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HARADA et al.(10) **Pub. No.: US 2018/0358572 A1**(43) **Pub. Date: Dec. 13, 2018**(54) **ORGANIC EL DISPLAY PANEL**(71) Applicant: **JOLED INC.**, Tokyo (JP)(72) Inventors: **Kenji HARADA**, Tokyo (JP);
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H01L 27/32 (2006.01)
H01L 51/52 (2006.01)
H01L 51/56 (2006.01)
G09G 3/3225 (2006.01)(57) **ABSTRACT**

An organic electroluminescence (EL) display panel includes a multi-layered wiring laminate including: a first part on which an organic EL element array is disposed and in which a first portion of a resin insulating layer is present, the resin insulating layer being a highest layer among insulating layers; a second part surrounding the first part in plan view and in which a second portion of the resin insulating layer having a bank-shape is present; and a third part disposed between the first part and the second part in plan view and having a shape of a circumferential groove in which the resin insulating layer is not present. In the third part, wiring is on an inorganic insulating layer that is lower by a layer than the resin insulating layer. The wiring on the inorganic insulating layer is spaced away from the second portion of the resin insulating layer.

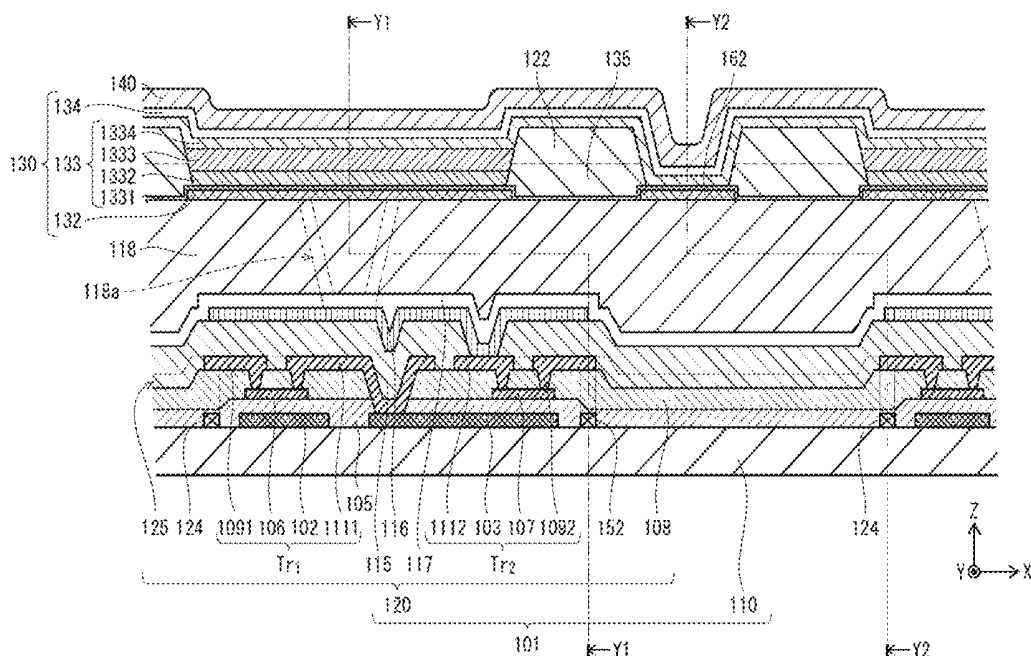


FIG. 1A

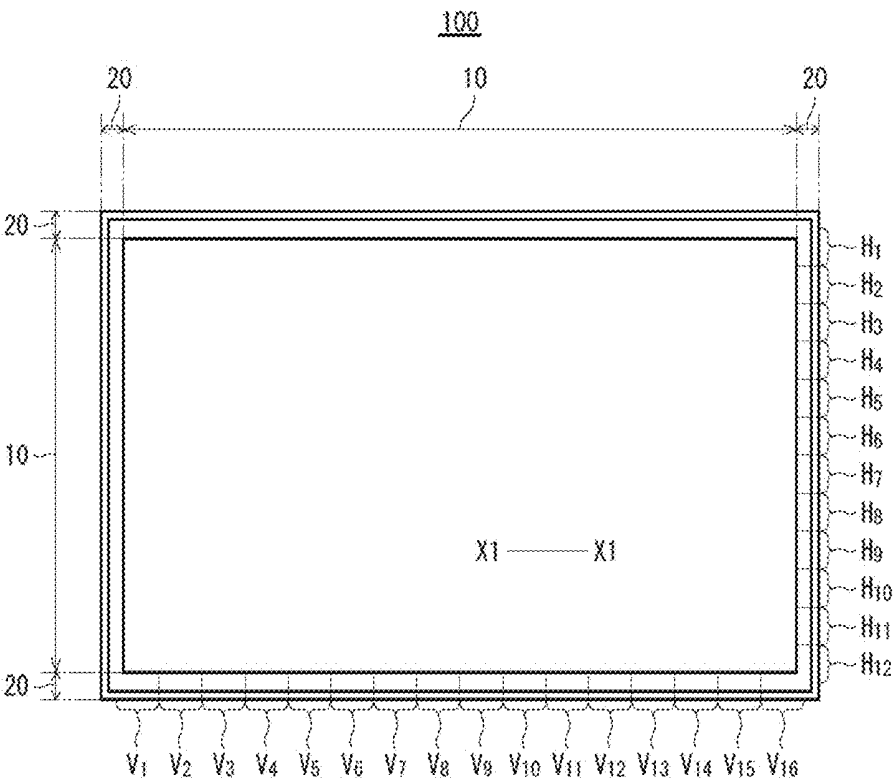
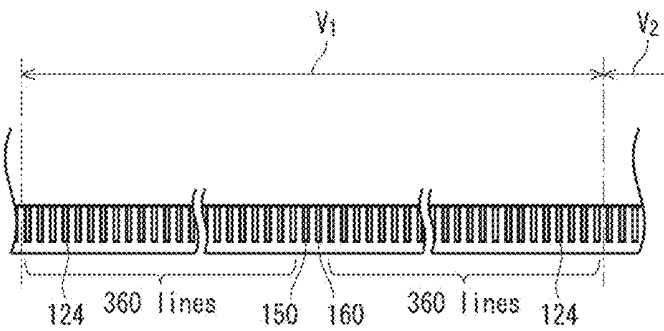


