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

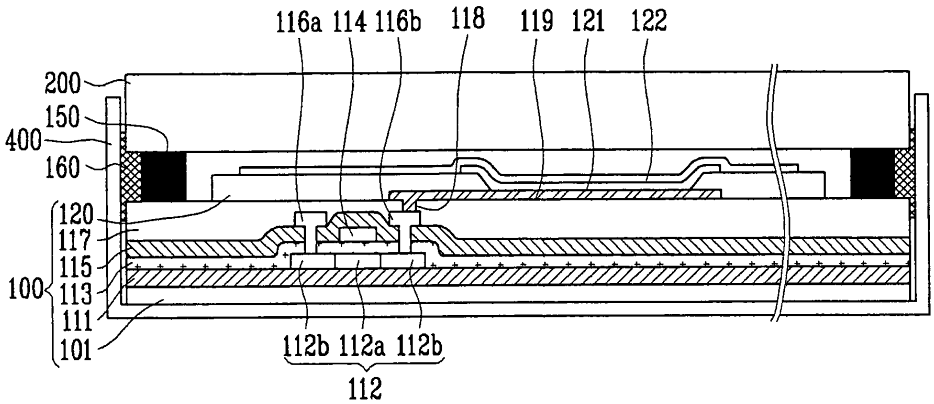
(72) Inventors:
- **Lee, Jae Sung**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Park, Jin-Woo**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Choi, Dong-Soo**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Lim, Dae Ho**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Lee, Jong Woo**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Lee, Ung Soo**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)
- **Sin, Sang Wook**
  Kiheung-eup, Yongin-si,
  Gyeonggi-do (KR)

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

(54) Organic light-emitting display with frit seal and reinforcing structure bonded to frame

(57) Disclosed is an organic light-emitting display device in which a substrate and an encapsulation substrate are joined by a frit and a reinforcing structure. The first substrate has a pixel region in which an organic light-emitting diode is formed, and a non-pixel region formed outside the pixel region. The second substrate is attached the first substrate by the frit. A bracket is joined with substrates by the reinforcing structure. A curable material is applied to inside the frame, moves between the first and second substrates, and then cured to form the reinforcing structure.

FIG. 3



EP 1 814 178 A2

Description

BACKGROUND

1. Field of the Invention

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

2. Discussion of Related Art

[0002] An organic light-emitting display device is a type of flat panel displays in which an electron injected to one electrode and a hole injected to the other electrode binds to each other in an organic light-emitting layer when the organic light-emitting layer is arranged between facing electrodes and a voltage is applied to both electrodes, wherein when luminescent molecules of the light-emitting layer are excited by binding of the electron and the hole, energy is emitted by returning to a ground state, and then converted into the light. Organic light-emitting display devices exhibiting such a light-emission principle have drawn attention as a next-generation display since they are excellent in visibility, and they may be also manufactured in a light weight and thin shape and driven at a low voltage. U.S. Patent No. 6,998,776 B2 discloses that an organic light-emitting display includes a first substrate plate, a second substrate plate and a frit connecting the plates.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

[0003] According to a first aspect of the invention, there is provided an organic light-emitting device as set out in claim 1. Preferred features of this aspect are set out in claims 2 to 20.

[0004] According to a second aspect of the invention, there is provided a method of making an organic light-emitting device as set out in claim 21. Preferred features of this aspect are set out in claims 22 to 25.

[0005] Still another aspect of the present invention provides an organic light-emitting display device including a first substrate comprising a pixel region in which an organic light-emitting diode is formed in a surface thereof, and a non-pixel region formed in a circumference of the pixel region, the organic light-emitting diode comprising an organic light-emitting layer between a first electrode and a second electrode; a second substrate attached to one surface comprising the pixel region of the first substrate; a frit provided between the non-pixel region of the first substrate and the second substrate and attaching the first substrate and the second substrate to each other; a bracket with which the first substrate and the second substrate, both attached to each other, are mounted; and a reinforcement material applied to an inner wall of the bracket, infiltrated between the attached first and second substrates, and then cured.

[0006] A aspect of the present invention provides a method for preparing an organic light-emitting display device including a first substrate including an organic light-emitting diode, and an encapsulation substrate for encapsulating at least a pixel region of the substrate, the method including the first step of applying a frit to form a line spaced apart from an edge of the encapsulation substrate; the second step of attaching a deposition substrate, on which an organic light-emitting diode is deposited, to the second substrate; the third step of melting the frit to attach the first substrate and the second substrate to each other by irradiating a laser or an infrared ray to the frit between the first substrate and the second substrate, both attached to each other; the fourth step of applying a reinforcement material for filling a gap between the first substrate and the second substrate in an inner wall of the bracket with which the attached first and second substrates are mounted; and the fifth step of mounting the first and second substrates so that the sealing material applied in the inner wall of the bracket can be in contact with the gap between the first substrate and the second substrate, both attached to each other. The organic light-emitting diode may be completely protected from the open air by completely coalescing a substrate and a encapsulation substrate to each other using a frit and solving brittleness of the organic light-emitting display device when the frit is used herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

[0008] FIG. 1 is a cross-sectional view showing an organic light-emitting display device;

[0009] FIG. 2 is a plan view showing an organic light-emitting display device according to one embodiment of the present invention;

[0010] FIG. 3 is a cross-sectional view taken along a line A-A' of FIG. 2;

[0011] FIGs. 4a to 4e are cross-sectional views showing a process for preparing an organic light-emitting display device according to an embodiment of the present invention;

[0012] FIG. 5A is a schematic exploded view of a passive matrix type organic light emitting display device in accordance with one embodiment.

[0013] FIG 5B is a schematic exploded view of an active matrix type organic light emitting display device in accordance with one embodiment.

[0014] FIG. 5C is a schematic top plan view of an organic light emitting display in accordance with one embodiment.

