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(71) Applicant: **Samsung SDI Co., Ltd.**
Suwon-Si
Gyeonggi-do 442-742 (KR)

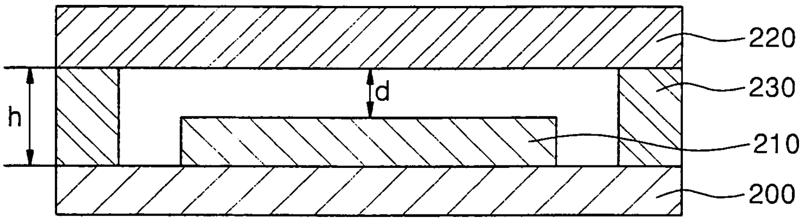
(72) Inventors:
- **Choi, Dong-Soo**
c/o Samsung SDI Co., Ltd.
Gyeonggi-do (KR)
- **Park, Jin-Woo**
c/o Samsung SDI Co., Ltd.
Gyeonggi-do (KR)
- **Jeong, Hee-Seong**
c/o Samsung SDI Co., Ltd.
Gyeonggi-do (KR)
- **Park, Hyun-Sook**
c/o Samsung SDI Co., Ltd.
Gyeonggi-do (KR)

(74) Representative: **Mounteney, Simon James**
Marks & Clerk
90 Long Acre
London WC2E 9RA (GB)

(54) Organic light emitting display device and method of fabricating the same

(57) Provided is an organic light emitting display device (OLED) for preventing Newton's rings to improve image quality. An organic light emitting display device according to one embodiment of the present invention comprises a first substrate (200) comprising a single layer or multiple layers; a second substrate (220) comprising a single layer or multiple layers, the second substrate comprising an inner surface facing the first substrate; an array of organic light emitting pixels (210) formed on the first substrate (200) and interposed between the first and second substrates, the array comprising a top surface opposing the inner surface of the second substrate, wherein the top surface and the inner surface has a gap ("d") therebetween, and the gap has a gap distance measured between the top surface and the inner surface; and a frit seal (230) interconnecting the first and second substrates while surrounding the array, wherein the frit seal, the first substrate and the second substrate in combination define an enclosed space in which the array is located, wherein the frit seal has a height between the first and second substrates so as to form the gap distance ("d") equal to or greater than about 10 μm.

FIG. 3



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Description

BACKGROUND

Field of the Invention

[0001] The present invention relates to organic light emitting display devices and, more particularly, to packaging such devices.

Description of the Related Art

[0002] In recent years, flat panel display devices (FPDs), such as liquid crystal display devices (LCDs), organic light emitting display devices (OLEDs), and plasma display panels (PDPs), have attracted much attention in order to solve the problems of conventional display devices, such as cathode ray tubes (CRTs). Since the LCD is a non-emissive device, the LCD has technical limits in brightness, contrast, viewing angle, and size. Also, the PDP is an emissive display, but the PDP is heavier, consumes more power, and is more complex to manufacture in comparison with other FPDs.

[0003] On the other hand, the OLED is an emissive device that is excellent in viewing angle and contrast. Therefore, the OLED can be made lightweight and thin since a separate light source, i.e., a back light is not required, unlike in the LCD, and consumes less power than the CRT. Furthermore, an OLED can be driven at a low DC voltage and has a fast response speed. Also, since the OLED is fabricated using only solid materials, the OLED is highly resistant to external shock, can be used in a wide range of temperature, and is simple and inexpensive to manufacture.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

[0004] According to a first aspect of the invention, there is provided an organic light emitting display as set out in Claim 1. Preferred features of this aspect are set out in Claims 2 to 15.

[0005] According to a second aspect of the invention, there is provided a method as set out in Claim 16. Preferred features of this aspect are set out in Claims 17 to 25.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The above and other features of the present invention will be described in reference to certain exemplary embodiments thereof with reference to the attached drawings in which:

[0007] FIG. 1 is an illustration of Newton's rings in an organic light emitting display device (OLED);

[0008] FIGS. 2 and 3 are cross-sectional views of an OLED according to an exemplary embodiment of the present invention;

[0009] FIGS. 4 and 5 are cross-sectional views of an OLED according to another exemplary embodiment of the present invention; and

[0010] FIG. 6 is a graph of luminance versus an air gap between a substrate and an encapsulation substrate;

[0011] FIG. 7A is a schematic exploded view of a passive matrix type organic light emitting display device in accordance with one embodiment;

[0012] FIG 7B is a schematic exploded view of an active matrix type organic light emitting display device in accordance with one embodiment;

[0013] FIG. 7C is a schematic top plan view of an organic light emitting display in accordance with one embodiment;

[0014] FIG. 7D is a cross-sectional view of the organic light emitting display of FIG. 7C, taken along the line d-d; and

[0015] FIG. 7E is a schematic perspective view illustrating mass production of organic light emitting devices in accordance with one embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown.

[0017] 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.

[0018] OLEDs can be generally grouped into two basic types dependent on the arrangement with which the stimulating electrical current is provided. Fig. 7A schematically illustrates an exploded view of a simplified structure of a passive matrix type OLED 1000. Fig. 7B 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.

[0019] Referring to Fig. 7A, 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.

[0020] Referring to Fig. 7B, the active matrix OLED (AMOLED) includes 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. 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.

[0021] 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.

[0022] Referring to common features of the PMOLED and AMOLED designs, the substrate 1002 provides structural support for the OLED pixels and circuits. In various arrangements, 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 arrangements, the anode 1004 and cathode 1006 are inverted; i.e., the cathode is formed on the substrate 1002 and the anode is opposingly arranged.

[0023] 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 arrangement, 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.

[0024] 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.

[0025] In some arrangements, a single layer may serve both electron injection and transportation functions or both hole injection and transportation functions. In some arrangements, one or more of these layers are lacking. In some arrangements, one or more organic layers are doped with one or more materials that help injection and/or transportation of the carriers. In arrangements 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.

[0026] 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 arrangements, these organic materials may be macromolecules including oligomers and polymers. In some arrangements, 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.

[0027] 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 arrangement, 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.

[0028] 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 arrangements, the cathode 1006 is made of a material transparent or at least partially transparent with respect to visible light. In certain arrangements, 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. 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.