FIG. 1B



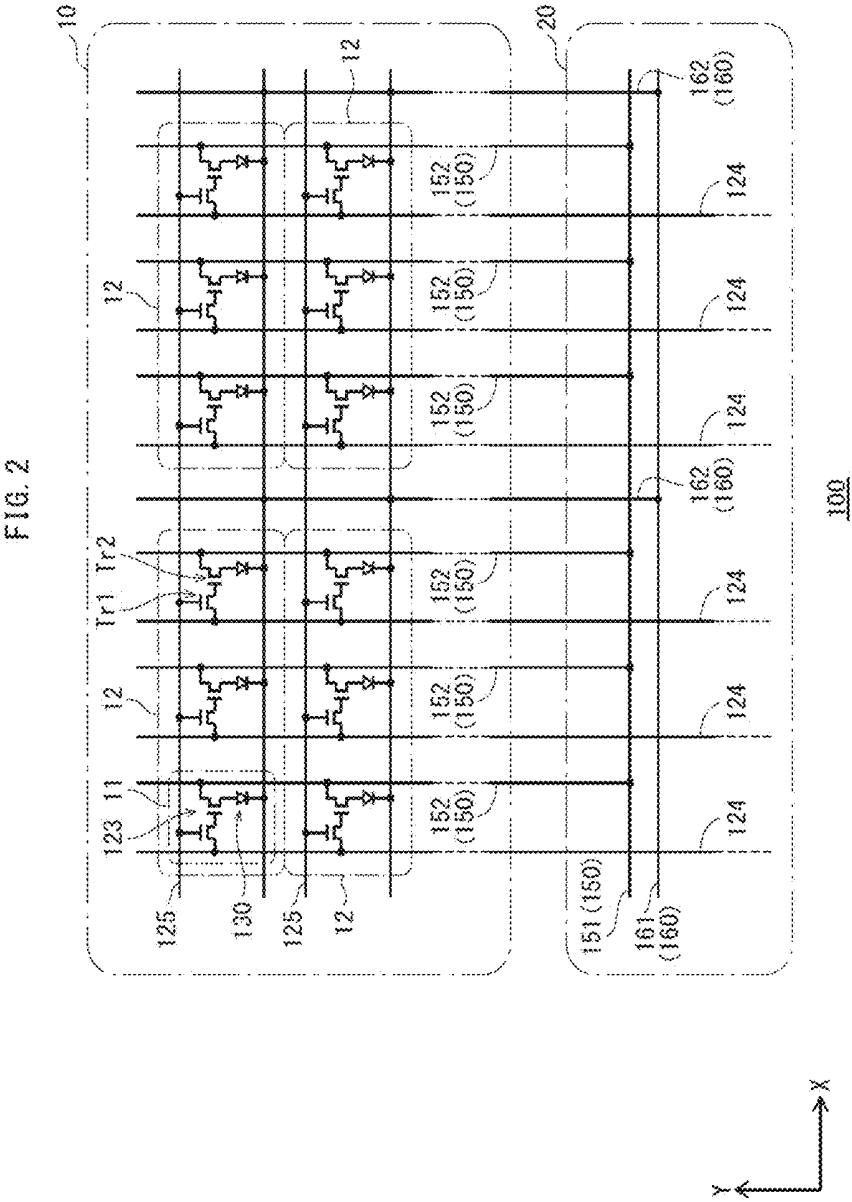


FIG. 3

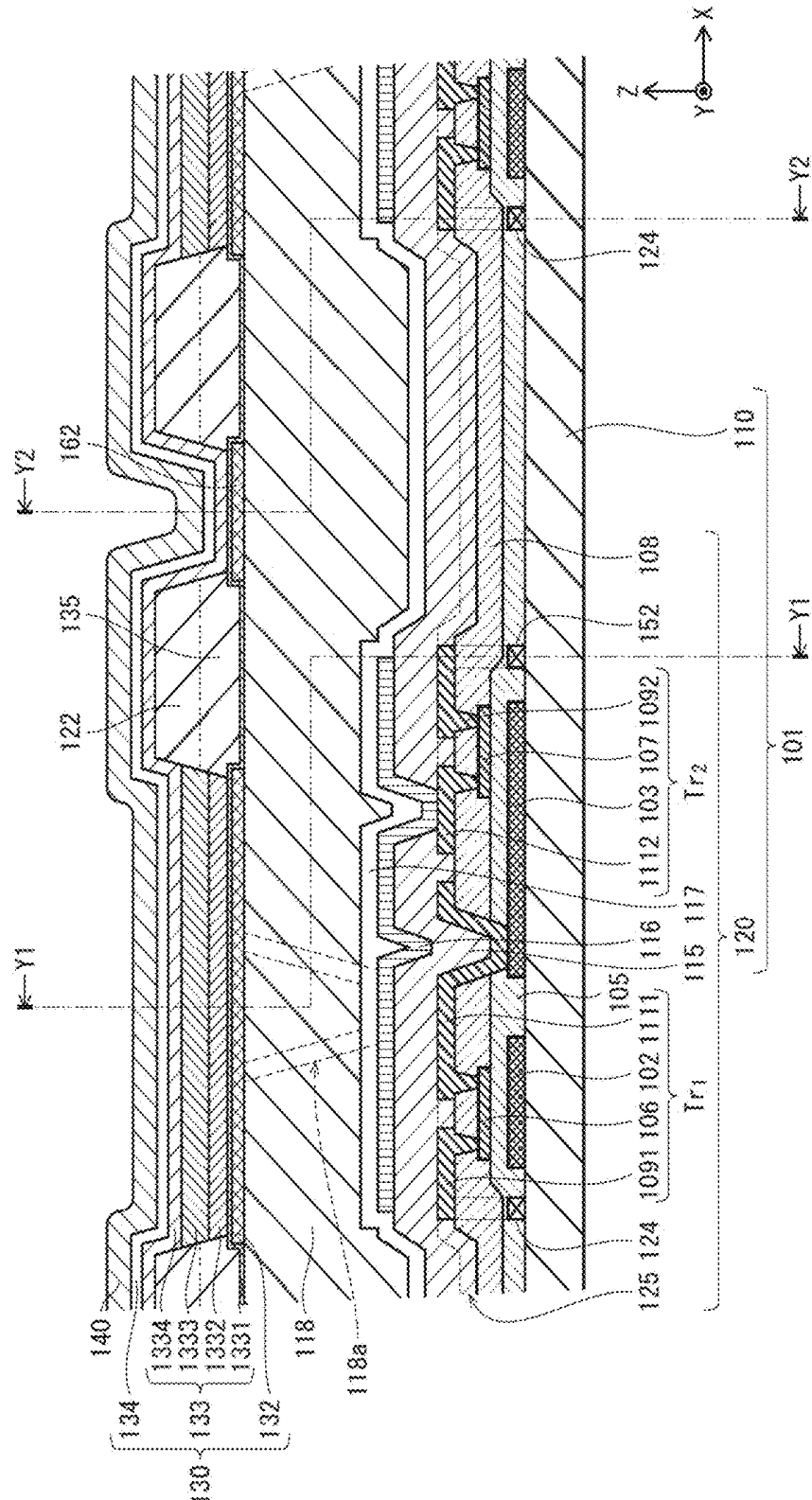


FIG. 4

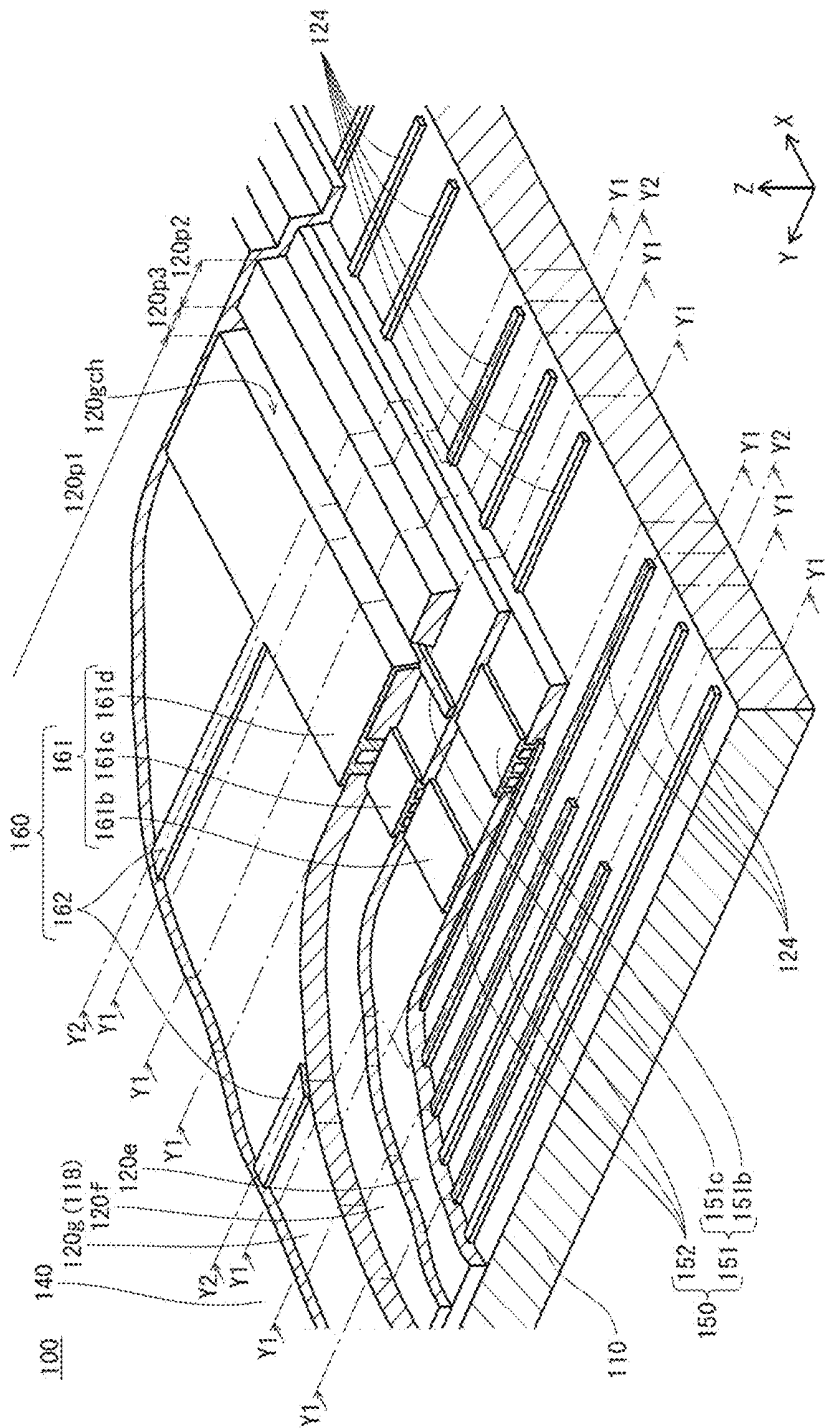


FIG. 5

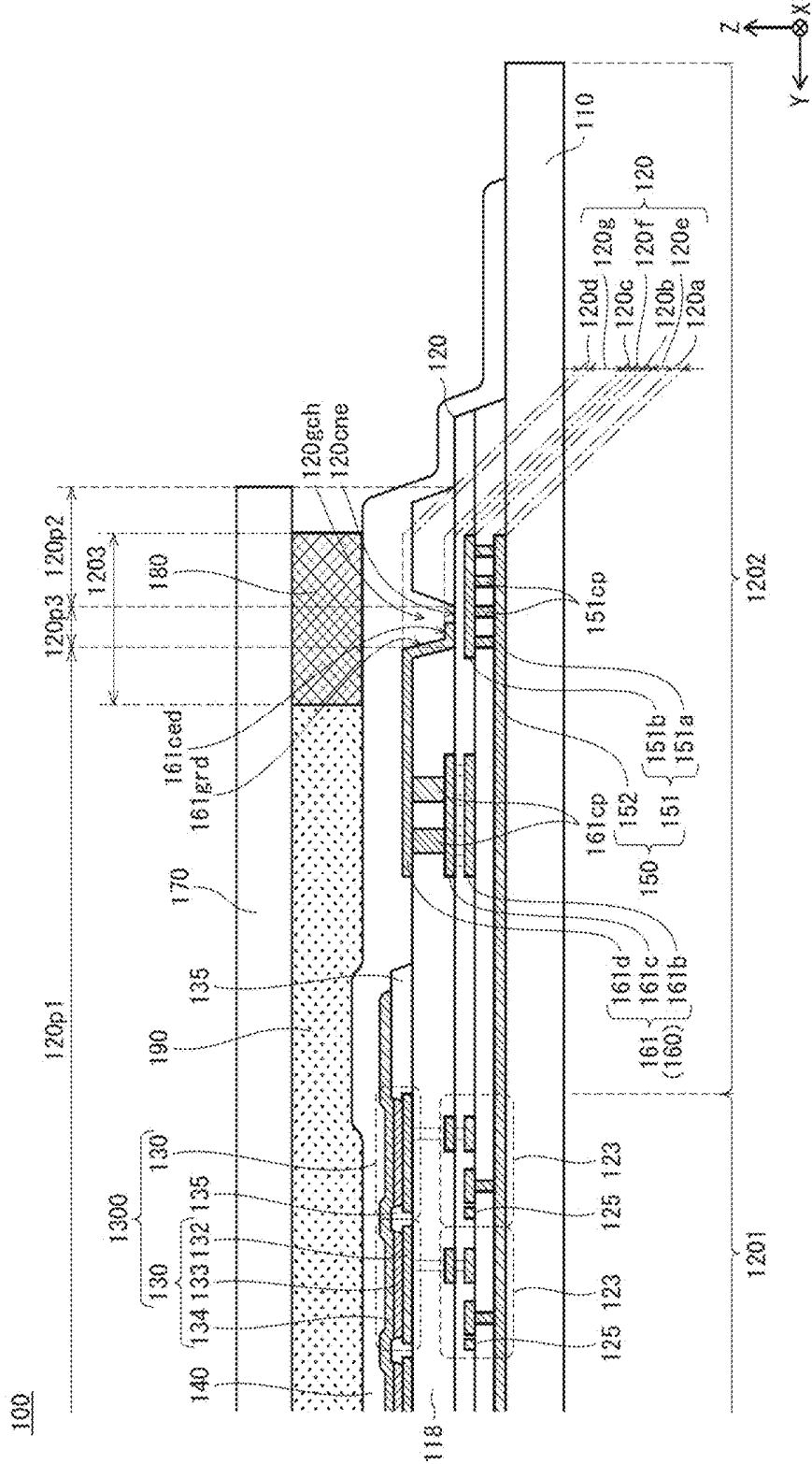
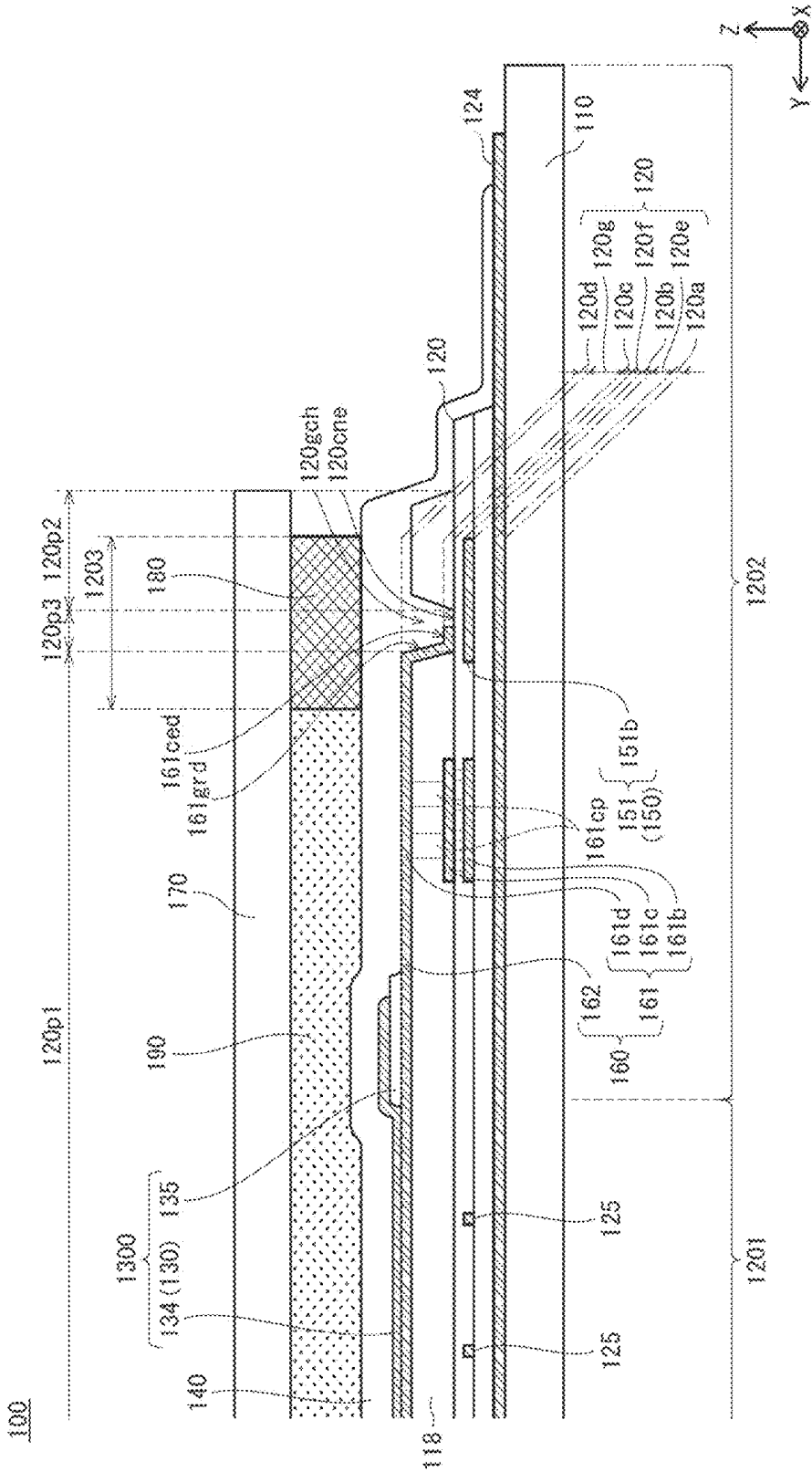