[0015] FIG. 5D is a cross-sectional view of the organic light emitting display of FIG. 5C, taken along the line d-d.

[0016] FIG. 5E is a schematic perspective view illustrating mass production of organic light emitting devices in accordance with one embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] Hereinafter, embodiments according to the present invention will be described with reference to the accompanying drawings.

[0018] 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.

[0019] OLEDs can be generally grouped into two basic types dependent on the arrangement with which the stimulating electrical current is provided. Fig. 5A schematically illustrates an exploded view of a simplified structure of a passive matrix type OLED 1000. Fig. 5B 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.

[0020] Referring to Fig. 5A, 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.

[0021] Referring to Fig. 5B, the active matrix OLED (AMOLED) includes localdriving 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.

[0022] 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.

[0023] Referring to common features of the PMOLED and AMOLED designs, the substrate 1002 provides structural support for the OLED pixels and circuits. In variousarrangements, 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. The anode 1004 and cathode 1006 can be inverted; i.e., the cathode is formed on the substrate 1002 and the anode is opposingly arranged.

[0024] 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 illustratedarrangement, 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.

[0025] 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.

[0026] In somearrangements, 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 somearrangements, 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.

[0027] 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 somearrangements, 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.

[0028] 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.

[0029] 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 certainarrangements, 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.

[0030] In manyarrangements, an OLED pixel array 1021 comprising a plurality of organic light emitting pixels is arranged over a substrate 1002 as shown in Fig. 5C. 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 certainarrangements, 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. 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.

[0031] 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. 5D schematically illustrates a cross-section of an encapsulated OLED device 1011 having a layout of Fig. 5C and taken along the line d-d of Fig. 5C. In thisarrangement, 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 arrangement, the seal 1071 extends along the periphery of the OLED pixel array 1021 or the bottom or top plate 1002, 1061.

[0032] The seal 1071 is made of a frit material as will be further discussed below. In variousarrangements, 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. At least one of the top plate 1061 and the bottom plate 1002 are formed of a substantially transparent material.

[0033] 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 somearrangements, a material that can take up oxygen and/or moisture is formed within the enclosed space 1081.

[0034] 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. 5D. The width varies among arrangements 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.

[0035] 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. 5D. 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, the height of the seal 1071 may vary at different positions thereof.

[0036] In the illustratedarrangement, 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. The shape of the seal can be designed such that the interfacial area can be increased.

[0037] 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 certainarrangements, 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 otherarrangements, 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 otherarrangements, at least part of the seal 1071 extends between the top plate 1061 and bottom plate 1002 in a curvilinear manner.

[0038] 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.

[0039] 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.

[0040] 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. The frit paste can contain 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. In some arrangements, the organic materials may include about 0-30 wt% binder(s) and about 70-100 wt% solvent(s). In some arrangements, about 10 wt% is binder(s) and about 90 wt% is solvent(s) among the organic materials. In some arrangements, the inorganic materials may include about 0-10 wt% additives, about 20-40 wt% fillers and about 50-80 wt% glass powder. In some arrangements, 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.

[0041] 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 can 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.

[0042] In one arrangment, 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.

[0043] 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.

[0044] OLED devices 1011 are often mass produced. In an embodiment illustrated in Fig. 5E, 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. 5D. In certain embodiments, 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.

[0045] One problem of an organic light-emitting display device is that the device can be deteriorated when moisture contacts organic materials constituting the organic light-emitting elements. FIG. 1 is a cross-sectional view showing an encapsulation structure of an organic light-emitting device that can prevent moisture from contacting organic materials. In the illustrated structure, the organic light-emitting display device includes a substrate 1, an encapsulation substrate 2, a sealing material 3, a moisture-absorbing material 4 and a bracket 5. The substrate 1 includes a pixel region including at least one organic light-emitting device, and a non-pixel region formed outside the pixel region, and the encapsulation substrate 2 is attached against a surface in which organic light-emitting elements of the substrate 1 are formed.

[0046] In order to attach the substrate 1 to the encapsulation substrate 2, the sealing material 3 is applied along edges of the deposition substrate 1 and the encapsulation substrate 2, and the sealing material 3 is then cured using UV irradiation, etc. A moisture-absorbing material 4 is included in the encapsulation substrate 2 for capturing moisture and certain gases such as hydrogen, oxygen. The bracket 5 is a kind of a frame for supporting an organic light-emitting panel to which the substrate 1 and the encapsulation substrate 2 are attached. The bracket 5 and the organic light-emitting device may be attached with a double side adhesive tape. Even in the illustrated device, however, the sealing material 3 may not completely prevent moisture or air entering into the enclosed space. Also, there may be cracks in the sealing material 3 and in the interfacial area where the sealing material 3 contacts the substrate for various reasons.

[0047] FIG. 2 is a plan view showing an organic light-emitting display device according to one embodiment of the present invention; and FIG. 3 is a plane view taken along a line A-A' of FIG. 2. Referring to figures, the organic light-emitting display device includes a substrate 100, an encapsulation substrate 200, a frit 150 and a reinforcement material or structure 160. For the sake of convenience, the deposition substrate 101 refers to a base, on which circuits and layers are formed, and the substrate 100 refers to an unfinished product including the deposition substrate 101 and circuits and layers formed thereon, including an array of organic light emitting pixels.

[0048] The substrate 100, which is equivalent to the bottom plate 1002, is a plate including organic light-emitting diodes or pixels, and includes a pixel region 100a in which at least one organic light-emitting diode or pixel is formed, and a non-pixel region 100b formed outside of the pixel region 100a, the organic light-emitting diode including a first electrode 119, an organic layer 121 and a second electrode 122. Hereinafter, the pixel region 100a is referred to as a region for displaying a predetermined image using the light emitted from an organic light-emitting diode, and the non-pixel region 100b is referred to as the entire region except the pixel region 100a on the substrate 100 in the description of this application.