[0029] In many arrangements, an OLED pixel array 1021 comprising a plurality of organic light emitting pixels is arranged over a substrate 1002 as shown in Fig. 7C. 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. 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 arrangements, 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. 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.

[0030] 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. 7D schematically illustrates a cross-section of an encapsulated OLED device 1011 having a layout of Fig. 7C and taken along the line d-d of Fig. 7C. 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 arrangements, 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 arrangement, the seal 1071 extends along the periphery of the OLED pixel array 1021 or the bottom or top plate 1002, 1061.

[0031] The seal 1071 is made of a frit material as will be further discussed below. In various arrangements, 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.

[0032] 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^2-day and to water of less than 10^{-6} g/m^2-day. Given that some oxygen and moisture can permeate into the enclosed space 1081, in some arrangements, a material that can take up oxygen and/or moisture is formed within the enclosed space 1081.

[0033] 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. 7D. The width varies among arrangments and ranges from about 300 μm to about 3000 μm, optionally from about 500 μm to about 1500 μm. Also, the width may vary at different positions of the seal 1071. 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.

[0034] 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. 7D. The height varies among arrangements and ranges from about 2 μm to about 30 μm, optionally from about 10 μm to about 15 μm. Generally, the height does not significantly vary at different positions of the seal 1071. However, in certain arrangements, the height of the seal 1071 may vary at different positions thereof.

[0035] In the illustrated arrangement, the seal 1071 has a generally rectangular cross-section. In other arrangements, 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 arrangements, the shape of the seal can be designed such that the interfacial area can be increased.

[0036] The seal 1071 can be arranged immediately adjacent the OLED array 1021, and in other arrangements, the seal 1071 is spaced some distance from the OLED array 1021. In certain arrangements, 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, generally parallel to respective boundaries of the OLED array 1021. In other arrangements, 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 arrangements, at least part of the seal 1071 extends between the top plate 1061 and bottom plate 1002 in a curvilinear manner.

[0037] As noted above, in certain arrangements, 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_2O), sodium oxide (Na_2O), potassium oxide (K_2O), boron oxide (B_2O_3), vanadium oxide (V_2O_5), zinc oxide (ZnO), tellurium oxide (TeO_2), aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P_2O_5), ruthenium oxide (Ru_2O), rubidium oxide (Rb_2O), rhodium oxide (Rh_2O), ferrite oxide (Fe_2O_3), copper oxide (CuO), titanium oxide (TiO_2), tungsten oxide (WO_3), bismuth oxide (Bi_2O_3), antimony oxide (Sb_2O_3), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate, etc. These particles can range in size from about 2 μm to about 30 μm, optionally about 5 μm to about 10 μm, 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.

[0038] 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 $ZnSiO_4$, $PbTiO_3$, ZrO_2, eucryptite.

[0039] A frit material as a dry composition can contain glass particles from about 20 to 90 about wt%, and the remaining includes fillers and/or additives. In some arrangements, the frit paste contains about 10-30 wt% organic materials and about 70-90% inorganic materials. In some arrangements, the frit paste contains about 20 wt% organic materials and about 80 wt% inorganic materials. The organic materials may include about 0-30 wt% binder(s) and about 70-100 wt% solvent(s). About 10 wt% may be binder(s) and about 90 wt% may be solvent(s) among the organic materials. The inorganic materials may include about 0-10 wt% additives, about 20-40 wt% fillers and about 50-80 wt% glass powder. About 0-5 wt% may be additive(s), about 25-30 wt% may be filler(s) and about 65-75 wt% may be the glass powder among the inorganic materials.

[0040] 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. The solvent may include one or more organic compounds. For example, applicable organic compounds are ethyl cellulose, nitro cellulose, hydroxyl propyl cellulose, butyl carbitol acetate, terpineol, butyl cellusolve, 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.

[0041] In one arrangement, 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 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.

[0042] 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.

[0043] OLED devices 1011 are often mass produced. In an arrangement illustrated in Fig. 7E, a plurality of separate OLED arrays 1021 is formed on a common bottom substrate 1101. In the illustrated arrangement, each OLED array 1021 is surrounded by a shaped frit to form the seal 1071. A 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. 7D. In certain arrangements, the individual OLED devices 1011 then further undergo additional packaging operations to further improve the sealing formed by the frit seal 1071 and the top and bottom substrates 1061, 1002.

[0044] A glass frit may be formed in a height of about 14 μm or less. Here, the height refers to the length or thickness of the frit in the direction interconnecting the top and bottom substrates. The top substrate may form a curvature, in which the central portion of the top substrate droops toward the bottom substrate due to its own weight by about 7 to 8 μm. As a result, the air gap between the top substrate and the pixel array may not be uniform, which can cause Newton's rings on the display surface. FIG. 1 shows Newton's rings in an organic light emitting display device (OLED).

[0045] FIGS. 2 and 3 are cross-sectional views of an organic light emitting display device (OLED) according to an exemplary embodiment of the present invention. Referring to FIG. 2, a substrate 200 is equivalent to the bottom plate 1002. The substrate 200 may be an insulating substrate, such as a glass substrate and a plastic substrate, or a conductive substrate. Subsequently, an organic light emitting diode or pixel 210 is formed on the substrate 200. The organic light emitting diode 210 may include a first electrode, an organic layer having at least an emission layer (EML), and a second electrode.

[0046] In the organic light emitting diode or pixel 210, the first electrode may be formed of indium tin oxide (ITO) or indium zinc oxide (IZO). Also, when the OLED is a top-emitting OLED, the organic light emitting diode 210 may further include a reflective layer. The organic layer includes at least the EML and may further include at least one of a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), and an electron injection layer (EIL). The second electrode may be formed of a material having a small work function, e.g., at least one selected from the group consisting of Mg, Ag, Al, Ca, and an alloy thereof. Also, the organic light emitting diode 210 may further include a thin film transistor (TFT) having a semiconductor layer, a gate electrode, and source and drain electrodes. The TFT may be a top gate type TFT in which a gate electrode is formed on a semiconductor layer or a bottom gate type TFT in which a gate electrode is formed under a semiconductor layer.

