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(54) **DISPLAY DEVICE AND METHOD OF MANUFACTURING THEREOF**

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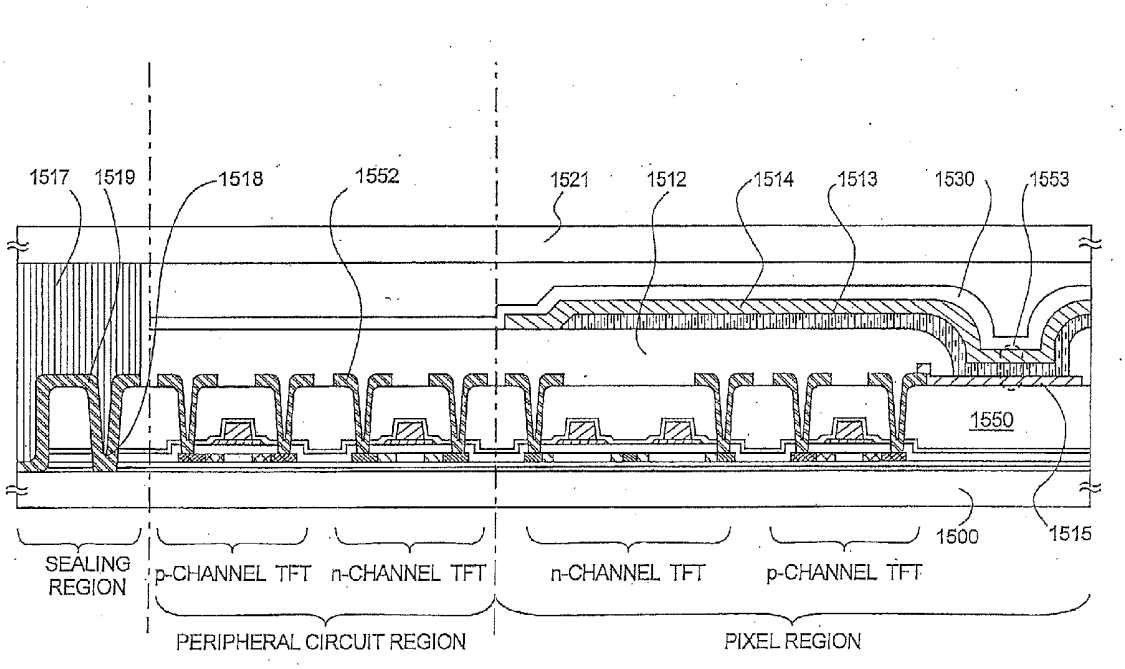
H01L 33/44	(2010.01)
H01L 23/00	(2006.01)
H01L 27/12	(2006.01)

(52) **U.S. Cl.**

CPC ***H01L 51/5246*** (2013.01); ***H01L 27/3262*** (2013.01); ***H01L 33/44*** (2013.01); ***H01L 27/3276*** (2013.01); *H01L 2227/323* (2013.01); ***H01L 27/3258*** (2013.01); ***H01L 27/3246*** (2013.01); ***H01L 27/124*** (2013.01); ***H01L 23/564*** (2013.01)

(57) **ABSTRACT**

A novel display device with higher reliability having a structure of blocking moisture and oxygen, which deteriorate the characteristics of the display device, from penetrating through a sealing region and a method of manufacturing thereof is provided. According to the present invention, a display device and a method of manufacturing the same comprising: a display portion formed by aligning a light-emitting element using an organic light-emitting material between a pair of substrate, wherein the display portion is formed on an insulating layer formed on any one of the substrates, the pair of substrates is bonded to each other with a sealing material formed over the insulating layer while surrounding a periphery of the display portion, at least one layer of the insulating layer is made of an organic resin material, the periphery has a first region and a second region, the insulating layer in the first region has an opening covered with a protective film, the sealing material is formed in contact with the opening and the protective film, an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.



