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Okamoto et al.

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(54) **ORGANIC EL DISPLAY DEVICE**

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CPC ... H01L 51/50; H01L 51/5016; H01L 51/524; H01L 51/5256; H01L 27/3244; H01L 27/3262; H01L 27/3276

See application file for complete search history.

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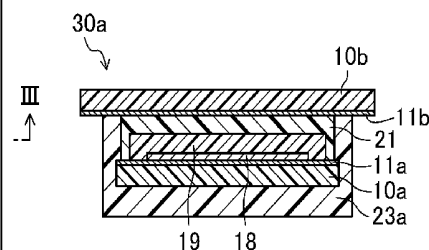
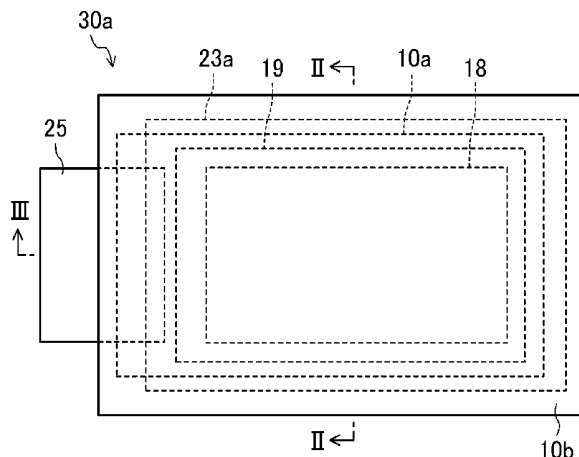
Primary Examiner — Thanh Y Tran

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

Disclosed is an organic EL display device which includes: a first resin substrate **10a**; a basecoat film **11a** provided on the first resin substrate **10a**; an organic EL element **18** provided over the basecoat film **11a**, a first sealing film **19** covering the organic EL element **18**; a second resin substrate **10b** facing the first resin substrate **10a**, and provided closer to the first sealing film **19** with an adhesive layer **21** interposed between the second resin substrate **10b** and the first sealing film **19**; and a second sealing film **23a** provided outside the first sealing film **19** and enhancing adhesion between the basecoat film **11a** and a stack including the first sealing film **19** and the adhesive layer **21**.

4 Claims, 7 Drawing Sheets



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- (52) **U.S. Cl.**
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(2013.01); *H01L 51/5253* (2013.01); *H05B*
33/04 (2013.01)