FIG. 6



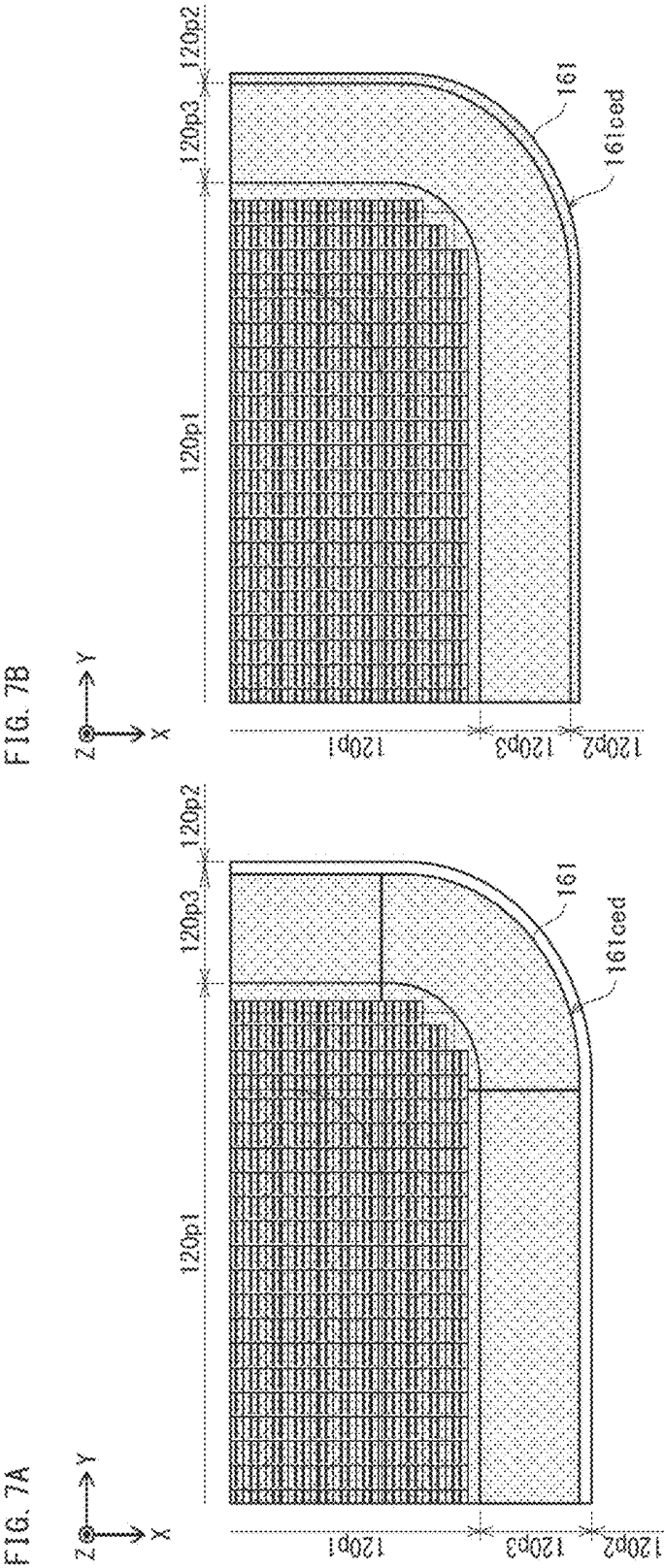


FIG. 8A



FIG. 8B

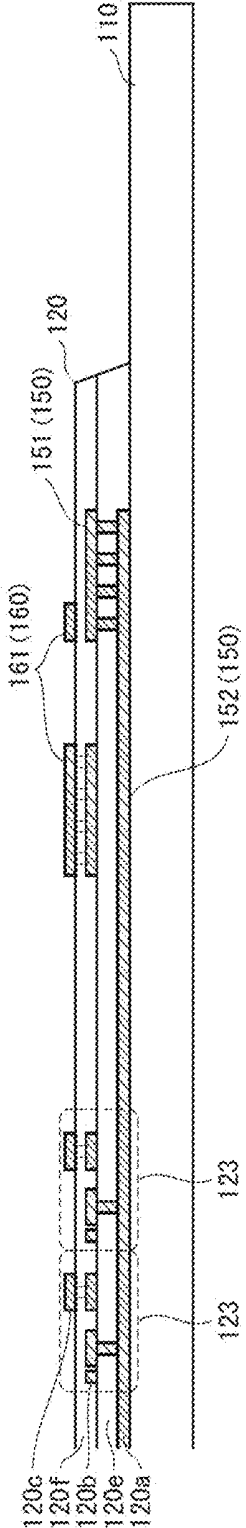


FIG. 8C

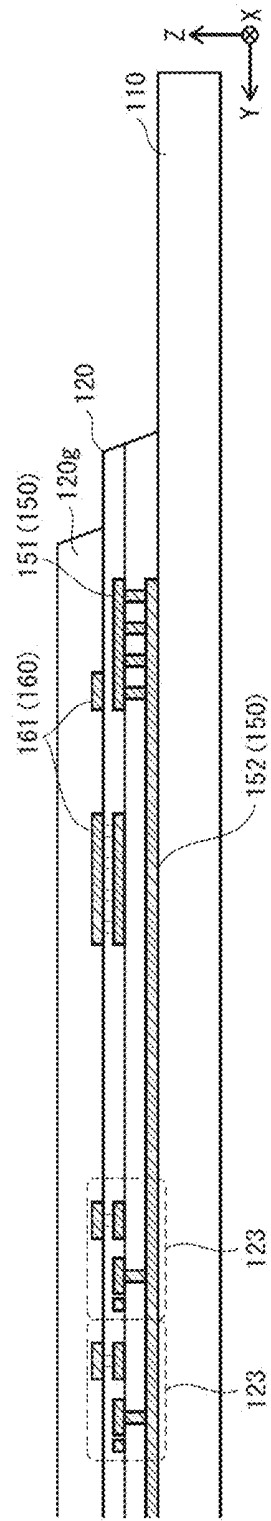


FIG. 10A

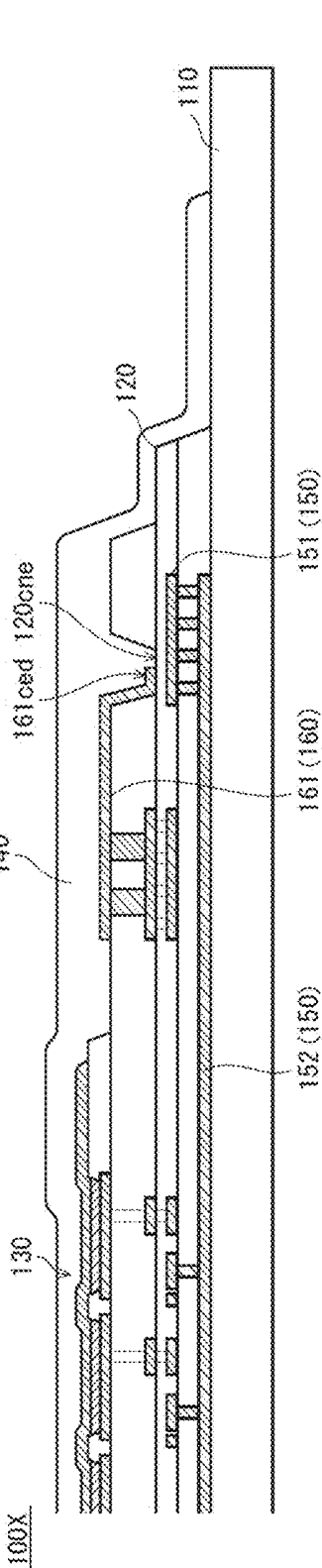
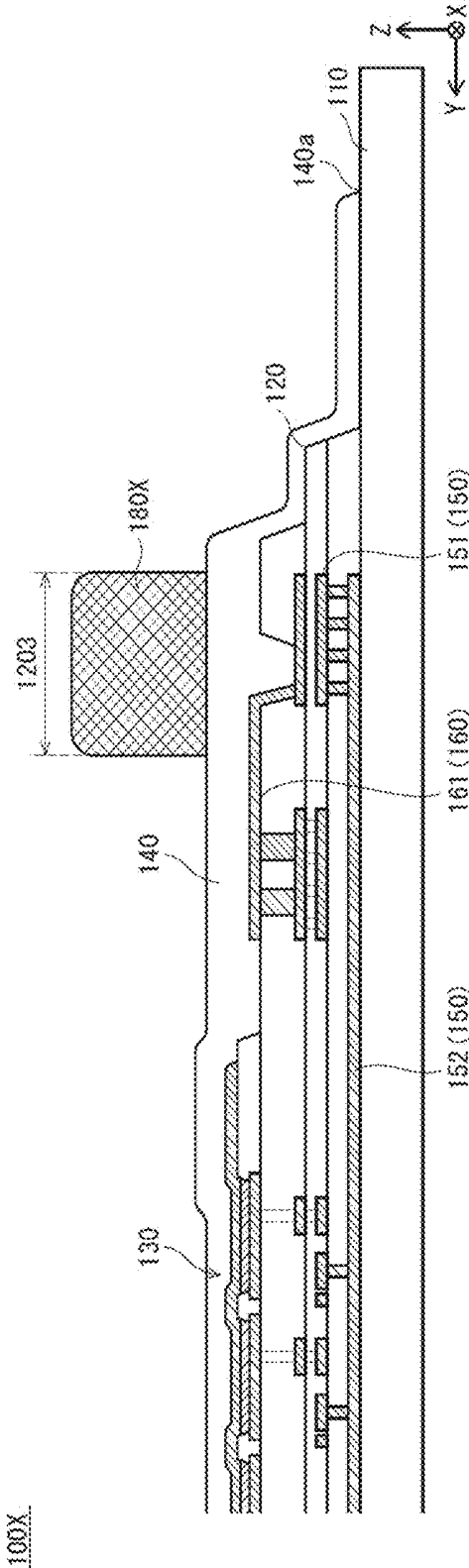
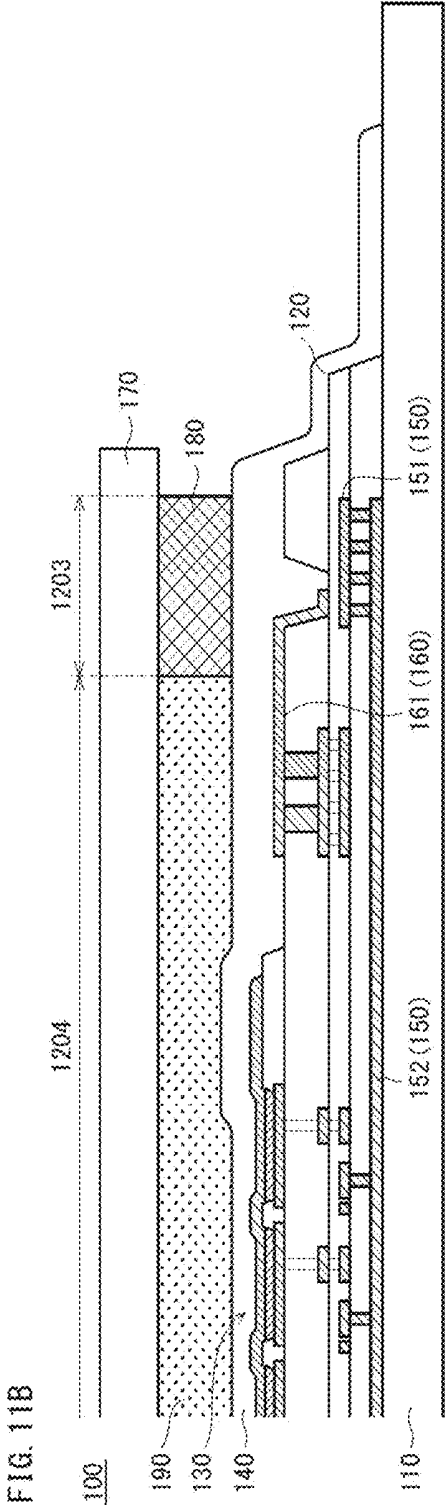
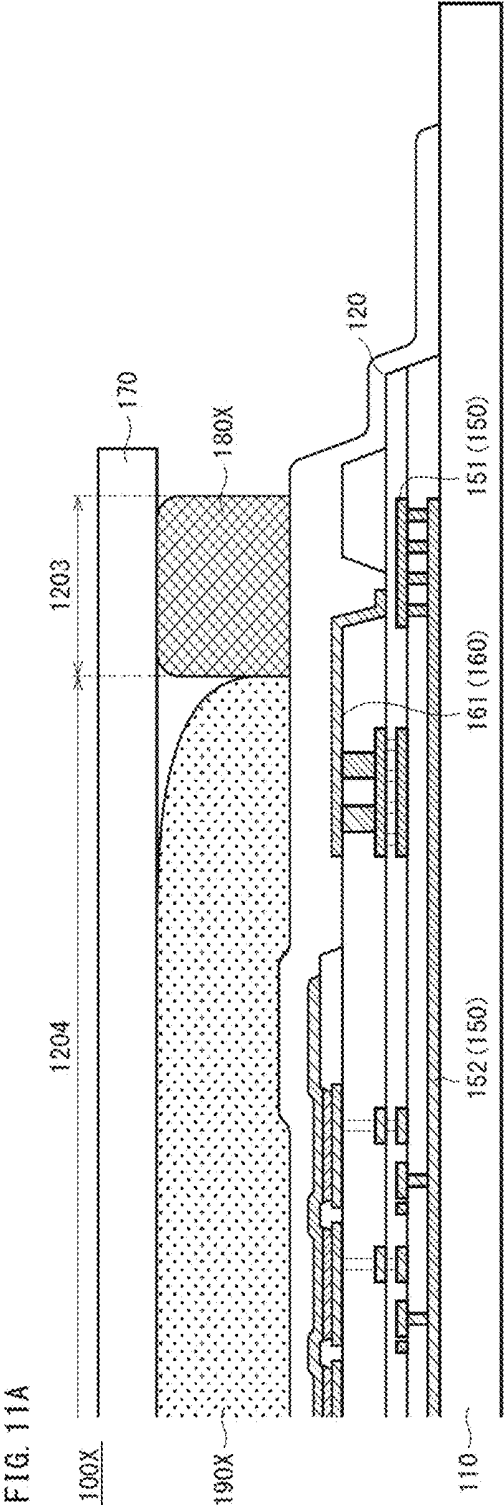


FIG. 10B





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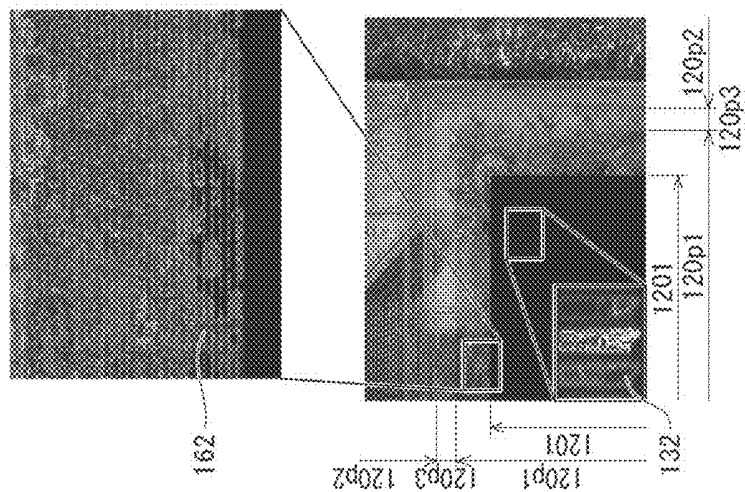
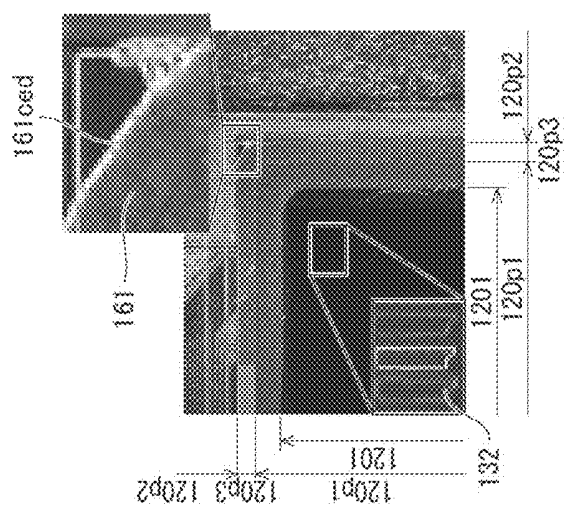