[0047] Referring to FIG. 3, an encapsulation substrate 220, which is equivalent to the top plate 1061, is provided opposite to the substrate 200. The encapsulation substrate 220 may be a flat insulating glass substrate. A sealant 230 is formed on the edge of the encapsulation substrate 220. In this case, when the sealant 230 is formed such that, when the substrate 200 is bonded with the encapsulation substrate 220, an air gap "d" between central portions of the substrate 200 and the encapsulation substrate 220 ranges from about 10 to about 300 μm. In one embodiment, the sealant 230 may be formed of an ultraviolet (UV) curable material, for example, acryl-based resin or polyimide-based resin.

[0048] In another embodiment, the sealant 230 can be a glass frit. The glass frit may be formed of one selected from the group consisting of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium oxide (Li_2O), sodium oxide (Na_2O), potassium oxide (K_2O), boron oxide (B_2O_3), vanadium oxide (V_2O_5), zinc oxide (ZnO), tellurium oxide (TeO_2), aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P_2O_5), ruthenium oxide (Ru_2O), rubidium oxide (Rb_2O), rhodium oxide (Rh_2O), ferrite oxide (Fe_2O_3), copper oxide (CuO), titanium oxide (TiO_2), tungsten oxide (WO_3), bismuth oxide (Bi_2O_3), antimony oxide (Sb_2O_3), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate, and a combination thereof. Also, the glass frit may be formed on the edge of the encapsulation substrate 220 or the edge of the substrate 200 by a screen printing method or a dispensing method.

[0049] The organic light emitting display device has a gap between the the top surface of the pixel array and the inner surface of the encapsulation substrate. Generally, the size of the gap depends on the height of the seal interconnecting two substrates. Dark rings called Newton's rings may be formed on the display surface due to optical interference created by light incident to the display surface. More specifically, when the gap size is about or less than 10 μm, the possibility of Newton's rings increases. Thus, in packaging an organic light emitting display device with the frit seal, the size of the gap can be a design factor in view of the Newton's rings. The frit seal, among other forms of sealing, allows the gap size significantly smaller than others. For example, when using frit seal, the gap size (the distance between the array and the encapsulation substrate) can be in the order of a few μm to several hundred μm. In one embodiment, the gap size is greater than about 10 μm. Optionally, the gap size is from about 10 to about 300 μm, further optionally from about 10 to about 30 μm. In certain embodiments, the gap size is about 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 34, 36, 38, 40, 43, 46, 50, 55, 60, 65, 70, 80, 90, 100, 120, 150, 200, 250 or 300 μm.

[0050] In one embodiment, the substrate 200 on which the organic light emitting diode 210 is formed and the encapsulation substrate 220 on which the sealant 230 is formed are aligned and then bonded to each other. In this case, the substrate 200 and the encapsulation substrate 220 are bonded to each other such that the air gap "d" between a top surface of the substrate 200 on which an array of the organic light emitting diodes or pixels 210 is formed and the central portion of the encapsulation substrate 220 is about 10 μm or more, preferably, ranges from about 10 to about 300 μm. In this case, the sealant 230, which is formed of a UV curable material or glass frit, may have a height h of 10 to 300 μm.

[0051] Subsequently, in one embodiment, when the sealant 230 includes the UV curable material, the UV curable material is cured with UV irradiation. Also, in an embodiment, when the sealant 230 is the glass frit, the glass frit is melted by laser irradiation and solidified. Thereby, the OLED according to an embodiment of the present invention is completed.

[0052] In the OLED fabricated according to this embodiment of the present invention, the substrate 200 on which the organic light emitting diode 210 is formed is bonded to the encapsulation substrate 200 such that the air gap "d" between the top surface of the substrate 200, particularly at the central portions of the substrate 200, and the encapsulation substrate 220 ranges from about 10 to about 300 μm, thereby preventing Newton's rings from occurring and thereby improving image quality.

[0053] FIGS. 4 and 5 are cross-sectional views of an OLED according to another embodiment of the present invention. Referring to FIG. 4, a substrate 300 is provided. The substrate 300 may be an insulating substrate, such as a glass substrate or a plastic substrate, or a conductive substrate. Subsequently, an organic light emitting diode 310 is formed on the substrate 300. The organic light emitting diode 310 may include a first electrode, an organic layer having at least an EML, and a second electrode.

[0054] In the organic light emitting diode 310, the first electrode may be formed of ITO or IZO. Also, when the OLED is a top-emitting OLED, the organic light emitting diode 310 may further include a reflective layer. The organic layer includes at least the EML and may further include at least one of a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), and an electron injection layer (EIL). The second electrode may be formed of a material having a small work function, e.g., at least one selected from the group consisting of Mg, Ag, Al, Ca, and an alloy thereof. Also, the organic light emitting diode 310 may further include a TFT having a semiconductor layer, a gate electrode, and source and drain electrodes. The TFT may be a top gate type TFT in which a gate electrode is formed on a semiconductor layer or a bottom gate type TFT in which a gate electrode is formed under a semiconductor layer.

[0055] Referring to FIG. 5, an encapsulation substrate 320 is provided opposite to the substrate 300. The encapsulation substrate 320 may be an etched insulating glass substrate. Specifically, when the encapsulation substrate 320 is bonded to the substrate 300 later, the encapsulation substrate 320 may be etched such that an air gap "d" between a top surface of the substrate 300 and a central portion of the encapsulation substrate 320 ranges about 10 to about 300 μm. By etching the encapsulation substrate 320 in order to keep the air gap "d" between the top surface of the substrate 300 and the central portion of the encapsulation substrate 320 about 10 μm or more, the glass frit can have a small height.

[0056] Thereafter, a glass frit 330 is formed on the edge of the encapsulation substrate 320. The glass frit 330 may be formed of one selected from the group consisting of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium oxide (Li_2O), sodium oxide (Na_2O), potassium oxide (K_2O), boron oxide (B_2O_3), vanadium oxide (V_2O_5), zinc oxide (ZnO), tellurium oxide (TeO_2), aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P_2O_5), ruthenium oxide (Ru_2O), rubidium oxide (Rb_2O), rhodium oxide (Rh_2O), ferrite oxide (Fe_2O_3), copper oxide (CuO), titanium oxide (TiO_2), tungsten oxide (WO_3), bismuth oxide (Bi_2O_3), antimony oxide (Sb_2O_3), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate, and a combination thereof. Also, the glass frit 330 may be formed on the edge of the encapsulation substrate 320 or the edge of the substrate 300 by a screen printing method or a dispensing method.