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FIG.1

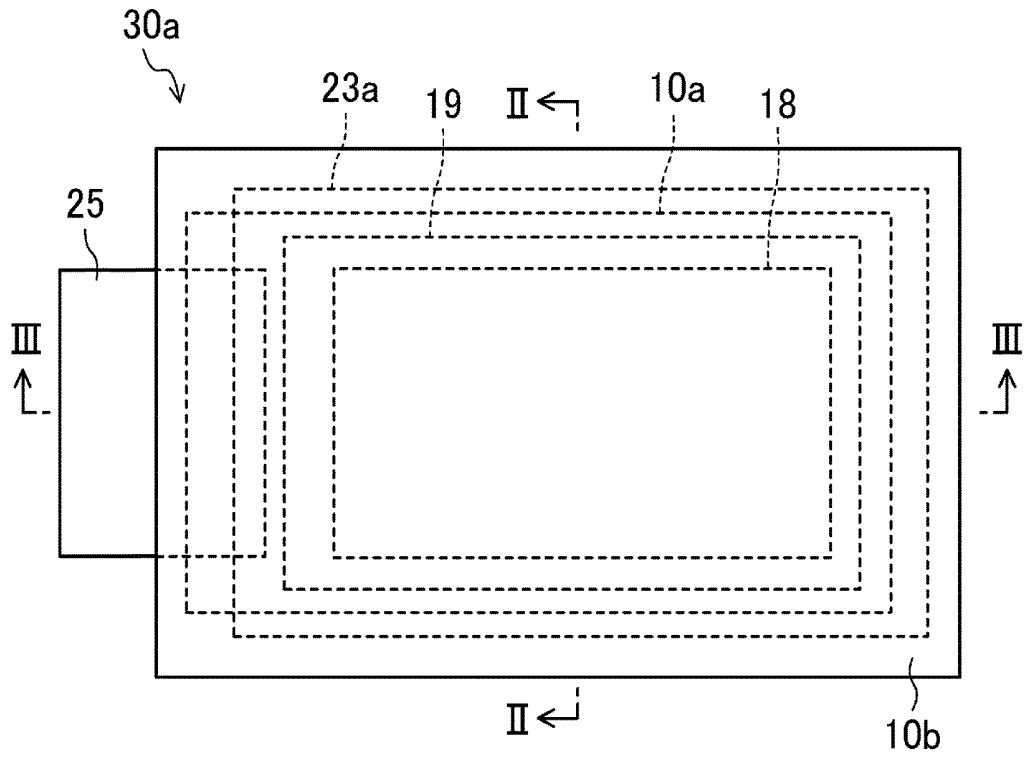


FIG.2

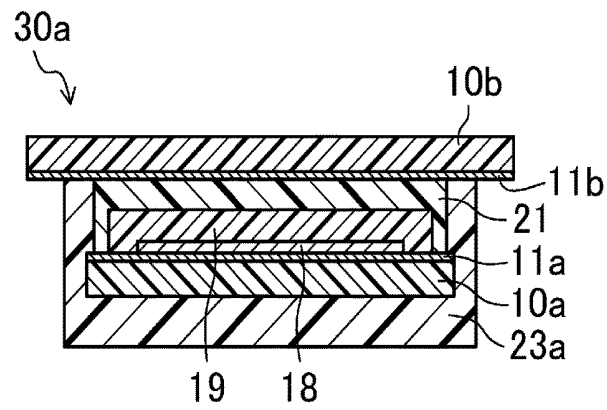


FIG.3

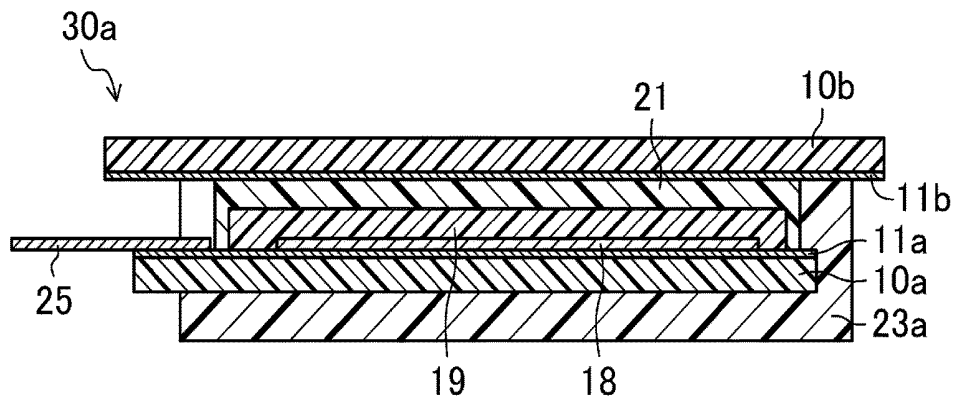