[0049] The pixel region 100a includes a plurality of scan lines (S 1 to Sm) arranged in a horizontal direction, and a plurality of data lines (D 1 to Dm) arranged in a vertical direction, and a plurality of pixels are formed in the scan lines (S 1 to Sm) and the data lines (D 1 to Dm), the pixels receiving signals from driver integrated circuits 300,400 for driving an organic light-emitting diode. Also, a driver integrated circuit (Driver IC) for driving an organic light-emitting diodes or pixels, and metal wirings electrically attached to each of the scan lines (S 1 to Sm) and the data lines (D 1 to Dm) of the pixel region are formed in the non-pixel region 100b. In an embodiment, the driver integrated circuit includes a data driving unit 170 and a scan driving unit 180.

[0050] The organic light-emitting diode shown in the drawings is driven using an active matrix method, as shown in the drawings, and its configuration will be described in brief. A buffer layer 111 is formed on a deposition substrate 101, and the buffer layer 111 is formed of insulating materials such as silicon oxide (SiO_2) or silicon nitride (SiNx). The buffer layer 111 prevents the substrate 100 from being damaged by factors such as heat from the outside, etc. On at least one region of the buffer layer 111 is formed a semiconductor layer 112 including an active layer 112a and an ohmic contact layer 112b. On the semiconductor layer 112 and the buffer layer 111 is formed a gate insulating layer 113, and on one region of the gate insulating layer 113 is formed a gate electrode 114 having a size corresponding to a width of the active layer 112a.

[0051] An interlayer insulating layer 115 includes the gate electrode 114 and is formed on the gate insulating layer 113, and source and drain electrodes 116a, 116b are formed on a predetermined region of the interlayer insulating layer 115. The source and drain electrodes 116a,116b are formed so that they can be connected to one exposed region of the ohmic contact layer 112b, and an overcoat 117 includes the source and drain electrodes 116a,116b and is formed on the interlayer insulating layer 115. A first electrode 119 is formed on one region of the overcoat 117, wherein the first electrode 119 is connected with one exposed region of either one of the source and drain electrodes 116a,116b by means of a via hole 118.

[0052] A pixel definition layer 120 includes the first electrode 119 and is formed on the overcoat 117, the pixel definition layer 120 having an opening (not shown) to which at least one region of the first electrode 119 is exposed. An organic layer 121 is formed on the opening of the pixel definition layer 120, and a second electrode layer 122 includes the organic layer 121 and is formed on the pixel definition layer 120. In an embodiment, a passivation layer may be further formed in an upper portion of the second electrode layer 122. However, various modifications and changes may be made in an active matrix structure or a passive matrix structure of the organic light-emitting diode.

[0053] The encapsulation substrate 200, which is equivalent to the top plate 1061, is a member for encapsulating at least one pixel region 100a of the substrate in which the organic light-emitting diode is formed, and is formed of transparent materials in the case of top emission or dual emission and formed of translucent materials in the case of bottom emission. Various materials of the encapsulation substrate 200 can be used in embodiments of the present invention, but a glass may be preferably used in this embodiment, for example in the case of the top emission, although not limited thereto.

[0054] The encapsulation substrate 200 is formed in a plate shape in this embodiment, and encapsulates a pixel region in which the organic light-emitting diode is formed on at least the substrate 100. The entire region is encapsulated except a data driving unit and a pad unit in this embodiment. The frit 150 is formed between the encapsulation substrate 200 and the non-pixel region 100b of the substrate 100 to seal the pixel region 100a so that the air or moisture is prevented from being infiltrated.

[0055] The frit 150 preferably forms a line spaced apart at a constant distance from an edge of an interface in which the encapsulation substrate 200 and the substrate 100 are coalesced to each other. This is to secure a space that forms a reinforcement material 160, as described later. The frit 150 includes a glass material, a absorbing material for absorbing a laser, a filler for reducing a thermal expansion coefficient, etc., and is applied to the encapsulation substrate 200 in a state of frit paste, melted and cured to form the frit seal between the encapsulation substrate 200 and the substrate 100 using a laser or an infrared ray to seal between the encapsulation substrate 200 and the substrate 100. In some embodiments, the line in which the frit 150 is formed preferably has a width of about 0.5 to about 1.5 mm. Also, a height of each frit 150 preferably ranges from about 10 to about 20μm.

[0056] Meanwhile, various configurations and materials of a surface of the substrate 100 which the frit 150 contacts can be used although not limited thereto. In some embodiments, the frit is not overlapped with a metal wiring, except an area where a metal wiring directly connected with a driver integrated circuit. As described above, if the frit 150 is overlapped with the metal wiring, the metal wiring may be damaged due to irradiation of a laser or an infrared ray.

[0057] The bracket 400 is a kind of a frame for supporting an organic light-emitting panel to which a substrate 100 and an encapsulation substrate 200 are attached. In the embodiment illustrated in Fig. 3, the bracket 400 has a rear wall 450 and a plurality of side walls 460 extending from the rear wall 450. As shown in Fig. 3, the bracket does not have a rear wall 450 and may have a closed loop shape formed by the plurality of side walls 460 shown in Fig. 3. In the embodiment illustrated in Fig. 3, the rear wall 450 of the bracket 400 and a surface of the organic light-emitting panel may be attached with an adhesive tape, etc.

[0058] The reinforcement material 160 is a member that is formed in a gap between a surface of the organic light-emitting panel and an inner surface of the bracket and then cured. Therefore the reinforcement material 160 prevents an organic light-emitting display device from being easily damaged or broken and also functions as a sealing material when the frit 150 is not attached or its adhesive force is reduced. Curable materials which are naturally cured, thermally cured or UV-cured, may be used. Liquid materials can be used for forming the reinforcement material 160. For example, cyanoacrylate may be used as the naturally cured material; acrylate may be used as the material that is thermally cured at a temperature of about 80°C or less; and epoxy, acrylate and urethane acrylate may be used as the UV-cured materials.