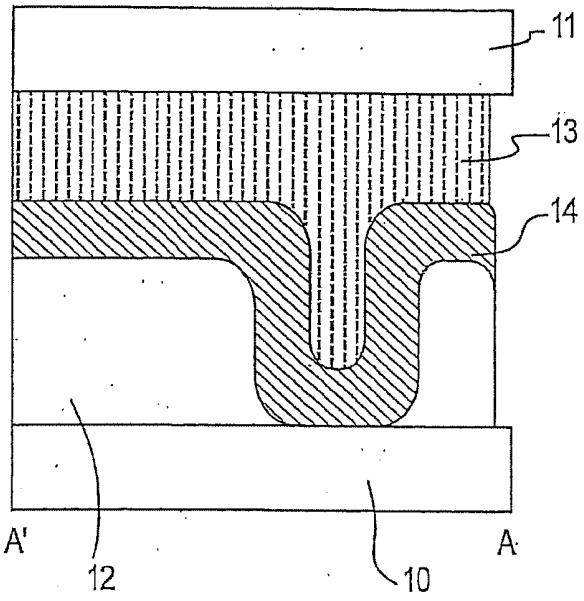


FIG. 1

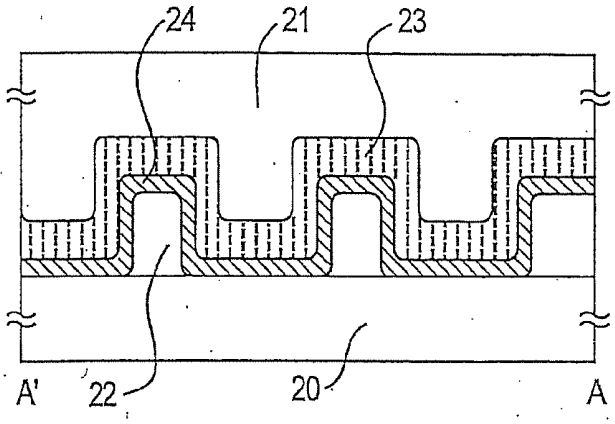


FIG. 2

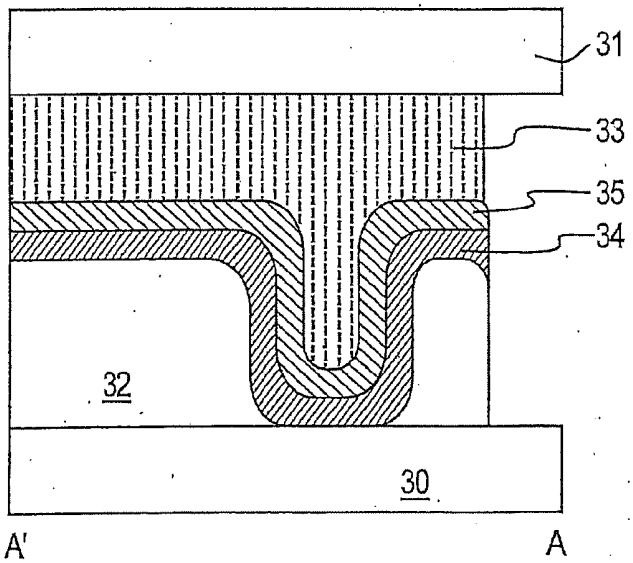


FIG. 3

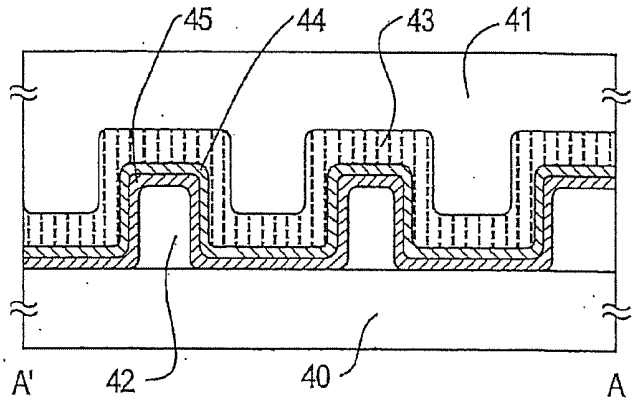


FIG. 4

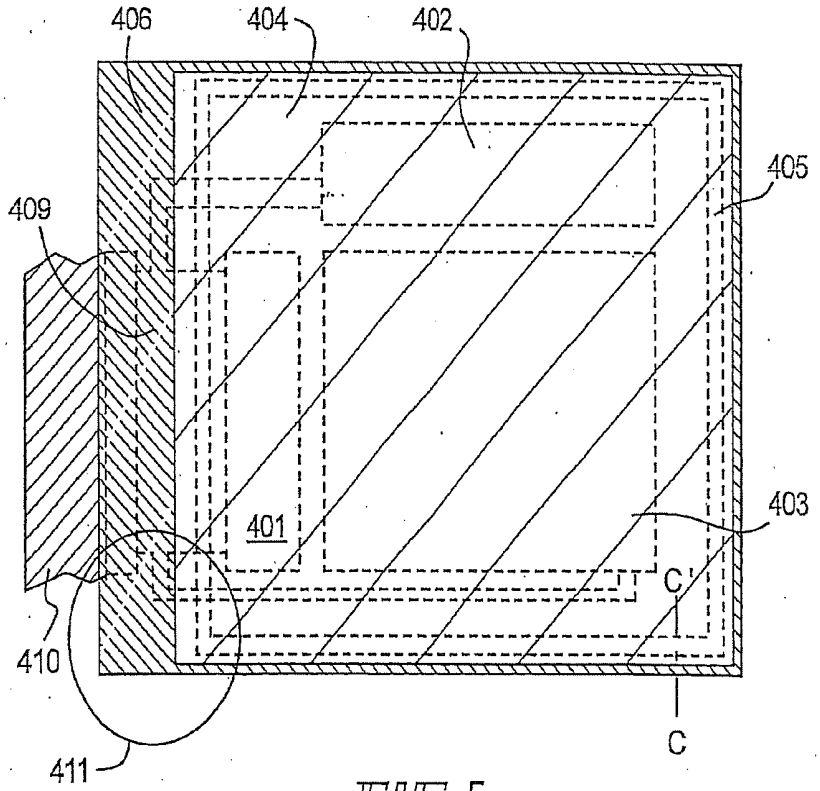


FIG. 5
PRIOR ART

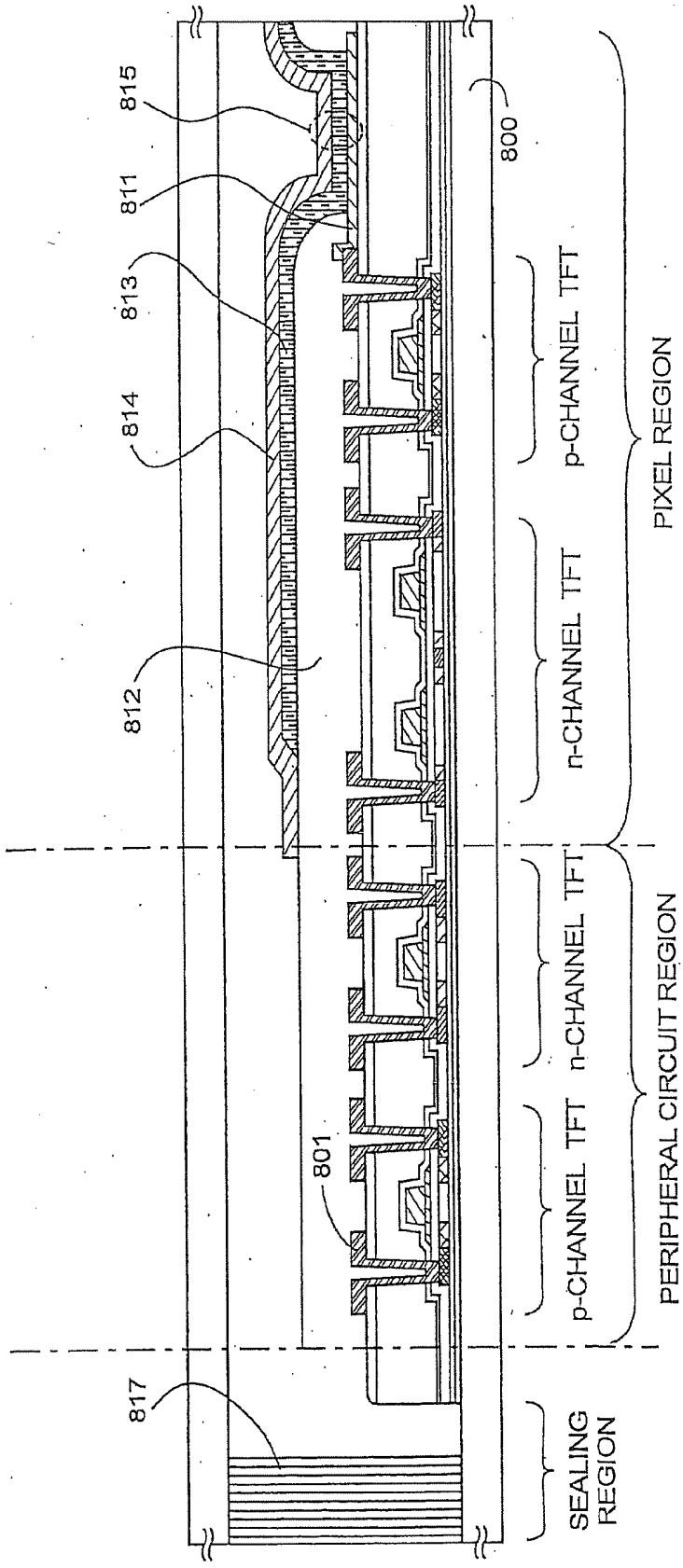


FIG. 6
PRIOR ART

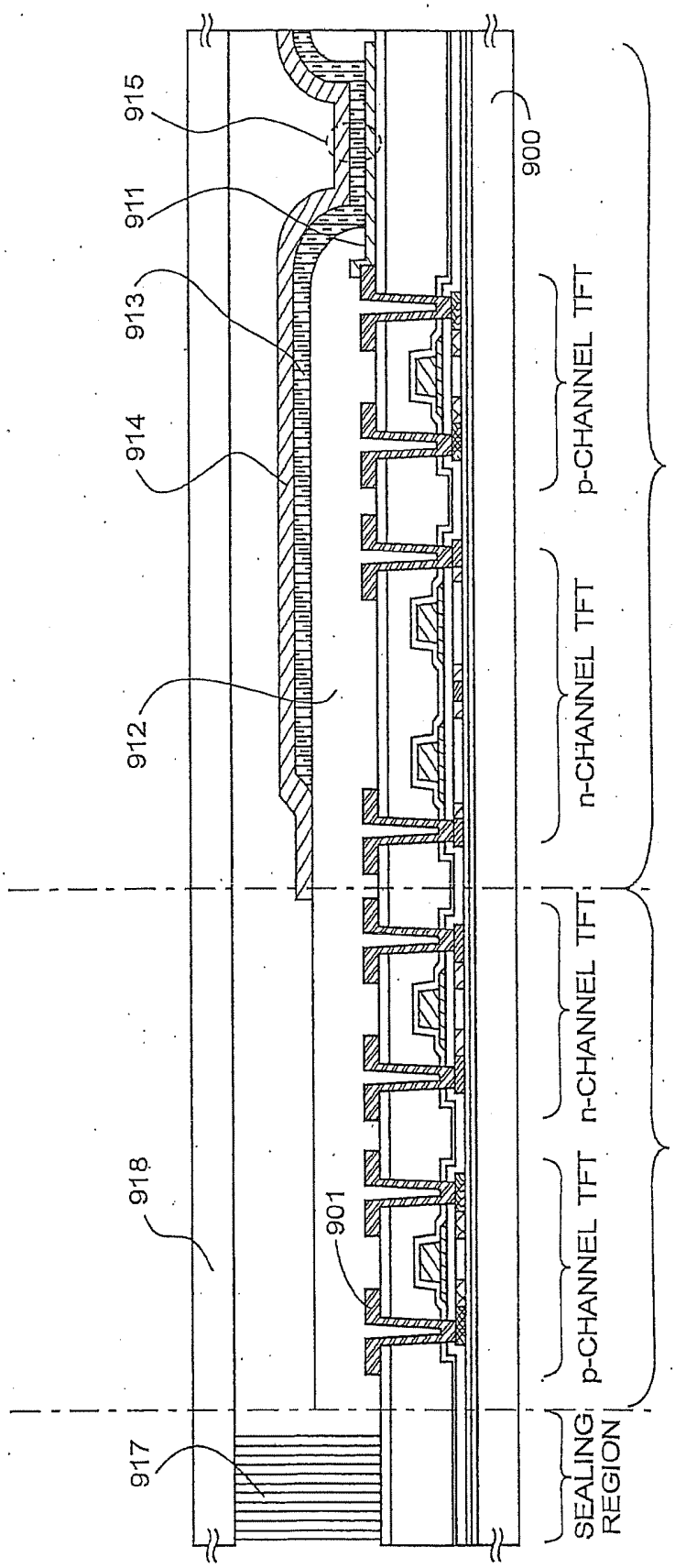


FIG. 7
PRIOR ART

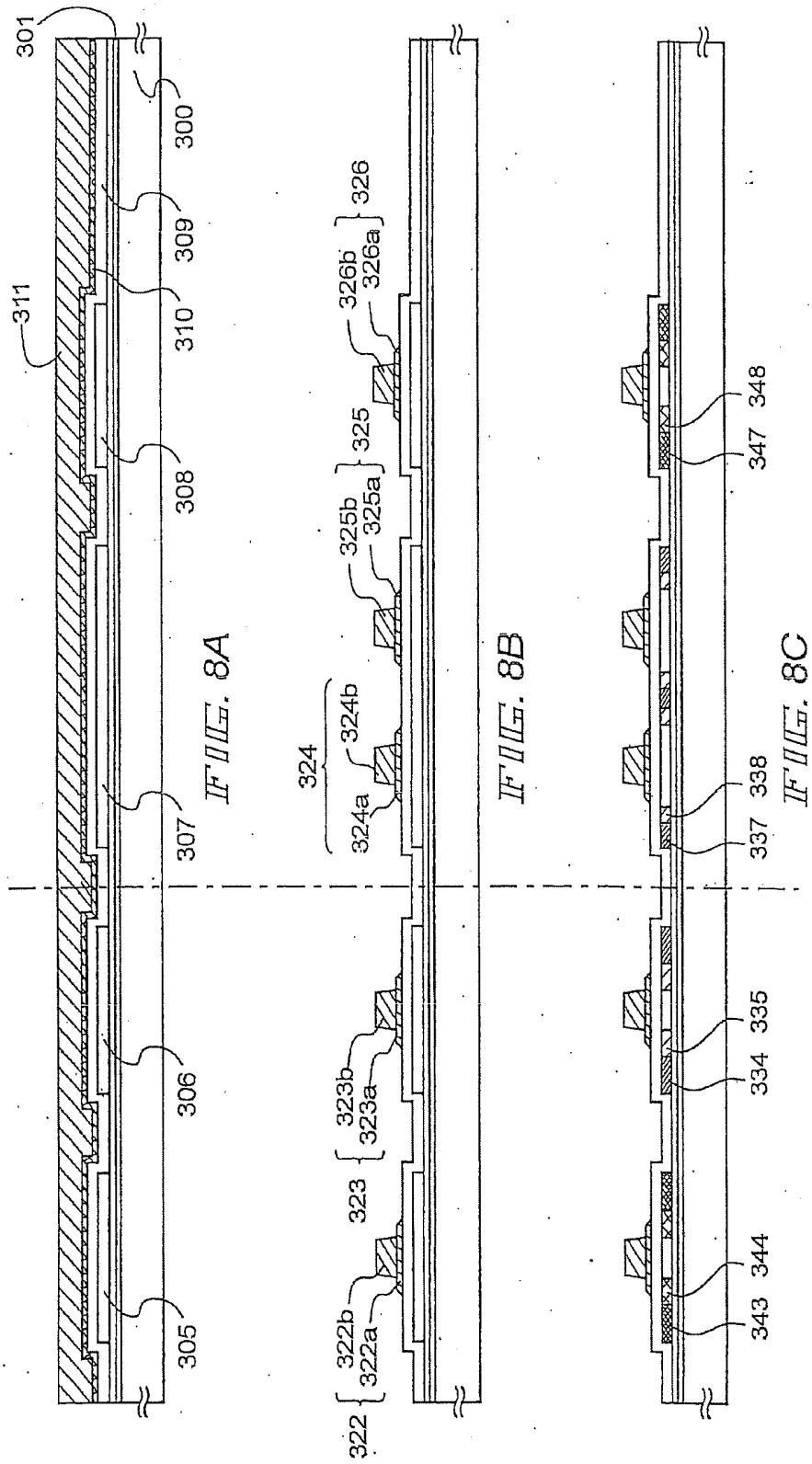


FIG. 8A FIG. 8B FIG. 8C

349

FIG. 9A

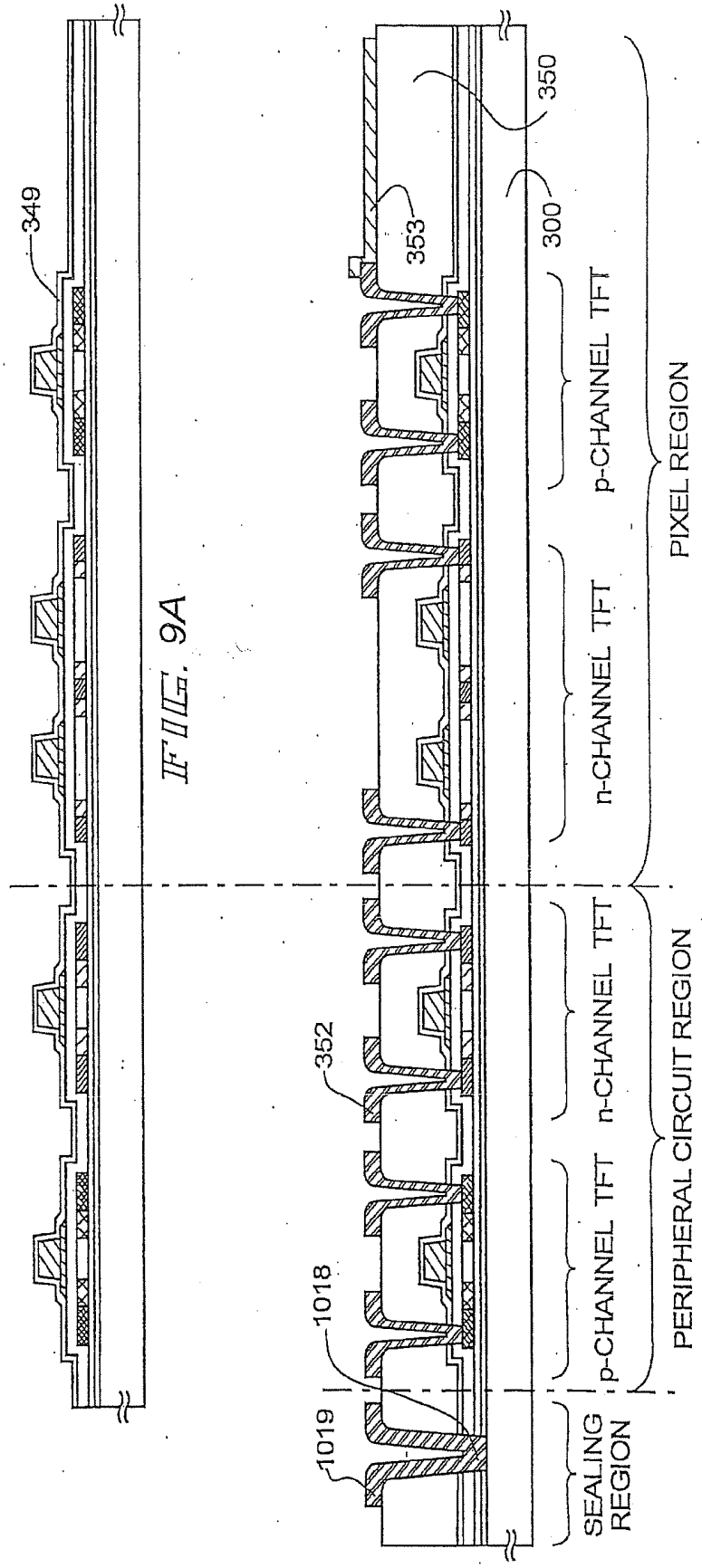

350
353
300
352
1018
1019
p-CHANNEL TFT
n-CHANNEL TFT
n-CHANNEL TFT
p-CHANNEL TFT
PIXEL REGION
PERIPHERAL CIRCUIT REGION
SEALING REGION

FIG. 9B

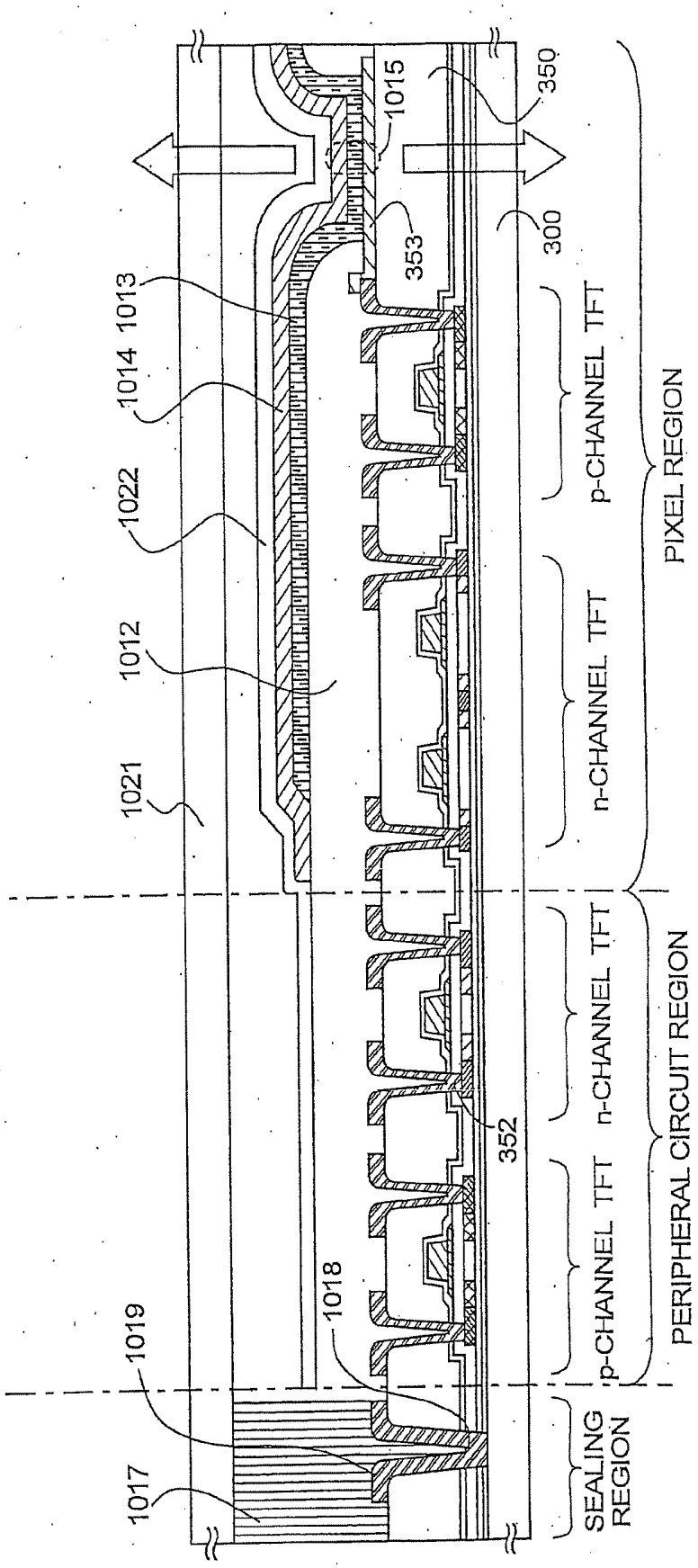

1017
1019
1018
1021
1012
1022
1014
1013
1015
350
353
300
352
SEALING REGION
p-CHANNEL TFT
n-CHANNEL TFT
n-CHANNEL TFT
p-CHANNEL TFT
PERIPHERAL CIRCUIT REGION
PIXEL REGION

FIG. 10

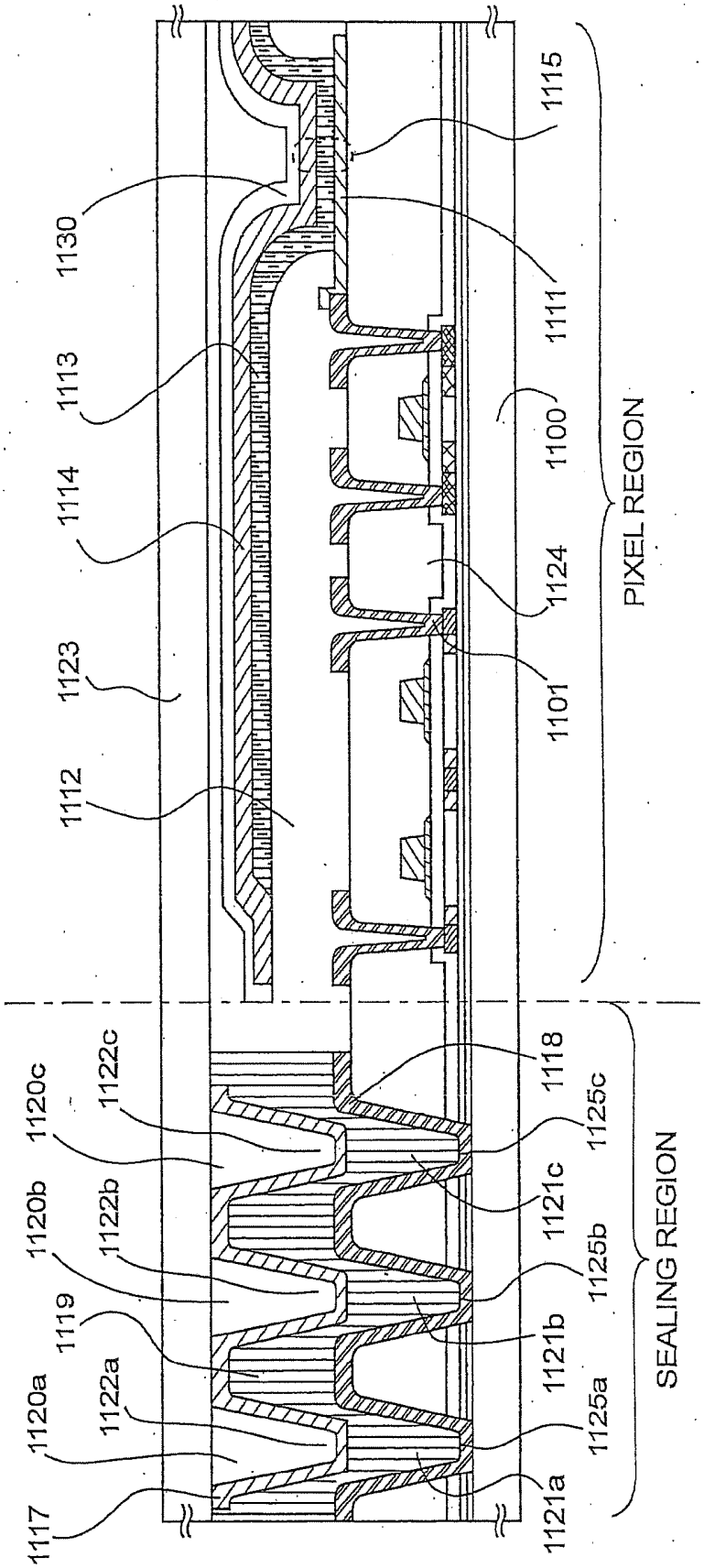

1130
1113
1114
1123
1112
1115
1111
1100
1124
1101
PIXEL REGION
1120c
1122c
1120b
1122b
1119
1120a
1122a
1117
1118
1125c
1121c
1125b
1121b
1125a
1121a
SEALING REGION

