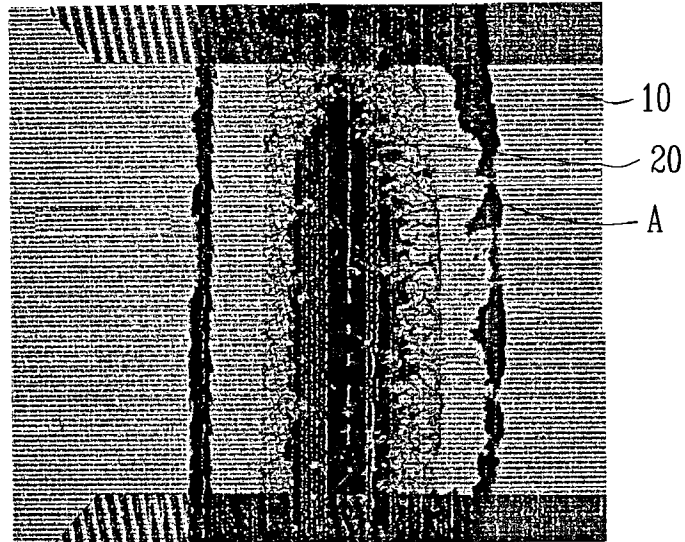


FIG. 2A

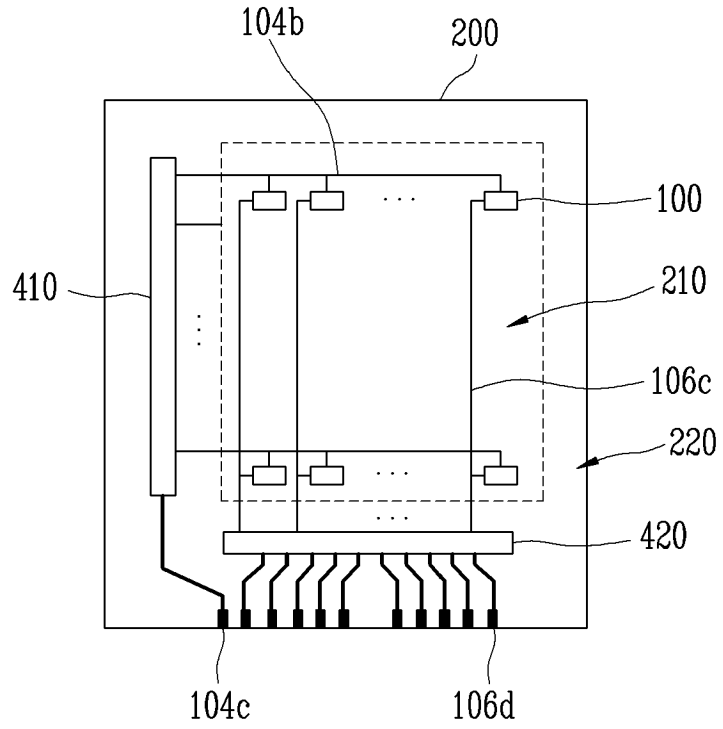


FIG. 2B

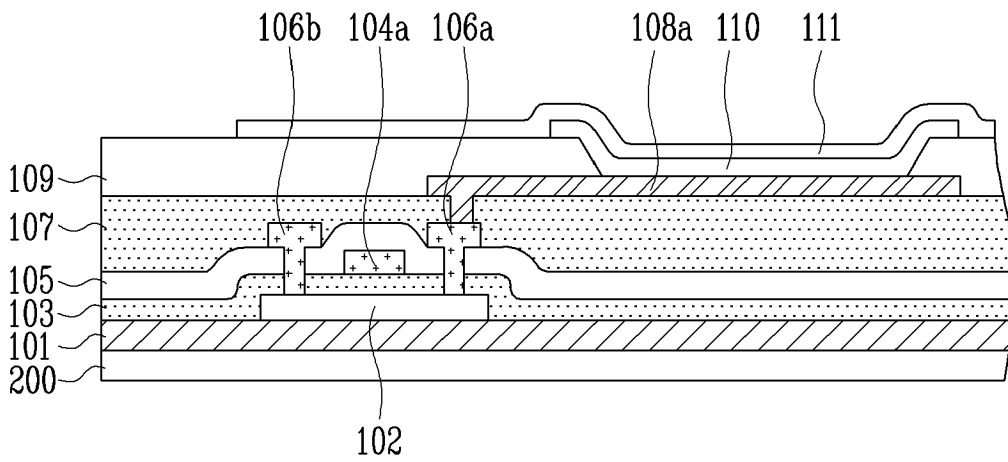


FIG. 3A

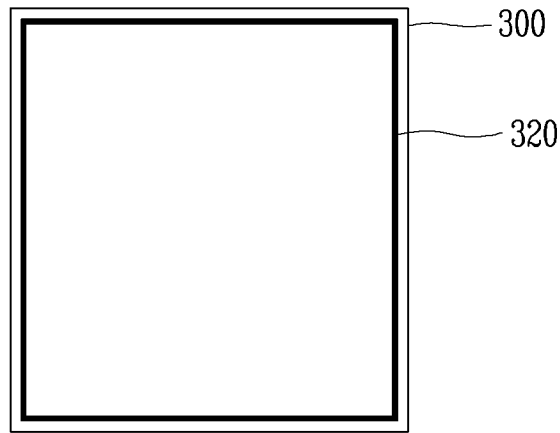


FIG. 3B

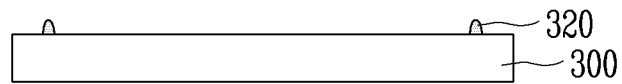


FIG. 4

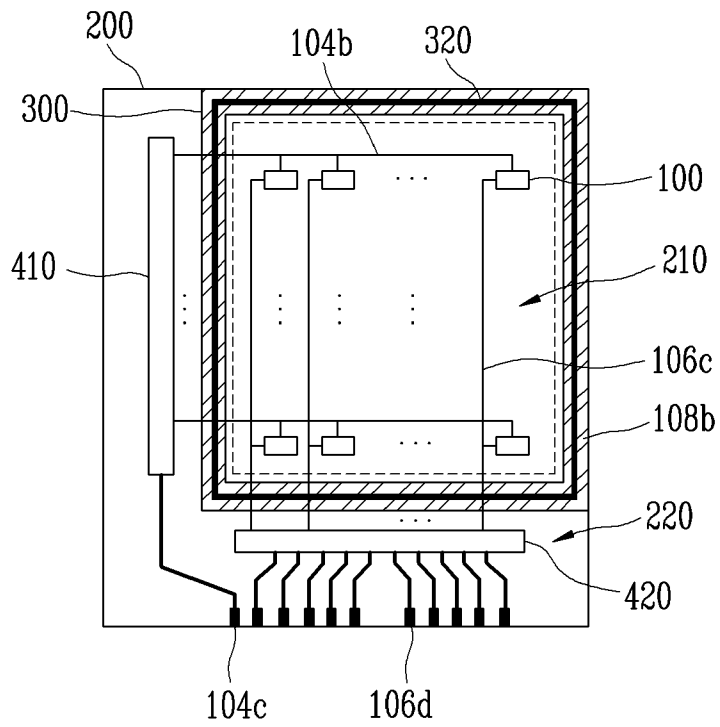


FIG. 5A

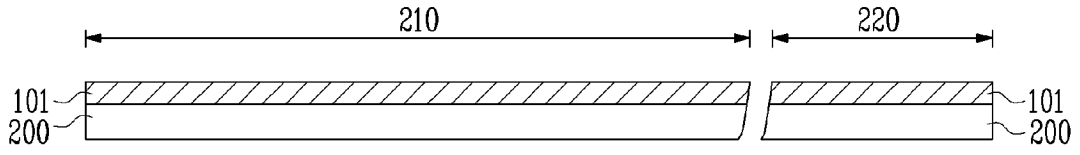


FIG. 5B

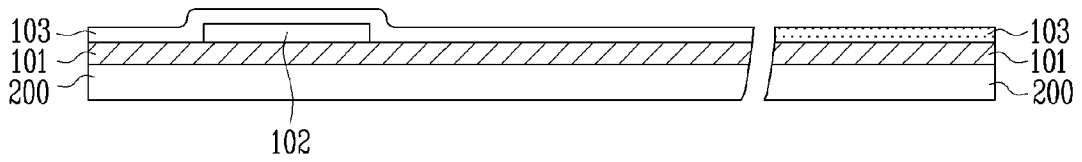