[0059] Hereinafter, embodiments of a method for preparing an organic light-emitting display device according to the present invention will be described in detail. FIGs. 4a to 4e are process views showing a process for preparing an organic light-emitting display device. Firstly, a frit 150 is applied in a linear shape in a point spaced apart at a predetermined distance from an edge of an encapsulation substrate 200, and the frit 150 is formed in a point corresponding to a non-pixel region 100a of the substrate 100, as described later. A height of the frit 150 preferably ranges from about 10 to about 20 μm. The frit 150 is applied to the encapsulation substrate 200 at a state of the frit paste, sintered to remove moisture or organic binders that are included in the paste, and then cured.

[0060] Next, a substrate 100 including a pixel region including an organic light-emitting diode, and a non-pixel region in which a driver integrated circuit and a metal wiring, etc. are formed is provided, and an encapsulation substrate 200 is coalesced. The encapsulation substrate 200 may or may not encapsulate a driver integrated circuit of the substrate 100, depending on its design. (FIG. 4b) Next, a laser or an infrared ray is irradiated to the frit 150 between the substrate 100 and the encapsulation substrate 200, both coalesced to each other, to melt the frit 150 between the substrate 100 and the encapsulation substrate 200. The irradiated laser or infrared ray preferably has, for example, a wavelength of about 800 to about 1200 nm (and preferably about 810 nm), its power preferably ranges from about 25 to about 45 watt, and a region except the frit is preferably masked. A bilayer of cooper and aluminum may be used as materials of the mask. Then, the substrate 100 and the encapsulation substrate 200 are attached to each other by curing the melted frit 150. (FIG. 4c)

[0061] Next, a curable material for forming a reinforcement material 160 is applied, for example by using a dispenser, in an inner wall surface of a bracket 400 for mounting an organic light-emitting panel including the substrate 100 and the encapsulation substrate 200, both attached to each other. Generally, metal materials are mainly used for the bracket 400, although not limited thereto, and plastics are also used for the bracket 400. The curable material for forming the reinforcement material 160 is preferably applied at a liquid state. (FIG. 4d)

[0062] Next, the organic light-emitting panel or device is mounted on the bracket 400. The organic light-emitting panel contacts the curable material for the reinforcement material 160 applied in the inner surface of the bracket 400 while it is mounted on the bracket 400, and then the curable material for the reinforcement material 160 moves into a gap between the substrate 100 and the encapsulation substrate 200. (FIG. 4e) Gaps are generated in the edge regions of the substrate 100 and the encapsulation substrate 200 since the frit 150 is not formed adjacent to the edges, but formed spaced apart at a predetermined distance from the edges. Accordingly, the curable material for the reinforcement material 160 moves into the gaps in the edge regions, and then cured. The dimension of the gap between the substrate 100 and the encapsulation substrate 200 will be identical to the height of the frit, and if a liquid of the reinforcement material is applied on the edges, then the liquid moves into gaps by a capillary phenomenon, and then is cured.

[0063] If the materials of the reinforcement material 160 are naturally cured, then preparation of an organic light-emitting diode may be completed without an additional process. However, if the materials of the reinforcement material 160 are UV-cured, then there is required an additional process for masking the reinforcement material 160 and irradiating it with UV ray. Furthermore, if the materials of the reinforcement material 160 are thermally cured, then there is required an additional process for subjecting the heat to the reinforcement material

[0064] The present invention has been described in detail with reference to embodiments. However, it would be appreciated that modifications and changes might be made in these embodiments without departing from the principles and spirit of the invention. For example, an encapsulation substrate may be prepared in a cap shape, and changes may be easily made in materials of a bracket or frame.

[0065] Although embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes might be made in this embodiment without departing from the principles of the present invention, the scope of which is defined in the claims and their equivalents.

Claims

1. An organic light-emitting display device, comprising:

an organic light-emitting display unit comprising:

a front substrate comprising a front surface and a first side surface,
a rear substrate comprising a rear surface and a first side surface, the rear substrate opposing the front substrate,
an array of organic light-emitting pixels interposed between the front and rear substrates,
a frit seal interposed between the front substrate and the rear substrate while surrounding the array, wherein the frit seal, the front substrate and the rear substrate together define an enclosed space in which the array is located, the frit seal comprising a first side surface, and
a first side of the display unit defined at least in part by the first side surfaces of the front substrate, the rear substrate and the frit seal; the display device further comprising:
a bracket comprising a first surface generally opposing the first side of the display unit

and connected to the first side of the display unit; and
a first structure interconnecting the first surface of the bracket and the first side of the display unit.

2. A device according to Claim 1, wherein the first structure is formed in substantially the entire area between the first surface of the bracket and the first side of the display unit.

3. A device according to Claim 1 or 2, wherein the first structure is formed on substantially all of the first surface of the bracket.

4. A device according to any one of Claims 1 to 3, wherein the first structure is bonded to the first surface of the bracket and bonded to either or both of the first side surfaces of the front and rear substrates.

5. A device according to any one of Claims 1 to 4, wherein the first structure is bonded to the first side surface of the frit seal.

6. A device according to any one of Claims 1 to 5, wherein the front substrate, the rear substrate and the first side surface of the frit seal together define a gap space, and wherein the first structure comprises a portion extending into the gap space and interposed between the front and rear substrates.

7. A device according to any one of Claims 1 to 6, wherein the bracket further comprises a rear wall opposing the rear substrate.