FIG. 11

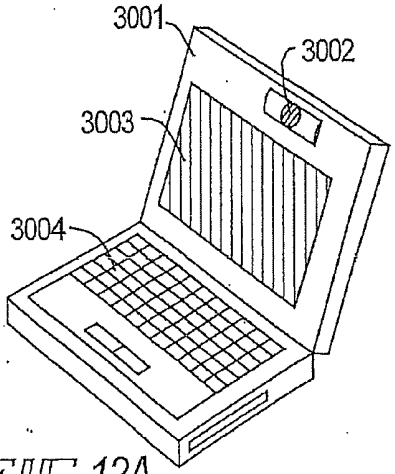


FIG. 12A

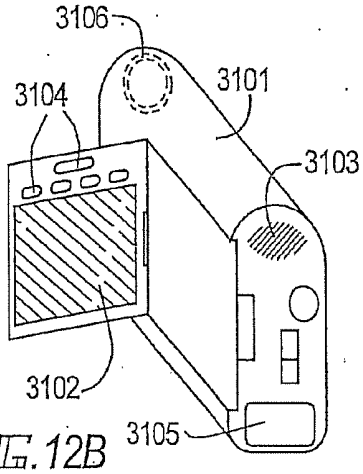


FIG. 12B

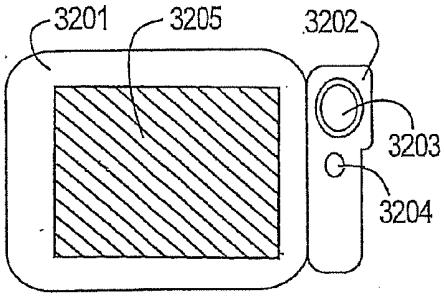


FIG. 12C

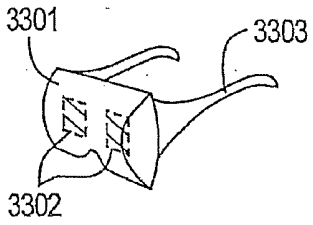


FIG. 12D

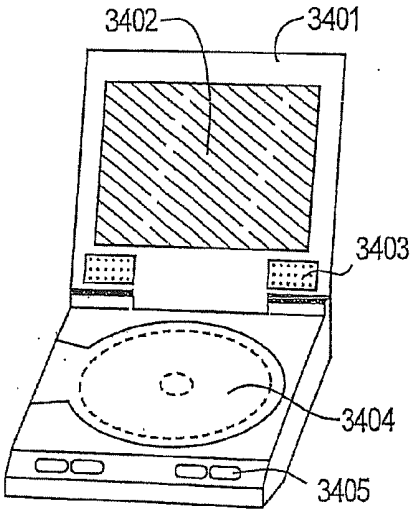


FIG. 12E

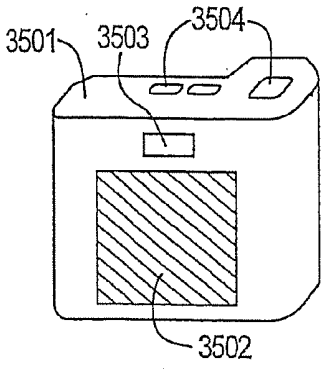


FIG. 12F

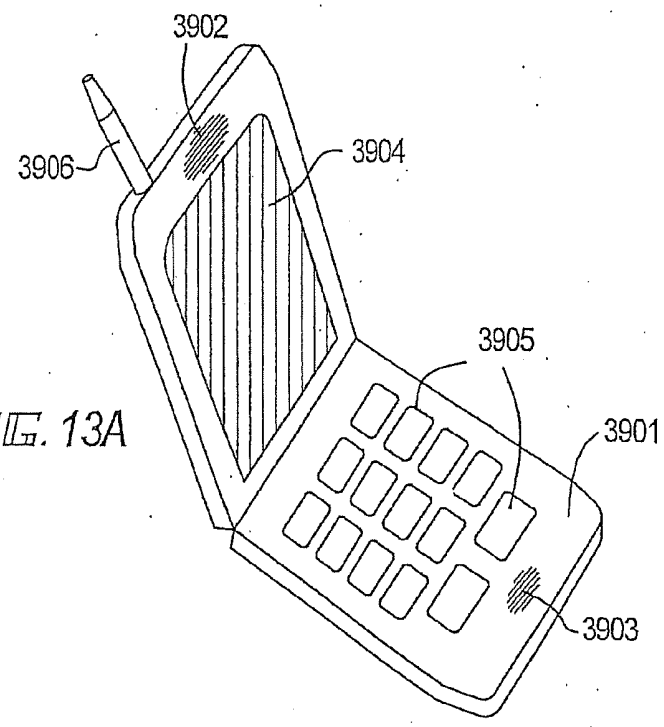


FIG. 13A

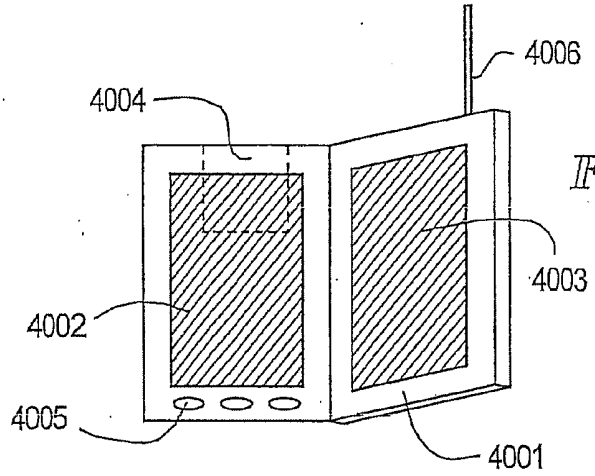


FIG. 13B

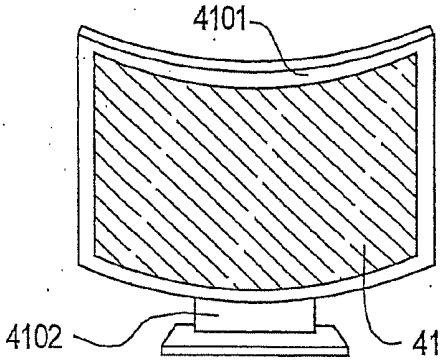


FIG. 13C

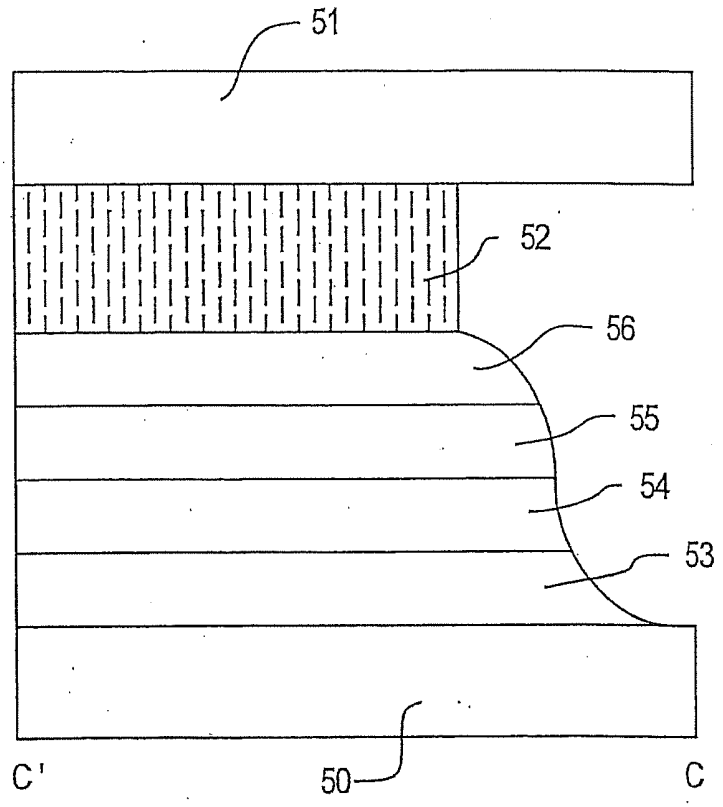


FIG. 14
PRIOR ART

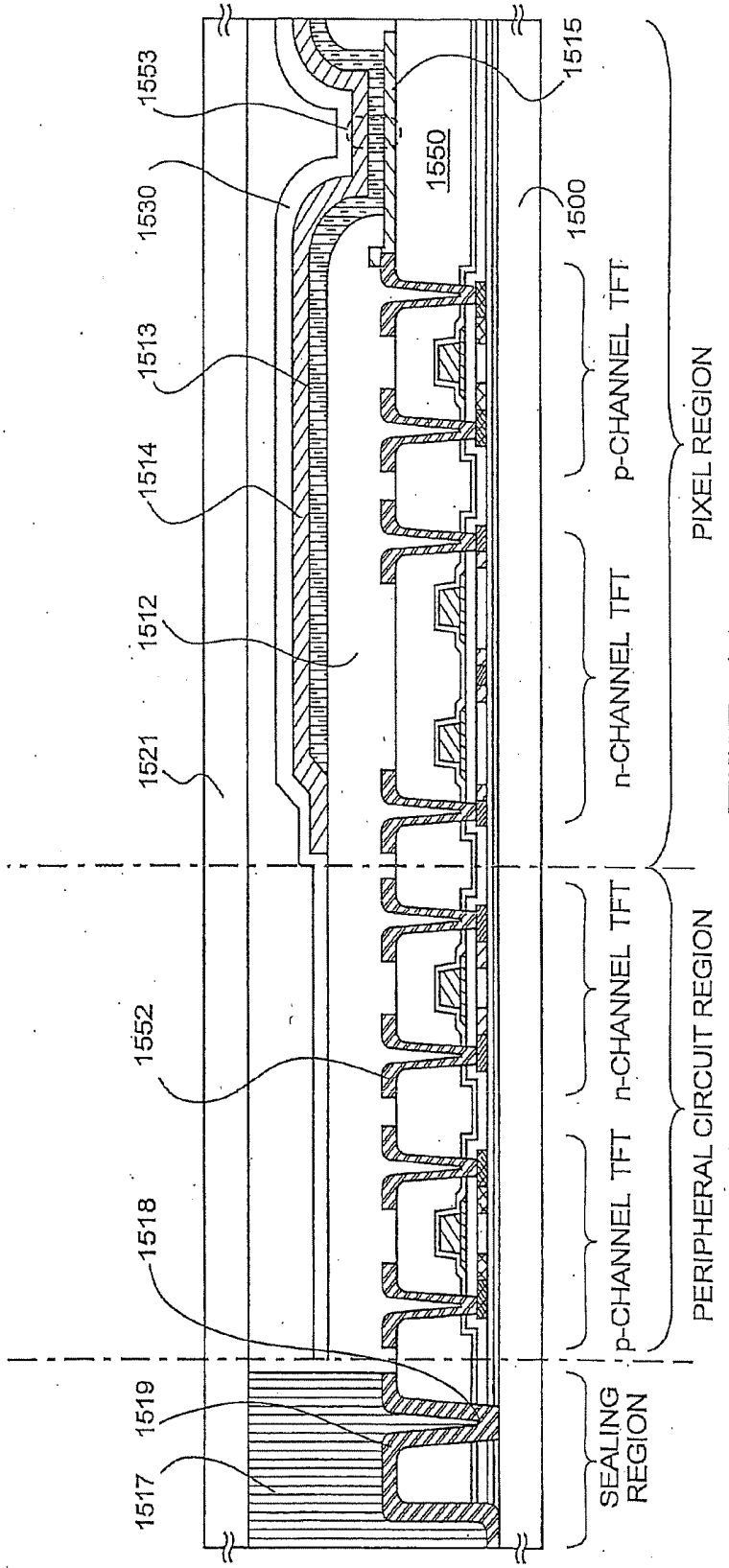

1553
1530
1513
1514
1512
1521
1552
1518
1519
1517
1550
1515
1500
p-CHANNEL TFT
n-CHANNEL TFT
n-CHANNEL TFT
p-CHANNEL TFT
SEALING REGION
PERIPHERAL CIRCUIT REGION
PIXEL REGION

FIG. 15

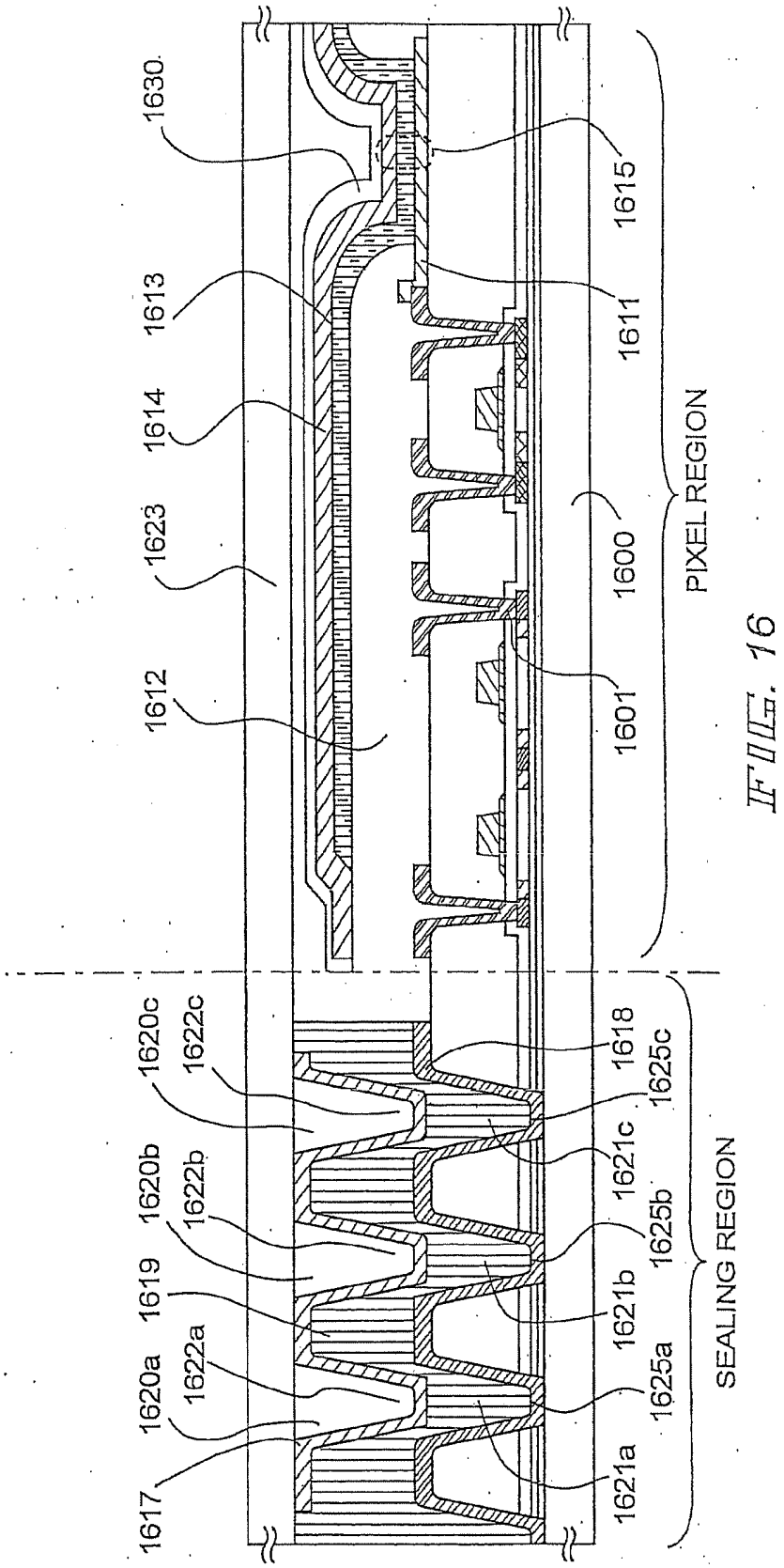

1630
1613
1614
1623
1612
1615
1611
1600
1601
PIXEL REGION
1620c
1622c
1620b
1622b
1619
1620a
1622a
1617
1618
1625c
1621c
1625b
1621b
1625a
1621a
SEALING REGION