FIG.4

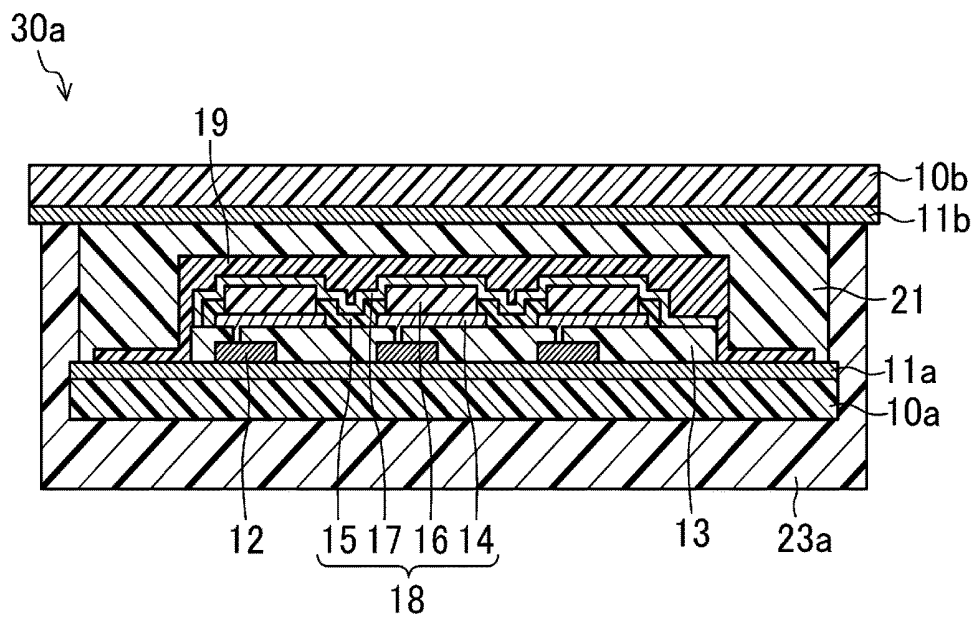


FIG.5

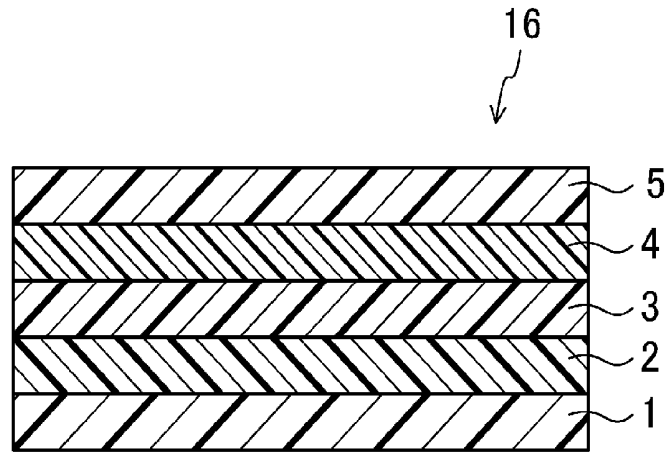


FIG.6

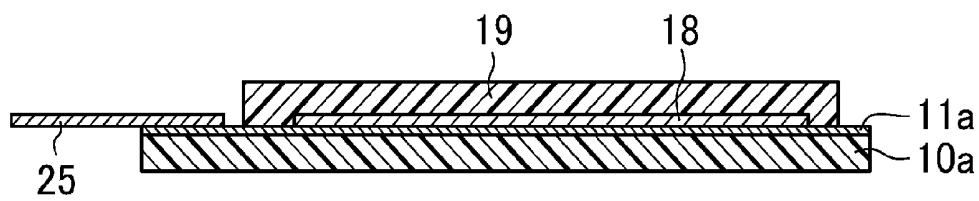


FIG.7

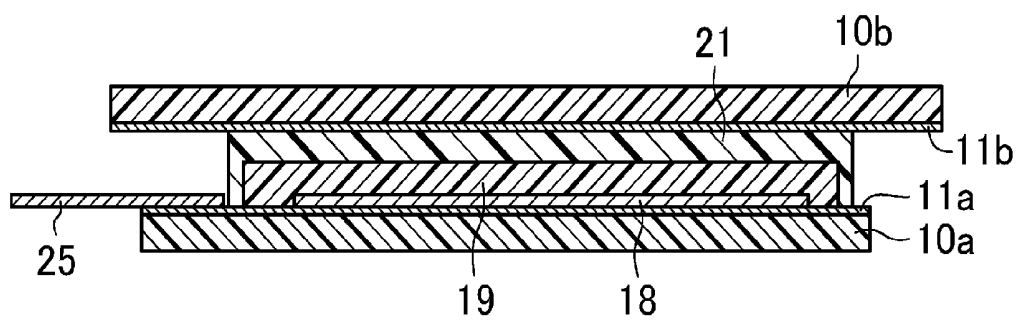