[0057] Thereafter, the substrate 300 on which the organic light emitting diode 310 is formed and the encapsulation substrate 320 on which the glass frit 330 is formed are aligned and then bonded to each other. The substrate 300 and the encapsulation substrate 320 are bonded to each other such that the air gap "d" between the top surface of the substrate 300 on which the organic light emitting diode 310 is formed and the central portion of the encapsulation substrate 320 is about 10 μm or more, preferably, ranges from about 10 to about 300 μm. The height h of the glass frit 330 may range from about 10 to about 300 μm. Also, since the glass frit 330 with the height of about 300 μm or less can be formed by melting by laser irradiation and solidifying.

[0058] Subsequently, the glass frit 330 is melted by laser irradiation and solidified, so that the OLED according to another embodiment of the present invention can be completed. In the OLED according to another embodiment of the present invention, the encapsulation substrate 320 may be etched such that the air gap "d" between the central portions of the substrate 300 and the encapsulation substrate 320 ranges from about 10 to about 300 μm□, thereby preventing Newton's rings from occurring and improving image quality.

[0059] Hereinafter, an experimental example is presented. However, the present invention should not be construed as being limited to the experimental example set forth herein. Rather, the experimental example is provided to facilitate understanding.

Example

[0060] FIG. 6 is a graph of luminance versus an air gap between a substrate and an encapsulation substrate. In FIG. 6, an abscissa denotes an air gap "d" between the top surface of an array at the central portions of a substrate on which the array of organic light emitting diodes is formed and an encapsulation substrate, which is expressed in nanometers (nm), and an ordinate denotes luminance of Newton's rings versus the air gap "d". Referring to FIG. 6, it can be seen that as the air gap "d" between the substrate on which the organic light emitting diode is formed and the encapsulation substrate increases, variation in the intensity of the Newton's rings, which is shown as amplitude, gradually decreases. Further, when the air gap "d" between the substrate and the encapsulation substrate exceeds about 10000 nm (i.e., 10 μm), the amplitude becomes fine.

[0061] Specifically, light reflected on the encapsulation substrate interferes with light that passes through the encapsulation substrate and is reflected on the substrate on which the organic light emitting diode is formed, so that destructive interference causes dark patterns, and constructive interference causes bright patterns. In this case, repetition of the dark and bright patterns is referred to as a Newton's rings. Thus, the amplitude refers to a difference in luminance between the dark and bright patterns of the Newton's rings. Accordingly, a reduction in the amplitude can be understood as a reduction in a difference in luminance between the dark and bright patterns of the Newton's rings.

[0062] Therefore, when the air gap "d" between the top surface of the substrate on which the organic light emitting diode is formed and the encapsulation substrate is more than about 10000 nm (i.e., 10 μm), the amplitude is scarcely distinguishable by the naked eye. Thus, the Newton's rings cannot be easily observed by the naked eye. Based on the above-described result, it can be concluded that when the air gap "d" between the central portions of the substrate on which the organic light emitting diode is formed and the encapsulation substrate is made to about 10 μm or more, the Newton's rings can be prevented. As described above, an OLED and a method of fabricating the same according to an embodiment of the present invention can prevent Newton's rings to improve image quality when a substrate and an encapsulation substrate are bonded to each other.

[0063] Although the present invention has been described with reference to certain embodiments thereof, it will be understood by those skilled in the art that a variety of modifications and variations may be made to the present invention without departing from the scope of the present invention defined in the appended claims, and their equivalents.

Claims

1. An organic light emitting display device, comprising:

a first substrate;
a second substrate comprising an inner surface facing the first substrate; and
an array of organic light emitting pixels formed on the first substrate, the array comprising a top surface opposing the inner surface of the second substrate, wherein the top surface and the inner surface has a gap therebetween, and the gap has a gap distance measured between the top surface and the inner surface of greater or equal to about 10 um.

2. A device according to Claim 1, further comprising a frit seal interconnecting the first and second substrates while surrounding the array, wherein the frit seal, the first substrate and the second substrate in combination define an enclosed space in which the array is located.

3. A display device according to Claim 2, wherein the frit seal has a height between the first and second substrates so as to form the gap distance.

4. A device according to Claim 2 or 3, wherein the frit seal has a height between the first and second substrate, and wherein the height is from about 2 to about 300 μm.

5. A device according to any one of Claims 1 to 4, wherein the gap distance is about 10 to about 300 μm.

6. A device according to any one of Claims 1 to 4, wherein the gap distance is from about 10 to about 100 μm.

7. A device according to any one of Claims 1 to 4, wherein the gap distance is from about 10 to about 30 μm.

8. A device according to any one of Claims 1 to 7, wherein the array is configured to emit visible light through the top surface.

9. A device according to Claim 3, wherein the height is the shortest distance between the first and second substrates, wherein the height is from about 10 to about 300 μm.

10. A device according to any one of Claims 1 to 9, wherein the second substrate comprises a display surface facing away from the first substrate and configured to display an image thereon, and wherein the device is configured to display an image on the display surface substantially free of Newton's rings.

11. A device according to any one of Claims 1 to 10, wherein the array comprises a first electrode, a second electrode and at least one organic layer interposed therebetween, wherein the second electrode is closer to the second substrate than the first electrode, and wherein the top surface comprises a surface of the second electrode facing the second substrate.

12. A device according to any one of Claims 1 to 10, wherein the array comprises a first electrode, a second electrode and at least one organic layer interposed therebetween, wherein the second electrode is closer to the second substrate than the first electrode, wherein the array further comprises a substantially transparent layer formed on the second electrode, and wherein the top surface comprises a surface of the substantially transparent layer which faces the second substrate.