FIG. 5C

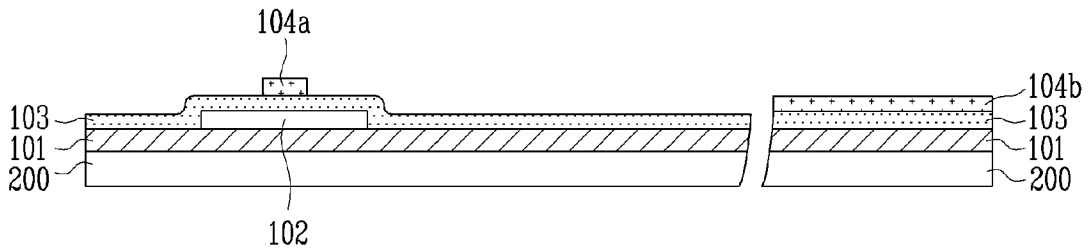


FIG. 5D

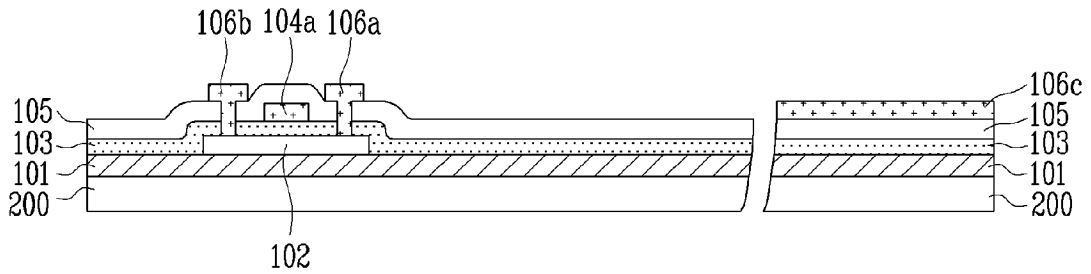


FIG. 5E

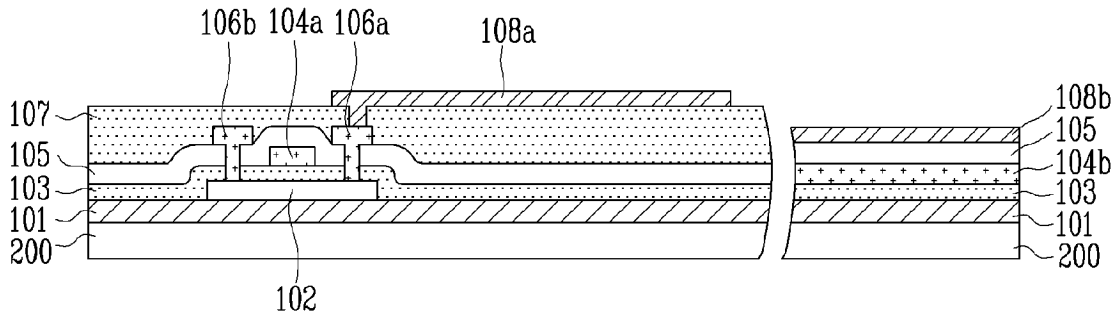


FIG. 5F

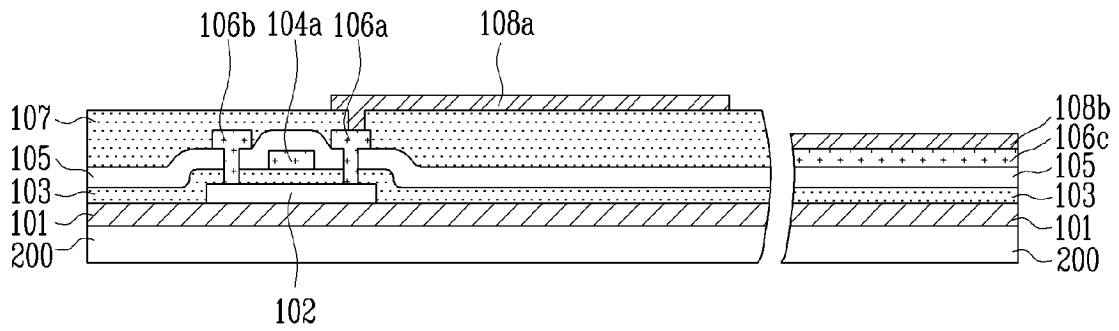


FIG. 5G

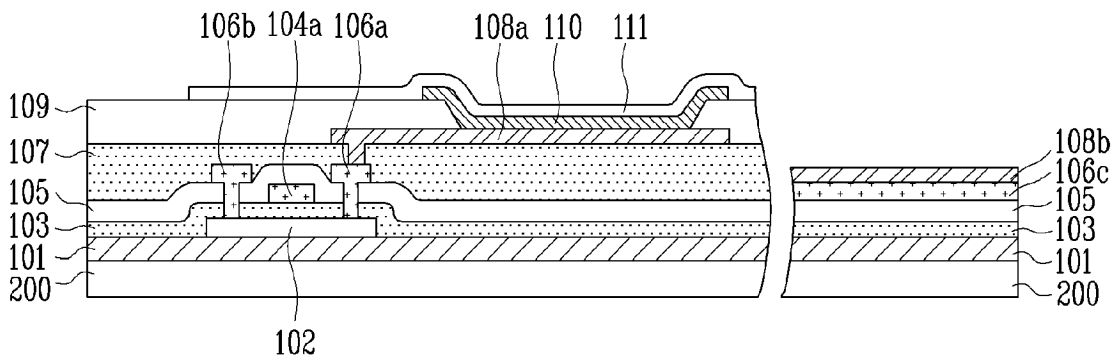


FIG. 6A

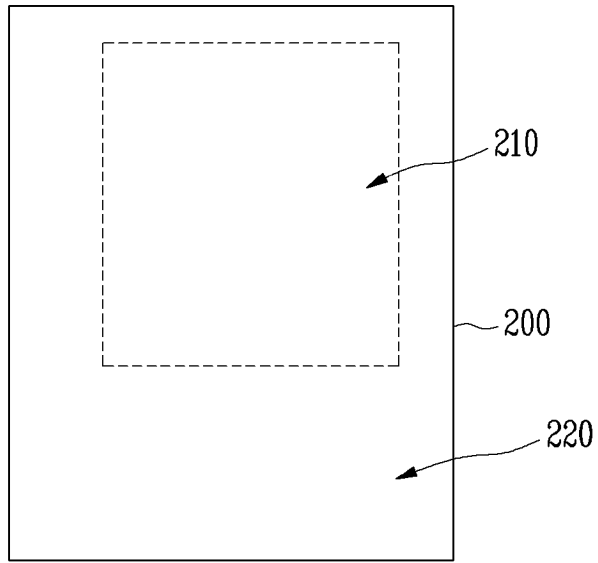


FIG. 6B

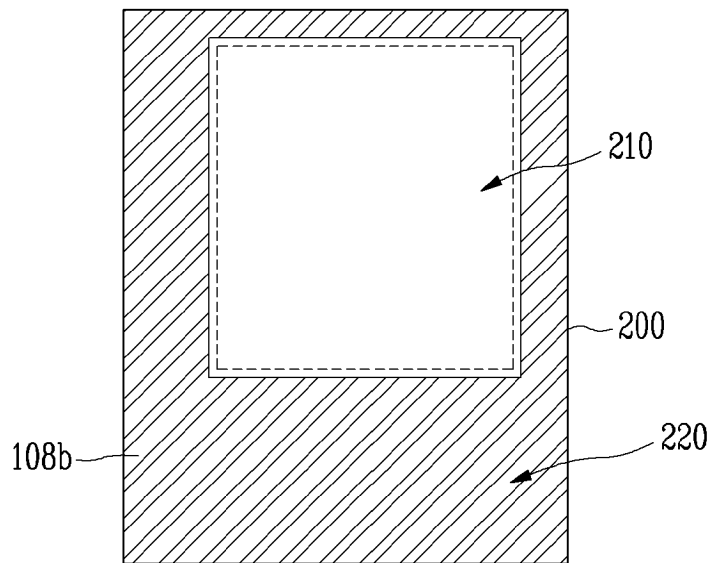


FIG. 7