Fig. 128



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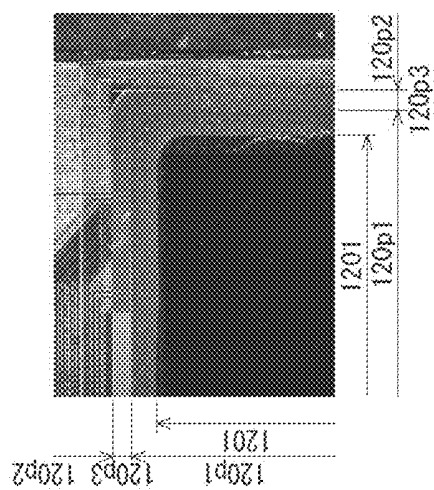
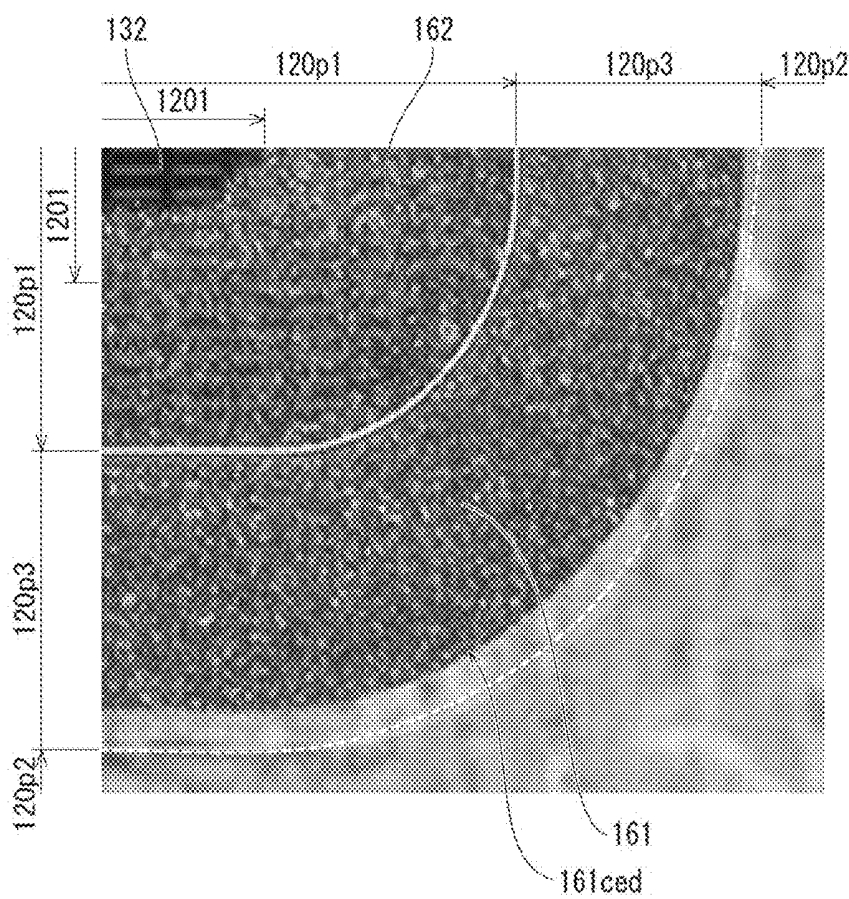


FIG. 13



ORGANIC EL DISPLAY PANEL

[0001] This application claims priority to Japanese Patent Application No. 2017-114710 filed Jun. 9, 2017, the contents of which are hereby incorporated by reference in its entirety.

BACKGROUND

Technical Field

[0002] The present disclosure relates to organic electroluminescence (EL) display panels including a plurality of organic EL elements, and in particular to a sealing technology for helping to suppress penetration of moisture from the surrounding environment.

Description of Related Art

[0003] Organic EL panels including a plurality of organic EL elements are conventionally known. An organic EL element has a multi-layered structure including a laminate of thin films of various materials, and includes at least a pixel electrode, a common electrode, and an organic light-emitting layer sandwiched between the pixel electrode and the common electrode on a thin film transistor (TFT) substrate covered by a planarization insulating layer. As necessary, a hole injection layer, a hole transport layer, an electron injection layer, an electron transport layer, or the like is disposed between the pixel electrode and the organic light-emitting layer or between the common electrode and the organic light-emitting layer. These layers may include a material whose light-emitting quality deteriorates when reacting with moisture. In order to help to suppress deterioration of display quality of organic EL display panels over time, a sealing technology for suppressing penetration of moisture from the surrounding environment is important.

[0004] In view of this, JP2011-90153 proposes a display device having a circumferential groove portion (separator) from which the planarization insulating layer is removed. Such a circumferential groove portion is in a position surrounding a display region in which a plurality of organic EL elements are arranged. In such a display device, in plan view, because a portion of the planarization insulating layer in the display region is separated from a portion of the planarization insulating layer in a peripheral region outside the circumferential groove portion, penetration of moisture remaining in the portion of the planarization insulating layer outside the circumferential groove portion into the display region can be suppressed.

SUMMARY

[0005] An organic EL display panel pertaining to at least one aspect of the present disclosure includes a substrate. The organic EL display panel further includes a multi-layered wiring laminate disposed on the substrate and including wiring and a plurality of insulating layers. The organic EL display panel further includes an organic EL element array disposed on the multi-layered wiring laminate and including a plurality of organic EL elements that are connected to the wiring. In the organic EL display panel, the multi-layered wiring laminate includes: a first part on which the organic EL element array is disposed and in which a first portion of a resin insulating layer is present, the resin insulating layer being a highest layer among the insulating layers; a second part that surrounds the first part in plan view and in which

a second portion of the resin insulating layer having a bank-shape is present; and a third part that is between the first part and the second part in plan view and that has a shape of a circumferential groove in which the resin insulating layer is not present. In the organic EL display panel, in the third part, the wiring is on an inorganic insulating layer that is lower by a layer than the resin insulating layer. In the organic EL display panel, the wiring on the inorganic insulating layer is spaced away from the second portion of the resin insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The advantages and features of the technology pertaining to the present disclosure will become apparent from the following description thereof taken in conjunction with the accompanying drawings, which illustrate at least one embodiment of the technology pertaining to the present disclosure.

[0007] FIG. 1A is a layout in plan view of an organic EL display panel 100 pertaining to at least one embodiment, and FIG. 1B is an enlarged view of a divisional region of the organic EL display panel 100 pertaining to at least one embodiment.

[0008] FIG. 2 is a circuit diagram of the display panel 100 pertaining to at least one embodiment.

[0009] FIG. 3 is a partial cross-sectional view of a display region of the display panel 100 pertaining to at least one embodiment, taken along line X1-X1 in FIG. 1.

[0010] FIG. 4 is a partially cut-away perspective view of a peripheral region of the display panel 100 pertaining to at least one embodiment.

[0011] FIG. 5 is a partial cross-sectional view of the peripheral region of the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0012] FIG. 6 is a partial cross-sectional view of the peripheral region of the display panel 100 pertaining to at least one embodiment, taken along line Y2-Y2 in FIG. 3 and FIG. 4.

[0013] FIG. 7A is a plan view of the peripheral region at a corner of the display panel 100 pertaining to at least one embodiment, seen from an upper surface of a multi-layered wiring laminate 120. FIG. 7B is a plan view similar to FIG. 7A of a comparative example, seen from an upper surface of the multi-layered wiring laminate 120.

[0014] FIG. 8A, FIG. 8B, and FIG. 8C are cross-sectional views of processes of manufacturing the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0015] FIG. 9A, FIG. 9B, and FIG. 9C are cross-sectional views of processes of manufacturing the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0016] FIG. 10A and FIG. 10B are cross-sectional views of processes of manufacturing the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0017] FIG. 11A and FIG. 11B are cross-sectional views of processes of manufacturing the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0018] FIG. 12A, FIG. 12B, and FIG. 12C are plane photographs of the multi-layered wiring laminate 120 at a corner of the display panel of the comparative example, seen

from the upper surface of the multi-layered wiring laminate **120**, after 0 hours, after 600 hours, and after 1000 hours, respectively.

[0019] FIG. 13 is a plane photograph of the multi-layered wiring laminate **120** at a corner of the display panel of a working example of the display panel **100** pertaining to at least one embodiment after 1000 hours, seen from the upper surface of the multi-layered wiring laminate **120**.

DETAILED DESCRIPTION

«Circumstances Leading to Embodiment of Present Disclosure»

[0020] A typical organic EL display panel includes, between a first substrate and an organic EL element array, a multi-layered wiring laminate for supplying signals and electricity from outside to organic EL elements. For example, the multi-layered wiring laminate includes wiring connected to drive circuits and a common electrode of the organic EL elements. In plan view of the organic EL display panel, the wiring extends from a display region in which the organic EL element array is disposed to a region surrounding the display region and connect to an external drive circuit (for example, see JP2009-123538).

[0021] Accordingly, even when a circumferential groove portion in which the planarization insulating layer is not present is in a position surrounding the display region as disclosed in JP2011-90153, in plan view, in a structure in which the wiring partially extends to the portion of the planarization insulating layer in the peripheral region outside the circumferential groove portion, moisture remaining in or penetrating from outside into the portion of the planarization insulating layer inside the circumferential groove portion may cause partial corrosion of the wiring. Such corrosion may progress into the display region and cause wiring function damage.

[0022] The present disclosure has been achieved in view of the above problems, and an aim thereof is to provide an organic EL display panel that helps to prevent, in a peripheral region surrounding a display region in which a plurality of organic EL elements are arranged, corrosion of wiring supplying signals and electricity to the organic EL elements.

«Overview of Embodiment of Present Disclosure»

[0023] An organic EL display panel pertaining to at least one embodiment of the present disclosure includes a substrate. The organic EL display panel further includes a multi-layered wiring laminate disposed on the substrate and including wiring and a plurality of insulating layers. The organic EL display panel further includes an organic EL element array disposed on the multi-layered wiring laminate and including a plurality of organic EL elements that are connected to the wiring. In the organic EL display panel, the multi-layered wiring laminate includes: a first part on which the organic EL element array is disposed and in which a first portion of a resin insulating layer is present, the resin insulating layer being a highest layer among the insulating layers; a second part that surrounds the first part in plan view and in which a second portion of the resin insulating layer having a bank-shape is present; and a third part that is between the first part and the second part in plan view and that has a shape of a circumferential groove in which the resin insulating layer is not present. In the organic EL

display panel, in the third part, the wiring is on an inorganic insulating layer that is lower by a layer than the resin insulating layer. In the organic EL display panel, the wiring on the inorganic insulating layer is spaced away from the second portion of the resin insulating layer.

[0024] According to this structure, in the peripheral region portion, no portion of the second power supply line extends to the second portion of the interlayer insulating layer located in the second part outside the circumferential groove portion in plan view. Accordingly, even when moisture remains in or penetrates from outside into the second portion of the interlayer insulating layer, this structure helps to prevent the second power supply line from partially corroding and prevent such corrosion from progressing into the display region portion and causing wiring function damage.

[0025] At least one embodiment of the organic EL display panel further includes a second inorganic insulating layer covering at least the organic EL element array, the second inorganic insulating layer extending to the second part of the multi-layered wiring laminate in plan view. In the third part, the second inorganic insulating layer is in contact with the inorganic insulating layer through a gap between the wiring and the second portion of the resin insulating layer.

[0026] This structure helps to prevent moisture remaining in or penetrating from outside into the second portion of the interlayer insulating layer located in the second part from causing partial corrosion of the second power supply line, progress of such corrosion into the display region portion, and wiring function damage.

[0027] According to at least one embodiment of the organic EL display panel, the second inorganic insulating layer extends outside the third part of the multi-layered wiring laminate in plan view.

[0028] According to this structure, an interlayer insulating layer that includes resin and absorbs moisture easily is covered up to the outer periphery by a protection layer including an inorganic material that does not absorb moisture. This structure thus helps to prevent moisture penetration from, for example, a substrate outer peripheral direction into the second portion of the interlayer insulating layer outside the circumferential groove portion in plan view (second part).

[0029] According to at least one embodiment of the organic EL display panel, the organic EL elements each include: a light-emitting unit that includes a pixel electrode, a common electrode opposing the pixel electrode, and an organic light-emitting layer sandwiched between the pixel electrode and the common electrode; and a transistor whose source is connected to the pixel electrode and that drives the light-emitting unit, the wiring being connected to: the common electrode; or the sources, drains, gates, or power lines of the transistors of the organic EL elements. According to at least one embodiment of the organic EL display panel, when the wiring is connected to the common electrode or the power lines, in the multi-layered wiring laminate, the wiring includes a plurality of branch lines extending from the organic EL elements to a vicinity of an outer periphery of the first part in plan view and a trunk line connected to the branch lines in the vicinity of the outer periphery of the first part. In the first part, the trunk line is in the highest layer in the multi-layered wiring laminate. An outer end of the trunk line is in the third part. According to at least one embodiment of the organic EL display panel, in the third part, the wiring

extends through a contact hole to a layer lower by one or more layers than the highest layer in the multi-layered wiring laminate.

[0030] According to this structure, the trunk line has a large substantial cross-section. This structure thus helps to suppress voltage decline in the trunk line. Further, this helps to prevent the second power supply line from partially corroding and prevent such corrosion from progressing into the display region portion and causing wiring function damage.

[0031] According to at least one embodiment of the organic EL display panel, the common electrode includes a metal. In plan view, the common electrode extends to the third part of the multi-layered wiring laminate and is spaced away from the second portion of the resin insulating layer.

[0032] According to this structure, in the peripheral region portion, no portion of the common electrode including a metal material including silver (Ag) or aluminum (Al) extends to the second portion of the interlayer insulating layer located in the second part outside the circumferential groove portion in plan view. This structure thus helps to prevent the common electrode including a metal material from partially corroding because of moisture remaining in or penetrating from outside into the interlayer insulating layer and prevent such corrosion from progressing into the display region portion and causing wiring function damage.

[0033] According to at least one embodiment of the organic EL display panel, the common electrode includes a metal oxide. In plan view, the common electrode extends at least to the second part of the multi-layered wiring laminate and is in contact with the second portion of the resin insulating layer.

[0034] According to this structure, in the peripheral region portion, even when a portion of the common electrode including a metal oxide including indium tin oxide (ITO), indium zinc oxide (IZO), or the like extends to the second portion of the interlayer insulating layer located in the second part outside the circumferential groove portion in plan view, the common electrode including a metal oxide would not corrode because of moisture remaining in or penetrating from outside into the second portion of the interlayer insulating layer, and such corrosion thus would not progress into the display region.

[0035] At least one embodiment of the organic EL display panel further includes: a second substrate covering at least the organic EL element array; and a sealing structure disposed between the substrate and the second substrate and surrounding the organic EL element array in plan view and partially covering the second inorganic insulating layer.

[0036] This structure helps to achieve an organic EL display panel that prevents corrosion of wiring supplying signals and electricity to the organic EL elements in a peripheral region surrounding a display region in which a plurality of organic EL elements are arranged.

[0037] According to at least one embodiment of the organic EL display panel, in the first part of the multi-layered wiring laminate, the second inorganic insulating layer covers the organic EL element array, the wiring, and the resin insulating layer.

[0038] Even when moisture penetrates from outside into the sealing layer, this structure helps to prevent such moisture from penetrating into the display region in which the organic EL elements are arranged.

[0039] The following describes a display panel pertaining to at least one embodiment of the present disclosure, with reference to the drawings.