8. A device according to any one of Claims 1 to 7, wherein the bracket comprises a rear wall opposing the rear substrate, and the bracket further comprises a plurality of side walls extending from the rear wall at an angle, and wherein a first one of the plurality of the side walls provides the first surface opposing the first side of the display unit.

9. A device according to any one of Claim 7 or 8, wherein the rear wall of the bracket is bonded to the rear surface of the rear substrate;

10. A device according to any one of Claim8 or 9, wherein the first side wall extends substantially parallel to at least one of the first side surfaces of the front and rear substrates.

11. A device according to any one of Claims 8 to 10, wherein the first side wall covers substantially the entirety of the first side of the display unit.

12. A device according to any one of Claims 8 to 10, wherein the first side wall does not cover at least part of the first side surface of the front substrate while generally opposing the first side of the display unit.

13. A device according to any one of Claims 8 to 10, wherein the first side wall does not cover the first side surface of the front substrate while generally opposing the first side of the unit.

14. A device according to any one of Claims 1 to 13, wherein the first structure comprises a layer comprising a polymeric material.

15. A device according to any one of Claims 1 to 14, wherein the display unit further comprises a plurality additional sides, wherein the bracket comprises a first side wall and a plurality of additional side walls, the first side wall providing the first surface of the frame, wherein each of the plurality of additional side walls of the bracket comprises a surface generally opposing one of the plurality of additional sides of the display unit, wherein the device further comprises a plurality of additional structures, each of which interconnects one of the plurality of additional side walls and one of the plurality of additional sides of the display unit.

16. A device according to Claims 15, wherein the first side wall and the plurality of additional side walls form a closed loop surrounding the first side and the plurality of additional sides of the unit.

17. A device according to any one of Claims 1 to 16, wherein the front substrate further comprises a second side surface, wherein the rear substrate further comprises a second side surface, wherein the frit seal further comprises a second side surface, wherein the second side surfaces of the front substrate, the second substrate and the frit seal generally face the same direction, wherein the display unit further comprises a second side defined at least in part by the second side surface of the front substrate, the second side surface of the rear substrate and the second side surface of the frit seal, wherein the bracket further comprises a second surface generally opposing the second side of the display unit, and wherein the device further comprises a second structure interconnecting the second side of the display unit and the second surface of the bracket.

18. A device according to Claim 17, wherein the first and second structures are integrated.

19. A device according to Claim 17 or 18, wherein the first and second structures are separated.

20. A device according to any one of Claims 1 to 19, 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.

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

providing a display unit comprising:

a front substrate comprising a front surface and a first side surface,
a rear substrate comprising a rear surface and a first side surface, the rear substrate opposing the front substrate,
an array of organic light-emitting pixels interposed between the front and rear substrates,
a frit seal interposed between the front substrate and the rear substrate while surrounding the array, wherein the frit seal, the front substrate and the rear substrate together define an enclosed space in which the array is located, the frit seal comprising a first side surface, and
a first side of the display unit defined at least in part by the first sides of the front substrate, the rear substrate and the frit seal; the method further comprising:
placing a bracket comprising a first surface so as to generally oppose the first side of the display unit; and
forming a structure between and interconnecting the first surface of the bracket and the first side of the display unit.

22. A method according to Claim 21, wherein the method further comprises forming a curable material on the first surface of the frame, and wherein placing the bracket comprises arranging the bracket with respect to the display unit such that the curable material contacts the first side of the display unit.

23. A method according to Claim 22, wherein the method further comprises curing the curable material, thereby forming the structure.

24. A method according to Claim 22 or 23, wherein a viscosity of the curable material is less than about 5000 cP.

25. A method according to any one of Claims 21 to 24, wherein the bracket further comprises a rear wall, and wherein placing the bracket further comprises arranging the rear wall so as to oppose the rear substrate.

FIG. 1

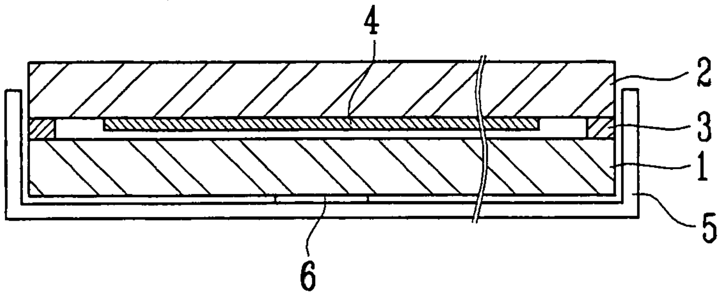
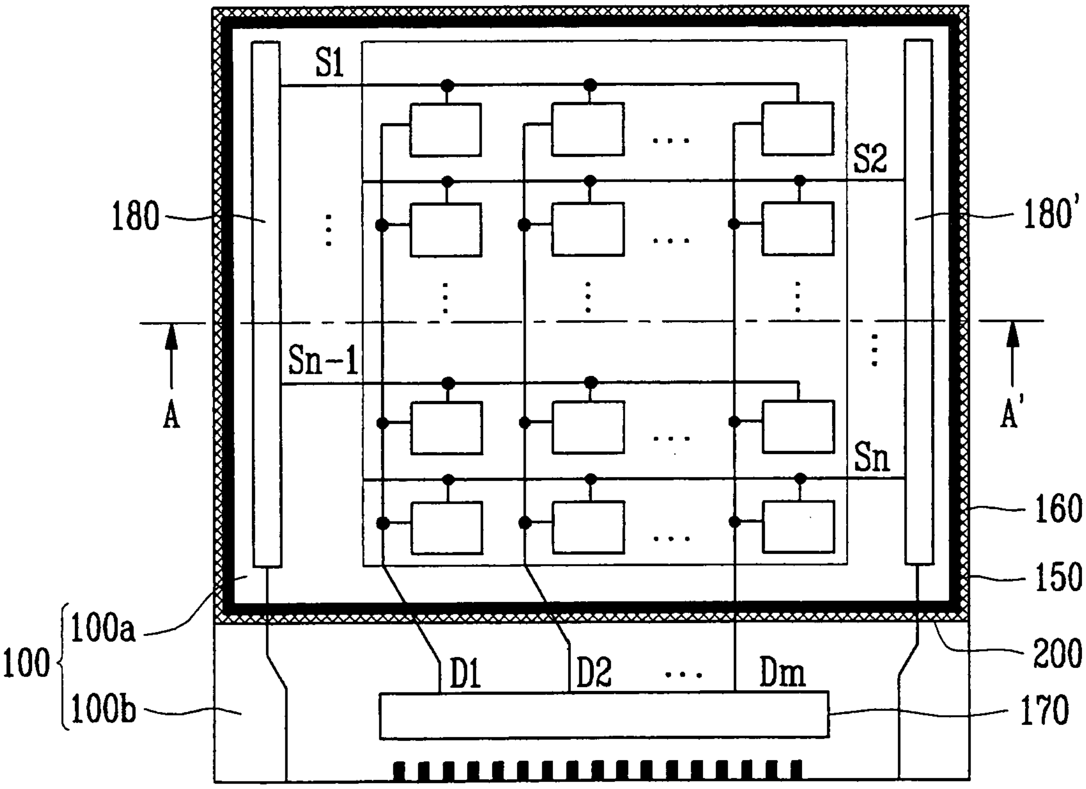