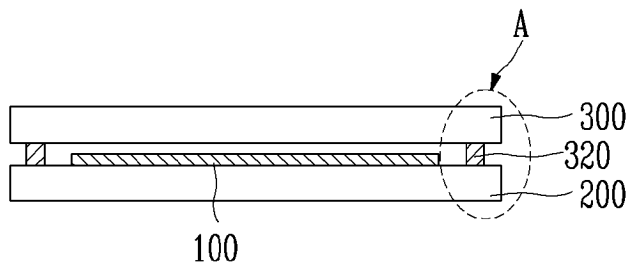


FIG. 8A

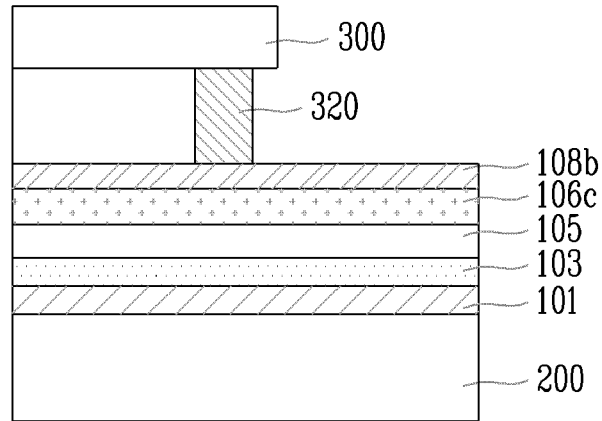


FIG. 8B

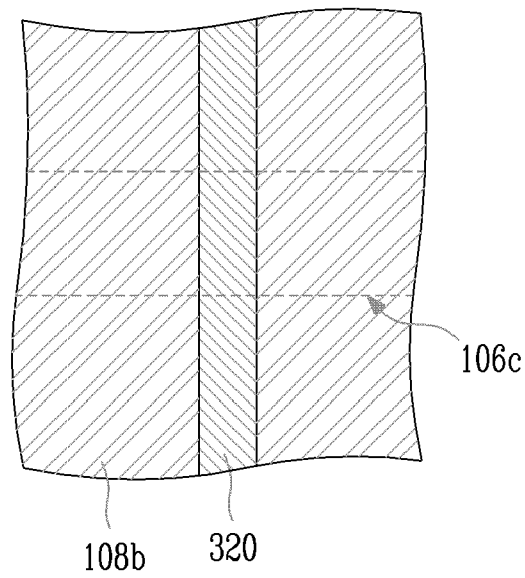


FIG. 9A

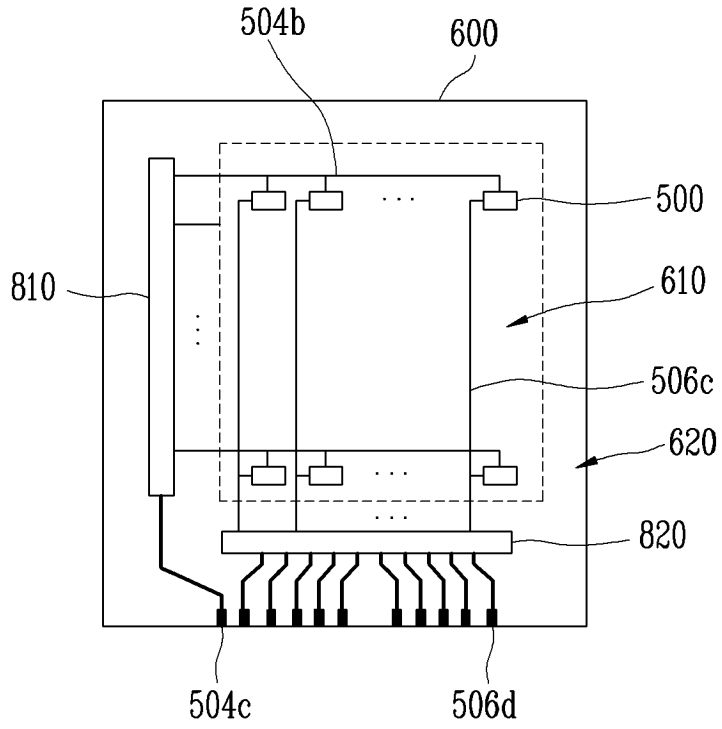


FIG. 9B

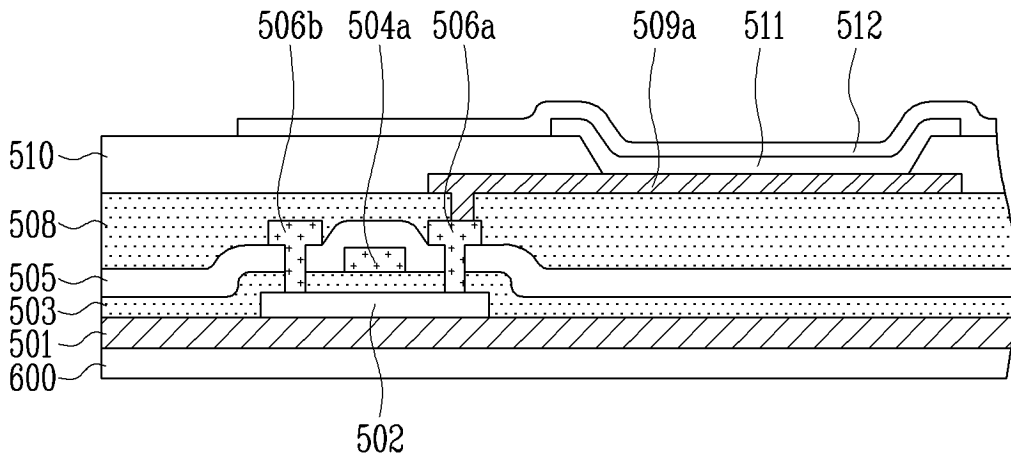


FIG. 10A

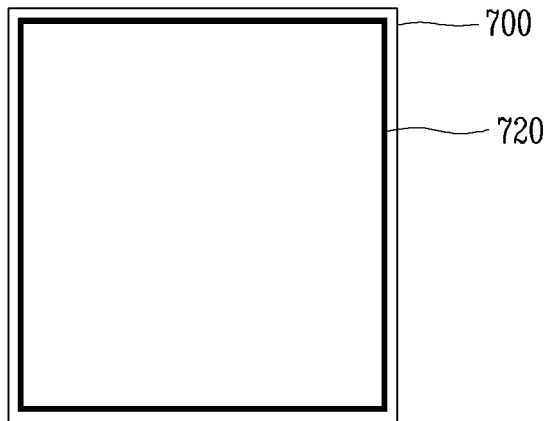


FIG. 10B

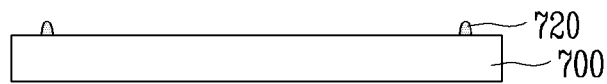


FIG. 11

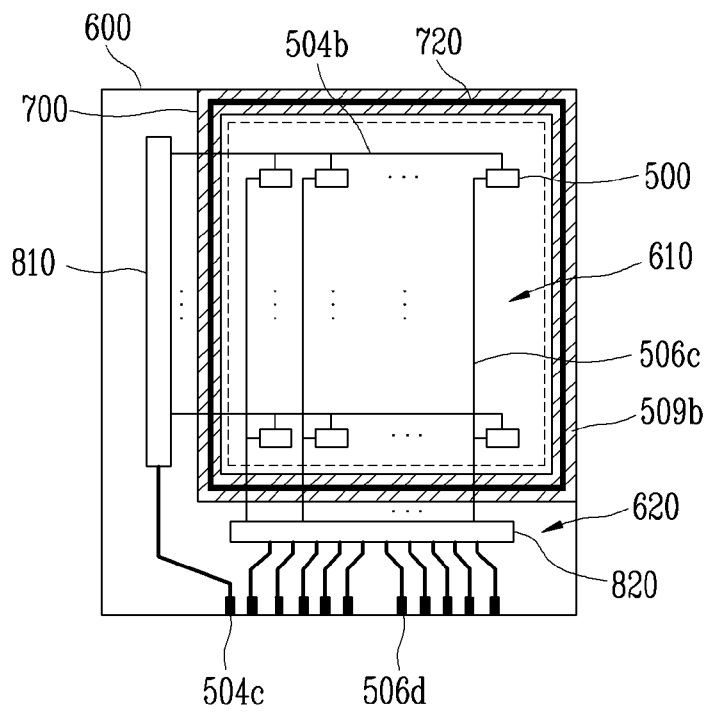


FIG. 12A