«Embodiment»

1. Structure of Display Panel

1.1. Overview of Structure

[0040] FIG. 1A is a layout in plan view of an organic EL display panel **100** pertaining to at least one embodiment, and FIG. 1B is an enlarged view of a divisional region of the organic EL display panel **100** pertaining to at least one embodiment. The organic EL display panel **100** (hereinafter referred to as “display panel **100**”) has, in plan view, a display region **10** and a peripheral region **20** surrounding the display region **10**.

[0041] In the display region **10**, a plurality of pixels are arranged in a matrix. For example, when the display panel **100** is a panel having resolution of 4K, 3840 pixels are arranged along a horizontal line and 2160 pixels are arranged along a vertical line. The pixels each include a plurality of subpixels of different colors. In the present embodiment, the pixels each include a red subpixel, a green subpixel, and a blue subpixel. Each subpixel corresponds to an organic EL element.

[0042] The peripheral region **20** has a shape of a rectangular frame, and has divisional regions **V1** through **V16** along the longer side of the peripheral region **20** and divisional regions **H1** through **H12** along the shorter side of the peripheral region **20**. The divisional regions **V1** through **V16** and **H1** through **H12** are each a region electrically connected to an external drive circuit.

[0043] FIG. 1B is an enlarged view of the divisional region **V1**. In the divisional region **V1**, a first power supply line **150**, a second power supply line **160** to which a voltage differing from a voltage applied to the first power supply line **150** is applied, and a plurality of data signal lines **124** are arranged.

[0044] The divisional regions **V2** through **V16** each have a structure similar to the structure of the divisional region **V1**, and in each of the divisional regions **V**, the first power supply line **150** and the second power supply line **160** supply electricity to organic EL elements of the pixels arrayed along a plurality of vertical lines.

[0045] The data signal lines **124** transmit voltage signals corresponding to luminances of the organic EL elements, to which electricity is supplied from the first power supply line **150** and the second power supply line **160**.

[0046] The divisional regions **H1** through **H12** have a structure similar to the divisional regions **V1** through **V16**, differing only with respect to the kinds of lines therein. Specifically, the divisional regions **H1** through **H12** each include a plurality of scan signal lines that transmit selection signals for selecting one of horizontal lines in the display region **10**.

[0047] Luminances of the organic EL elements are set by selecting one of the horizontal lines by a selection signal transmitted by one of the scan signal lines and transmitting, through each of the data signal lines **124** to a corresponding one of the organic EL elements in the selected one of the horizontal lines, a voltage signal corresponding to the corresponding one of the organic EL elements. Due to this structure, the data signal lines **124** and the scan signal lines

serve as signal lines transmitting signals for setting luminances of the organic EL elements.

1.2. Circuit Structure

[0048] FIG. 2 is a circuit diagram of the display panel 100 pertaining to at least one embodiment. The display panel 100 has a plurality of pixels 12 arrayed in a horizontal direction (X direction in FIG. 2) and a vertical direction (Y direction in FIG. 2). In the present embodiment, the pixels 12 are each composed of three subpixels 11 arrayed along the horizontal direction. The subpixels 11 each include an organic EL element 130 and a subpixel drive circuit 123 that is composed of thin film transistors Tr_2 and Tr_1 that are connected to the organic EL element 130.

[0049] The display panel 100 further includes the data signal lines 124 that extend in the vertical direction and the scan signal lines 125 that extend in the horizontal direction. The data signal lines 124 and the scan signal lines 125 transmit signals for causing the organic EL elements 130 to each emit a desired luminance. Because the data signal lines 124 and the scan signal lines 125 are known, explanations thereof are not provided here.

[0050] The display panel 100 further includes the first power supply line 150 and the second power supply line 160. The first power supply line 150 includes a trunk line 151 and a plurality of branch lines 152 connected to the trunk line 151. The second power supply line 160 includes a trunk line 161 and a plurality of branch lines 162 connected to the trunk line 161. In FIG. 2, the trunk line 151 and the trunk line 161 each extend in the horizontal direction in the peripheral region 20 of the display panel 100, and the branch lines 152 and the branch lines 162 each extend in the vertical direction in the display region 10 of the display panel 100. Note that the trunk lines 151 and 161 extend in the horizontal direction because FIG. 2 illustrates a portion of the peripheral region 20 extending in the horizontal direction. In portions of peripheral region 20 extending in the vertical direction (Y direction), the trunk line 151 and the trunk line 161 extend in the vertical direction.

[0051] In the present embodiment, the first power supply line 150 is connected through the thin film transistor Tr_2 to anodes of the organic EL elements 130, and the second power supply line 160 is connected to a cathode of the organic EL elements 130. To the first power supply line 150, a first voltage (for example, 20 V) is applied, and to the second power supply line 160, a second voltage differing from the first voltage (for example, 0 V) is applied.

1.3. Structure of Display Region

[0052] FIG. 3 is a partial cross-sectional view of the display region of the display panel 100 pertaining to at least one embodiment, taken along line X1-X1 in FIG. 1. The display region 10 of the display panel 100 includes a multi-layered wiring laminate 120 and the organic EL elements 130 that are laminated on a substrate 110 in this order. In FIG. 3, only a region corresponding to an organic EL element included in a subpixel is shown.

1.3.1. Substrate 110

[0053] The substrate 110 is made of an inorganic material or an organic material. For example, the substrate 110 is made of an electrically-insulating material such as alkali-

free glass, soda glass, nonfluorescent glass, phosphate glass, borate glass, quartz, alumina, or the like.

[0054] Alternatively, an organic resin film can be used. Such a resin material can be acrylic resin, styrenic resin, polycarbonate resin, epoxy resin, polyethylene, polyester, silicone resin, or the like, and thermoplastic resin or thermosetting resin may be used. Further, the film may be made of a flexible material. Further, the film may be light-transmissive. Specifically, the substrate 110 can be made by using a resin material such as: polyimide, polyimidebenzoxazole, polyimidebenzimidazole, or other copolymers containing polyimide as a unit structure; polyolefin such as polyester, polytetrafluoroethylene, polyphenylene sulfide, polyamide, polyamideimide, polycarbonate, polystyrene, polypropylene, polyethylene, polyvinyl chloride, polyether sulfone, polyethylene naphthalene, an ethylene-propylene copolymer, an ethylene-vinyl acetate copolymer; cyclic polyolefin; modified polyolefin; polyvinyl chloride; polyvinylidene chloride; acrylic resin; polymethyl methacrylate; an acrylic-styrene copolymer; a butadiene-styrene copolymer; an ethylene vinyl alcohol copolymer; polyether; polyether ketone; polyether ether ketone; polyether imide; polyacetal; polyphenylene oxide; modified polyphenylene oxide; polyarylate; aromatic polyester; polytetrafluoroethylene, polyvinylidene fluoride, or the like. Alternatively, the substrate 110 may have a multi-layered structure of layers each including one or more of the above-described materials.

1.3.2. Multi-Layered Wiring Laminate 120

[0055] Gate electrodes 102 and gate electrodes 103 that are spaced away from each other are disposed on the substrate 110. The gate electrodes 102 and 103 are made of, for example, aluminum, an aluminum alloy, copper, or a copper alloy. The gate electrodes 102 and 103 may have a single-layered structure of one of an aluminum layer, an aluminum alloy layer, a copper layer, and a copper alloy layer, or may each be a laminate including at least one of these layers and another metal layer. For example, the gate electrodes 102 and 103 may be a laminate of a copper layer and a titanium layer, a laminate of a copper layer and a molybdenum layer, or a laminate of an aluminum layer and a titanium layer.

[0056] Further, the data signal lines 124 and the branch lines 152 of the first power supply line 150 are disposed on the substrate 110. The data signal lines 124 extend in a vertical line direction of the display panel 100 to the peripheral region 20. Each of the data signal lines 124 is electrically connected through contact holes to drain electrodes 1091 of the organic EL elements 130 in all the subpixels that belong to the same vertical line as the data signal line 124, which are of the same color.

[0057] The branch lines 152 of the first power supply line 150 extend in the vertical line direction of the display panel 100 to the peripheral region 20. Each of the branch lines 152 is electrically connected through contact holes to drain electrodes 1092 of the organic EL elements 130 in all the subpixels that belong to the same vertical line as the branch line 152, which are of the same color.

[0058] Surfaces of the gate electrodes 102 and 103, the data signal lines 124, the branch lines 152 of the first power supply line 150, and the substrate 110 are covered by a gate

insulating layer 105. The gate insulating layer 105 is made of a known gate insulating material such as silicon oxide (SiO) or the like.

[0059] Channel layers 106 are disposed on portions of the gate insulating layer 105 that correspond to the gate electrodes 102. Further, on portions of the gate insulating layer 105 that correspond to the gate electrodes 103, channel layers 107 are disposed.

[0060] Surfaces of the channel layers 106, the channel layers 107, and the gate insulating layer 105 are covered by a channel protection layer 108.

[0061] The drain electrodes 1091, the drain electrodes 1092, source electrodes 1111, and source electrodes 1112 are disposed on the channel protection layer 108. The drain electrodes 1091 and the source electrodes 1111 are electrically connected to the channel layers 106 through contact holes that pass through the channel protection layer 108. The drain electrodes 1092 and the source electrodes 1112 are electrically connected to the channel layers 107 through contact holes that pass through the channel protection layer 108. The drain electrodes 1091, the drain electrodes 1092, the source electrodes 1111, and the source electrodes 1112 are made of tungsten, molybdenum tungsten, vanadium, ruthenium, gold, or copper, or an alloy thereof.

[0062] Further, on the channel protection layer 108, the scan signal lines 125 are disposed. The scan signal lines 125 extend in a horizontal line direction of the display panel 100 to the peripheral region 20. Each of the scan signal lines 125 is electrically connected through contact holes to the gate electrodes 102 of the organic EL elements 130 in all the subpixels that belong to the same horizontal line as the scan signal line 125.

[0063] A lower passivation layer 115 covers the drain electrodes 1091, the drain electrodes 1092, the source electrodes 1111, the source electrodes 1112, the scan signal lines 125, and the channel protection layer 108. The lower passivation layer 115 is made of an inorganic material such as silicon oxide (SiO) or the like. The lower passivation layer 115 has contact holes above the source electrodes 1112.

[0064] Connection electrodes 116 are disposed to extend along side walls of the contact holes. The connection electrodes 116 have lower portions electrically connected to the source electrodes 1112 and upper portions present on the lower passivation layer 115. The connection electrodes 116 may be made of the same material as the source electrodes 1112.

[0065] An upper passivation layer 117 covers surfaces of the connection electrodes 116 and the lower passivation layer 115. On the upper passivation layer 117, a planarization layer 118 (interlayer insulating layer 120g) is disposed. The planarization layer 118 has a function of compensating for surface unevenness caused by wiring of the multi-layered wiring laminate and achieving surface planarization. The planarization layer 118 is made of an electrically-insulating material such as polyimide resin, acrylic resin, or the like. The planarization layer 118 preferably has a thickness from 3 μm to 10 μm , and more preferably has a thickness from 3 μm to 4 μm .

[0066] The upper passivation layer 117 and the planarization layer 118 have contact holes 118a. The connection electrodes 116 are exposed by the contact holes 118a.

[0067] On the planarization layer 118, the branch lines 162 of the second power supply line 160 are disposed. The branch lines 162 extend in the vertical line direction of the

display panel 100, and a branch line 162 is provided for every three subpixels arrayed in the horizontal line direction.

[0068] In the multi-layered wiring laminate 120 having the structure described above, a gate electrode 102, the gate insulating layer 105, a channel layer 106, a drain electrode 1091, and a source electrode 1111 are included in a thin film transistor Tr₁ of a subpixel drive circuit 123. Further, a gate electrode 103, the gate insulating layer 105, a channel layer 107, a drain electrode 1092, and a source electrode 1112 are included in a thin film transistor Tr₂ of the subpixel drive circuit 123. The thin film transistor Tr₁ is used as a selection transistor, and the thin film transistor Tr₂ is used as a drive transistor.

1.3.3. Organic EL Elements 130

[0069] The organic EL elements 130 each have a laminated structure in which the following layers are laminated on the multi-layered wiring laminate 120: a pixel electrode 132; a functional layer 133 including a hole injection layer, a hole transport layer, an organic light-emitting layer, and an electron transport layer; and a common electrode 134. The pixel electrodes 132 function as anodes of the organic EL elements 130, and the common electrode 134 functions as a cathode of the organic EL elements 130. The functional layers 133 have a function of emitting light through recombination of holes injected from the pixel electrodes 132 and electrons injected from the common electrode 134.

[0070] The pixel electrodes 132 are the first electrodes in the present disclosure, are arranged in a line or in a matrix on the planarization layer 118 of the multi-layered wiring laminate 120, and are electrically connected to the connection electrodes 116 of the multi-layered wiring laminate 120 through the contact holes 118a. Transparent conductive layers may further be laminated.

[0071] The pixel electrodes 132 are each a metal layer made of a material having small sheet resistance and high light reflectivity. For example, a metal material including silver (Ag) or aluminum (Al) can be used for the pixel electrodes 132. Alternatively to a layer of a metal such as aluminum, an alloy layer of a silver, palladium, and copper alloy (APC), a silver, rubidium, gold alloy (ARA), a molybdenum chromium alloy (MoCr), a nickel chromium alloy (NiCr), or the like can be used. The transparent conductive layers can be made by using indium tin oxide (ITO), indium zinc oxide (IZO), or the like. Further, in view of cost efficiency, a metal layer including aluminum as a main component or an alloy layer including aluminum as a main component is preferably used. The pixel electrodes 132 preferably have a thickness from 200 nm to 400 nm. In cases where the transparent conductive layers are laminated, the transparent conductive layers each preferably have a thickness of several nm.

[0072] Surfaces of the planarization layer 118, the branch lines 162 of the second power supply line 160, and the pixel electrodes 132 are covered by a hole injection layer 1331. The hole injection layer 1331 is made of an oxide of a transition metal element such as an oxide of a metal including a transition metal element or an oxide of an alloy including a transition metal element. Such a material is preferable as a metal or an alloy for a hole injection layer for a display panel.