4
2
3
1
5
6

FIG. 2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S2
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D2
Dm
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FIG. 3

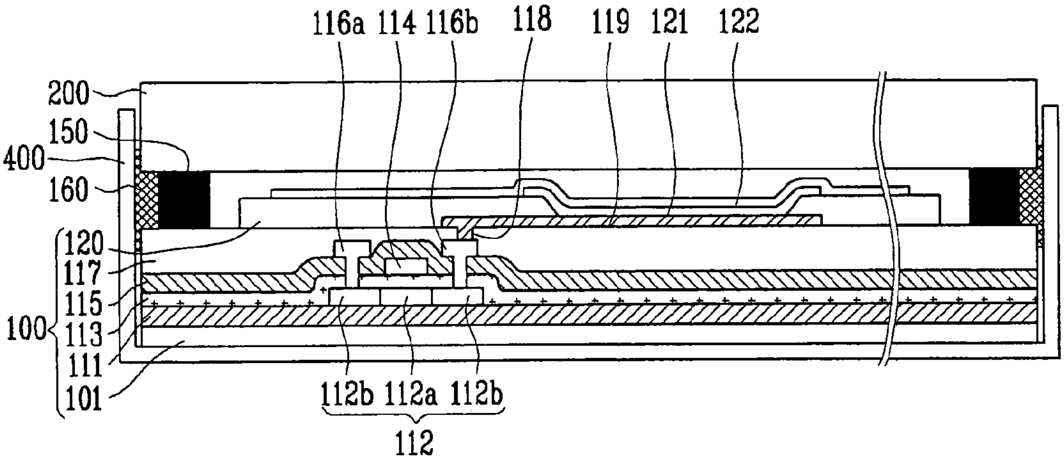


FIG. 4A

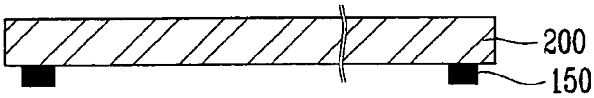


FIG. 4B