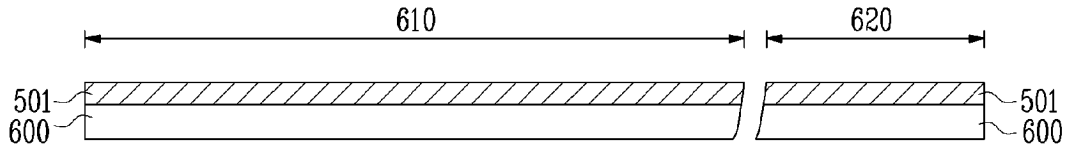


FIG. 12B

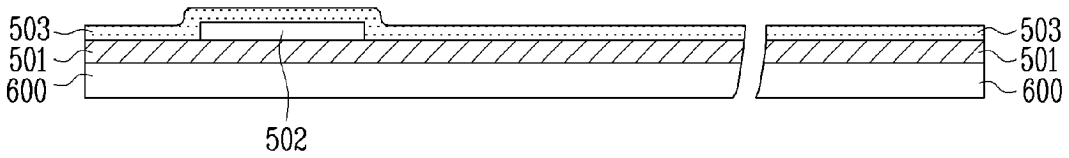


FIG. 12C

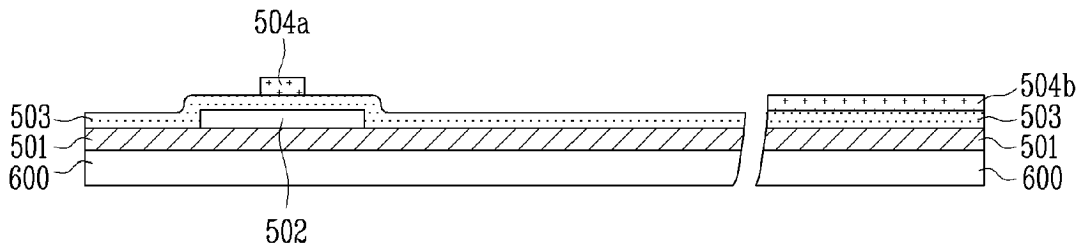


FIG. 12D

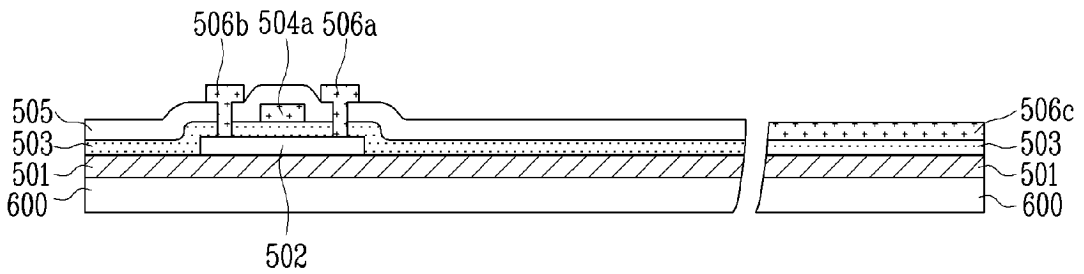


FIG. 12E

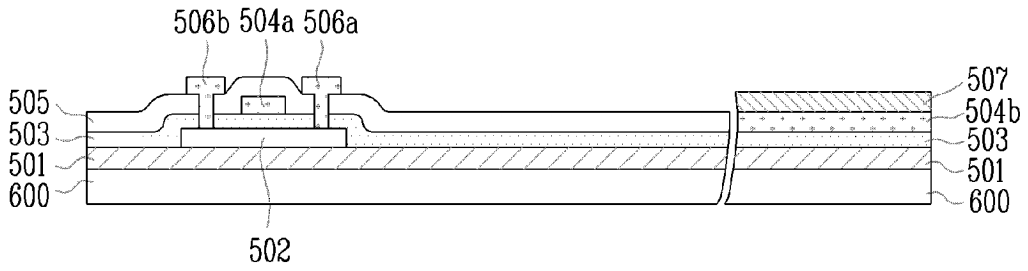


FIG. 12F

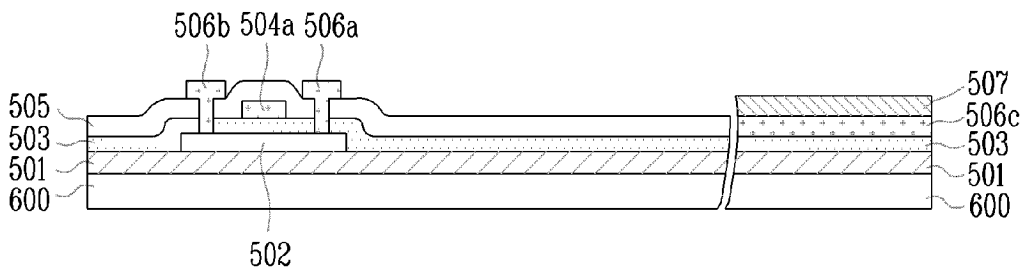


FIG. 12G

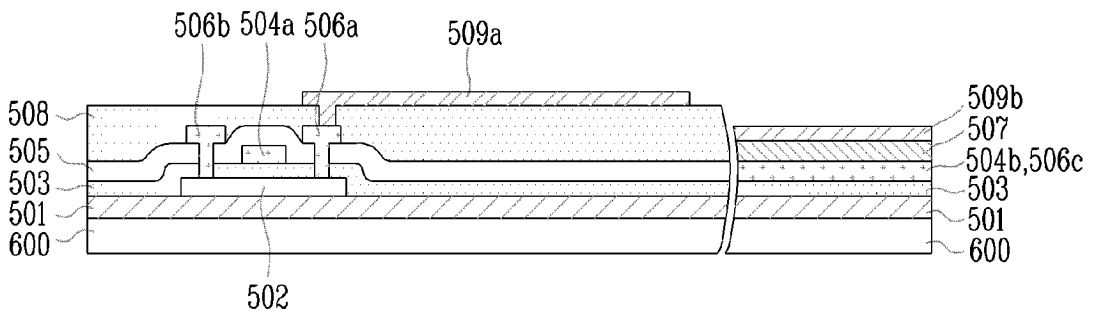


FIG. 12H

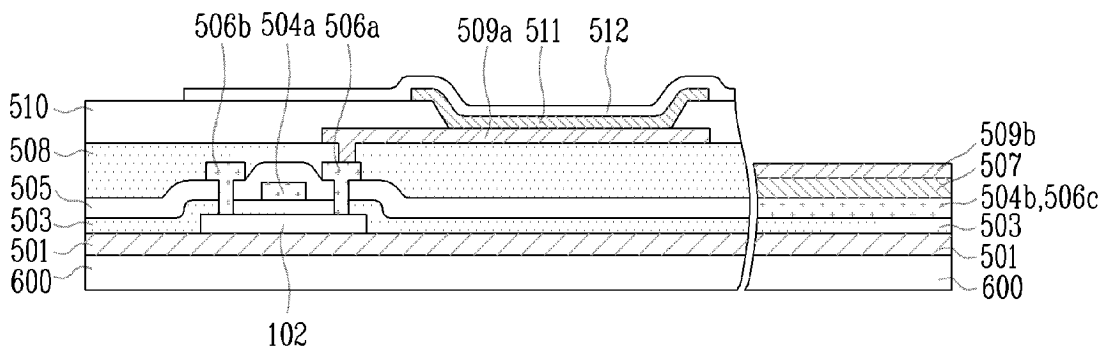