FIG. 16

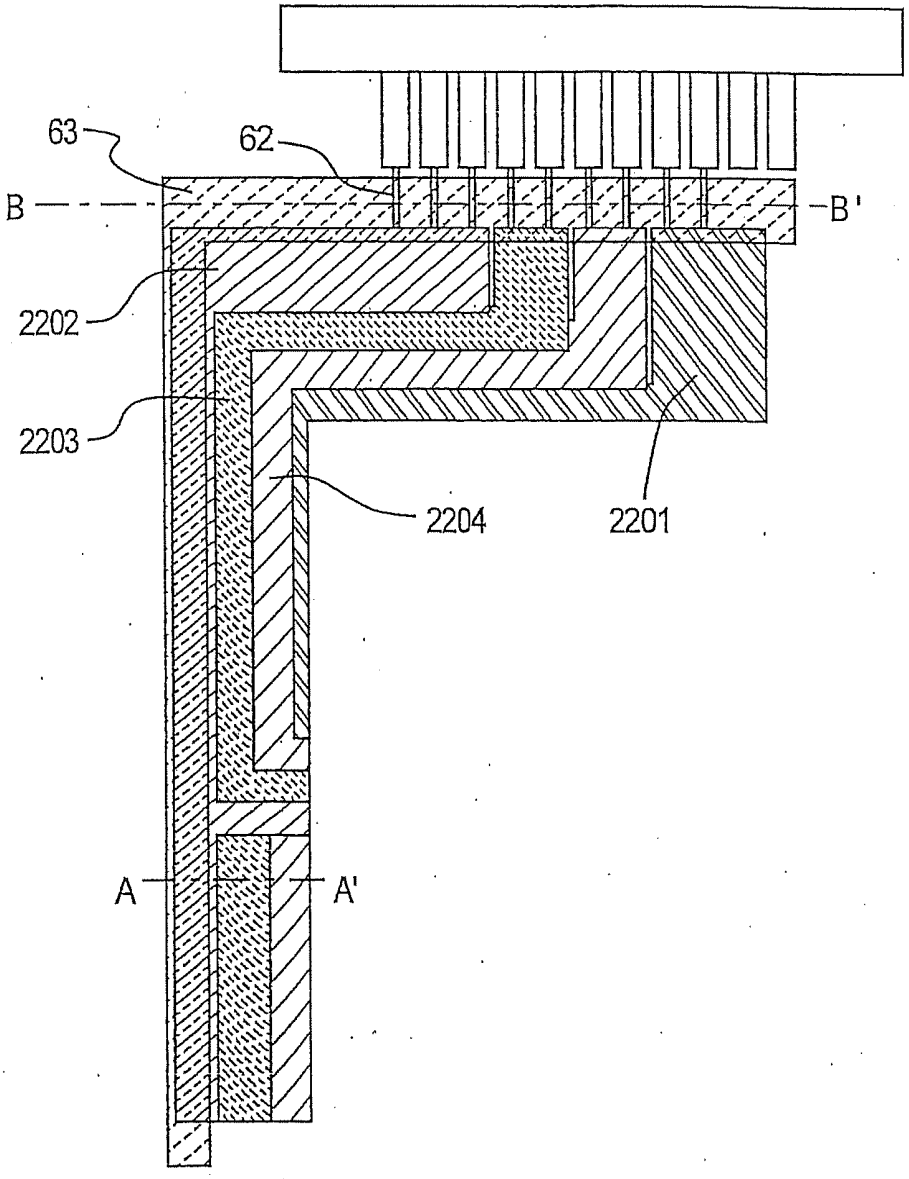


FIG. 17

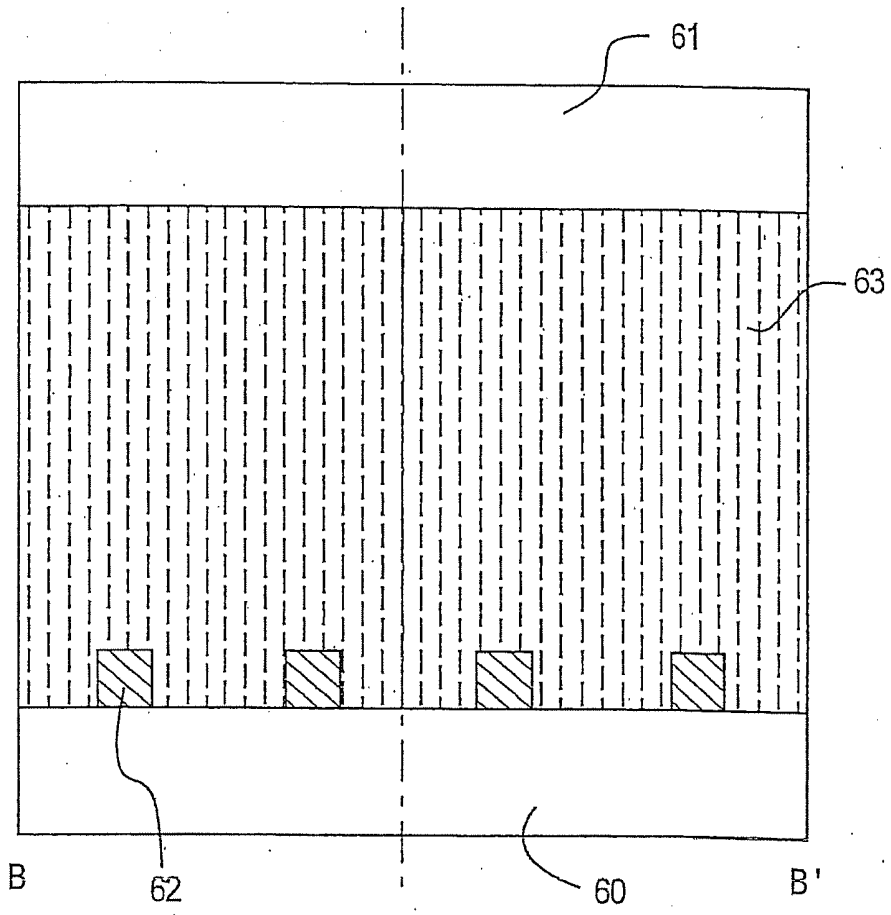


FIG. 18

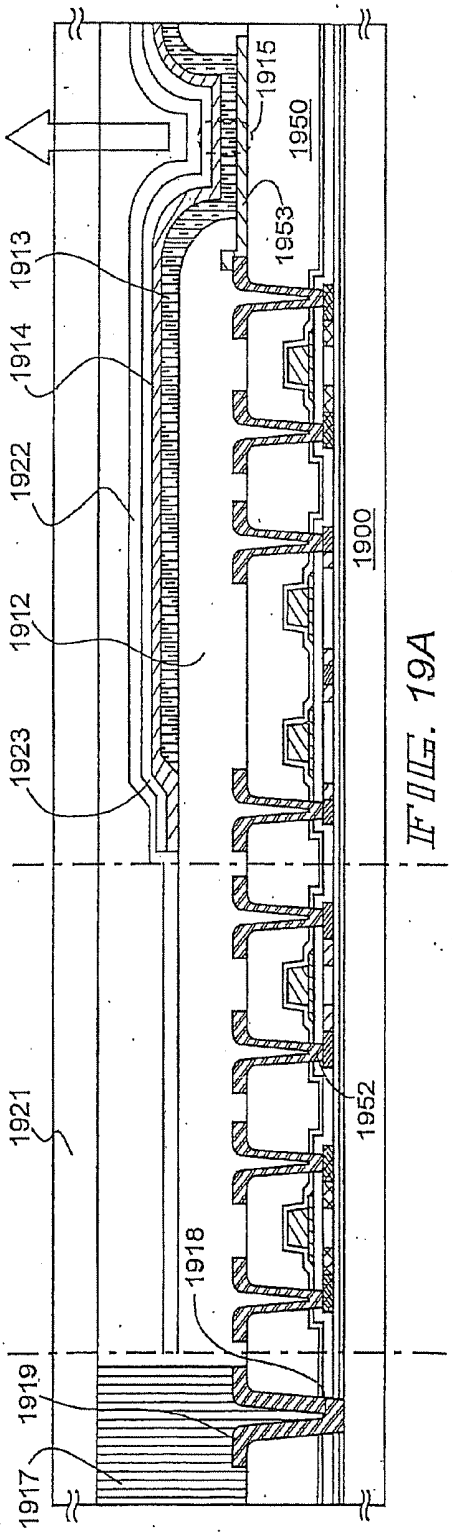


FIG. 19A

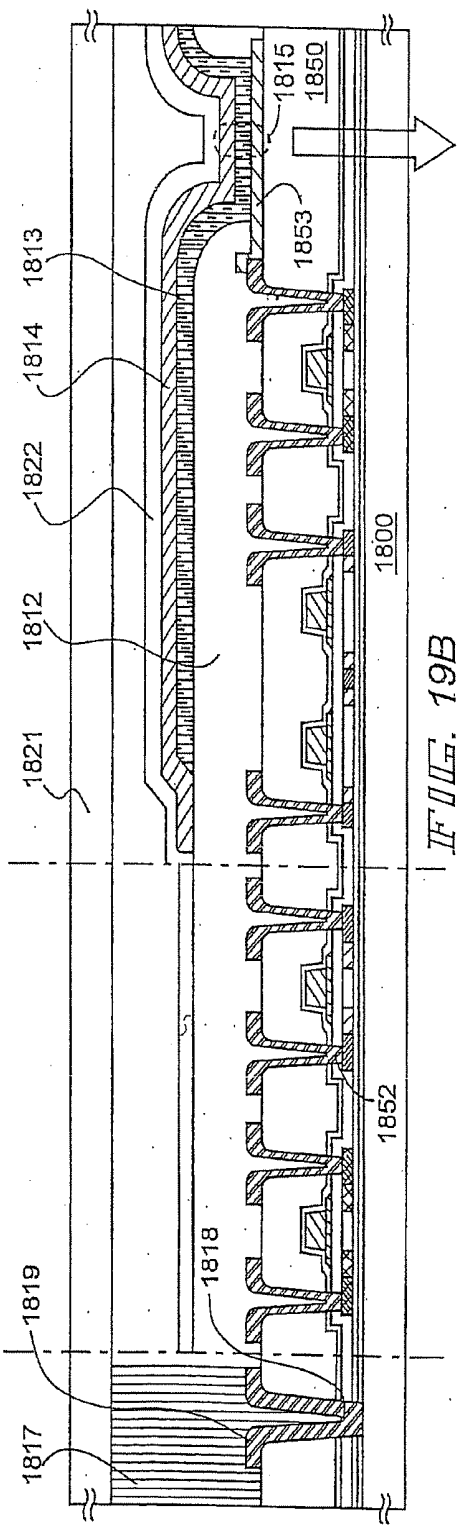


FIG. 19B

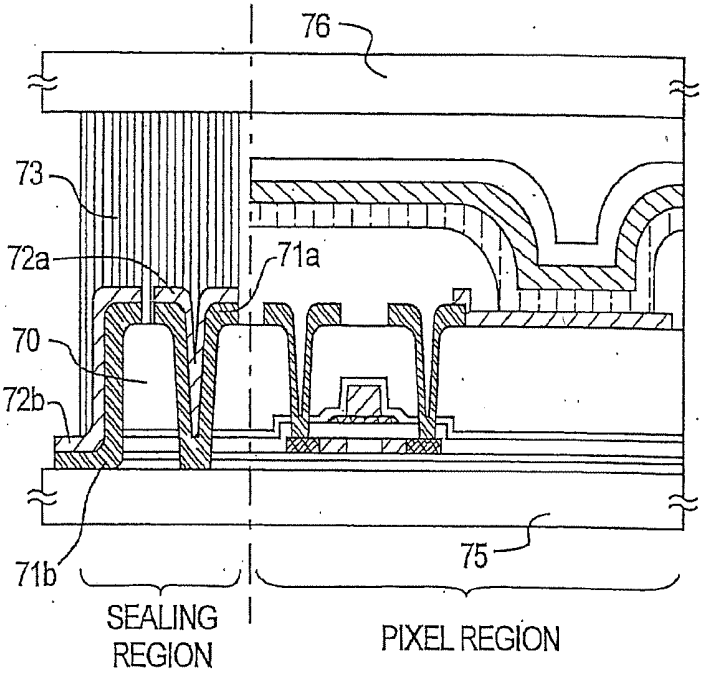


FIG. 20A

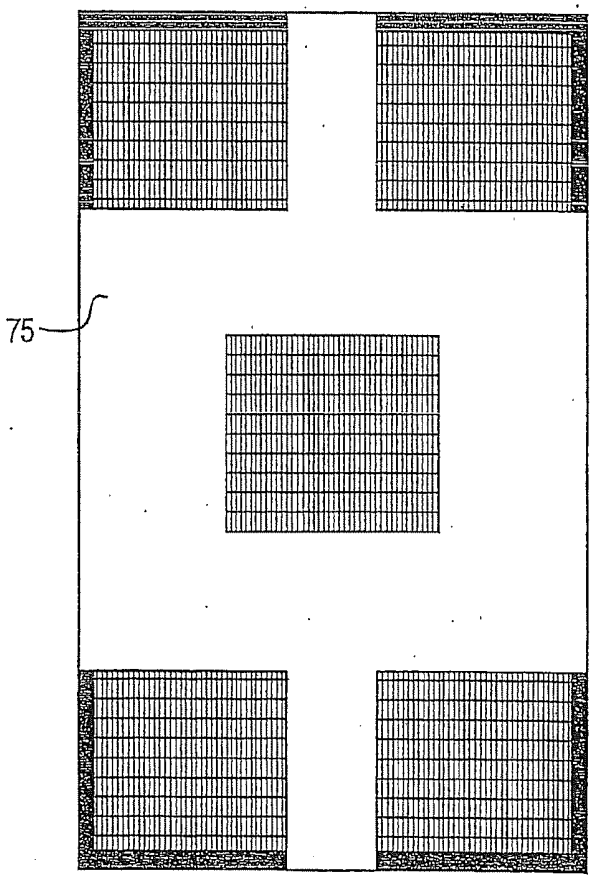


FIG. 20B

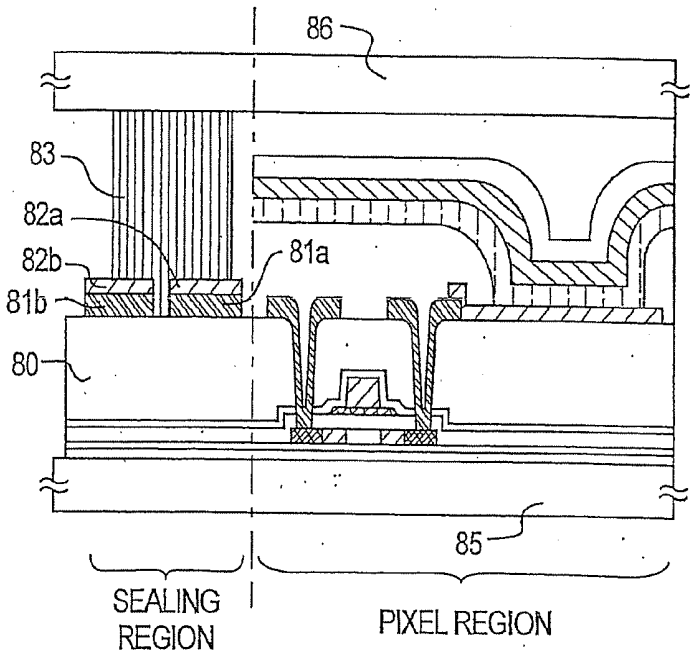


FIG. 21A

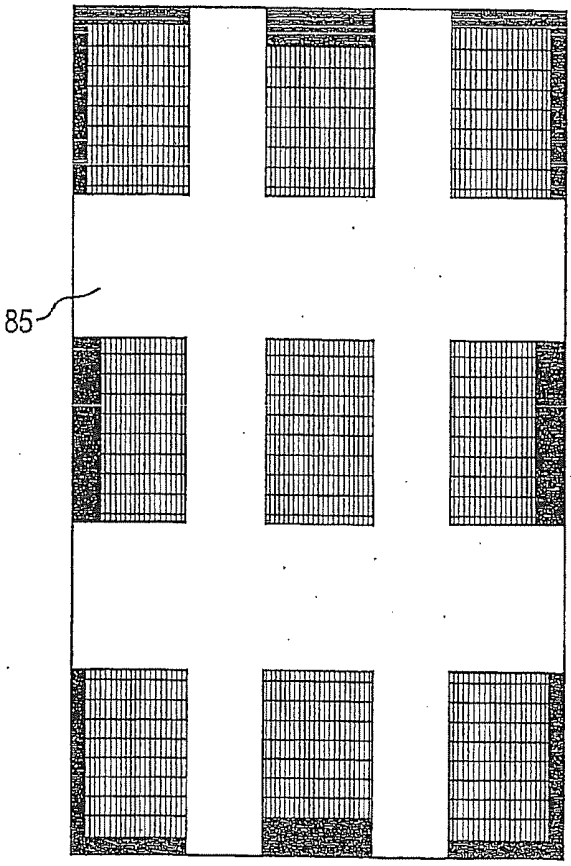


FIG. 21B

DISPLAY DEVICE AND METHOD OF MANUFACTURING THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a display device comprising an element (hereinafter referred to as a light-emitting element) in which a light-emitting material is interposed between a pair of electrode, and to a method of manufacturing thereof. More particularly, the present invention relates to a sealing structure of a display device using a light-emitting material that generates electroluminescence (EL) and a method of manufacturing the same.

2. Description of the Related Art

[0002] In recent years, development of a display device (EL display device) using a light-emitting element (hereinafter referred to as an EL element) which utilizes electroluminescent phenomenon of a light-emitting material has been advanced. Since the light-emitting element of the EL display device is a self-luminous type, a backlight, which is used for a conventional liquid crystal display device, is unnecessary. In addition, the EL display device has merits of the wide viewing angle, the excellent visibility and the like.

[0003] It has been said that the EL element emits photons as follows. By applying a voltage to an organic compound layer interposed between a pair of electrodes, electrons injected from a cathode and positive holes injected from an anode recombine together at a center of luminescence in the organic compound layer to form excited molecules, and hence, energy is released to emit photons when the excited molecules return to the base state. There are known two different excited states: a singlet excited state and a triplet excited state. Luminescence can be generated through either of the states.

[0004] Although there are inorganic light-emitting materials and organic light-emitting materials as the material used for the EL element, the organic light-emitting materials so which can be driven at lower voltage than the inorganic light-emitting materials has been attracting much attention.

[0005] However, when the EL element comprising an organic material is driven for a certain period, luminance and light emitting properties such as nonuniformity of light emission are drastically deteriorated as compared with those in the initial state, which results in a problem of low reliability. The low reliability of the EL element is a limiting factor in practical application of the EL material.

[0006] Further, moisture and oxygen which penetrate from outside into the EL element are another factor of deteriorating the reliability of the EL element.

[0007] In an EL display device (panel) using an EL element, moisture penetrating into the interior of the device causes a serious degraded reliability, which further reads to a dark spot, shrinkage, and deterioration in luminance from a periphery of The EL display device. The dark spot is a phenomenon in which luminance is partly degraded (which includes nonluminous portion), and is generated when a hole is formed in an upper electrode. Meanwhile, the shrinkage is a phenomenon in which luminance is deteriorated from edges of a pixel.

[0008] Accordingly, a display device comprising a structure for preventing the above-mentioned deteriorations of the EL element has been researched and developed. In order to prevent the foregoing problems, there is a method in which the EL element is accommodated in an airtight container and a desiccant is provided in an airtight space (for ample, see patent document 1).

[Patent Document 1]

[0009] Japanese Patent Application Laid-Open No. Hei 9-148066

[0010] Further, there is another method in which a sealing material is formed on an insulator with the EL element formed thereon, and an airtight space surrounded by a covering material and the sealing material is filled with a filler such as a resin so as to shield the EL element from an exterior portion (for example, see patent document 2).

[Patent Document 2]

Japanese Patent Application Laid-Open No. 13-203076

[0011] FIG. **5** shows a top view of the EL display device as disclosed in the patent document 2. Reference numeral **401** surrounded by a doted line denotes a source side driving circuit, reference numeral **402** denotes a gate side driving circuit, reference numeral **403** denotes a pixel portion, and reference numeral **409** denotes a flexible printed circuit (FPC). Further, reference numeral **404** denotes a covering material, reference numeral **405** denotes a first sealing material, and reference numeral **406** denotes a second sealing material. FIG. **6** shows a cross sectional view of a conventional EL display device as illustrated in FIG. **5** (the second sealing material **406** is not illustrated therein). In FIG. **6**, reference numeral **800** is a substrate, reference numeral **801** is an electrode, reference numeral **811** is a pixel electrode, reference numeral **812** is an insulating film, reference numeral **813** is an EL layer reference numeral **814** is a cathode, and reference numeral **815** is an EL element. As illustrated in FIG. **6**, in a sealing region, the EL element is encapsulated in an interior portion with the sealing material **817**.

[0012] According to the patent documents 1 and 2, in the sealing region, the EL element is protected from moisture exists outside by providing the sealing material as depicted in FIG. **6**.

[0013] With respect to the patent document 1, however when the structure in which the EL element is accommodated in the airtight container is taken, the EL display device is grown in size for the size of the airtight container. Although the EL display device is only grown in size, the light-emitting area is not changed. Therefore, the advantage of a thin EL display device, which dispenses with a backlight cannot be utilized.

[0014] Furthermore, with respect to the patent document 2, since the sealing material is applied to a substrate to form the airtight space in the sealing region, it is inevitable that the EL display device is grown in size.

[0015] As set forth above, as the area of the sealing region is increased, nonluminous regions are further increased. Accordingly, it is inevitable that the display device is grown in size in order to obtain a light-emitting portion with a desired area.

[0016] In view of the above mentioned problems, a display device with a narrow frame in which the scaling region

is made as narrow as possible has been researched and developed (for example, see patent document 3).

[Patent Document 3]

[0017] Japanese Patent Application Laid-Open No. 2002-329576

[0018] In the patent document 3, a sealing pattern used for sealing is formed over a substrate with a depression formed thereon. When the width of the sealing pattern in the sealing region is narrowed in order to achieve a narrower frame portion, since the surface area through which the sealing pattern and the substrate contact becomes large, reduction in the bond strength therebetween can be suppressed.

[0019] However, in the patent document 3, the sealing material is applied over the substrate in the sealing region as well as the patent documents 1 and 2, and therefore there is a limitation on a narrower frame formation.

[0020] Further there is another method in which the sealing material is directly applied to a film such as an interlayer film, and a protective film as substitute for the substrate so as to eliminate the sealing region for applying the sealing material. An EL display device manufactured according to this method is illustrated in FIG. **7**. An enlarged cross sectional view of an edge of the sealing region taken along a line C-C' in FIG. **5** is illustrated in FIG. **14**.

[0021] As depicted in FIG. **14**, a first coating film **53**, a second coating film **54**, a third coating film **55**, and a fourth coating film **56** are laminated over a substrate **50** in a display device. Further, a sealing material **52** is applied thereon. This structure allows to reduce the sealing region. The first coating film **53**, the second coating film **54**, the third coating film **55**, and the fourth coating film **56** corresponds to a base film, a gate insulating film, a protective film, an interlayer film, a conductive film, and the like, respectively.

[0022] However, when the sealing material for sealing is formed over a laminated film as illustrated in FIG. **14**, each laminated film is directly in contact with an ambient air outside of the display device. Therefore, moisture and oxygen existing outside of the display device penetrate into the display device through the each laminated film. In addition, when a material having high moisture permeability such as acrylic is used as the interlayer film, more moisture and oxygen penetrate into the display device.

[0023] Moisture and oxygen penetrate through the acrylic included in the interlayer film or top and bottom interfaces of acrylic by using the acrylic as a path. The moisture and oxygen ultimately reach to the EL element via a disconnection portion in a contact hole due to poor film formation properties of source and drain electrodes and the like. The interior of the EL display device and the EL element are contaminated by these moisture and oxygen, thereby causing various deteriorations such as deterioration of the electric characteristics, a dark spot, and shrinkage.

SUMMARY OF TAB INVENTION

[0024] In view of the foregoing problems, it is an object of the present invention to provide an EL display device with higher reliability by preventing intrusion of moisture and oxygen that reads to deterioration in characteristics of an EL element, without increasing the size of the device, and to provide a method of manufacturing thereof.

[0025] In the present invention, a film having functions of blocking contaminants from penetrating into the display device, protecting a display element, and preventing various deteriorations is referred to as a protective film.