13. A device according to any one of Claims 1 to 12, wherein the gap comprises an air gap.

14. A device according to any one of Claims 1 to 12, wherein the gap is substantially filled with a solid material.

15. A device according to any one of Claims 3 to 14, wherein the frit seal comprises one or more materials selected from the group consisting of magnesium oxide (MgO), calcium oxide (CaO), barium oxide (BaO), lithium oxide (Li_2O), sodium oxide (Na_2O), potassium oxide (K_2O), boron oxide (B_2O_3), vanadium oxide (V_2O_5), zinc oxide (ZnO), tellurium oxide (TeO_2), aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), lead oxide (PbO), tin oxide (SnO), phosphorous oxide (P_2O_5), ruthenium oxide (Ru_2O), rubidium oxide (Rb_2O), rhodium oxide (Rh_2O), ferrite oxide (Fe_2O_3), copper oxide (CuO), titanium oxide (TiO_2), tungsten oxide (WO_3), bismuth oxide (Bi_2O_3), antimony oxide (Sb_2O_3), lead-borate glass, tin-phosphate glass, vanadate glass, and borosilicate.

16. A method of making an organic light emitting display device, the method comprising:

providing an unfinished device comprising a first substrate and an array of organic light emitting pixels formed on the first substrate, the array comprising a top surface facing away from the first substrate;
arranging a second substrate over the unfinished device so as to interpose the array between the first and second substrates with a gap between the top surface and the second substrate, the gap having a gap distance; and
forming a frit seal between and interconnecting the first and second substrates while surrounding the array such that the gap distance is equal to or greater than about 10 μm.

17. A method according to Claim 16, wherein forming the frit seal comprises:

interposing a frit material between the first and second substrate; and
bonding the frit material to the first and second substrate so as to form a substantially hermetic seal.

18. A method according to Claim 17, wherein bonding comprises melting and solidifying the frit material.

19. A method according to any one of Claims 16 to 18, wherein the frit seal has a height measured between the first and second substrate, wherein the height is from about 2 to about 300 μm.

20. A method according to any one of Claims 16 to 18, wherein the gap distance is about 10 to about 300 μm.

21. A method according to any one of Claims 16 to 20, wherein the gap distance is from about 10 to about 30 μm.

22. A method according to any one of Claim 16 to 21, wherein the second substrate comprises a display surface facing away from the first substrate and configured to display an image thereon, and wherein the organic light emitting device is configured to display an image on the display surface substantially free of Newton's rings.

23. A method according to any one of Claims 16 to 22, wherein the unfinished device further comprises a plurality of additional arrays of organic light emitting pixels formed on the first substrate, wherein the method further comprising forming a plurality of additional seals between and interconnecting the first and second substrates, wherein a first one of the additional seals surrounds a first one of the additional arrays.

24. A method according to Claim 23, wherein the first additional array and the second substrate forms a gap therebetween with a gap distance equal to or greater than about 10 μm.