[0073] Insulating layers 135 are over surface portions of the planarization layer 118 that are present in gaps between the pixel electrodes 132 adjacent to each other in the

horizontal direction. The insulating layers **135** are made of an electrically-insulating material such as polyimide resin, acrylic resin, or the like.

[0074] Banks **122** are over the surface portions of the planarization layer **118** that are present in gaps between the pixel electrodes **132** adjacent to each other in the vertical direction. The banks **122** are made of, for example, an organic material such as acrylic resin, polyimide resin, novolac-type phenolic resin, or the like, or an inorganic material such as silicon oxide (SiO), silicon nitride (SiN), or the like, and define the subpixels. A height from an upper surface of the planarization layer **118** to upper surfaces of the banks **122** is approximately 1 μm , and the regions defined by the banks **122** are subpixel regions. Pixel regions are each composed of three subpixel regions arrayed in the horizontal line direction.

[0075] In each of the subpixel regions defined by the banks **122** and the insulating layers **135**, a hole transport layer **1332** and an organic light-emitting layer **1333** are laminated in this order.

[0076] The hole transport layers **1332** are made of, for example, an electrically conductive polymer material such as poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT-PSS) or a derivative (such as a copolymer) of PEDOT-PSS, and have a function of transporting holes injected from the hole injection layers **1331** to the organic light-emitting layers **1333**.

[0077] The organic light-emitting layers **1333** are made of, for example, poly(9,9-di-n-octylfluorene-alt-benzothiadiazole) (F8BT), which is an organic polymer, and has a function of emitting light with use of electroluminescence. The organic light-emitting layers **1333** are not limited to a structure made of F8BT, and can have a structure including a known organic material. For example, as described in JPHS-163488, the organic light-emitting layers **1333** are preferably made of a fluorescent substance such as an oxinoid compound, perylene compound, coumarin compound, azacoumarin compound, oxazole compound, oxadiazole compound, perinone compound, pyrrolo-pyrrole compound, naphthalene compound, anthracene compound, fluorene compound, fluoranthene compound, tetracene compound, pyrene compound, coronene compound, quinolone compound and azaquinolone compound, pyrazoline derivative and pyrazolone derivative, rhodamine compound, chrysene compound, phenanthrene compound, cyclopentadiene compound, stilbene compound, diphenylquinone compound, styryl compound, butadiene compound, dicyanomethylene pyran compound, dicyanomethylene thiopyran compound, fluorescein compound, pyrylium compound, thiapyrylium compound, selenapyrylium compound, telluropirylium compound, aromatic aldadiene compound, oligophenylene compound, thioxanthene compound, cyanine compound, acridine compound, metal complex of an 8-hydroxyquinoline compound, metal complex of a 2-bipyridine compound, complex of a Schiff base and a group III metal, metal complex of oxine, or rare earth metal complex.

[0078] An electron transport layer **1334**, the common electrode **134**, and the protection layer **140** are laminated in this order and are each continuous over the regions defined by the banks **122**.

[0079] The electron transport layer **1334** is made of, for example, barium, phthalocyanine, or lithium fluoride, or a mixture including at least one of these materials, and has a

function of transporting electrons injected from the common electrode **134** to the organic light-emitting layers **1333**.

[0080] The common electrode **134** is the second electrode in the present disclosure, and is made of, for example, indium tin oxide (ITO), indium zinc oxide (IZO), or the like. When the display panel **100** includes top-emission type organic EL elements, the common electrode **134** is preferably made of a light-transmissive material. When the common electrode **134** is made by using silver (Ag) or an alloy including silver, the common electrode **134** is thin enough to transmit light. Specifically, the common electrode **134** preferably has a thickness from 10 nm to 20 nm.

[0081] The organic EL elements **130** may be configured to include at least one of a hole injection layer, a hole transport layer, an electron injection layer, and an electron transport layer according to requirements. Further, the pixel electrodes **132**, the organic light-emitting layers **1333**, and the common electrode **134** may each have a single-layered structure or a multi-layered structure. In the present embodiment, the common electrode **134** is continuous over the organic EL elements **130** to form a single common electrode. The insulating layers **135** and the banks **122** have a function of electrically insulating the organic light-emitting layers **1333** of the organic EL elements **130**.

1.3.4. Protection Layer **140**

[0082] The protection layer **140** has a function of suppressing exposure of organic layers such as the functional layers **133** to moisture, air, or the like, and is made by using, for example, a light-transmissive material such as silicon nitride (SiN), silicon oxynitride (SiON), or the like. Further, a sealing resin layer made of a resin material such as acrylic resin, silicone resin, or the like may be disposed on the layer made by using a material such as silicon nitride (SiN), silicon oxynitride (SiON), or the like. When the organic EL elements **130** are of a top-emission type, the protection layer **140** is made of a light-transmissive material. The protection layer **140** preferably has a thickness from 1 μm to 10 μm , and more preferably has a thickness from 5 μm to 6 μm . In the present embodiment, the protection layer **140** is made by using silicon nitride (SiN) and has a thickness of approximately 5.5 μm .

1.4. Structure of Peripheral Region

1.4.1. Structure

[0083] The following describes a structure of the peripheral region of the display panel **100**. FIG. **4** is a partially cut-away perspective view of the peripheral region of the display panel **100** pertaining to at least one embodiment. FIG. **4** shows a portion of the peripheral region **20**, illustrated in FIG. **1A**. FIG. **5** is a partial cross-sectional view of the peripheral region of the display panel **100** pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. **3** and FIG. **4**. FIG. **6** is a partial cross-sectional view of the peripheral region of the display panel **100** pertaining to at least one embodiment, taken along line Y2-Y2 in FIG. **3** and FIG. **4**.

[0084] In FIG. **4** and FIG. **5**, the display panel **100** includes the substrate **110**, the multi-layered wiring laminate **120**, an organic EL element array **1300**, the protection layer **140**, a second substrate **170**, a sealing structure **180**, and a sealing layer **190**.

[0085] As described above, the substrate 110 is made of, for example, glass or resin.

[0086] The multi-layered wiring laminate 120 is disposed on the substrate 110. The multi-layered wiring laminate 120 includes wiring layers 120a through 120d and interlayer insulating layers 120e through 120g. The wiring layers 120a through 120d are each made of a metal material. The interlayer insulating layers 120e through 120g are each made of an inorganic material or an organic material. Correspondence between (i) the wiring layers 120a through 120d and the interlayer insulating layers 120e through 120g and (ii) the components of the thin film transistors Tr₁ and Tr₂, which compose a subpixel drive circuit 123 in FIG. 3, are as described below. The gate electrodes 102 and 103, the data signal lines 124, the branch lines 152 of the first power supply line 150 are in the wiring layer 120a. The gate insulating layer 105 and the channel protection layer 108 are in the interlayer insulating layer 120e. The drain electrodes 1091 and 1092, the source electrodes 1111 and 1112, and the scan signal lines 125 are in the wiring layer 120b. The lower passivation layer 115 corresponds to the interlayer insulating layer 120f. As described above, the interlayer insulating layer 120f is made of an inorganic material. The branch lines 162 of the second power supply line 160 are in the wiring layer 120d. The planarization layer 118 corresponds to the interlayer insulating layer 120g. As described above, the interlayer insulating layer 120g is made of a resin material. The connection electrodes 116 are in the wiring layer 120c.

[0087] The wiring layers 120a through 120d may each have a single-layered structure or a multi-layered structure. Similarly, the interlayer insulating layers 120e through 120g may each have a single-layered structure or a multi-layered structure. The multi-layered wiring laminate 120 has different wiring structures in a display region portion 1201 corresponding to the display region 10 of the display panel 100 and in a peripheral region portion 1202 corresponding to the peripheral region 20 of the display panel 100. The display region portion 1201 of the multi-layered wiring laminate 120 includes the branch lines 152 of the first power supply line 150, the subpixel drive circuits 123, and the branch lines 162 of the second power supply line 160 (see FIG. 5). The peripheral region portion 1202 of the multi-layered wiring laminate 120 includes the trunk line 151 of the first power supply line 150 and the trunk line 161 of the second power supply line 160.

[0088] The organic EL element array 1300 is disposed on the multi-layered wiring laminate 120. The organic EL element array 1300 includes a plurality of organic EL elements 130, and the insulating layers 135 and the banks 122 disposed between the organic EL elements 130. As described above, the organic EL elements 130 each have a multi-layered structure including a laminate of thin films of various materials, and each include a pixel electrode 132, a functional layer 133 disposed on the pixel electrode 132, and a common electrode 134 disposed on the functional layer 133.

[0089] As described above, the protection layer 140 covers the organic EL element array 1300 and the multi-layered wiring laminate 120. The protection layer 140 may have a single-layered structure or a multi-layered structure. The protection layer 140 is made by using, for example, a light-transmissive material such as silicon nitride (SiN), silicon oxynitride (SiON), or the like, and has a function of

suppressing exposure of organic layers such as the functional layers 133 to moisture, air, or the like.

[0090] In the peripheral region portion 1202, in plan view, the protection layer 140 having functions described above extends outside an outer periphery of the interlayer insulating layer 120g, which is made of a resin material, and is in close contact with the interlayer insulating layers 120e and 120f, which are each made of an inorganic material. This structure helps to improve sealing property of the protection layer 140 and prevent moisture penetration from outside the substrate in plan view into the interlayer insulating layer 120g. Further, in the display region portion 1201, the protection layer 140 covers the organic EL element array 1300, the power supply line 160, and the interlayer insulating layer 120g. Even when moisture passes through the sealing structure 180 and penetrates into the sealing layer 190, this structure helps to prevent moisture penetration from the sealing layer 190 into the interlayer insulating layer 120g.

[0091] The second substrate 170 is disposed above the organic EL element array 1300. Because the display panel 100 is a top-emission type of panel, the second substrate 170 is made by using a light transmissive material such as cover glass, light transmissive resin film, or the like. Further, the second substrate 170 helps to improve, for example, rigidity of the display panel 100 and prevent penetration of moisture, air, or the like into the display panel 100.

[0092] The sealing structure 180 is disposed between the substrate 110 and the second substrate 170 and surrounds the organic EL element array 1300. The sealing structure 180 has a function of joining the second substrate 170 to a “back panel” formed by each layer from the substrate 110 to the protection layer 140, and has a function of preventing each layer from being exposed to moisture or air. The sealing structure 180 partially covers the peripheral region portion 1202 of the multi-layered wiring laminate 120, and does not cover the display region portion 1201 of the multi-layered wiring laminate 120. A lower surface of the sealing structure 180 that covers an outer circumferential portion 1203 of the multi-layered wiring laminate 120 is in close contact with the protection layer 140, and an upper surface of the sealing structure 180 that covers the outer circumferential portion 1203 of the multi-layered wiring laminate 120 is in close contact with the second substrate 170. This structure helps to improve sealing property of the sealing structure 180 and prevent moisture penetration from outside into the sealing layer 190 inside the sealing structure 180 in plan view.

[0093] The sealing layer 190 is disposed between the substrate 110 and the second substrate 170 in a region surrounded by the sealing structure 180, and covers the organic EL element array 1300. Because the display panel 100 is a top-emission type of panel, the sealing layer 190 is made by using light-transmissive resin. For a material of the sealing layer 190, for example, acrylic resin, styrenic resin, polycarbonate resin, epoxy resin, silicone resin, or the like may be used.

1.4.2. Structure of Interlayer Insulating Layer 120g (Planarization Layer 118)

[0094] The following describes a structure of the interlayer insulating layer 120g.

[0095] In FIG. 4, FIG. 5, and FIG. 6, the multi-layered wiring laminate 120 has a circumferential groove portion 120gch having a groove structure formed by removing the interlayer insulating layer 120g in the peripheral region

portion 1202, which surrounds the display region portion 1201 in which the organic EL element array 1300 is arranged. Specifically, the multi-layered wiring laminate 120 has a first part 120p1, a second part 120p2, and a third part 120p3. The first part 120p1 corresponds to a portion of the resin interlayer insulating layer 120g, which is the highest layer among the interlayer insulating layers 120e, 120f, and 120g, and the organic EL element array 1300 is arranged on the first part 120p1. The second part 120p2 surrounds the first part 120p1 in plan view, and a bank-shaped portion of the interlayer insulating layer 120g is present in the second part 120p2. The third part 120p3 is between an outer circumference of the first part 120p1 and an inner circumference of the second part 120p2 in plan view and corresponds to the circumferential groove portion 120gch having a shape of a circumferential groove in which the interlayer insulating layer 120g is not present. The gap in the circumferential groove portion 120gch, from which the interlayer insulating layer 120g is removed, is preferably from 300 μm to 800 μm , and more preferably is from 400 μm to 600 μm . In the present embodiment, the gap in the circumferential groove portion 120gch is approximately 500 μm .

[0096] As described above, the interlayer insulating layer 120g is made of an electrically-insulating material such as polyimide resin, acrylic resin, or the like, and absorbs moisture easily. However, the circumferential groove portion 120gch helps to prevent moisture penetration into the display region portion 1201 even when moisture penetrates from a substrate outer peripheral direction into a portion of the interlayer insulating layer 120g outside the circumferential groove portion 120gch in plan view (second part 120p2). That is, in plan view, because the portion of the interlayer insulating layer 120g inside the circumferential groove portion 120gch (first part 120p1) is spaced away from the portion of the interlayer insulating layer 120g outside the circumferential groove portion 120gch (second part 120p2) through the circumferential groove portion 120gch, moisture in the portion of the interlayer insulating layer 120g outside the circumferential groove portion 120gch (second part 120p2) can be prevented from penetrating through the portion of the interlayer insulating layer 120g inside the circumferential groove portion 120gch (first part 120p1) into the display region portion 1201.

1.4.3. Wiring Structure in Multi-Layered Wiring Laminate 120

[0097] The following describes a wiring structure in the multi-layered wiring laminate 120.

[0098] In FIG. 5 and FIG. 6, the data signal lines 124 are in the wiring layer 120a and extend in the vertical direction (Y direction) from the subpixel drive circuits 123 in the display region portion 1201 to an outer periphery of the peripheral region portion 1202.

[0099] The scan signal lines 125 are in the wiring layer 120b and extend in the horizontal direction (X direction) from the subpixel drive circuits 123 in the display region portion 1201 to the outer periphery of the peripheral region portion 1202.