FIG. 13A

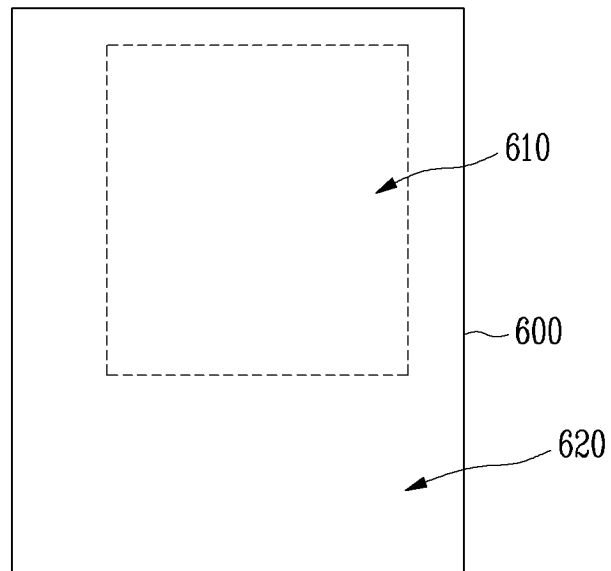


FIG. 13B

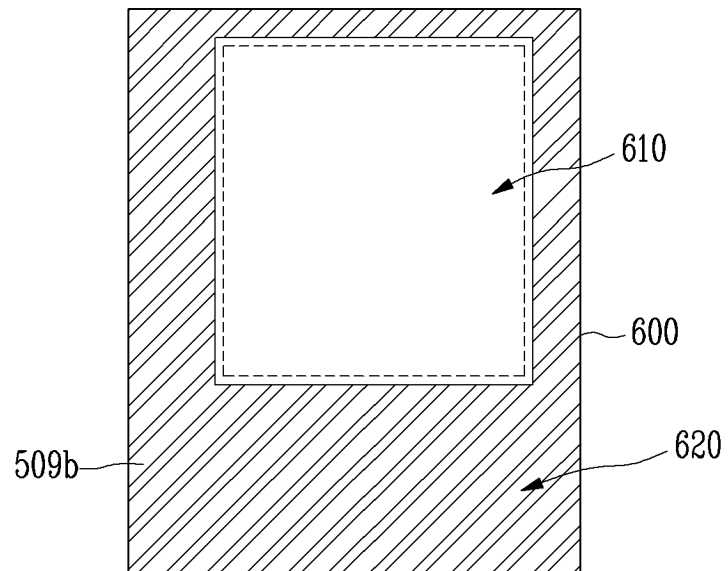


FIG. 14

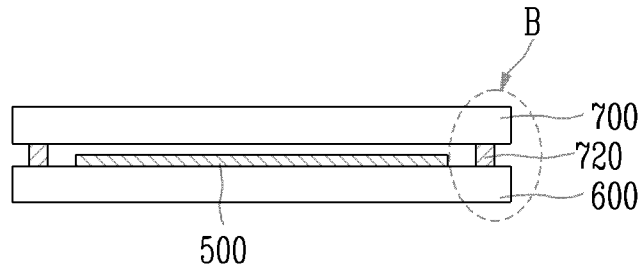


FIG. 15A

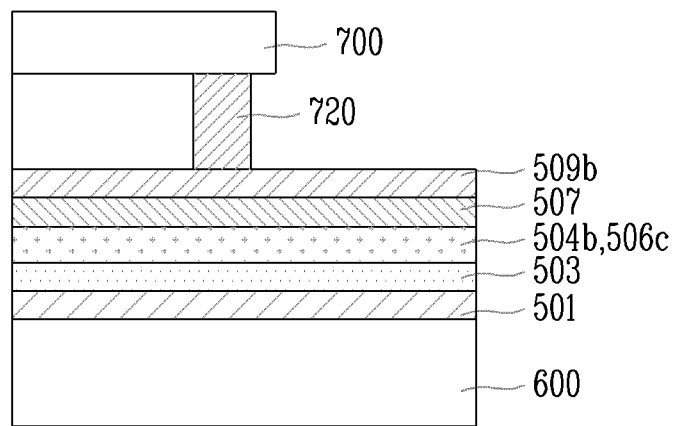


FIG. 15B

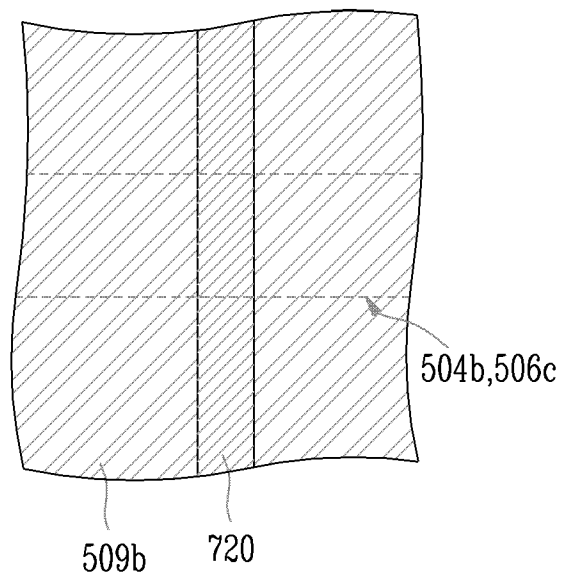


FIG. 16

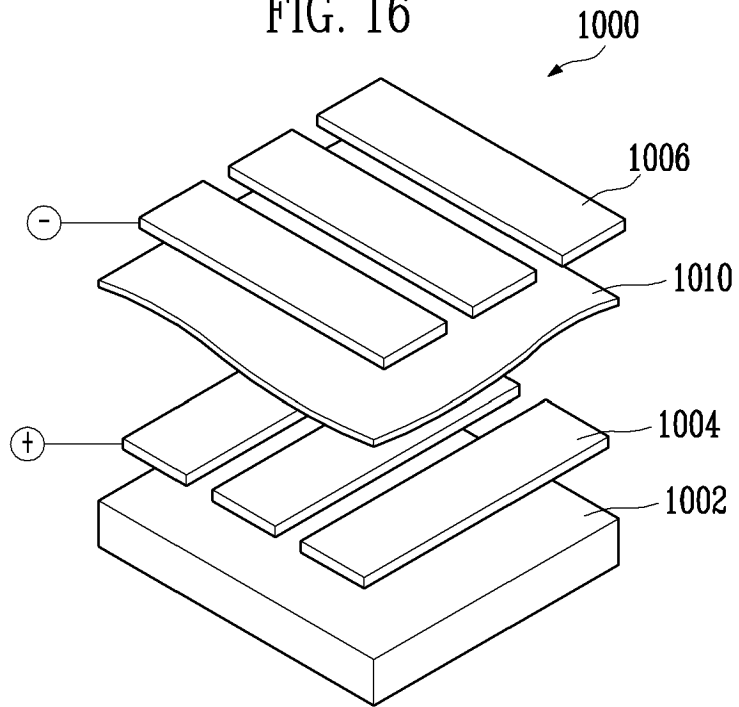


FIG. 17

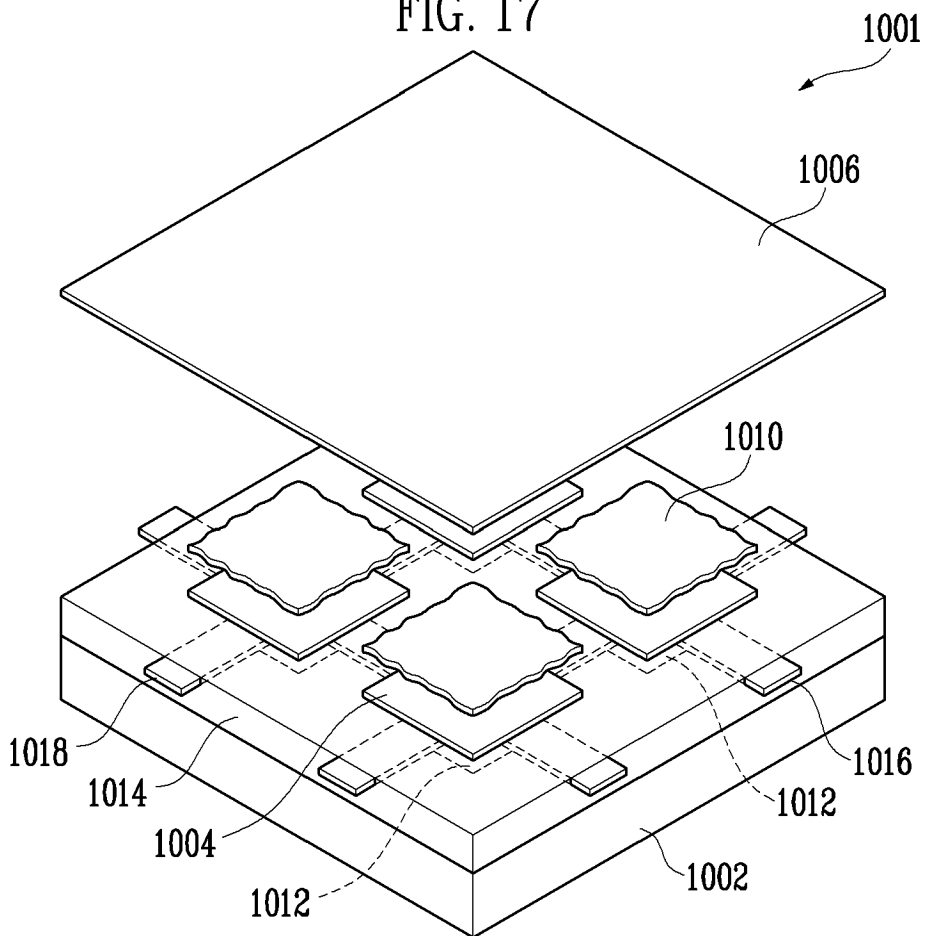


FIG. 18