FIG.8

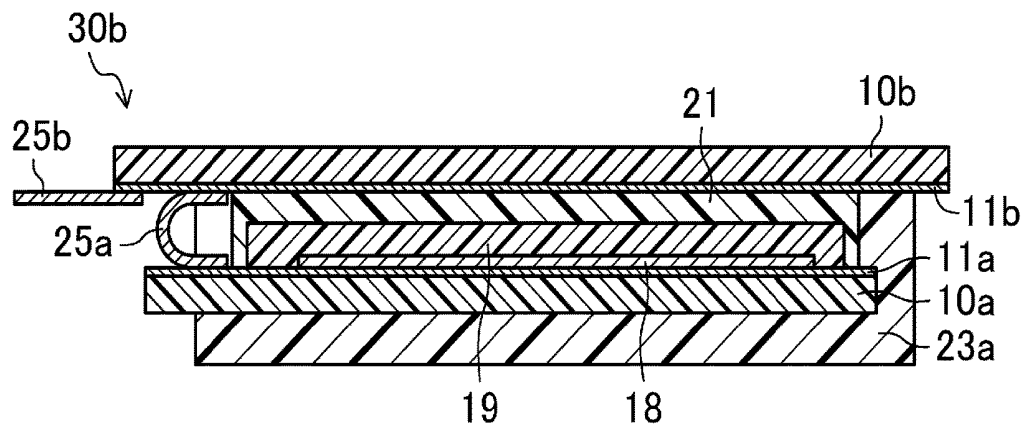


FIG.9

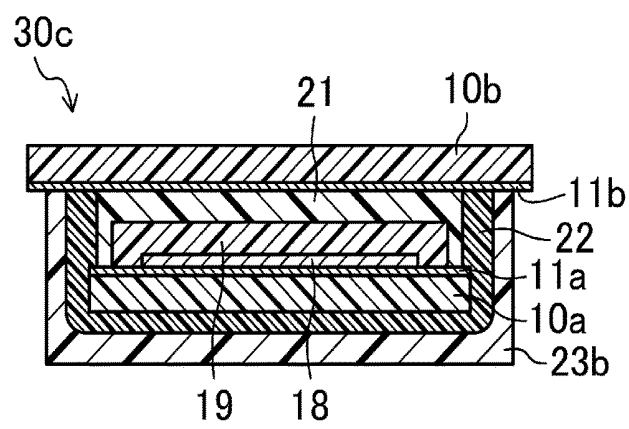


FIG.10

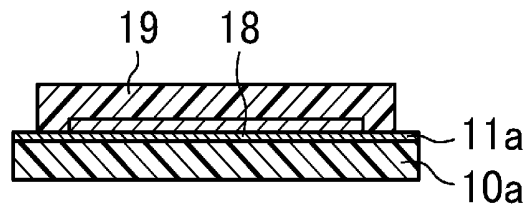


FIG.11

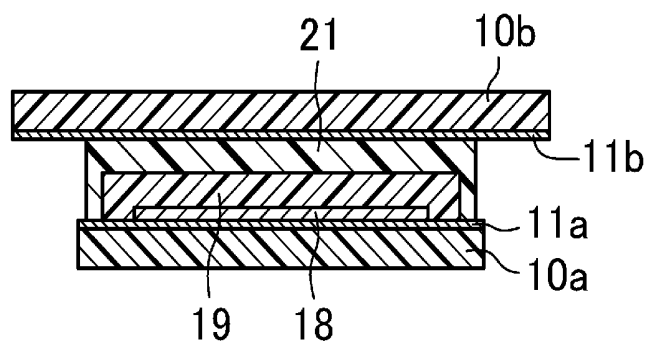