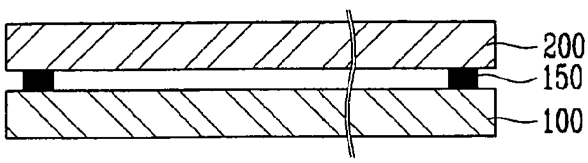


FIG. 4C

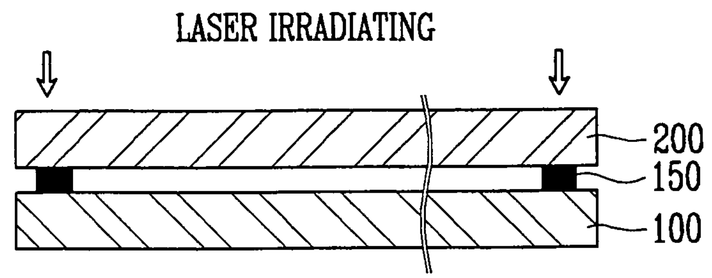


FIG. 4D

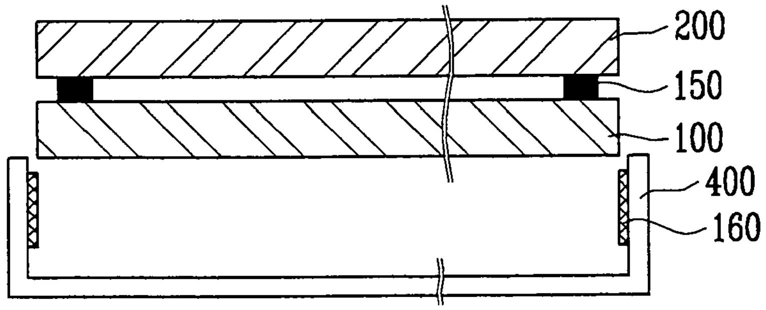


FIG. 4E

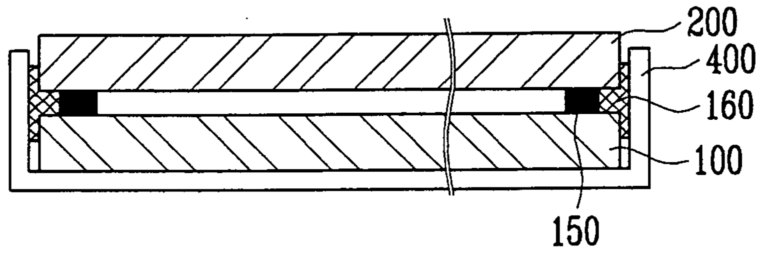


FIG. 5A

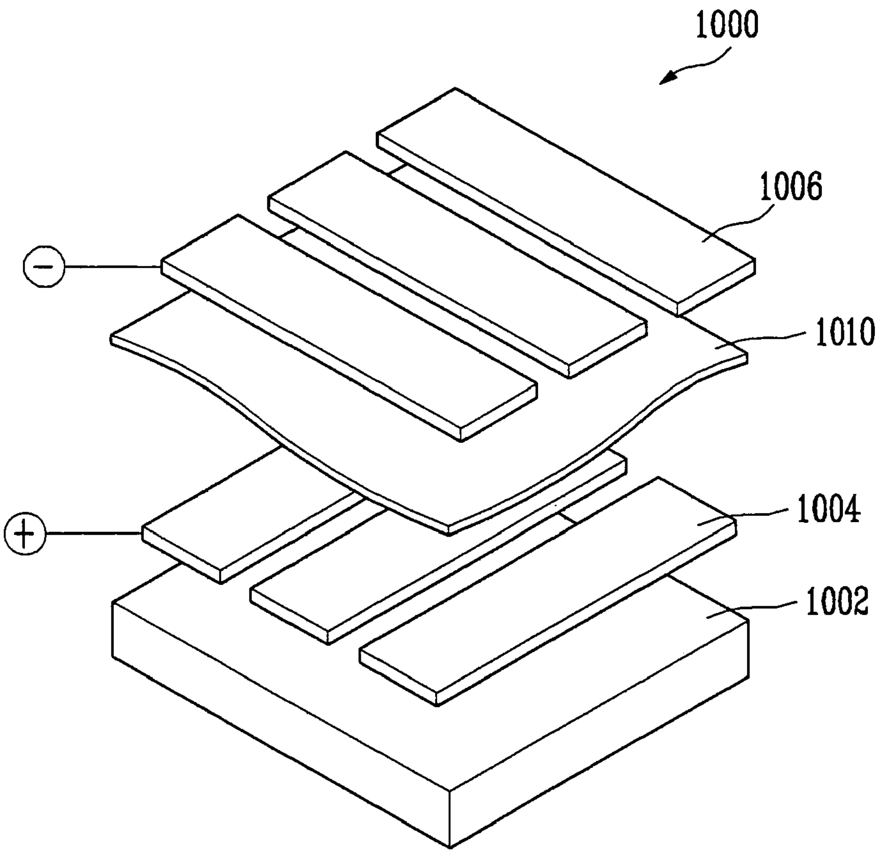
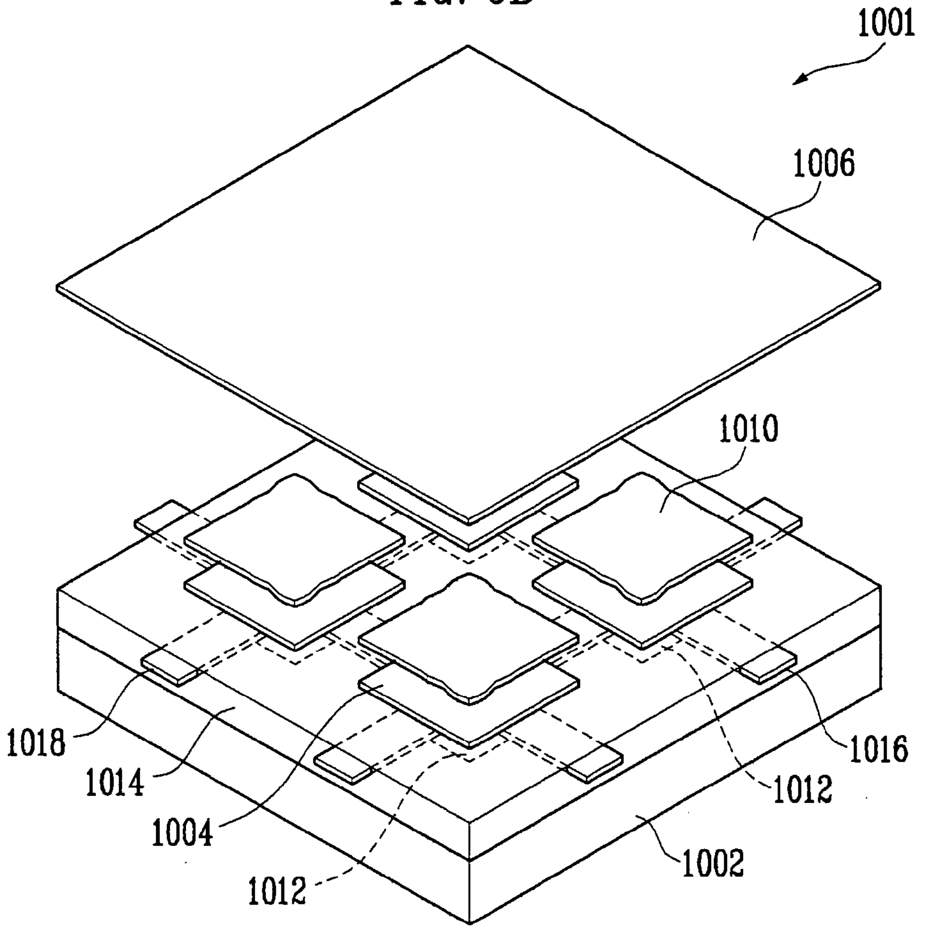