[0100] The branch lines 152 of the first power supply line 150 are in the wiring layer 120a and extend from the subpixel circuits 123 in the display region portion 1201 to the peripheral region portion 1202 to connect to the trunk line 151. The trunk line 151 of the first power supply line

150 includes a wire 151a in the wiring layer 120a and a wire 151b in the wiring layer 120b. In FIG. 5, the wire 151a and the wire 151b extend in the vertical direction (Y direction) and are connected to each other through contact plugs 151cp. The contact plugs 151cp have appropriate gaps in the horizontal direction between each other. That is, in the third part 120p3 of the multi-layered wiring laminate 120, which corresponds to the circumferential groove portion 120gch, and in the second part 120p2, which is outside the third part 120p3 in plan view, the first power supply line 150 extends to a layer (120e, 120f) lower than the highest layer (120g) by one or more layers through contact plugs 151cp in contact holes. Because the trunk line 151 includes two wires 151a and 151b as described above, the trunk line 151 has a large substantial cross-section and thus voltage decline in the trunk line 151 can be suppressed.

[0101] The branch lines 162 of the second power supply line 160 are in the wiring layer 120d, are connected to the common electrode 134 in the display region portion 1201, and extend to the peripheral region portion 1202 to connect to the trunk line 161. The trunk line 161 of the second power supply line 160 includes a wire 161b in the wiring layer 120b, a wire 161c in the wiring layer 120c, and a wire 161d in the wiring layer 120d. In FIG. 3, the wire 161b, the wire 161c, and the wire 161d extend in the vertical direction (Y direction) and are connected to each other through contact plugs 161cp. The contact plugs 161cp have appropriate gaps in the horizontal direction between each other. Because the trunk line 161 includes three wires 161b, 161c, and 161d as described above, the trunk line 161 has a large substantial cross-section, and thus voltage decline in the trunk line 161 can be suppressed. Further, the wire 161d of the trunk line 161 has a greater width than the wire 161b and the wire 161c. This further helps the trunk line 161 to have a large cross-section.

1.4.4. Structure of Circumferential Groove Portion 120gch in Interlayer Insulating Layer 120g

[0102] In the third part 120p3 of the multi-layered wiring laminate 120, which corresponds to the circumferential groove portion 120gch, and in the second part 120p2, which is outside the third part 120p3 in plan view, the second power supply line 160 is on the inorganic interlayer insulating layer 120f, which is at a layer lower by a layer than the resin interlayer insulating layer 120g, which is the highest layer among the interlayer insulating layers 120e, 120f, and 120g. Further, an outer end 161ced of the second power supply line 160 on the interlayer insulating layer 120f is spaced away from the portion of the interlayer insulating layer 120g in the second part 120p2 of the multi-layered wiring laminate 120. As a result, the protection layer 140 extends at least to the second part 120p2 of the multi-layered wiring laminate 120 in plan view, and in the third part 120p3, the protection layer 140 is in contact with the interlayer insulating layer 120f through a second power supply line 160 absence region 120cne in a bottom surface of the circumferential groove portion 120gch of the interlayer insulating layer 120g.

[0103] Specifically, in the present embodiment, as illustrated in FIG. 5 and FIG. 6, the second power supply line 160 is connected to the common electrode 134 and includes the branch lines 162 extending from the organic EL elements 130 to a vicinity of an outer periphery of the first part 120p1 of the multi-layered wiring laminate 120 in plan view and

the trunk line 161 connected to the branch lines 162 in the vicinity of the outer periphery of the first part 120p1. Further, the branch lines 162 and the trunk line 161 are in the wiring layer 120d on the portion of the interlayer insulating layer 120g in the first part 120p1 of the multi-layered wiring laminate 120 and are connected to the wiring layer 120c through an inclined electrode portion 161grd on a side wall of the circumferential groove portion 120gch of the interlayer insulating layer 120g. Further, the outer end 161ced of the trunk line 161 is in the third part 120p3 (inside the circumferential groove portion 120gch) of the multi-layered wiring laminate 120.

[0104] FIG. 7A is a plan view of the peripheral region at a corner of the display panel 100 pertaining to at least one embodiment, seen from an upper surface of the multi-layered wiring laminate 120. FIG. 7A shows that, in plan view, the outer end 161ced of the trunk line 161 of the second power supply line 160 is inside the substrate relative to a boundary between the third part 120p3 of the multi-layered wiring laminate 120 and the second part 120p2, which is outside the third part 120p3.

[0105] Because of the above-described structure, in the peripheral region portion 1202, no portion of the second power supply line 160 extends to the portion of the interlayer insulating layer 120g in the second part 120p2, which is outside the circumferential groove portion 120gch in plan view. Accordingly, even when moisture remains in or penetrates from outside into the interlayer insulating layer 120g, the above-described structure helps to prevent the second power supply line 160 from partially corroding and prevent such corrosion from progressing into the display region portion 1201 and causing wiring function damage.

[0106] Further, the protection layer 140 may extend outside the second part 120p2 of the multi-layered wiring laminate 120 in plan view and cover the interlayer insulating layers 120e and 120f and the substrate 110.

[0107] Because of this, the interlayer insulating layer 120g, which is made of resin and absorbs moisture easily, is covered by the protection layer 140, which is made of an inorganic material that does not absorb moisture, up to the outer periphery. This structure helps to prevent moisture penetration from, for example, the substrate outer peripheral direction into the portion of the interlayer insulating layer 120g outside the circumferential groove portion 120gch in plan view (second part 120p2).

2. Manufacturing Method of Display Panel

[0108] The following describes a method of manufacturing the display panel 100. FIG. 8A, FIG. 8B, FIG. 8C, FIG. 9A, FIG. 9B, FIG. 9C, FIG. 10A, FIG. 10B, FIG. 11A, and FIG. 11B are cross-sectional views of processes of manufacturing the display panel 100 pertaining to at least one embodiment, taken along line Y1-Y1 in FIG. 3 and FIG. 4.

[0109] First, the substrate 110 is prepared (FIG. 8A), and the multi-layered wiring laminate 120 is formed by sequentially forming the wiring layers 120a through 120c and the interlayer insulating layers 120e through 120f on the substrate 110 (FIG. 8B). The wiring layers 120a through 120c and the interlayer insulating layers 120e through 120f can be manufactured by known TFT manufacturing methods. In the present embodiment, the pixel electrodes 132 of the organic EL elements 130 are formed in the same process as forming of the wires 161 and 162 of the second power supply line 160.

[0110] Then, the interlayer insulating layer 120g (planarization layer 118) is formed by applying a component material (photosensitive resin material) of the interlayer insulating layer 120g described above as a photoresist on surfaces of the interlayer insulating layer 120f and the wiring layer 120c to achieve surface planarization (FIG. 8C).

[0111] The contact holes 118a and 118b and the circumferential groove portion 120gch are formed by the following processes. After the interlayer insulating layer 120g is formed, a photomask having predefined apertures is placed on the interlayer insulating layer 120g, and the pattern of the photomask is transferred to the interlayer insulating layer 120g by exposing the interlayer insulating layer 120g from above to ultraviolet rays. Then, the interlayer insulating layer 120g in which the contact holes 118a and 118b and the circumferential groove portion 120gch are patterned is formed by developing (FIG. 9A). The wiring layer 120c on the interlayer insulating layer 120f is exposed at the bottom of the contact holes.

[0112] Next, the multi-layered wiring laminate 120 including the third part 120p3, the first part 120p1, and the second part 120p2 is formed. In plan view, the third part 120p3 corresponds to the circumferential groove portion 120gch, from which the resin interlayer insulating layer 120g, which is the highest layer among the interlayer insulating layers 120e, 120f, and 120g, is removed; the first part 120p1 is inside the circumferential groove portion 120gch, and a portion of the interlayer insulating layer 120g is present in the first part 120p1; and the second part 120p2 is outside the circumferential groove portion 120gch, and a portion of the interlayer insulating layer 120g is present in the second part 120p2.

[0113] Then, a surface of the interlayer insulating layer 120g is cleaned by dry-etching before film-forming. Then, a metal layer for forming the trunk line 161d and the branch lines (not illustrated) of the second power supply line 160 and the pixel electrodes 132 is formed on the surface of the interlayer insulating layer 120g by a vapor phase growth process such as sputtering, vacuum vapor deposition, or the like. In the present embodiment, a film made of aluminum or an alloy whose main component is aluminum is formed by sputtering.

[0114] Then, a photoresist layer is formed by applying a photoresist made of photosensitive resin or the like. Then, a photomask having predefined apertures is placed on the photoresist layer, and the pattern of the photomask is transferred to the photoresist layer by exposing the photoresist layer from above to ultraviolet rays. Then, the photoresist layer is patterned by developing. Then, the metal layer is patterned by etching the metal layer through the patterned photoresist layer to form the pixel electrodes 132 and the trunk line 161 and the branch lines (not illustrated) of the second power supply line 160 (FIG. 9B).

[0115] Here, the branch lines 162 and the trunk line 161 of the second power supply line 160 are in the wiring layer 120d on the interlayer insulating layer 120g at least in the first part 120p1 of the multi-layered wiring laminate 120, and the inclined electrode portion 161grd on the side wall of the circumferential groove portion 120gch of the interlayer insulating layer 120g is formed to connect to the wire 161c formed on the wiring layer 120c. Further, the outer end 161ced of the trunk line 161 is in the third part 120p3 (inside the circumferential groove portion 120gch) of the multi-layered wiring laminate 120 and the outer end 161ced of the

trunk line 161 on the interlayer insulating layer 120f is patterned such that the outer end 161ced is spaced away from the portion of the interlayer insulating layer 120g in the second part 120p2.

[0116] Then, the insulating layers 135 and the banks 122 (not illustrated) are formed on the multi-layered wiring laminate 120, the functional layers 133 are formed on the pixel electrodes 132, and the common electrode 134 is formed on the functional layers 133 (FIG. 9C). By these processes, the organic EL element array 1300 is formed on the multi-layered wiring laminate 120.

[0117] Here, prior to forming of the insulating layers 135 and the banks 122, a metal layer for forming the hole injection layers 1331 (not illustrated) may be formed on surfaces of the pixel electrodes 132, the second power supply line 160, and the interlayer insulating layer 120g by a vapor phase growth process. In such cases, a layer of tungsten is preferably formed by sputtering.

[0118] Then, the protection layer 140, which covers the organic EL element array 1300 and the multi-layered wiring laminate 120, is formed to extend at least to the second part 120p2 of the multi-layered wiring laminate 120 in plan view by, for example, chemical vapor deposition (CVD) or sputtering (FIG. 10A). Here, the protection layer 140 is in contact with the interlayer insulating layer 120f through the second power supply line 160 absence region 120cne in the bottom surface of the circumferential groove portion 120gch of the interlayer insulating layer 120g. By these processes, a panel intermediate product 100X including the substrate 110, the multi-layered wiring laminate 120, the organic EL element array 1300, and the protection layer 140 is obtained.

[0119] Then, a sealing structure material 180X is applied on the panel intermediate product 100X (FIG. 10B). The sealing structure material 180X is an uncured resin material and is a liquid having low viscosity. The sealing structure material 180X may be applied by, for example, dispensing, screen printing, or inkjets. The sealing structure material 180X covers the outer circumferential portion 1203 of the multi-layered wiring laminate 120 including an outer periphery 140a of the protection layer 140.

[0120] Then, a sealing material 190X is applied in a region 1204 surrounded by the outer circumferential portion 1203 on the panel intermediate product 100X (FIG. 11A). The sealing material 190X is a material in an uncured state for the sealing layer 190 and is a liquid having viscosity lower than the sealing structure material 180X. The sealing material 190X may be applied by, for example, dispensing, screen printing, or inkjets.

[0121] Then, the second substrate 170 is placed on the panel intermediate product 100X (FIG. 11A), and the second substrate 170 is bonded by using vacuum pressure (FIG. 11B). Here, simultaneously with or after the vacuum-pressure bonding, a process of curing the sealing material 190X is performed. For example, the sealing material 190X is heated when the sealing material 190X has a thermosetting property; alternatively, the sealing material 190X is irradiated by using ultraviolet rays when the sealing material 190X has an ultraviolet-curing property. By these processes, the display panel 100 is completed.

3. Evaluation Examination

[0122] An evaluation examination was performed using a comparative example and a working example of the display panel 100 pertaining to the present embodiment.

3.1. Samples to Be Tested

[0123] FIG. 7A is a plan view of the peripheral region at a corner of the working example of the display panel 100 used in the evaluation examination, seen from an upper surface of the multi-layered wiring laminate 120. FIG. 7B is a plan view similar to FIG. 7A of the comparative example, seen from an upper surface of the multi-layered wiring laminate 120.

[0124] In FIG. 7A, in the working example, in plan view, the outer end 161ced of the trunk line 161 of the second power supply line 160 is inside the substrate relative to a boundary between the third part 120p3 of the multi-layered wiring laminate 120 and the second part 120p2, which is outside the third part 120p3. In contrast, in the comparative example, in plan view, the outer end 161ced of the trunk line 161 of the second power supply line 160 is outside the substrate relative to a boundary between the third part 120p3 of the multi-layered wiring laminate 120 and the second part 120p2, which is outside the third part 120p3, and the trunk line 161 is present over the portion of the interlayer insulating layer 120g in the second part 120p2.

3.2. Examination Procedure

[0125] The two samples were placed under temperature of 60° C. and relative humidity of 90%, and moisture penetration into the power supply lines was observed after 600 hours and after 1000 hours.

3.3. Examination Result

[0126] FIG. 12A, FIG. 12B, and FIG. 12C are plane photographs of the multi-layered wiring laminate 120 at a corner of the display panel of the comparative example, seen from the upper surface of the multi-layered wiring laminate 120, after 0 hours, after 600 hours, and after 1000 hours, respectively. FIG. 13 is a plane photograph of the multi-layered wiring laminate 120 at a corner of the display panel of the working example of the display panel 100 pertaining to at least one embodiment after 1000 hours, seen from the upper surface of the multi-layered wiring laminate 120.

[0127] In the comparative example, in FIG. 12B and FIG. 12C, corrosion of the trunk line 161 of the second power supply line 160 caused by moisture penetration was observed at the corner after 600 hours. After 1000 hours, it was observed that the corrosion progressed to the trunk line 161, the branch lines 162, and the pixel electrodes 132 in the display region portion 1201.