25. A method according to Claim 23 or 24, further comprising cutting the unfinished device into two pieces.

FIG. 1

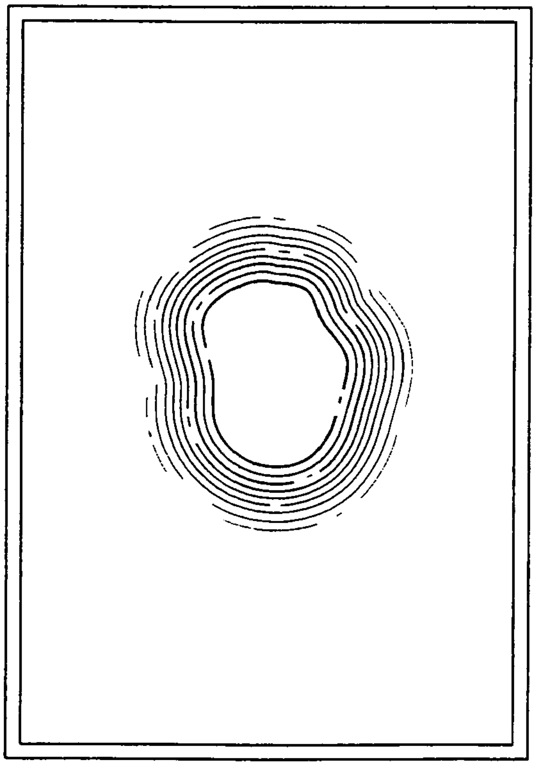


FIG. 2

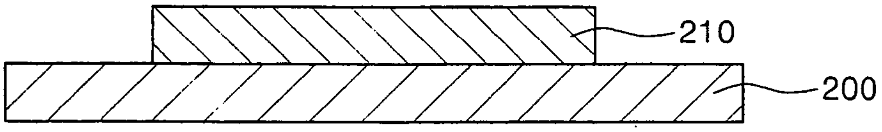


FIG. 3

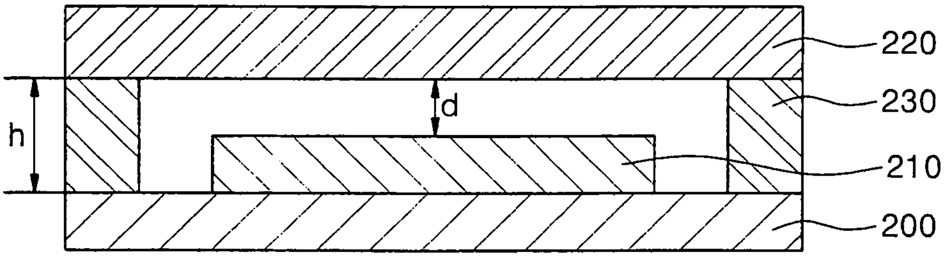


FIG. 4

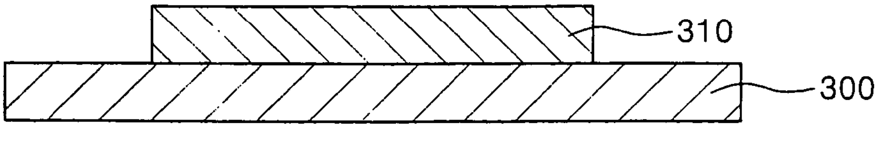


FIG. 5

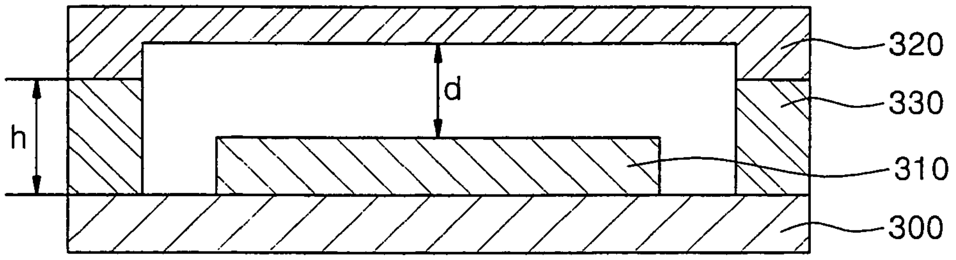

320
330
310
300
d
h

FIG. 6

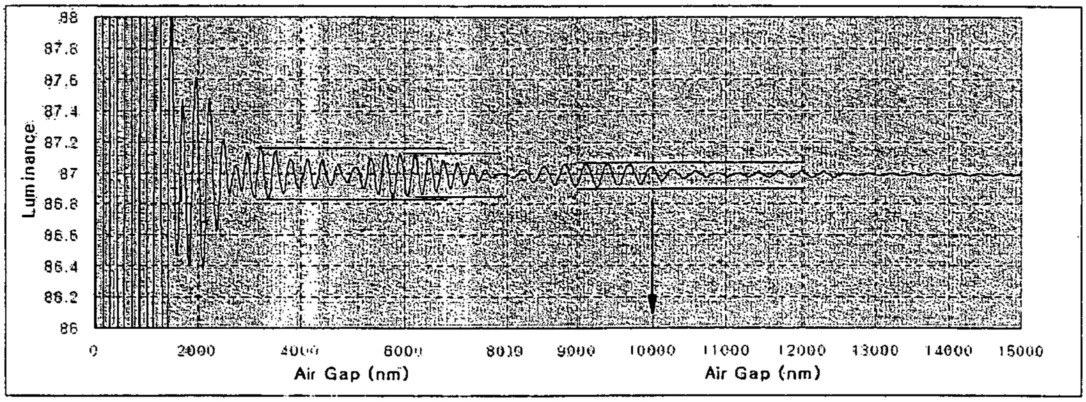

Luminance
88
87.8
87.6
87.4
87.2
87
86.8
86.6
86.4
86.2
86
0
2000
4000
6000
8000
9000
10000
11000
12000
13000
14000
15000
Air Gap (nm)
Air Gap (nm)