FIG. 5B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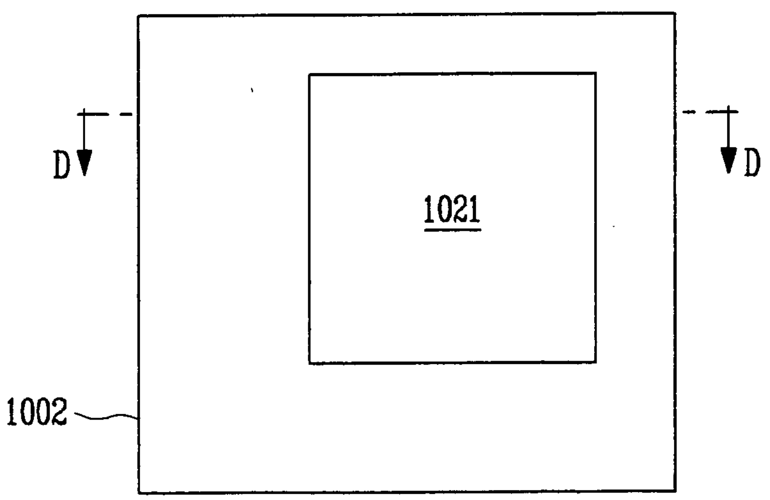
1012
1002

FIG. 5C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D
1021
1002

FIG. 5D

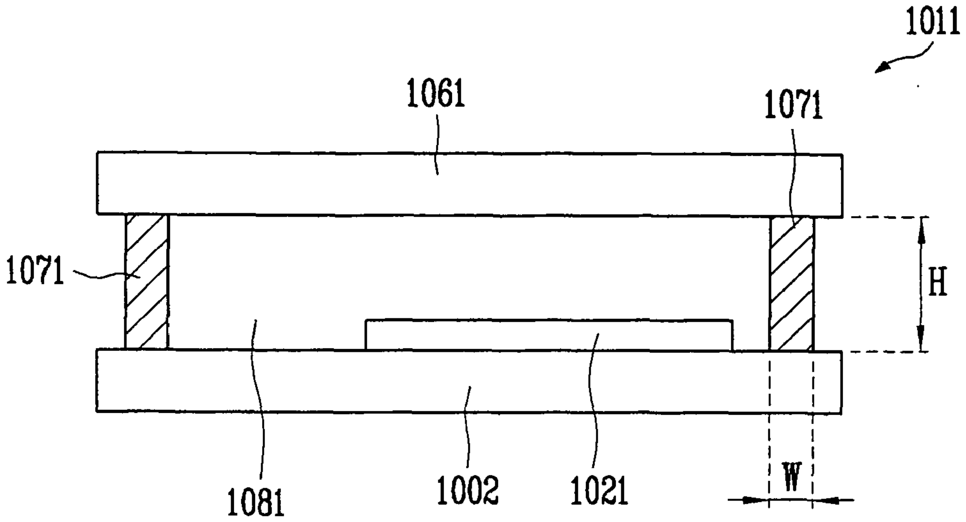
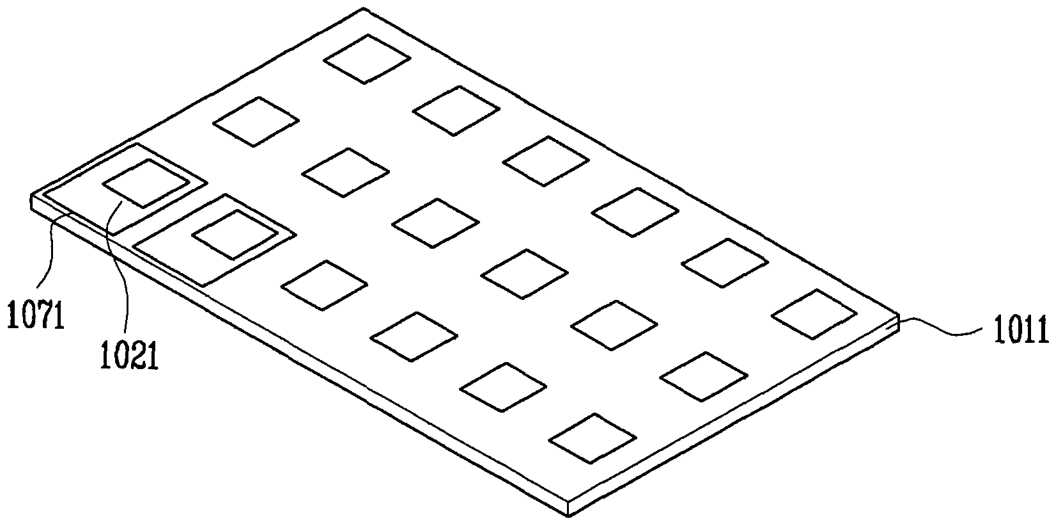


FIG. 5E



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 6998776 B2 **[0002]**

专利名称(译)	有机发光显示器，玻璃密封和加强结构粘合到框架上		
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申请号	EP2007250299	申请日	2007-01-25
[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.		
[标]发明人	LEE JAE SUNG PARK JIN WOO CHOI DONG SOO LIM DAE HO LEE JONG WOO LEE UNG SOO SIN SANG WOOK		
发明人	LEE, JAE SUNG PARK, JIN-WOO CHOI, DONG-SOO LIM, DAE HO LEE, JONG WOO LEE, UNG SOO SIN, SANG WOOK		
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摘要(译)

公开了一种有机发光显示装置，其中基板和封装基板通过玻璃料和加强结构接合。第一基板具有其中形成有机发光二极管的像素区域和形成在像素区域外部的非像素区域。第二基板通过玻璃料附接到第一基板。支架通过加强结构与基板接合。将可固化材料施加到框架的内部，在第一和第二基板之间移动，然后固化以形成加强结构。

FIG. 3