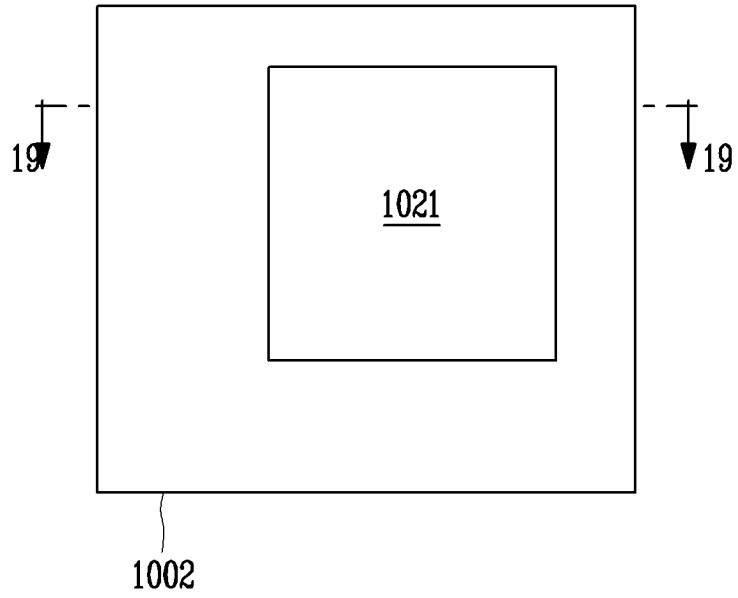


FIG. 19

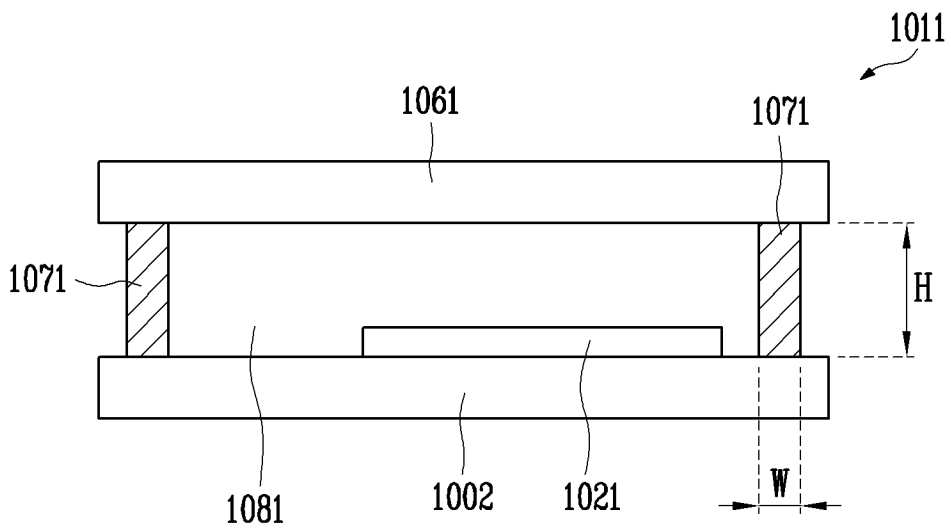
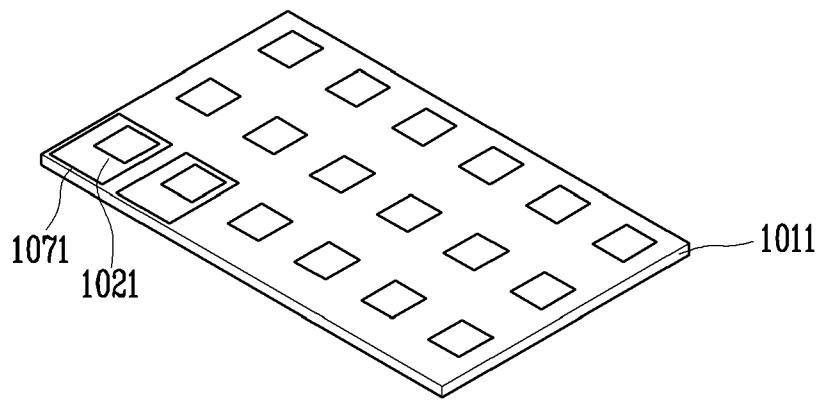


FIG. 20



**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- KR 2002000994 W [0007]
- US 10414794 B [0008]
- KR 20010084380 [0009]
- KR 20020051153 [0010]

专利名称(译)	有机电致发光显示装置		
公开(公告)号	<a href="#">EP1818997A2</a>	公开(公告)日	2007-08-15
申请号	EP2007101707	申请日	2007-02-05