[0128] In contrast, in the working example, in FIG. 13, no corrosion was observed in the trunk line 161, the branch lines 162, or the pixel electrodes 132 in the display region portion 1201 after 1000 hours.

[0129] When comparing the structure of the comparative example with the structure of the working example, the working example differs from the comparative example in that the outer end 161ced of the second power supply line 160 on the interlayer insulating layer 120f is spaced away from the portion of the interlayer insulating layer 120g in the second part 120p2 of the multi-layered wiring laminate 120 and is in contact with the interlayer insulating layer 120f through the second power supply line 160 absence region 120cne in the bottom surface of the circumferential groove portion 120gch in the third part 120p3. Because of this difference, no corrosion caused by moisture remaining in or penetrating from outside into the portion of the interlayer

insulating layer 120g in the second part 120p2 occurred in any portion of the second power supply line 160 in the working example.

4. Effects

[0130] As described above, in the third part 120p3 of the multi-layered wiring laminate 120 corresponding to the circumferential groove portion 120gch, and in the second part 120p2 outside the third part 120p3 in plan view, the second power supply line 160 is on the inorganic interlayer insulating layer 120f that is lower by a layer than the resin interlayer insulating layer 120g (the highest layer among the interlayer insulating layers 120e, 120f, and 120g) in the display panel 100. Further, the outer end 161ced of the second power supply line 160 on the interlayer insulating layer 120f is spaced away from the portion of the interlayer insulating layer 120g in the second part 120p2 of the multi-layered wiring laminate 120. As a result, the protection layer 140 extends at least to the second part 120p2 of the multi-layered wiring laminate 120 in plan view, and in the third part 120p3, the protection layer 140 is in contact with the interlayer insulating layer 120f through the second power supply line 160 absence region 120cne in the bottom surface of the circumferential groove portion 120gch of the interlayer insulating layer 120g.

[0131] Because of the above-described structure, in the peripheral region portion 1202, no portion of the second power supply line 160 extends to the portion of the interlayer insulating layer 120g in the second part 120p2, which is outside the circumferential groove portion 120gch in plan view. Accordingly, even when moisture remains in or penetrates from outside into the interlayer insulating layer 120g, the above-described structure helps to prevent the second power supply line 160 from partially corroding and prevent such corrosion from progressing into the display region portion 1201 and causing wiring function damage.

[0132] Further, the protection layer 140 extends at least to the second part 120p2 of the multi-layered wiring laminate 120 in plan view, and in the third part 120p3, the protection layer 140 is in contact with the interlayer insulating layer 120f through the second power supply line 160 absence region 120cne in the bottom surface of the circumferential groove portion 120gch of the interlayer insulating layer 120g. The protection layer 140 may extend outside the third part 120p3 of the multi-layered wiring laminate 120 in plan view and cover the interlayer insulating layers 120e and 120f and the substrate 110.

[0133] Because of this, the interlayer insulating layer 120g, which is made of resin and absorbs moisture easily, is covered by the protection layer 140, which is made of an inorganic material that does not absorb moisture, up to the outer periphery. This structure helps to prevent moisture penetration from, for example, the substrate outer peripheral direction into the portion of the interlayer insulating layer 120g outside the circumferential groove portion 120gch in plan view (second part 120p2).

[0134] As described above, the organic EL display panel pertaining to at least one embodiment helps to prevent, in a peripheral region surrounding a display region in which a plurality of organic EL elements are arranged, corrosion of power supply lines that supply signals and electricity to the organic EL elements.

5. Modification

[0135] The display panel 100 according to at least one embodiment has been described, but the present invention is not limited to the embodiment above. For example, various modifications of embodiments conceived by a person having ordinary skill in the art, and any combination of elements and functions of embodiments and modifications that does not depart from the spirit of the present invention are also included in the present invention. The following describes such modifications of the display panel 100.

[0136] (1) According to a display panel pertaining to Modification 1, in addition to the structure of the display panel 100 pertaining to the above embodiment, when the common electrode 134 is made of a metal, the common electrode 134 may extend to the third part 120p3 of the multi-layered wiring laminate 120 in plan view and be spaced away from a portion of the resin interlayer insulating layer 120g in the second part 120p2. Because of this structure, in the peripheral region portion 1202, the common electrode 134 made of a metal material including silver (Ag) or aluminum (Al) does not extend to a portion of the interlayer insulating layer 120g in the second part 120p2, which is outside the circumferential groove portion 120gch in plan view. As a result, partial corrosion of the common electrode 134 made of a metal material caused by moisture included in the portion of the interlayer insulating layer 120g in the second part 120p2, progress of such corrosion into the display region portion 1201, and wiring function damage can be prevented.

[0137] (2) According to a display panel pertaining to Modification 2, in addition to the structure of the display panel 100 pertaining to the above embodiment, when the common electrode 134 is made of a metal oxide such as indium tin oxide (ITO), indium zinc oxide (IZO), or the like, the common electrode 134 may extend to the second part 120p2 of the multi-layered wiring laminate 120 in plan view and be spaced away from a portion of the resin interlayer insulating layer 120g in the second part 120p2. In such a structure, corrosion would not occur even when, in the peripheral region portion 1202, the common electrode 134 made of a metal oxide partially extends to a portion of the interlayer insulating layer 120g in the second part 120p2, which is outside the circumferential groove portion 120gch in plan view. This is because corrosion caused by moisture included in the portion of the interlayer insulating layer 120g in the second part 120p2 would not occur in the common electrode 134 made of a metal oxide and thus would not progress into the display region portion 1201.

[0138] (3) Other Modifications

[0139] In a display panel pertaining to the above embodiment, the light-emitting layer continuously extends in a column direction on a row bank. However, in the above-described structure, the light-emitting layer may be separate on the row bank to correspond one-to-one with the pixels.

[0140] According to the display panel pertaining to the above embodiment, there are three colors of the pixels: red pixels, green pixels, and blue pixels, but the present invention is not limited to this example. For example, there may be only one color of light-emitting layer, or there may be four colors of light-emitting layer such as red, green, blue, and yellow.

[0141] Further, according to the above embodiment, pixel units are arranged in a matrix, but the present invention is not limited to this example. For example, when the pixel

regions are spaced at one pitch, the effects of the present invention are achieved even when the pixel regions are shifted by a half pitch in the column direction between adjacent gaps. In high definition display panels, visually distinguishing slight shifts in the column direction is difficult even if film thickness unevenness on a straight line (or staggered line) having a certain width is lined up, as the shifts in the column direction are visually recognized as a band shape. Accordingly, improving display quality of a display panel, suppressing luminance unevenness, by using a staggered line arrangement is possible.

[0142] Further, according to the above embodiment, the hole injection layers, the hole transport layers, the light-emitting layers, and the electron transport layer are disposed between the pixel electrodes and the common electrode, but the present invention is not limited to this example. For example, a structure in which the hole injection layers, the hole transport layers, and the electron transport layer are not used and only the light-emitting layers are present between the pixel electrodes and the common electrode is possible. Further, for example, a structure may be used in which hole injection layers, hole transport layers, an electron transport layer, an electron injection layer, or the like is present, and a structure may be used in which some or all of these layers are present. Further, at least one of these layers may not necessarily be made of organic compounds, and a structure may be used in which an inorganic compound is used.

[0143] Further, according to the above embodiment, a wet film-forming process such as printing, spin coating, inkjets, or the like is used as a process of forming the light-emitting layers, but the present invention is not limited to this example. For example, a dry process can be used such as vacuum deposition, electron beam deposition, sputtering, reactive sputtering, ion plating, a vapor phase growth process, or the like. Further, publicly-known materials may be appropriately used as materials of each component.

[0144] Further, according to the above embodiment, a structure is used in which pixel electrodes, which are anodes in a lower portion of an EL element unit, are connected to TFT sources, but a structure may be used in which a common electrode layer is in the lower portion of an EL element unit and an anode is disposed in an upper portion. In such a case, a cathode disposed in a lower portion is connected to a drain of the TFT.

[0145] Further, according to the above embodiment, a structure is used in which two transistors Tr_1 and Tr_2 are provided for a subpixel, but the present invention is not limited to this example. For example, a structure may be used in which a single transistor is provided for a subpixel; alternatively, a structure may be used in which three transistors or more are provided for a subpixel.

[0146] Further, according to the above embodiment, a top-emission type of EL display panel is given as an example, but the present invention is not limited to this. For example, a bottom-emission type of display panel or the like can be used. In such a case, each structure can be changed appropriately.

[0147] Embodiments and modifications described show examples of the present invention. Values, shapes, materials, components, component positions and connections, processes, process order, and the like illustrated by the embodiments and modifications do not indicate limitations of the present invention. Further, among the elements of the embodiments, processes not described in the independent

claims that recite top level concepts of the present invention are described as elements of a more preferable embodiment.

[0148] Further, the order of processes described above are examples for describing the present invention in detail, and may be different from the order described above. Further, a part of the processes described above may be executed simultaneously (in parallel) with another process.

[0149] Further, in order to facilitate understanding of the present invention, scale of the elements in each of the drawings mentioned for the embodiment above may be different from actual scale. Further, the present invention is not limited by the description of the embodiment, and can be appropriately changed without departing from the scope of the present invention.

[0150] Further, at least part of the functions of the embodiments and various modifications thereof may be combined.

[0151] Further, the present invention includes various modifications of the embodiments that may be conceived of by a person having ordinary skill in the art.

[0152] Although one or more embodiments pertaining to the present disclosure have been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications depart from the scope of the present disclosure, they should be construed as being included therein.

1. An organic electroluminescence (EL) display panel, comprising:

- a substrate;
- a multi-layered wiring laminate disposed on the substrate and including wiring and a plurality of insulating layers; and
- an organic EL element array disposed on the multi-layered wiring laminate and including a plurality of organic EL elements that are connected to the wiring, wherein

the multi-layered wiring laminate includes:

- a first part on which the organic EL element array is disposed and in which a first portion of a resin insulating layer is present, the resin insulating layer being a highest layer among the insulating layers;
- a second part that surrounds the first part in plan view and in which a second portion of the resin insulating layer having a bank-shape is present; and
- a third part that is between the first part and the second part in plan view and that has a shape of a circumferential groove in which the resin insulating layer is not present,

in the third part, the wiring is on an inorganic insulating layer that is lower by a layer than the resin insulating layer, and

the wiring on the inorganic insulating layer is spaced away from the second portion of the resin insulating layer.

2. The organic EL display panel of claim 1 further comprising

- a second inorganic insulating layer covering at least the organic EL element array, wherein

the second inorganic insulating layer extends to the second part of the multi-layered wiring laminate in plan view, and

in the third part, the second inorganic insulating layer is in contact with the inorganic insulating layer through a gap between the wiring and the second portion of the resin insulating layer.

3. The organic EL display panel of claim 2, wherein the second inorganic insulating layer extends outside the third part of the multi-layered wiring laminate in plan view.

4. The organic EL display panel of claim 1, wherein the organic EL elements each include:

a light-emitting unit that includes a pixel electrode, a common electrode opposing the pixel electrode, and an organic light-emitting layer sandwiched between the pixel electrode and the common electrode; and a transistor whose source is connected to the pixel electrode and that drives the light-emitting unit, wherein

the wiring is connected to: the common electrode; or the sources, drains, gates, or power lines of the transistors of the organic EL elements.

5. The organic EL display panel of claim 4, wherein when the wiring is connected to the common electrode or the power lines,

in the multi-layered wiring laminate, the wiring includes a plurality of branch lines extending from the organic EL elements to a vicinity of an outer periphery of the first part in plan view and a trunk line connected to the branch lines in the vicinity of the outer periphery of the first part,

in the first part, the trunk line is in the highest layer in the multi-layered wiring laminate, and

an outer end of the trunk line is in the third part.

6. The organic EL display panel of claim 1, wherein in the third part, the wiring extends through a contact hole to a layer lower by one or more layers than the highest layer in the multi-layered wiring laminate.

7. The organic EL display panel of claim 5, wherein the common electrode includes a metal, and in plan view, the common electrode extends to the third part of the multi-layered wiring laminate and is spaced away from the second portion of the resin insulating layer.

8. The organic EL display panel of claim 5, wherein the common electrode includes a metal oxide, and in plan view, the common electrode extends at least to the second part of the multi-layered wiring laminate and is in contact with the second portion of the resin insulating layer.

9. The organic EL display panel of claim 2, further comprising:

a second substrate covering at least the organic EL element array; and

a sealing structure disposed between the substrate and the second substrate and surrounding the organic EL element array in plan view and partially covering the second inorganic insulating layer.

10. The organic EL display panel of claim 2, wherein in the first part of the multi-layered wiring laminate, the second inorganic insulating layer covers the organic EL element array, the wiring, and the resin insulating layer.

* * * * *

专利名称(译)	有机EL显示板		
公开(公告)号	US20180358572A1	公开(公告)日	2018-12-13
申请号	US15/987938	申请日	2018-05-24
申请(专利权)人(译)	JOLED INC.		
当前申请(专利权)人(译)	JOLED INC.		
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IPC分类号	H01L51/50 H01L27/32 H01L51/52 H01L51/56 G09G3/3225		
CPC分类号	H01L51/5012 H01L27/3246 H01L27/3276 H01L27/3262 H01L51/5056 H01L51/5072 H01L51/5092 H01L51/5218 H01L51/5221 H01L51/56 H01L51/5253 G09G3/3225		
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摘要(译)

一种有机电致发光 (EL) 显示面板, 包括: 多层布线叠层, 包括: 第一部分, 其上设置有机EL元件阵列, 并且其中存在树脂绝缘层的第一部分, 所述树脂绝缘层是最高的绝缘层之间的层; 在平面图中围绕第一部分的第二部分, 其中存在具有堤岸形状的树脂绝缘层的第二部分; 第三部分在平面图中设置在第一部分和第二部分之间, 并且具有周向槽的形状, 其中不存在树脂绝缘层。在第三部分中, 布线在无机绝缘层上, 该无机绝缘层比树脂绝缘层低一层。无机绝缘层上的布线与树脂绝缘层的第二部分隔开。