[0026] A display device of the present invention comprises: a pair of substrates; an insulating layer comprising an organic resin material, formed over one of the substrates; a display portion formed over the insulating layer, the display portion comprising a light-emitting element including an organic material; and a scaling material surrounding a periphery of the display portion, formed over the insulating layer, wherein the pair of substrates is bonded to each other with the sealing material, wherein the periphery of the display portion comprises a first region and a second region, wherein the insulating layer in the first region has an opening covered with a protective film, and the sealing material is formed in contact with the opening and the protective film, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0027] A display device of the present invention comprises: an insulating layer comprising an organic resin material, formed over one of the substrates; a display portion formed over the insulating layer, the display portion comprising a light-emitting element including an organic material; and a sealing material surrounding a periphery of the display portion, formed over the insulating layer, wherein the pair of substrates is bonded to each other with the sealing material, wherein the periphery of the display portion comprises a first region and a second region, wherein the insulating layer in the first region comprises a plurality of depressions and projections covered with a protective film, and the sealing material is formed in contact with the plurality of depressions and projections and the protective film, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0028] A display device of the present invention comprises: first and second substrates; an insulating layer comprising an organic resin material, formed over the first substrate; a display portion formed over the insulating layer, the display portion comprising a light-emitting element including an organic material; and a sealing material surrounding a periphery of the display portion, formed over the insulating layer, wherein the first and second substrates are bonded to each other with the sealing material, wherein the periphery of the display portion comprises a first region and a second region, wherein the insulating layer and the second substrate in the first region has a plurality of depressions and projections, the plurality of depressions and projections of the insulating layer are covered with a protective film, wherein in the first region, the scaling material is formed in contact with the plurality of depressions and projections covered with the protective film and the plurality of depressions and projections of the second substrate, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0029] A display device of the present invention comprises: first and second substrates; an insulating layer comprising an organic resin material, formed over the first substrate; a display portion formed over the insulating layer, the display portion comprising a light-emitting element including an organic material; and a sealing material surrounding a periphery of the display portion, formed over the insulating layer, wherein the first and second substrates are

bonded to each other with the sealing material, wherein the periphery of the display portion comprises a first region and a second region, wherein the insulating layer and the second substrate comprises a plurality of depressions and projections covered with a protective film, wherein the sealing material in the first region is formed in contact with the insulating layer the plurality of depressions and projections of the second substrate, and the protective film, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0030] The first substrate comprising the insulating layer and the second substrate are adhered to each other so as to match the depressions with the corresponding projection formed thereon respectively, and therefore the sealing material sandwiched by these substrates is pressed and extended to a gap between the depressions and projections to bond the substrates. Accordingly, even if minute amounts of moisture and oxygen intrude from the sealing material, since the moisture and oxygen have to move through a long zigzag path along the depressions and projections, they hardly penetrate into the interior of the display device. As a result, the effect of blocking the contaminants can be further improved, thereby providing a display device having high reliability.

[0031] According to the above-mentioned structure, the outer edge portion of the insulating layer in the first region may be coated with the protective film or the scaling material. In the case of covering the outer edge portion of the insulating layer, the insulating layer is not exposed to the atmospheric air, and hence, the effect of blocking the contaminants is further enhanced. Note that the outer edge portion of the insulating layer may be coated with the scaling material. In such case, the outer edge portion is preferably covered with a scaling material having a film thickness and width that do not damage the effect of narrower frame formation.

[0032] According to the above-mentioned structure, the protective film may be made so of one kind or plural kinds of films selected from thin conductive films and thin insulating films. As for the thin conductive films, a film made of one kind or plural kinds of elements selected from the group consisting of Al, Ti, Mo, W, and Si may be employed. Meanwhile, as for the thin insulating films, a film made of one kind or plural kinds of materials selected from silicon nitride, silicon oxide, silicon oxynitride, aluminum nitride, aluminum oxynitride, aluminum nitride oxide, aluminum oxide, diamond like carbon (DLC), a carbon nitride film (CN), siloxane polymer may be used.

[0033] According to the above-mentioned structure, as for the organic resin material, a film composed of one kind or plural kinds of materials selected from acrylic, polyamide, polyimide, resist, benzocyclobutene, and siloxane polymer or laminated layer of these, etc. may be used. The siloxane polymer is a material in which a skeleton structure is composed by bonding silicon (Si) and oxygen (O), and a substituent comprises at least one kind of hydrogen, fluorine, alkyl group, and aromatic hydrocarbon. A film formed by applying siloxane polymer and then burning can be referred to as a silicon oxide film (SiOx) containing alkyl group.

[0034] A method of manufacturing a display device of the present invention comprises: forming an insulating layer comprising an organic resin material over a first substrate; forming an opening in the insulating film; forming a protective film on the opening; forming a display portion comprising a light-emitting element including an organic material over the insulating layer, forming a sealing material surrounding a periphery of the display portion, in contact with the opening and the protective film; and bonding the first substrate to a second substrate with the sealing material, wherein the periphery has a first region and a second region, wherein the opening is formed in the insulating layer of the first region, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the scaling material.

[0035] A method of manufacturing a display device of the present invention comprises: forming an insulating layer comprising an organic resin material over a first substrate; forming a plurality of depressions and projections in the insulating film; forming a protective film on the plurality of depressions and projections; forming a display portion comprising a light-emitting element including an organic material over the insulating layer forming a sealing material surrounding a periphery of the display portion, in contact with the plurality of depressions and projections and the protective film; and bonding the first substrate to a second substrate with the sealing material, wherein the periphery has a first region and a second region, wherein the plurality of depressions and projections are formed in the insulating layer of the first region, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0036] A method of manufacturing a display device of the present invention comprises: forming an insulating layer comprising an organic resin material over a first substrate; forming a plurality of depressions and projections in the insulating layer; covering the plurality of depressions and projections with a protective film; forming a display portion comprising a light-emitting element including an organic material over the insulating layer; forming a scaling material surrounding a periphery of the display portion over the insulating layer; and bonding the first substrate to a second substrate with the sealing material, wherein the periphery has a first region and a second region, wherein the plurality of depressions and projections formed in the insulating layer is provided in the first region, wherein in the first region, the sealing material is formed in contact with the plurality of depressions and projections covered with the protective film and a plurality of depressions and projections formed on the second substrate, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0037] A method of manufacturing a display device of the present invention comprises: forming an insulating layer comprising an organic resin material over a first substrate; forming a plurality of depressions and projections on the insulating layer; covering the plurality of depressions and projections on the insulating layer with a protective film; forming a display portion comprising a light-emitting element including an organic material over the insulating layer; forming a sealing material surrounding a periphery of the display portion over the insulating layer; and bonding the first substrate to a second substrate with the sealing material, wherein a plurality of depressions and projections are formed on the second substrate, and the plurality of depressions and projections on the second substrate is covered with a protective film, wherein the periphery has a first region and a second region, wherein the plurality of depressions and

projections on the insulating layer is provided in the first region, wherein in the first region, the sealing material is in contact with the protective films covering the plurality of depressions and projections on the insulating layer and the second substrate, and wherein an outer edge portion of the insulating layer in the second region is covered with the protective film or the sealing material.

[0038] The first substrate comprising the insulating layer and the second substrate are adhered to each other so as to fit the depressions into the co responding projections formed thereon respectively, and therefore the sealing material sandwiched by these substrates is pressed and extended to a gap between the depressions and projections to bond the substrates. Accordingly, even if minute amounts of moisture and oxygen intrude from the sealing material, since the moisture and oxygen have to move through a long zigzag path along the depressions and projections, they hardly penetrate into the interior of the display device. As a result, the effect of blocking the contaminants can be further improved, thereby providing a display device having high reliability.

[0039] According to the above-mentioned structure, the outer edge portion of the insulating layer located outside of the sealing material may be coated with the protective film. In the case of covering the outer edge portion of the insulating layer, the insulating layer is not exposed to the atmospheric air and hence, the effect of blocking the contaminants is further enhanced. Note that the outer edge portion of the insulating layer may be coated with the sealing material. In such case, the outer edge portion is preferably covered with a sealing material having a film thickness and width that do not damage the effect of narrower frame formation.

[0040] According to the above-mentioned structure, the protective film may be made of one kind or plural kinds of films selected from thin conductive films and thin insulating films. As for the thin conductive films, a film made of one kind or plural kinds of elements selected from the group consisting of Al, Ti, Mo, W, and Si may be employed. Meanwhile, as for the thin insulating films, a film made of one kind or plural kinds of materials selected from silicon nitride, silicon oxide, silicon oxynitride, so aluminum nitride, aluminum oxynitride, aluminum nitride oxide, aluminum oxide, diamond like carbon (DLC), a carbon nitride film (CN), siloxane polymer may be used.

[0041] According to the above-mentioned structure, as for the organic resin material, a film composed of one kind or plural kinds of materials selected from acrylic, polyamide, polyimide, resist, benzocyclobutene, and siloxane polymer, or laminated layer of these etc. may be used.

[0042] According to the present invention, the path for moisture in the insulating layer which contains the organic resin material of the display device is blocked. Therefore, it is possible to prevent moisture and oxygen exist outside of the display device from penetrating into a display element in the interior of the display device via the insulating to film containing an organic material with a hygroscopic property and the like. In addition, it is also possible to prevent various deteriorations caused by moisture and oxygen such as contamination of the interior of the display device, deterioration in the electric characteristics, a dark spot, and shrinkage, thereby enhancing the reliability of the display device. Since the film constituting the display device is used as the protective film according to the present invention, the display device with high reliability can be manufactured without increasing the number of steps.

[0043] By utilizing the structure of the present invention, following advantageous effects can be obtained.

[0044] According to the present invention, it is possible to prevent moisture and oxygen exist outside of a display device from penetrating into a display element in the interior of the display device via an insulating film containing an organic material with a hygroscopic property and the lire. Therefore, various deteriorations caused by moisture and oxygen such as contamination of the interior of the display device, deterioration of the electric characteristics, a dark spot, and shrinkage can be prevented, thereby enhancing the reliability of the display device.

[0045] In addition, since a film constituting the display device and a film used as a protective film are simultaneously formed by a same material in the invention, the display device with high reliability can be manufactured without increasing the number of steps.

[0046] The display device manufactured above comprises a structure of blocking contaminants in a sealing region of an edge portion of a display device, and hence, the operational characteristics and reliability of the display device can be improved sufficiently. Furthermore, electronic appliances using the display device of the present invention can exhibit high degrees of reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] In the accompanying drawings:

[0048] FIG. **1** is a diagram showing a structure according to the present invention;

[0049] FIG. **2** is a diagram showing a structure according to the present invention;

[0050] FIG. **3** is a diagram showing a structure according to the present invention;

[0051] FIG. **4** is a diagram showing a structure according to the present invention;

[0052] FIG. **5** is a diagram showing a conventional structure;

[0053] FIG. **6** is a cross sectional view of a conventional EL display device;

[0054] FIG. **7** is a cross sectional view of a conventional EL display device;

[0055] FIGS. **8**A to **8**C are cross sectional views showing steps for manufacturing an active matrix substrate;

[0056] FIGS. **9**A and **9**B are cross sectional views showing steps for manufacturing an active matrix substrate;

[0057] FIG. **10** is a cross sectional view of a display device according to the present invention;

[0058] FIG. **11** is a cross sectional view of a display device according to the present invention;

[0059] FIGS. **12**A to **12**F are diagrams showing examples of a display device;

[0060] FIGS. **13**A to **13**C are diagrams showing examples of a display device;

[0061] FIG. **14** is a diagram showing a conventional structure;

[0062] FIG. **15** is a cross sectional view showing a display device according to the present invention;

[0063] FIG. **16** is a cross sectional view of a display device according to the present invention;

[0064] FIG. **17** is a top view of a display device according to the present invention;

[0065] FIG. **18** is a cross sectional view of a display device according to the present invention;

[0066] FIGS. **19**A and **19**B are cross sectional views showing a display device according to the present invention;

[0067] FIGS. **20**A and **20**B are diagrams showing reliability evaluation of a display device according to the present invention; and

[0068] FIGS. **21**A and **21**B are diagrams showing reliability evaluation of a display device of a comparative example.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0069] The present invention has been fully described by way of Embodiment Modes and Embodiments with reference to the accompanying drawings. As has been easily understood by the person skilled in the art, the present invention can be embodied in several forms, and the embodiment modes and its details can be changed and modified without departing from the purpose and scope of the present invention. Accordingly, interpretation of the present invention should not be limited to descriptions mentioned in the foregoing embodiment modes and embodiments. Note that in the structures according to the present invention described above, portions identical to each other or portions having a similar function are commonly denoted by same reference numerals in the accompanying drawings such that additional descriptions are omitted.

Embodiment Mode 1

[0070] Preferred embodiment modes of the invention will hereinafter be described with reference to the accompanying drawings.

[0071] FIG. **17** is a tow view of a display device according to the present invention. An edge portion of the display device taken along a line A-A' in FIG. **17** is described in FIG. **1**. In FIG. **1**, an, opening is formed in an insulating layer **12** containing an organic resin material, and the opening is covered with a protective film **14**. A sealing material **13** is applied over the protective film **14** so as to fill a depression due to the opening. A substrate **10** comprising the depression and opposing substrate **11** are adhered (or bonded) to each other with the sealing material **13**. In the embodiment mode, the protective film **14** and wirings are made of the same material through the same steps.

[0072] In Embodiment Mode 1, the opening is only formed in the insulating layer containing the organic resin material. However another opening may be formed in an insulating layer on which a gate insulating film, an interlayer film and the like are laminated, and may be covered with the protective film and then the sealing material may be applied thereon. Of course, the laminated film constituting the insulating layer may include a conductive film. In the present invention, such laminated film is referred to as an insulating layer in the sense that the laminated layer includes an organic resin material. On the insulating layer, a display element made of an organic light-emitting material is formed.

[0073] The insulating layer containing the organic resin material, which can serve as a path for contaminants, is isolated by the protective film inside the display device. Accordingly, the insulating layer is protected with the sealing material and the protective film formed thereon, and therefore the contaminants cannot pentrate into the interior of the display device even if outer edge portions of the insulating layer in the display device are posed to the atmospheric air and moisture and oxygen exist outside of the display device penetrate into the display device through a gap between the interlayer films or the other films. Therefore, it is possible to prevent various deteriorations due to moisture, oxygen etc. such as contamination of the interior of the display device, deterioration of the electric characteristics, a dark spot, and shrinkage, thereby improving the reliability of the display device. In addition, a film constituting the display device and the protective film are simultaneously formed by using a same material, and hence, the reliability of the display device to be manufactured can be further improved without increasing the number of steps.

[0074] The protective film may be formed of one or more kinds of films selected from thin conductive films and thin insulating films. As for the thin conductive films, a film made of one or more kinds of elements selected from the group consisting of Al, Ti, Mo, W, and Si may be employed. Meanwhile, as for the thin insulating films, a film made of one or more kinds of materials selected from silicon nitride, silicon oxide, silicon oxynitride, aluminum nitride, aluminum oxynitride, aluminum nitride oxide, aluminum oxide, diamond like carbon (DLC), a carbon nitride film ((CN), siloxane polymer may be used.

[0075] The insulating layer may be made of a film comprising one or more kinds of materials selected from inorganic materials (such as silicon oxide, silicon nitride, silicon oxynitride, and silicon nitride oxide) and photosensitive or nonphotosensitive organic resin materials (such as polyimide, acrylic, polyamide, polyimide amide, resist, benzocyclobutene, and siloxane polymer), or a laminated layer of these and the like. The siloxane polymer can be made of an inorganic-siloxane-based insulating material including a Si—O—Si bond, and an organosiloxane-based insulating material in which an organic radical such as methyl and phenyl is substituted for hydrogen bonded silicon among compounds comprising silicon, oxygen, and hydrogen formed by using a siloxane-based material as a starting material.

[0076] Note that a plurality of openings may be formed in the insulating film. The plurality of openings may be partly or entirely covered with the protective film and the sealing film. Further, each opening may be formed at any portion inside of the display device.

[0077] Although the opening is formed so as to contact with the glass substrate **10** in FIG. **1** of the present embodiment mode, the structure of the present invention is not limited to the structure. That is, the insulating film containing an organic material having a hygroscopic property and the like may be covered with the protective film, and a depression due to the formation of the opening may be filled with the sealing material so as to seal the opening, and therefore, the opening may be formed until the opening reaches to a film having dense structure such as a silicon nitride film.

[0078] Meanwhile, two or more protective films may be formed as a first protective film **34** and a second protective film **35** as depicted in FIG. **3** rather than only one protective film. In FIG. **3**, a substrate **30** and an opposing substrate **31** are bonded to each other with a sealing material **33**, and an insulating layer **32** on the substrate is isolated by the protective films **34** and **35**. In order to prevent short circuit in the so interior of the insulated display device, a portion to

be covered with the protective film is necessary to be designed by a mask etc. When the insulating layer is shielded with the two-layered protective films, the effect of blocking the contaminants can be further improved as compared with the case of using a single-layer protective film.

[0079] Further, the inclined surface of the opening is desirably smooth. When the inclined surface of the opening is not smooth, the protective film covering the surface thereof is affected by the unevenness on the surface of the opening. The protective film is destroyed in the portion of thinner film thickness. The contaminants cannot be blocked sufficiently by such destroyed protective film, thereby reducing the advantageous effect of the present invention. Accordingly, when the opening has a smooth surface, favorable coverage of the protective film laminated on the opening can be obtained, thereby improving the advantageous effect of the present invention. Therefore, it is preferable to perform wet etching on a film to form an opening thereon by using a photosensitive material such that unevenness formed on the surface of the film is reduced and its smoothness of the surface is improved.

[0080] As set forth above, the display device in which the frame of the display device is narrowed and the contaminants due to the deterioration are blocked can be obtained.

Embodiment Mode 2

[0081] Another embodiment mode of the present invention will hereinafter be described in more detail with reference to the accompanying drawings.

[0082] FIG. **17** is a top view of a display device according to the present invention. An edge portion of the display device taken along a line A-A' in FIG. **17** is illustrated in FIG. **2**. In FIG. **2**, a plurality of openings is formed in an insulating layer **22** containing an organic resin material. The surface of the insulating layer **22** comprised depressions and projections. Each opening is covered with a protective film **24**. In Embodiment Mode 2, an opposing substrate **21** attached to the substrate **20** is also comprises depressions and projections in the direction of the substrate **20** side. The opposing substrate **21** and the substrate **20** are adhered (or bonded) to each other with a sealing material **23** such that the depressions and the corresponding projections of each substrate are matched with each other.

[0083] Since the substrate **20** comprising the insulating layer and the opposing substrate **21** are bonded to each other such that the respective depressions and projections thereof are matched with each other, the sealing material sandwiched therebetween is pressed and extended to the gap between the depressions and projections to bond the substrates. Accordingly, when minute amounts of moisture and oxygen intrude from the sealing material, since the moisture and oxygen have to move through a long zigzag path along the depressions and projections, they hardly penetrate into the interior of the display device. As a result, the effect of blocking the contaminants can be improved, thereby providing a display device having high reliability. In this embodiment mode, the protective film and a wiring are made of the same material through the same steps.