FIG. 7A

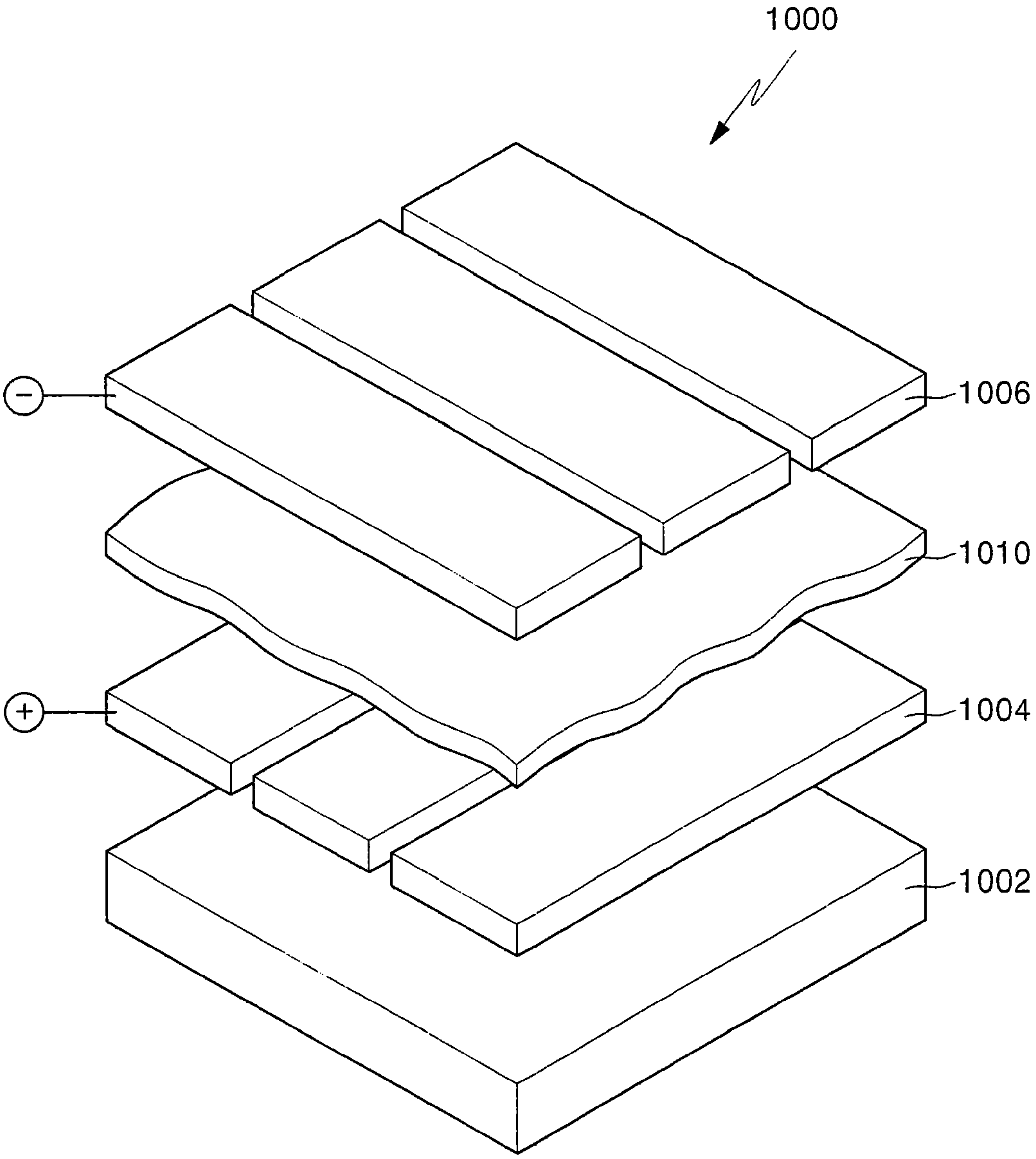


FIG. 7B

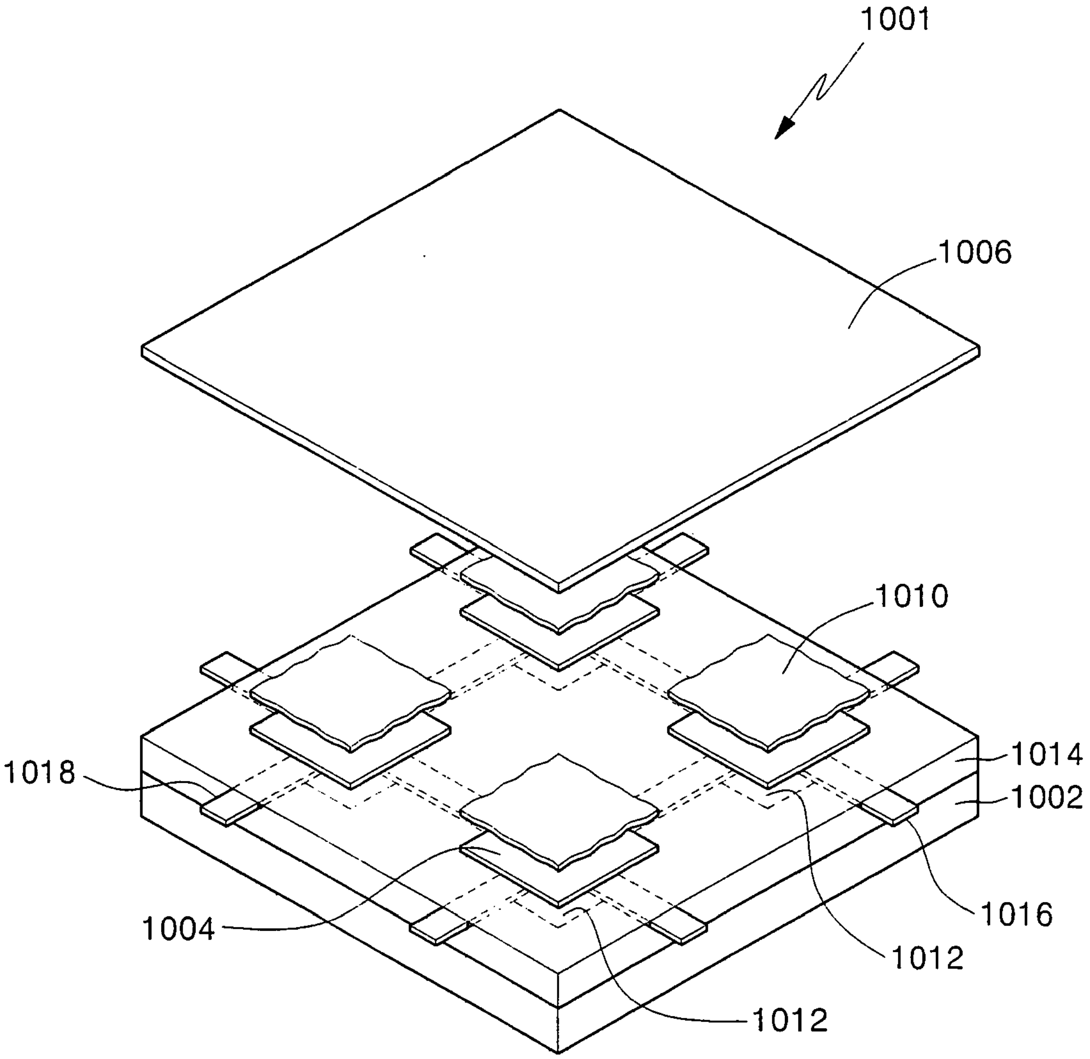


FIG. 7C

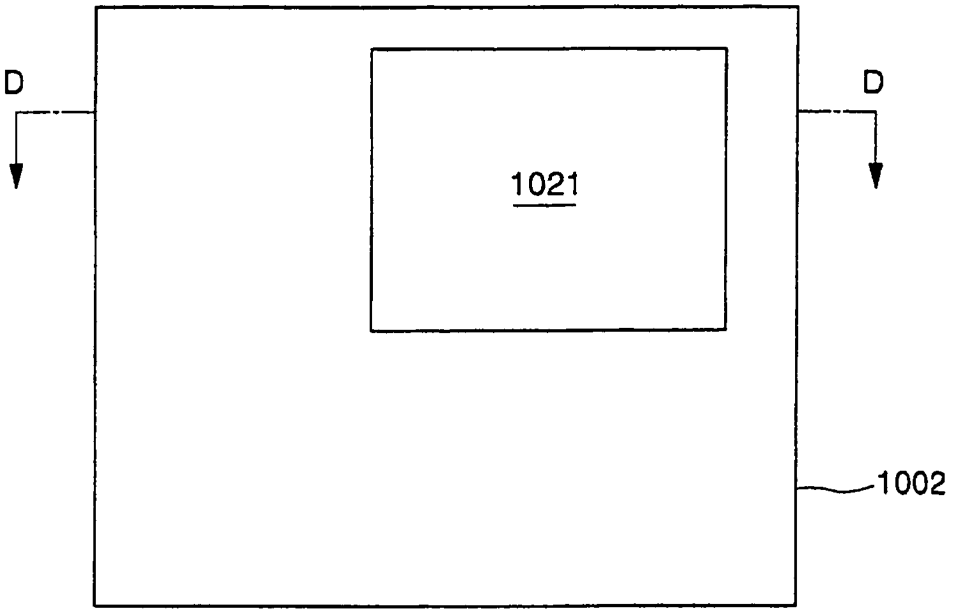


FIG. 7D

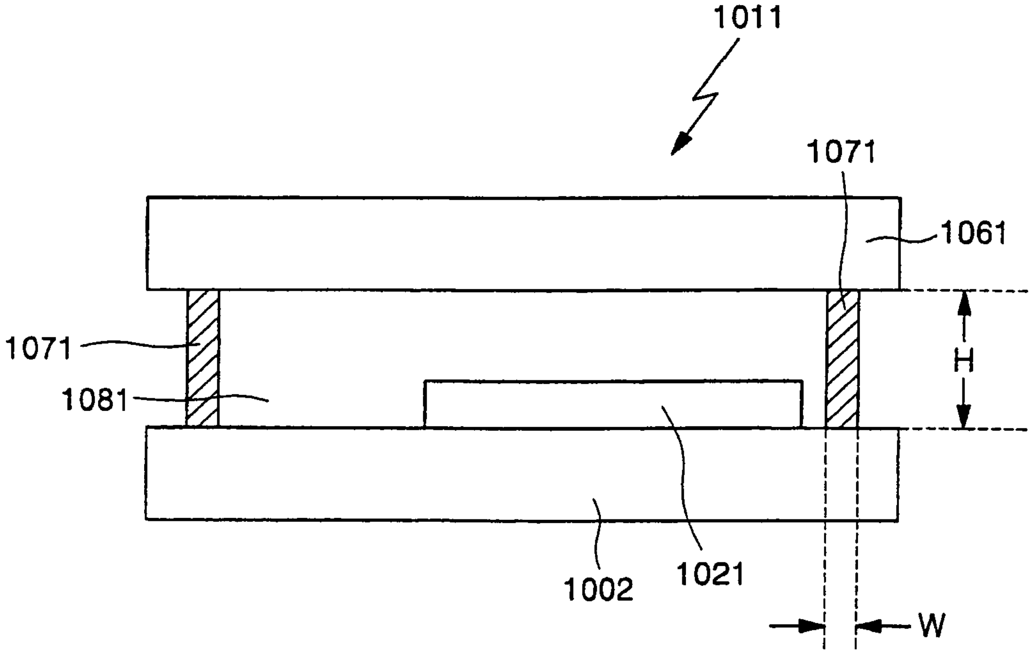
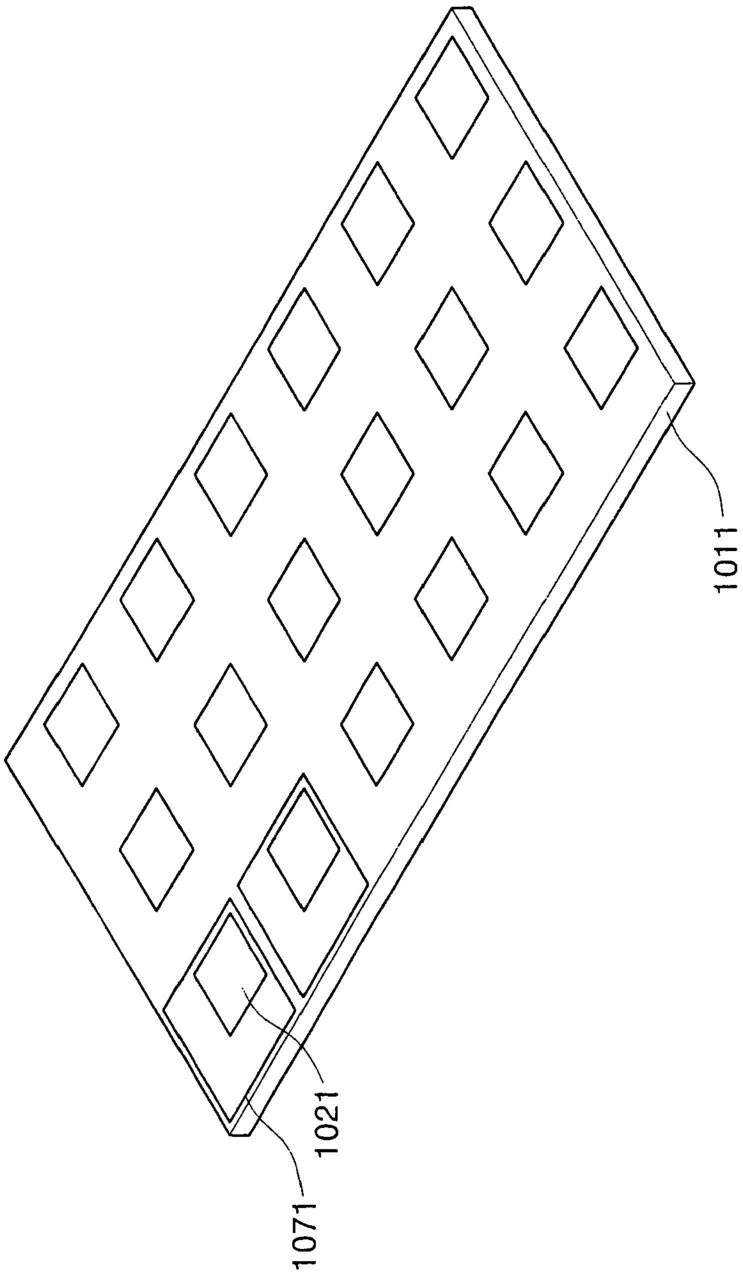


FIG. 7E



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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	CHOI, DONG-SOO C/O SAMSUNG SDI CO., LTD. PARK, JIN-WOO C/O SAMSUNG SDI CO., LTD. JEONG, HEE-SEONG C/O SAMSUNG SDI CO., LTD. PARK, HYUN-SOOK C/O SAMSUNG SDI CO., LTD.		
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摘要(译)

提供一种用于防止牛顿环改善图像质量的有机发光显示装置（OLED）。根据本发明的一个实施例的有机发光显示装置包括：第一基板（200），包括单层或多层;第二基板（220），包括单层或多层，第二基板包括面向第一基板的内表面;形成在第一基板（200）上并介于第一和第二基板之间的有机发光像素阵列（210），该阵列包括与第二基板的内表面相对的顶表面，其中顶表面和内表面在它们之间具有间隙（“d”），并且间隙具有在顶表面和内表面之间测量的间隙距离;以及在围绕所述阵列时互连所述第一和第二基板的玻璃料密封件（230），其中所述玻璃料密封件，所述第一基板和所述第二基板组合形成所述阵列所在的封闭空间，其中所述玻璃料密封件具有高度在第一和第二基板之间形成间隙距离（“d”）等于或大于约10μm。

FIG. 3