[标]申请(专利权)人(译)	三星斯笛爱股份有限公司		
申请(专利权)人(译)	三星SDI CO., LTD.		
当前申请(专利权)人(译)	三星SDI CO., LTD.		
发明人	KIM, DEUK JONG, SAMSUNG SDI CO., LTD. SONG, SEUNG YONG, SAMSUNG SDI CO., LTD.		
IPC分类号	H01L51/52 H01L27/32		
CPC分类号	H01L51/5246 H01L27/3244 H01L27/3281		
代理机构(译)	hengelhaupt, Jürgen		
优先权	1020060014324 2006-02-14 KR 1020060020108 2006-03-02 KR		
其他公开文献	EP1818997A3		
外部链接	<a href="#">Espacenet</a>		

摘要(译)

本发明涉及一种有机电致发光显示器，包括：由有机电致发光元件（100,500）形成的第一基板（200,600），每个有机电致发光元件包括第一电极（108a, 509a），有机薄膜层（110,511）和第二电极（111,512）和用于将信号传输到有机电致发光元件（100,500）的金属布线，布置在第一基板（200,600）的上侧的第二基板（300,700），玻璃料（320,720）设置在第一基板（200,600）和第二基板（300,700）之间，和（i）保护膜（108b），其由与第一电极（108a）相同的材料形成并且布置在金属配线和玻璃料（320）；或者（ii）第一保护膜（507）和第二保护膜（509b），其设置为金属布线和玻璃料（720）之间的堆叠结构，其中第二保护膜（509b）由与第一保护膜（509b）相同的材料形成。第一电极（509a）。

FIG. 4