[0084] The number of the depressions and projections formed on the substrate **20** comprising the insulating layer and the opposing substrate **21** is not limited. Further how to fit the depressions into the corresponding projections is not limited to the present embodiment mode, and the depressions may face each other while the projections may face each other, or the depressions may be fit into the corresponding projections, respectively.

[0085] The depressions and projections formed on the opposing substrate may be formed by processing the substrate, or a film having the depressions and projections may be formed on the opposing substrate. The film having the depressions and projections is preferably made of a substance which can block the contaminants as well as the protective film.

[0086] The protective film **24** may be made of one kind or plural kinds of films selected from thin conductive films and thin insulating films. As the thin conductive films, a film made of one kind or plural kinds of elements selected from the group consisting of Al, Ti, Mo, W, and Si may be used. Meanwhile, as the thin insulating films, a film made of one kind or plural kinds of materials selected from silicon nitride, silicon oxide, silicon oxynitride, aluminum nitride, aluminum oxynitride, aluminum nitride oxide, aluminum oxide, diamond like carbon (DLC), a carbon nitride film (CN), so siloxane polymer may be used.

[0087] The insulating layer may be made of a film comprising one or more kinds of materials selected from inorganic materials (such as silicon oxide, silicon nitride, silicon oxynitride, and silicon nitride oxide) and photosensitive or nonphotosensitive organic resin materials (such as polyimide, acrylic, polyamide, polyimide amide, resist, benzocyclobutene, and siloxane polymer), or a laminated layer of these and the like.

[0088] In Embodiment Mode 2, each opening is formed only in the film containing the organic resin material. In addition to that, the openings may be formed in an insulating layer with a gate insulating film, an interlayer film and the like laminated thereon, and covered with the protective film and then applied with the scaling material. Of course, the laminated film constituting the insulating layer may comprise a conductive film. In the present invention, such laminated film is referred to as an insulating layer at least in the sense that the laminated layer includes the organic resin material. On the insulating layer, a display element made of an organic light-emitting material is formed.

[0089] The insulating layer containing the organic resin material, which can serve as a s path for contaminants, is isolated by the protective film in the interior of the display device. Accordingly, the insulating layer is shielded with the sealing material and the protective film formed thereon, and therefore the contaminants cannot penetrate into the interior of the display device even if outer edge portions of the insulating layer in the display device are exposed to the atmospheric air and moisture and oxygen exist outside of the display device penetrate into the display device through the gap between the interlayer films or the other films. Therefore, it is possible to prevent various deteriorations due to moisture, oxygen and the like such as contamination of the interior of the display device, deterioration of the electric characteristics, dark spots, and shrinkage, thereby improving the reliability of the display device. In addition, a film constituting the display device and the protective film are simultaneously formed by using the same material, and hence, the reliability of the display device to be manufactured can be farther improved without increasing the number of steps.

[0090] The organic resin materials such as acrylic, polyamide, and polyimide may be used for the insulating layer, and the materials for the insulating layer is not limited thereto.

[0091] A plurality of openings may be formed in the insulating layer, and the openings may be partly or entirely covered with the protective film and the sealing material. The openings may be formed at any portion in the interior of the display device.

[0092] Although the openings are formed so as to contact with the glass substrate **20** in FIG. **2** of the present embodiment mode, the structure of the present invention is not limited thereto. That is, the insulating film containing an organic material having a hygroscopic property may be covered with the protective film, and the depressions due to the formation of the openings may be filled with the sealing material so as to seal the openings, and therefore, the openings may be formed until the opening reaches to a film having dense structure such as a silicon nitride film.

[0093] Meanwhile, not only one protective film but also two or more protective films may be formed as depicted in FIG. **4**. In FIG. **4**, a substrate **40** and an opposing substrate **41** are bonded to each other with a scaling material **43**, and an insulating layer **42** on the substrate is isolated by a protective films **44** and **45**. In order to prevent short circuit in the insulated display device, when the insulating film is covered with a conductive film, a portion to be covered with the protective film is necessary to be designed by a mask etc. When the insulating layer is shielded with the two-layer protective films, the effect of blocking the contaminants can be further improved as compared with the case of using a one-layer protective film.

[0094] Further, inclined surfaces of the openings covered with the protective films are desirably smooth. When the inclined surfaces of the openings are not smooth, the protective films covering the surface thereof are affected by the shape of the unevenness on the surfaces. The protective films are destroyed in the portion of thin film thickness. The contaminants cannot be sufficiently blocked by such destroyed protective film, and the advantageous effect of the present invention is lessened. Accordingly, when the openings have smooth surfaces, favorable coverage of the protective films formed thereon can be obtained, thereby improving the advantageous effect of the present invention. Therefore, it is preferable to perform wet etching on a film to form an opening thereon by using a photosensitive material such that unevenness formed on the so surface of the film is reduced and its smoothness of the surface is improved.

[0095] As set forth above, the display device with high reliability in which the frame of the display device is narrowed and the contaminants causing various deteriorations are blocked can be obtained.

Embodiment

Embodiment 1

[0096] In Embodiment 1, an example of manufacturing a display device having a dual emission structure according to the present invention will hereinafter be described. In the present invention, a display panel in which an EL element formed on a substrate is to sealed between the substrate and a covering material and a display module comprising TFTs in the display panel are generically referred to as the display device. The EL element comprises a layer including an organic compound that generates electroluminescence (a light emitting layer), an anode layer, and a cathode layer. Luminescence obtained from organic compounds is classified into light emission upon returning to the base state from singlet excited state (fluorescence) and light emission upon returning to the base state from triplet excited state (phosphorescence). EL materials, which can be used for the present invention, include all light-emitting materials that emit photons via either the singlet excited state or the triplet excited state, or via each excited state.

[0097] In the present invention, all the layers that are formed between an anode and a cathode in an EL element are collectively defined as a light-emitting layer. Specifically, the light-emitting layer includes an EL layer, a hole injecting layer an electron injecting layer, a hole transporting layer an electron transporting layer, etc. Basically, the EL element comprises a structure in which an anode layer, an EL layer, and a cathode layer are sequentially laminated. In addition to that, the EL element may also comprises a structure in which an anode layer, a hole injecting layer, an EL layer, a cathode layer, etc. are sequentially laminated, or another structure in which an anode layer a hole injecting layer, an EL layer, an electron transporting layer a cathode layer, etc. are sequentially laminated.

[0098] As a base film **301**, a silicon oxynitride film with a thickness of from 10 nm to 200 nm (preferably, from 50 nm to 100 nm) is formed on a substrate **300** having an insulated surface, and a silicon nitride oxide film with a thickness of form 50 nm to 200 nm (preferably, from 100 nm to 150 nm) is laminated thereon by plasma CVD. In this embodiment, the silicon oxynitride film with a thickness of 50 nm and the silicon nitride oxide film with a thickness of 100 nm are formed by plasma CVD. As for the substrate **300**, a glass substrate, a quartz substrate, a silicon substrate, a metal substrate, or a stainless substrate each of which has an insulated surface on a surface thereof may be used. In addition, a plastic substrate or a flexible substrate, which can withstand processing temperatures of this embodiment, may be used. Further, a two-layer structure may be adopted as the base film, and a single-layer film or a laminated structure having more than two layers of the base (insulating) film may also be adopted.

[0099] Subsequently, a semiconductor film is formed on the base film. The semiconductor film may be formed to have a thickness of from 25 nm to 200 nm (preferably, from 30 nm to 150 nm) by a known technique (sputtering, LPCVD, plasma CVD, and the like). A material for the semiconductor film is not particularly limited, however, the semiconductor film is preferably formed of silicon or a silicon germanium (SiGe) alloy.

[0100] In this embodiment, an amorphous silicon film is formed as the semiconductor film to have a thickness of 54 nm by plasma CVD. In this embodiment, the amorphous silicon film is crystallized by thermal crystallization and laser crystallization with the use of a metal element for promoting crystallization. Alternatively, without introducing the metal element into the amorphous silicon film, hydrogen included in the amorphous silicon film may be released to lower hydrogen concentration to 1×10^{20} atoms/cm^3 or less by heating under a nitrogen atmosphere at a temperature of 500° C. for one hour. Thereafter, the laser crystallization may be performed. The dehydrogenation is performed

because the amorphous silicon film is damaged by laser irradiation when the film contains much hydrogen.

[0101] Nickel is used as the metal element, and is doped into the amorphous silicon film by solution application. The method of doping the metal element into the amorphous silicon film is not particularly limited on condition that the metal element can exist on the surface of or inside the amorphous silicon film. For example, a method such as sputtering, CVD, plasma processing (including plasma CVD adsorption, and a method for applying a metal salt solution can be employed. Among them, the method using the metal salt solution is simply and easily performed, and is useful for easily adjusting concentration of the metal element. At this time, an oxide film is preferably formed by ultraviolet (UV) ray irradiation under an oxygen atmosphere, thermal oxidation, treatment with ozone water or hydrogen peroxide including hydroxyl radical, and the like in order to improve wettability of the surface of an amorphous semiconductor film and to spread aqueous solution over an entire surface of the amorphous silicon film.

[0102] Subsequently, a heat treatment is performed at temperatures of from 500° C. to 550° C. for from 4 hours to 20 hours to crystallize the amorphous silicon film. In this embodiment, after forming a metal-containing layer by solution application with the use of nickel as the metal element, the metal-containing layer is introduced on the amorphous silicon film, and heat treatment is performed thereto at a temperature of 550° C. for four hours, thereby obtaining a first crystalline silicon film.

[0103] Next, the first crystalline silicon film is irradiated with laser beam to promote crystallization, and therefore a second crystalline silicon film is obtained. Laser crystallization is performed by irradiating laser beam to the semiconductor film. A solid-state laser, a gas laser or a metal laser of continuous oscillation is preferable to be used for the laser crystallization. The solid-state laser includes: YAG laser, YVO_4 laser, YLF laser, $YAlO_3$ laser, glass laser, ruby laser, alexandrite laser, Ti:sapphire laser, and the like of continuous oscillation. The gas laser includes: Ar laser, Kr laser, CO_2 laser, and the like of continuous oscillation. The metal laser includes: helium cadmium laser, copper vapor laser, and gold vapor laser of continuous wave oscillation. Note that an excimer laser of continuous light emission can also be applied. The laser beam may be converted to higher harmonics by a nonlinear optical device. A crystal used for the nonlinear optical device such as LBO, BBO, KDP, KTP, KB5, and CLBO is superior in conversion efficiency. The conversion efficiency can be drastically so increased by introducing such nonlinear optical device into a laser resonator. A laser of the higher harmonics is typically doped with Nd, Yb, Cr, and the like, and these are excited to oscillate laser beam. The type of a dopant may be appropriately selected by those who operate the present invention.

[0104] For example, the semiconductor film may be made of a material as follows: an amorphous semiconductor (hereinafter referred to as "AS") manufactured by vapor phase growth or sputtering with the use of semiconductor material gas represented by silane, germanium etc.; a polycrystalline semiconductor manufactured by crystallizing the amorphous semiconductor with the use of light energy, thermal energy etc.; a semi-amorphous (which is also referred to as a microcrystal) semiconductor (hereinafter referred to as "SAS"), and the like.

[0105] The SAS is a semiconductor which comprises an intermediate structure between an amorphous structure and a crystalline structure (including single crystal and poly crystal), and a third stable state in view of free energy. The SAS further includes a crystalline region having a short-range order along with lattice distortion. A crystalline region in a range of from 0.5 nm to 20 nm can be observed in a part of the region among the semi-amorphous semiconductor film. In the case where the semi-amorphous semiconductor film contains silicon as its principal constituent, the Raman spectrum is shifted to a lower wavenumber side than 520 cm^{-1}. The diffraction peak of (111) and (220) which is believed to be originated in a crystalline silicon lattice, is observed in the semi-amorphous semiconductor film by X-ray diffraction. Further, the semi-amorphous semiconductor film is added with at least 1 atom % of hydrogen or halogen as a naturalizing agent for dangling bonds. The SAS is formed by glow discharge decomposition with silicide gas (by plasma CVD). As for the silicide gas, in addition to SiH_4, Si_2H_6, SiH_2Cl_2, $SiHCl_3$, SiC_4, SiF_4, and the like can be used. Furthermore, GeF_4 may be mixed in the above-mentioned gases for the silicide gas. The silicide gas may also be diluted in one or more rare gas elements selected from the group consisting of H_2, a mixture of H_2 and He, Ar, Kr, and Ne. The dilution ratio is in the range of 1:2 to 1:1,000. The pressure is approximately in the range of from 0.1 Pa to 133 Pa. The power supply frequency is in a range of from 1 MHz to 120 MHz, preferably 13 MHz to 60 MHz. The substrate heating temperature may be at most at 300° C. As for the impurity element in a film, respective concentrations of impurities of atmospheric constituents such as oxygen, nitrogen, or carbon are preferably set to $1\times10^2/cm^{-1}$ or less; in particular, the oxygen concentration is set to $5\times10^{19}/cm^3$ or less, more preferably, $1\times10^{19}/cm^3$ or less. Note that, a compound semiconductor film having an amorphous structure such as an amorphous silicon germanium film, and an amorphous silicon carbide film may also be employed.

[0106] The crystalline semiconductor film thus obtained is patterned by a patterning treatment using photolithography so as to form semiconductor layers **305** to **308**.

[0107] After forming the semiconductor layers **305** to **308**, minute amounts of impurity elements (boron or phosphorous) may be doped to control a threshold value of a TFT.

[0108] Subsequently, a gate insulating film **309** covering the semiconductor layers **305** to **308** is formed. The gate insulating film **309** is formed of an insulating film including silicon to have a thickness of from 40 nm to 150 nm by plasma CVD or sputtering. In this embodiment, a silicon oxynitride film is formed to have a thickness of 115 nm by plasma CVD. The material for the gate insulating film is not limited to the silicon oxynitride film, and other insulating films with a single layer structure or a laminated structure may be used.

[0109] A first conductive film with a film thickness of from 20 nm to 100 nm and a second conductive film with a film thickness of from 100 nm to 400 nm are formed and laminated over the gate insulating film. The first and the second conductive films may be made of an element selected from Ta, W, Ti, Mo, Al, and Cu, or an alloy material or a compound material having the foregoing element as a main component. A semiconductor film represented by a polycrystalline silicon film that is doped with an impurity element such as phosphorus or an AgPdCu alloy may be used as the first and the second conductive films. The

conductive films are not limited to a two-layer structure, and, for example, a three-layer structure in which a 50-nm-thick tungsten film, a 500-nm-thick alloy (Al—Si) film of aluminum and silicon, and a 30-nm-thick titanium nitride film are sequentially laminated may be applied. In the case of the three-layer structure, tungsten nitride may be used as substitute for tungsten of the first conductive film; an alloy (Al—Ti) film of aluminum and titanium may be used as substitute for an alloy (Al—Si) film of aluminum and silicon of the second conductive film; or a titanium film may be used as substitute for a titanium nitride film of a third conductive film. Further, a single layer structure may also be applied. In this embodiment, a tantalum nitride film **310** of 30 nm in thickness and a tungsten film **311** of 370 nm in thickness are sequentially laminated over the gate insulating film **309** (FIG. **8**A).

[0110] Next, a mask comprising a resist is formed by photolithography, and a first etching treatment is performed to form an electrode and a wiring. The first conductive film and the second conductive film can be etched into a desired tapered shape by appropriately adjusting etching conditions (such as electric energy applied to a coil-shaped electrode, electric energy applied to an electrode on a substrate side, and temperature of the electrode on the substrate side) with the used of ICP (Inductively Coupled Plasma) etching. For an etching gas, a chlorine-based gas typified by Cl_2, BCl_3, $SiCl_4$, CCl_4 and the like; a fluorine-based gas typified by CF_4, SF_6, NF_3 and the like; or O_2 can be appropriately used.

[0111] A first-shape conductive layer (a first conductive layer and a second conductive layer) comprising the first conductive layer and the second conductive layer is formed by the first etching treatment.

[0112] Subsequently, a second etching treatment is performed without removing a mask made of resist. Here, a W film is etched selectively. Then, the second conductive layers **322***b* to **326***b* are formed by the second etching treatment. On the other hand, the first conductive layers **322***a* to **326***a* are hardly etched, and second-shape conductive layers **322** to **326** are formed (FIG. **8**B).

[0113] An impurity element imparting n-type conductivity is added to the semiconductor layer in low concentration by performing a first doping treatment without removing the mask made of the resist. The doping treatment may be performed by ion doping or ion implantation. An element belonging to Group 15 in the periodic table, typically phosphorus (P) or arsenic (As) is used for the impurity element imparting n-type conductivity, and phosphorus (P) is used here. In this case, the second-shape conductive layers **322** to **326** serve as masks for preventing the impurity element imparting n-type conductivity from being doped into the semiconductor layer, and an impurity region is formed in a self-aligning manner. The impurity region is doped with the impurity element imparting n-type conductivity in a concentration range of from 1×10^{18} atoms/cm^3 to 1×10^{20} atoms/cm^3.

[0114] After removing the mask made of the resist, another mask made of a resist is newly formed, and a second doping treatment is performed at a higher accelerating voltage than the first doping treatment. The second doping treatment is performed by using the second conductive layers **323***b* and **326***b* as masks for preventing the impurity element from doping into the semiconductor layer so as to add the impurity element to the semiconductor layer below the tapered portion of the first conductive layers **322***a* to **326***a*. Subsequently, a third doping treatment is performed at a lower accelerating voltage than the second doping treatment. According to the second doping treatment and the third doping treatment, a lower concentration impurity region **335** overlapping the first conductive layer is added with the impurity element imparting n-type conductivity in a concentration range of from 1×10^{18} atoms/cm^3 to 5×10^{19} atoms/cm^3, and higher concentration impurity regions **334** and **337** are added with the impurity element imparting n-type conductivity in a concentration range of from 1×10^{19} atoms/cm^3 to 5×10^{21} atoms/cm^3.

[0115] Of course, the lower concentration impurity region and the higher concentration impurity regions can be formed by once doping treatment with a combination of the second doping treatment and the third doping treatment by setting an accelerating voltage appropriately.

[0116] Next, after removing the mask made of the resist, still another mask made of a resist is newly formed, and a fourth doping treatment is carried out. According to the fourth doping treatment, impurity regions **343**, **344**, **347**, and **348** that are added with an impurity element imparting a conductivity type opposite to the previously doped conductivity type are formed in the semiconductor layers to be active layers of a p-channel TFT. The impurity regions are formed in a self-aligning manner by using the second-shape conductive layers **322** and **326** as masks for preventing the impurity element from doping into the semiconductor layer and by adding an impurity element imparting p-type conductivity. In this embodiment, the impurity regions **343**, **344**, **347**, and **348** are formed by ion doping using diborane (B_2H_6). In the case of the fourth doping treatment, a semiconductor layer forming an n-channel TFT is covered with the mask made of the resist. According to the first to third doping treatments, the impurity regions are doped with phosphorus in different concentrations, respectively. However, any problems do not arise since the impurity regions function as a source region and a drain region of a p-channel TFT by carrying out the doping treatments so as to have a concentration of an impurity element imparting p-type conductivity of from 1×10^{19} atoms/cm^3 to 5×10^{21} atoms/cm^3.

[0117] According to the above-described steps, the impurity regions are formed in each semiconductor layer (FIG. **8**C).

[0118] Subsequently, the mask comprising the resist is removed, and an insulating film **349** is formed as a passivation film. The insulating film **349** is formed of an insulating film including silicon with a thickness of from 100 nm to 200 nm by plasma CVD or sputtering (FIG. **9**A). Of course, the insulating film **349** is not limited to a silicon oxynitride film, and other insulating films including silicon and having a single layer structure or a laminated structure may be adopted. In this embodiment, a silicon oxynitride film of 150 nm in thickness is formed by plasma CVD.

[0119] Moreover, a step of hydrogenating the semiconductor layers is performed by heat treatment at temperatures of from 300° C. to 550° C. for 1 hour to 12 hours under a nitrogen atmosphere. The step is preferably performed at temperatures of from 400° C. to 500° C. The step is a step for terminating dangling bonds of the semiconductor layers due to hydrogen contained in the first insulating film **349**. In this embodiment, the heat treatment is performed at 410° C. for one hour.

[0120] The insulating film **349** is formed of a material selected from silicon nitride, silicon oxide, silicon oxynitride

(SiON), silicon nitride oxide (SiNO), aluminum nitride (AlN), aluminum oxynitride (AlON), aluminum nitride oxide having more nitrogen content than oxygen content (AlNO), aluminum oxide, diamond like carbon (DLC), and a carbon nitride (CN) film.

[0121] In the present invention, a silicon oxynitride (SiON) film denotes a film containing Si of from 25 atom % to 35 atom %, oxygen of from 55 atom % to 65 atom %, nitrogen of from 1 atom % to 20 atom %, and hydrogen of from 0.1 atom % to 10 atom %. Meanwhile, a silicon nitride oxide (SiNO) film denotes a film including Si of from 25 atom % to 35 atom %, oxygen of from 15 atom % to 30 atom %, nitrogen of from 20 atom % to 35 atom %, and hydrogen of from 15 atom % to 25 atom %.

[0122] In order to activate the impurity element, heat-treatment, irradiation of intense light, or irradiation of laser beam may be carried out. Simultaneously with the activation, plasma damage in the gate insulating film or plasma damage in an interface between the gate insulating film and the semiconductor layer can be repaired.

[0123] An interlayer film **350** containing an organic resin material is formed on the insulating film **349**. As the interlayer film **350**, a film comprising one kind of or plural kinds of materials selected from inorganic materials (such as silicon oxide, silicon nitride, silicon oxynitride, and silicon nitride oxide) and photosensitive or nonphotosensitive organic materials (or organic resin materials) (such as polyimide, acrylic, polyamide, polyimide amide, resist, benzocyclobutene, and siloxane polymer), or a laminated layer of these and the like can be used. Further, a negative type photosensitive organic material that becomes insoluble in etchant by photosensitive light, and a positive type photosensitive organic material that becomes soluble in etchant by light, can be also used as the interlayer film. In this embodiment, the interlayer film **350** is made of a positive photosensitive acrylic that is the photosensitive organic resin material. A curved surface having a curvature radius (0.2 μm to 3.0 μm) only in an upper edge portion of the interlayer film is preferably provided in the case of using the positive photosensitive acrylic. Thereafter, a passivation film made of the following materials may be formed on the interlayer film **350**: silicon nitride; silicon oxide; silicon oxynitride (SiON); silicon nitride oxide (SiNO); aluminum nitride (AlN); aluminum oxynitride (AlON); aluminum nitride oxide having more nitrogen content than oxygen content (AlNO); aluminum oxide; diamond like carbon (DLC); a carbon nitride (CN) film; or siloxane polymer.

[0124] Subsequently, the interlayer film **350**, the insulating film **349**, and the gate insulating film **309** are etched to form openings that are in contact with a source region and a drain region. In order to form the openings, the insulating film **349** and the gate insulating film may be etched by newly forming a mask after etching the interlayer film or by using the etched interlayer film **350** as the mask. Then, a metal film is formed and etched so as to form a source electrode or drain electrode **352**, and each wiring (not shown) for electrically connecting to each impurity region, respectively. The metal film may be made of a film comprising an element of aluminum (Al), titanium (Ti), molybdenum (Mo), tungsten (W), pr silicon (Si), of an alloy film comprising these elements. In this embodiment, after laminating a titanium film/a silicon-aluminum alloy film/a titanium film (Ti/Si-Al/Ti) to be 100 nm/350 nm/100 nm in thickness respectively, the source electrode or drain electrode **352** and each wiring (not shown) are formed by patterning and etching the laminated film into a desired shape.

[0125] In this embodiment, after forming the interlayer film **350**, an opening **1018** connecting to the substrate **300** is formed in a sealing region. A protective film **1019** is formed so as to cover the opening **1018**. The protective film **1019** and the source electrode or drain electrode **352** are made of the same material through the same processing step.

[0126] Subsequently, a pixel electrode **353** is formed. In this embodiment, a transparent conductive film is formed and etched into a predetermined shape to form the pixel electrode **353** (FIG. **8**B).

[0127] As for the transparent conductive film, for example, a compound of indium oxide and tin oxide, a compound of indium oxide and zinc oxide, zinc oxide, tin oxide, or indium oxide can be used. A transparent conductive film doped with gallium may also be used. The pixel electrode **353** may be formed on a flat interlayer insulating film prior to the formation of the above-mentioned wirings. It is effective to planarize a step due to a TFT by using a planarizing film comprising resin. Since an EL layer to be formed later is very thin, the step may cause a defect in light emission. Consequently, the step is preferably leveled before forming the pixel electrode so as to form the EL layer on a surface as smooth as possible.

[0128] According to the above-described steps, an active matrix substrate comprising so a TFT is completed. In this embodiment, the active matrix substrate comprises a double gate structure in which two channel formation regions are formed in the n-channel TFT of the pixel region. Furthermore, the active matrix substrate may comprise a single gate structure having one channel formation region or a triple gate structure having three channel formation regions. Although a TFT for the driving circuit portion comprises a single gate structure in this embodiment, the TFT may have a double gate structure or a triple gate structure.

[0129] Not limited to a method for manufacturing a TFT described in this embodiment, the present invention can be applied to a top gate type (planar type), a bottom gate type (inversely staggered type), or a dual gate type having two gate electrodes disposed above and below a channel region while interposing a gate insulating film therebetween.

[0130] As shown in FIG. **10**, an insulator **1012** is formed after forming the pixel electrode **353**. The insulator **1012** may be formed by patterning an insulating film or an organic resin film including silicon with a thickness of from 100 nm to 400 nm.

[0131] Since the insulator **1012** is an insulating film, electrostatic discharge damage to a device in deposition needs attention. In this embodiment, the resistivity is reduced by adding a carbon particle or a metal particle into an insulating film to be a material of the insulator **1012**, thereby suppressing generation of static electricity. At this time, the amount of a carbon particle or a metal particle to be added may be adjusted such that the resistivity becomes from 1×10^{6} Ωm to 1×10^{12} Ωm (preferably from 1×10^{8} Ωm to 1×10^{10} Ωm).

[0132] An EL layer **1013** is formed on the pixel electrode **353**. Only one pixel is shown in FIG. **10**; however, in this embodiment, EL layers corresponding to respective colors of R (red), G (green), and B (blue) are formed separately. In this embodiment, a low molecular weight organic light-emitting material is formed by vapor deposition. Specifically, the EL layer has a laminated structure having a copper

phthalocyanine (CuPc) film provided with a thickness of 20 nm as the hole injecting layer and a tris-8-quinolinolato aluminum complex (Alq_3) film provided thereupon with a thickness of 70 nm as the EL layer. Colors of light emission can be controlled by adding fluorescent dye such as quinacridone, perylene, or DCM 1 to Alq_3.

[0133] However, the foregoing example is one example of the organic light-emitting material, which can be used as the EL layer and the organic light-emitting material is not necessarily limited thereto. The EL layer (layer for light emission and for carrier movement for the light emission) may be formed by freely combining the EL layer the charge transporting layer and the charge injecting layer. Although the example in which the low molecular weight organic light-emitting material is used as the EL layer is described in this embodiment, for example, an intermediate molecular weight organic light-emitting material or a high molecular weight organic light-emitting material may be used as substitute for the low molecular weight organic light-emitting material. Throughout the present specification, an organic light-emitting material which does not sublimate and has molecularity of equal to or less than 20 or a molecular chain length of equal to or less than 10 μm is defined as the intermediate molecular weight organic light-emitting material. In addition, as an example of using the high molecular weight organic light-emitting material, a laminated structure having a polythiophene (PEDOT) film provided by spin coating with a thickness of 20 nm as the hole injecting layer and a paraphenylene-vinylene (PPV) film with a thickness of approximately 100 nm provided thereupon as the EL layer may be given. In addition, emission wavelength can be selected from red through blue by using m-conjugated polymer of PPV. An inorganic material such as silicon carbide can be used for the charge transporting layer and the charge injecting layer. These organic light-emitting materials and inorganic materials can be made of known materials.

[0134] Next, a cathode **1014** comprising a conductive film is provided on the EL film **1013**. The cathode **1014** may be made of a material having lower work function (for example, Al, Ag, Li, and Ca, or alloy of these elements such as MgAg, MgIn, AlLi, CaF_2, and CaN). In the present embodiment, the cathode **1014** is formed by laminating a thin metal film (MgAg: 10 nm in thickness), a 110-nm-thick transparent conductive film (such as ITO (indium tin oxide alloy), indium zinc oxide alloy, zinc oxide, tin oxide, and indium oxide) such that light generated in the EL layer passes through the cathode.

[0135] An EL element **1015** is completed at the time of forming up to the cathode **1014**. The EL element **1015** is made of the pixel electrode (anode) **353**, the EL layer **1013**, and the cathode **1014**.

[0136] It is effective to provide a passivation film **1022** so as to completely cover the EL device **1015**. The passivation film is made of an insulating film including an element as follows: silicon nitride; silicon oxide; silicon oxynitride (SiON); silicon nitride oxide (SiNO); aluminum nitride (AlN); aluminum oxynitride (AlON); aluminum nitride oxide (AlNO) containing more nitrogen content than oxygen content; aluminum oxide; diamond like carbon (DLC); a carbon nitride film (CN); or siloxane polymer. The passivation film may be formed by the single-layer insulating film or a laminated layer of these insulating films.

[0137] In such the case, a film favorable in coverage is preferably used as the passivation film. It is effective to use a carbon film, particularly a DLC film. Since the DLC film can be formed in a temperature range of from room temperature to equal to or less than 100° C., the DLC film can be easily formed above the EL layer **1013** having low heat resistance. The DLC film has a high blocking effect to oxygen and can suppress oxidization of the EL layer **1013**. Consequently, a problem of oxidation of the EL layer **1013** during the following sealing step can be avoided.

[0138] According to the embodiment, in the sealing region, the sealing material **1017** is applied on the protective film **1019** so as to fill the depressions generated due to the openings, thereby adhering (bonding) the substrate **300** and the covering material **1021**. In this embodiment, the protective film **1019** and the wirings are made of the same material through the same step.

[0139] The material for a scaling material **1017** is not particularly limited, and the scaling material is preferably made of typical visible light curable resin, ultraviolet curable resin, or thermal curable resin. In this embodiment, thermal curable epoxy resin is used for the sealing material **1017**. Further, the covering material **1021** is made of a glass substrate, a quartz substrate, a plastic substrate (including a plastic film), or a flexible substrate with carbon films (more preferably, a DLC film or a CN film) formed on each surface thereof. Aluminum films (such as AlON, AlN, and AlO), SiN, and the lie can be used as well as the carbon films.

[0140] Thus, a dual emission display device, which can emit light in an upward direction and a downward direction, having a structure as shown in FIG. **10** is completed. A region in which the edge portion of the insulating layer of the display device is exposed in FIG. **10** is covered with the protective film **1019** in FIG. **15**. In FIG. **15**, reference numeral **1500** is a substrate, reference numeral **1550** is an interlayer insulating film, reference numeral **1552** is an electrode, reference numeral **1512** is an insulating film, reference numeral **1515** is a pixel electrode, reference numeral **1513** is an EL layer reference numeral **1514** is a cathode, reference numeral **1553** is an EL element, and reference numeral **1530** is a passivation film. In a sealing region, an opening portion **1518** is formed at the side of the substrate **1500**, and the opening portion **1518** is covered with a protective film **1519**. The substrate **1500** and a cover member **1521** are adhered with each other by a sealing member **1517**. In FIG. **15** of the present invention, the openings and the edge portion of the insulating layer are covered with the same protective film **1519**. However, each opening and the edge portion of the insulating layer may be covered with different protective films, respectively. According to the structure in FIG. **15**, intrusion of the contaminants into the interior of the display device can be further prevented, thereby enhancing the reliability of the display device.

[0141] It is effective to continuously carry out the steps of up to forming the passivation film after forming the insulator **1012** by using a deposition apparatus having a multi-chamber system (or an in-line system) without exposure to the atmosphere. In addition, with further development, the steps of up to sealing with the covering material **1021** can be carried out without exposure to the atmospheric air.

[0142] By providing an impurity region overlapping a gate electrode with an insulating film therebetween, an n-channel TFT resistive to deterioration resulting from a hot-carrier effect can be formed. Consequently, a semiconductor device with high reliability can be realized.

[0143] In this embodiment, only a structure of a pixel portion and a driving circuit is shown. However according to the manufacturing steps in this embodiment, logic circuits such as a signal division circuit, a D/A converter, an operation amplifier, and a γ-correction circuit can be also formed on the same insulator. Furthermore, a memory or a microprocessor can be formed thereon.

[0144] In this embodiment, the opening **1018** is formed in the insulating layer including the organic resin material and the surface thereof is covered with the protective film **1019**. Therefore, the insulating layer that becomes a path for the contaminants is isolated, which prevents the contaminants from penetrating into a display element. In the case where the protective film **1019** is made of a conductive film, it is necessary to design a portion to be covered with the protective film by a mask etc. so as to prevent a short circuit inside the display device. As shown in FIG. **4**, when the insulating layer is isolated by the protective film with a laminated structure for covering the openings, the effect of blocking the contaminants is further improved as compared with the case of using the protective film with a single layer.

[0145] According to the present invention, the path for moisture, which is the insulating layer containing the organic resin material of the display device is shut out. As a result, it is possible to prevent moisture and oxygen exist outside of the display device from penetrating into a display element inside the display device via the insulating film having a hygroscopic organic material and the like. Therefore, various deteriorations caused by moisture and oxygen such as contamination of the interior of the display device, deterioration in the electric characteristics, a dark spot, and shrinkage can be prevented, thereby enhancing the reliability of the display device. In addition, since a film made of the same material as the film constituting the display device is used as the protective film for covering the openings, a display device with high reliability can be manufactured without increasing the number of the steps.

Embodiment 2

[0146] In Embodiment 2, an example of a display device manufactured according to Embodiment 1, which has a different structure in a sealing region from that in Embodiment 1, will be described with reference to FIG. **11**.

[0147] In FIG. **11**, reference numeral **1100** denotes a substrate, reference numeral **1101** denotes an electrode, reference numeral **1111** denotes a pixel electrode, reference so numeral **1112** is an insulating film, reference numeral **1113** denotes an EL layer, reference numeral **1114** denotes a cathode, reference numeral **1115** denotes an EL element, and reference numeral **1130** denote a passivation film. In a scaling region, depressions **1121***a*, **1121***b* and **1121***c* are formed at the side of the substrate **1100** by openings **1125***a*, **1125***b*, and **1125***c* and a protective film **1118** for covering the openings. At the side of the covering material **1123**, projections **1122***a*, **1122***b*, and **1122***c* are formed by insulators **1120***a*, **1120***b*, and **1120***c*, and another protective film **1117** for covering the insulators. The substrate **1100** having the depressions and the covering material **1123** having the projections are adhered to each other so as to face each depression and each projection.

[0148] In this embodiment, the protective film **1118** and the electrode **1101** are made of a same material through same steps. The protective films **1118** and **1117** may be made of one kind or plural kinds of films selected form thin conductive films and thin insulating films. As for the thin conductive films, a film made of one or more elements selected from Al, Ti, MO, W, and Si may be used. As for the thin insulating film, a film composed of one or more materials selected from silicon nitride, silicon oxide, silicon nitride oxide, aluminum nitride, aluminum oxynitride, aluminum nitride oxide, aluminum oxide, diamond like carbon (DLC), a carbon nitride (CN) film, and siloxane polymer may be used.

[0149] An interlayer film **1124** may be made of a film comprising one kind or plural kinds of materials selected from inorganic materials (such as silicon oxide, silicon nitride, silicon oxynitride, and silicon nitride oxide) and photosensitive or nonphotosensitive organic resin materials (such as polyimide, acrylic, polyamide, polyimide amide, resist, benzocyclobutene, and siloxane polymer), or a laminated layer of these and the like. In this embodiment, the interlayer film **1124** is made of photosensitive acrylic.

[0150] In this embodiment, in order to form the projections at the side of the covering material, the insulators (also referred to as banks, partition walls, barriers, embankments etc.) **1120***a*, **1120***b*, and **1120***c* and the protective film **1117** are laminated. However the present invention is not limited to the laminated structure. The projections may be so formed by a single layer structure or a laminated structure comprising four or more layers, or by processing the covering material. The covering material may be processed by mechanically cutting the covering material in accordance with the material of the covering material, or by dry etching or wet etching to form the projections. When the projections are formed by using a film at the side of the covering material, the material for the projections is not particularly limited, and the above-mentioned materials used for the protective film and the interlayer film may be used. In this embodiment, the insulators **1120***a*, **1120***b*, and **1120***c* are made of the photosensitive acrylic which is an organic resin material, whereas the protective film **1117** is made of a silicon nitride film.

[0151] The depressions **1121***a*, **1121***b*, and **1121***c* in the sealing region are formed so as to contact with the substrate in this embodiment. Alternatively, these depressions may be formed until they contact with a dense base film. The openings may be formed in a hydrophilic film, which serves as a path for moisture, and hence, the depth of each opening may be set arbitrarily. Although the openings may be covered with a single-layer protective film in this embodiment, the openings may also be covered with a laminated protective film in which plural films are laminated.

[0152] Since the depressions formed over the substrate **1100** and the projections formed over the covering material **1123** are formed so as to match with each other, a sealing material sandwiched therebetween is pressed, extended, and adhered to a gap between the depressions and projections. Accordingly, when minute amounts of moisture and oxygen penetrate through the sealing material, such contaminants hardly intrude into the interior of the display device since the contaminants have to move along a long zigzag path due to the depressions and projections.

[0153] Meanwhile, as illustrated in FIG. **16**, a portion in which the edge portion of the insulating layer of the display device in this embodiment is exposed, is covered with the protective film **1118**. In FIG. **16**, reference numeral **1600** is a substrate, reference numeral **1601** is an electrode, reference numeral **1611** is a pixel electrode, reference **1612** is an

insulating film, reference numeral **1613** is an EL layer reference numeral **1614** is a cathode, reference numeral **1615** is an EL element, and reference numeral **1630** is a passivation film. In a sealing region, depressions **1621***a*, **1621***b* and **1621***c* are formed at the side of the substrate **1600** by openings **1625***a*, **1625***b*, and **1625** *c* and a protective film **1618** for covering the openings. At the side of the covering material **1623**, projections **1622***a*, **1622***b*, and **1622***c* are formed by insulators **1620***a*, **1620***b*, and **1620***c*, and another protective film **1617** for covering the insulators. The substrate **1600** having the depressions and the covering material **1623** having the projections are adhered to each other by a sealing member **1619** so as to face each depression and each projection. In this embodiment, a region between the openings and the edge portion of the insulating layer is covered with the same protective film **1617** and **1618**. However, the openings and the edge portion of the insulating layer may be covered with different protective films, respectively. According to the structure in FIG. **15**, intrusion of the contaminants into the interior of the display device can be further prevented, thereby enhancing the reliability of the display device.

[0154] According to the present invention, even if moisture and oxygen penetrate through the sealing material and the interlayer film **1124** made of acrylic etc., which is exposed to the atmospheric air, since moisture and oxygen are shut out by the protective film, an EL element and TFTs formed inside the display device can be protected. As a result, deterioration of an EL display device due to moisture and oxygen can be prevented. When a plurality of protective films are laminated, the function of blocking the contaminants such as moisture can be further improved, thereby obtaining a display device with higher reliability.

[0155] Although the foregoing structure of the sealing region is applied to the case of the EL display device in this embodiment, the structure of the sealing region of the present invention can also be applied to a liquid crystal display device. In the case of the liquid crystal display device, a display device in which a display portion is formed of a liquid crystal as substitute for the EL element may be manufactured by utilizing the structure of the sealing region according to the present invention.

Embodiment 3

[0156] In Embodiment 3, an arrangement of wirings formed around the periphery of a display device will be described with reference to FIG. **17**. In this embodiment, a protective film and the wirings are made of a same material through same steps.

[0157] In FIG. **5**, in a portion **411** surrounded by a circle, the wirings for a pixel portion are connected to a FPC (flexible printed circuit). The arrangement of the wirings of the display device according to the present invention is depicted in FIG. **17**. A first anode **2202** having an outermost wiring connected to the FPC is arranged in the outmost edge of the device, whereas a cathode **2201** is arranged in the innermost edge of the device. Subsequently, a sealing material is formed so as to cover a connection portion between the outermost first anode **2202** and the FPC. The periphery of the display device comprises a first region with the first anode formed thereon and a second region where is the connection portion between the wirings and the FPC. In this embodiment, the second region resides in one side of the periphery of the display device composed of four sides, whereas the first regions reside in the other three sides thereof.

[0158] FIG. **18** shows a cross sectional view taken along a like B-B' of the display device in FIG. **17**. An electrode **62** connected to the FPC is formed on a substrate **60**, and the sealing material **63** is formed thereon. A film such as an interlayer film including an organic resin material underneath the electrode, which is connected to the FPC, is removed by etching and the like in advance, and an insulating layer including the organic resin material etc. is not exposed to the outer portion. Therefore, in the edges of the display device, the insulating layer including the organic resin material underneath the sealing material is perfectly protected from the outside air with the protective film made of the same material as the anodes, and the scaling material. In the display device according to the present invention, the peripheral edges thereof can be completely covered with no space, thereby blocking moisture sufficiently.

[0159] With respect to the arrangement of the wirings, an outermost wiring may be connected to the other wiring such as the FPC at the outmost portion, and the kind, polarity, and number of the wirings may be arbitrarily selected.

Embodiment 4

[0160] Various display devices (such as an active matrix display device, and an active matrix EC display device) can be manufactured by applying the present invention. That is, the present invention can be applied to various electronic equipment in which such display devices are incorporated in display portions.

[0161] The following can be given as such electronic equipment a video camera; a digital camera; a projector; a head mounted display (a goggle type display); a car navigation system; a car stereo; a personal computer; a mobile information terminal (such as a mobile compute a cellular phone, and an electronic book); and the like. Examples of the electronic equipment are illustrated in FIGS. **12**A to **12**F, and **13**A to **13**C.

[0162] FIG. **12**A is a personal computer including a main body **3001**, an image input portion **3002**, a display portion **3003**, a keyboard **3004**, and the like. The personal computer of the present invention is completed by applying the present invention to the display portion **3003**.

[0163] FIG. **12**B is a video camera including a main body **3101**, a display portion **3102**, a voice input portion **3103**, operation switches **3104**, a battery **3105**, an image receiving portion **3106**, and the like. The video camera of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3102**.

[0164] FIG. **12**C is a mobile computer including a main body **3201**, a camera section **3202**, an image receiving portion **3203**, an operation switch **3204**, a display portion **3205**, and the like. The mobile computer of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3205**.

[0165] FIG. **12**D is a goggle type display including a main body **3301**, a display portion **3302**, an arm portion **3303**, and the like. A flexible substrate is used as a substrate for the display portion **3302**, and the goggle type display is manufactured by making the display portion **3302** carved. A lightweight and thin goggle type display is realized. The

goggle type display of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3302**.

[0166] FIG. **12**E is a player using a recording medium recording a program (hereinafter referred to as a recording medium) which includes a main body **3401**, a display portion **3402**, a speaker portion **3403**, a recording medium **3404**, operation switches **3405**, and the like. The player uses a DVD (digital versatile disc), a CD (compact disc), and the like as the recording medium, and can be used for music appreciation, film appreciation, games, and Internet. The recording medium of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3402**.

[0167] FIG. **12**F is a digital camera including a main body **3501**, a display portion **3502**, a view finder **3503**, operation switches **3504**, an image receiving portion (not shown), and the like. The digital camera of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3502**.

[0168] FIG. **13**A is a cellular phone including a main body **3901**, a voice output portion **3902**, a voice input portion **3903**, a display portion **3904**, operation switches **3905**, an antenna **3906**, and the like. The cellular phone of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **3904**.

[0169] FIG. **13**B is a portable book (electronic book) including a main body **4001**, display portions **4002** and **4003**, a recording medium **4004**, operation switches **4005**, an antenna **4006**, and the like. The mobile book of the present invention is completed by applying the display device manufactured according to the present invention to the display portions **4002** and **4003**.

[0170] FIG. **13**C is a display including a main body **4101**, a supporting section **4102**, a display portion **4103**, and the like. The display portion **4103** is manufactured by using a flexible substrate, thereby realizing a lightweight and thin display. In addition, the display portion can be made curved. The display of the present invention is completed by applying the display device manufactured according to the present invention to the display portion **4103**.

[0171] As set forth above, the application range of the present invention is extremely so wide, and the present invention can be applied to the electronic equipment in various fields.

Embodiment 5

[0172] In Embodiment 5, an example of a one-sided emission type display device manufactured according to Embodiment 1 will be described with reference to FIGS. **19**A and **19**B.

[0173] In FIG. **19**A, reference numeral **1900** denotes a substrate, reference numeral **1950** is an interlayer insulating film, reference numeral **1952** denotes an electrode, reference numeral **1953** denotes a pixel electrode, reference numeral **1913** denotes an EL layer, reference numerals **1914**, **1923** denote cathodes, reference numeral **1915** denotes an EL element, reference numeral **1922** denotes a passivation film, and reference numeral **1921** denotes a covering material. In a sealing region, an opening **1918** is formed at the side of the substrate **1900**, and the opening is covered with the protective film **1919**. The covering material **1921** and the substrate **1900** are bonded to each other with a scaling material **1917** formed over the opening and a protective film.

[0174] A display device as illustrated in FIG. **19**A is a one-sided emission type and has a structure in which light is emitted in an upward direction as depicted by an arrow. In this case, the pixel electrode **1953** functions as an anode and is made of a reflective metal film. As for the reflective metal film, a metal film having higher work function such as platinum (Pt), and gold (Au) is used for making the metal film to serve as the anode. Since such metal films having higher work function are expensive, the pixel electrode may be formed as follows. The metal films having higher work function is laminated on an inexpensive metal film such as aluminum film and a tungsten film such that platinum or gold is exposed at least on a top surface. The cathode **1914** is a thin metal film (preferably with a thickness of from 10 nm and 50 nm), and is made of a material including an element belonging to Group 1 or 2 in the periodic table (for example, Al, Ag, Li, Ca, or an alloy of these such as MgAg, MgIn, AlLi, CaF_2, and CaN) with lower work function in order to make the metal film to function as a cathode. Further, a conductive oxide film (typically, an ITO film) that serves as the cathode **1923** is laminated on the cathode **1914**, and then the passivation film **1922** is formed thereon.

[0175] When the structure as illustrated in FIG. **19**A is employed, light generated from the EL element is reflected by the pixel electrode **1953**, and emitted through the cathodes **1914** and **1923**.

[0176] In FIG. **19**B, reference numeral **1800** denotes a substrate, reference numeral **1852** denotes an electrode, reference numeral **1853** denotes a pixel electrode, reference numeral **1813** denotes an EL layer, reference numeral **1814** denotes a cathode, reference numeral **1815** denotes an EL element, reference numeral **1822** denotes a passivation film, and reference numeral **1821** denotes a covering material. In the sealing region, an opening **1818** is formed at the side of the substrate **1800**, and the opening is covered with a protective film **1819**. The covering material **1821** and the substrate **1800** are bonded together with a sealing material **1817** provided between the opening and the protective film.

[0177] FIG. **19**B also shows a display device of one-sided emission type, which emits light in a downward direction as depicted by an arrow. In this embodiment, a transparent conductive film is formed and etched into a predetermined shape so as to form a pixel electrode **1853**, which serves as an anode. As for the transparent conductive film, a compound of indium oxide and tin oxide, a compound of indium oxide and zinc oxide, zinc oxide, and tin oxide can be used. Preferably, the cathode **1814** is made of a metal film (with a thickness of from 50 nm to 200 nm) comprising Al, Ag, Li, Ca, or an alloy of these such as MgAg, MgIn, and AlLi. The passivation film **1822** is formed on the cathode **1814**.

[0178] In the case of using the structure as depicted in FIG. **19**B, light generated from the EL element passes through the pixel electrode **1853** and is emitted through the substrate **1800** side.

[0179] According to the present invention, the path for moisture in the display device, which is an insulating layer containing an organic resin material, is shut out. Therefore, it is possible to prevent moisture and oxygen, which exist outside, of the display device from penetrating into the display element in the interior of the display device through the insulating film containing a hygroscopic organic material

and the like. As a result, the deterioration of the display device can be prevented, thereby improving the reliability of the display device.

Embodiment 6

[0180] The reliability evaluation of a display device manufactured according to the present invention is carried out. More specifically, it is confirmed that the display device according to the present invention has an advantageous effect of blocking moisture from penetrating into the interior of the display device so as to prevent various deteriorations such as decrease in luminance of an EL element.

[0181] As described in Embodiment 3, the display device is manufacturing in such a manner that wirings are formed in the periphery of a display panel. A sealing material is formed on the wirings to bond a TFT substrate and an opposing substrate. A cross sectional view of a sealing region composed of a sealing material in the periphery of the display panel is illustrated in FIG. **20**A, while a result of reliability evaluation on the display panel is illustrated in FIG. **20**B.

[0182] The display panel applied with the present invention is manufactured as follows. An insulating layer **70** is partly removed to form a depression, and then wirings and protective films **71***a* and **72***a*, which are made of the same material as a pixel electrode, are formed so as to cover the depression through the same step. The outer edge portion of the insulating layer **70** is also formed to cover the wirings and protective films **71***b*, **72***b* made of the same material as the pixel electrode, and a sealing material **73** is formed thereon. A TFT substrate **75** and an opposing substrate **76** are bonded to each other with the sealing material **73**. The wirings are made of Al, the pixel electrode is made of ITO, and the insulating layer is made of acrylic.

[0183] The display panel manufactured as illustrated in FIG. **20**A is stored under an atmosphere with a temperature of 65° C. and a humidity of 95% for 1,000 hours, and then a voltage is applied thereto so as to make the display panel to emit light FIG. **20**B shows five observation photographs in which four photographs indicate corner portions and one photograph shows a central portion inside of a pixel portion of the display panel manufactured according to the present invention. The pixel portion as shown in the photographs is enlarged with a microscope, wherein a plurality of pixels emitting light respectively and constituting the pixel portion can be observed. Emission failures such as decrease in luminance and nonluminous portions are not observed in each pixel in any portions. It is further confirmed that deterioration in the EL element which contributes to light emission is not generated. As a result, the present invention provides an advantageous effect of blocking moisture outside of the display device which causes deterioration of the EL element from penetrating into the display device.

[0184] As a comparative example, another display panel is manufactured as follows. A depression is not formed in an insulating layer **80**, wirings and wirings **81***a*, **81***b*, **82***a*, and **82***b* made of a pixel electrode are formed over the insulating layer **80**, and then a TFT substrate **85** and an opposing substrate **86** are adhered to each other with a sealing material **83** formed over the wirings. A cross sectional view of the display device of the comparative example is illustrated in FIG. **21**A, while the result of the reliability evaluation of the display panel is shown in FIG. **21**B. In FIG. **21**A, the insulating layer **80** is exposed to the outside air.

[0185] The display panel manufactured as depicted in FIG. **21**A is stored under an atmosphere with a temperature of 65° C. and a humidity of 95% for 190 hours, and then a voltage is applied thereto so as to make the display panel to emit light FIG. **21**B shows nine observation photographs in which eight photographs indicate peripheral edge portions and one photograph indicates a central portion inside a pixel portion of the display panel of the comparative example. The pixel portion shown in the photographs is enlarged with a microscope, and a plurality of pixels emitting light individually and constituting the pixel portion can be observed in the photograph. In each pixel in the peripheral portions, however, nonluminous portions or portions in which luminance is degraded are generated from four corners of the panel nearly to pixels in the third rows and seventh columns even though the display panel is stored only for 190 hours. This is attributed to the fact that light-emitting materials constituting the EL element and the like are deteriorated by the penetration of moisture through the insulating layer **80** from the peripheral portions.

[0186] As set forth above, it is confirmed that a display panel with higher reliability in which decrease in luminance of the EL element is prevented can be manufactured according to the present invention.

What is claimed is:

1. A display device comprising:

a substrate;

a thin film transistor formed over the substrate;

a interlayer insulating film formed over the thin film transistor,

an opening formed in the interlayer insulating film;

a protective film formed on the opening;

a second substrate provided over the interlayer insulating film; and

a sealing material for adhering the first and second substrates, formed over the interlayer insulating film,

wherein the opening is formed at a periphery of the substrate.

* * * * *

专利名称(译)	显示装置及其制造方法		
公开(公告)号	US20180090710A1	公开(公告)日	2018-03-29
申请号	US15/714478	申请日	2017-09-25
[标]申请(专利权)人(译)	株式会社半导体能源研究所		
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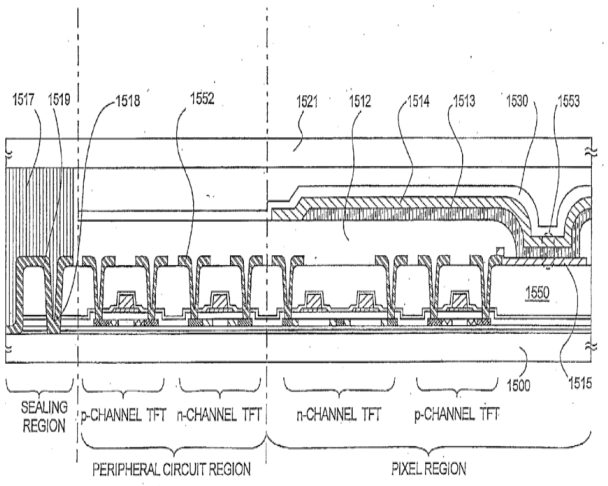
IPC分类号	H01L51/52 H01L27/32 H01L33/44 H01L23/00 H01L27/12 G02F1/1333 H05B33/04 H05B33/10 H05B33/12 H05B33/14 H05B33/22		
CPC分类号	H01L27/3276 H01L33/44 H01L2227/323 H01L51/5246 H01L27/3262 H01L27/124 H01L27/3246 H01L27/3258 H01L23/564 H01L51/5237 H01L2251/5323 H05B33/04 H05B33/14 Y10T428/24777		
优先权	2003184354 2003-06-27 JP		
其他公开文献	US10270056		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种具有较高可靠性的新型显示装置，该装置具有阻挡湿气和氧气的结构，这使显示装置的特性变差，从而不会穿过密封区域及其制造方法。根据本发明，显示装置及其制造方法包括：通过在一对基板之间使用有机发光材料对齐发光元件而形成的显示部，其中显示部形成在绝缘层形成在任何一个衬底上，所述一对衬底利用形成在所述绝缘层上的密封材料彼此结合，同时围绕所述显示部分的外围，所述绝缘层的至少一个层由有机树脂材料，周边具有第一区域和第二区域，第一区域中的绝缘层具有被保护膜覆盖的开口，密封材料形成为与开口和保护膜接触，第二区域的外边缘部分第二区域中的绝缘层被保护膜或密封材料覆盖。