FIG.12

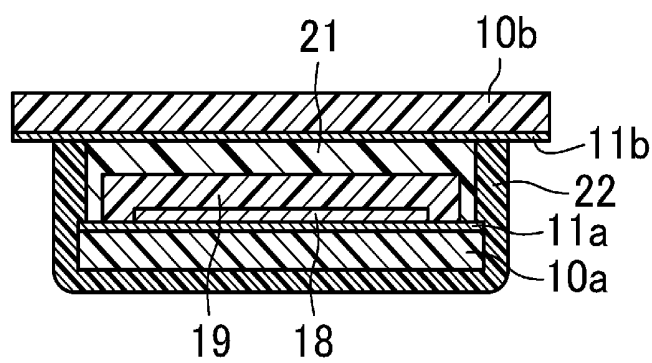


FIG.13

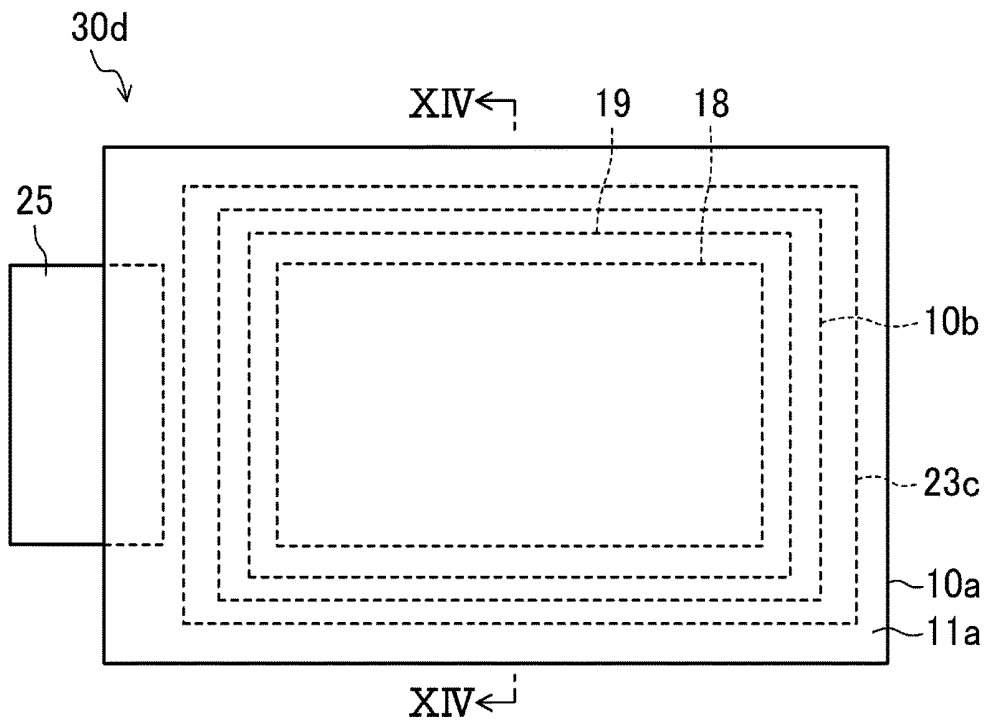


FIG.14

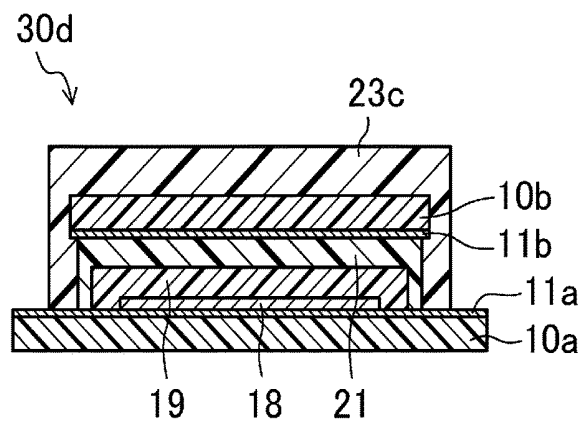


FIG.15

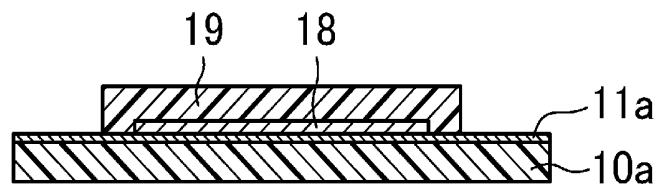
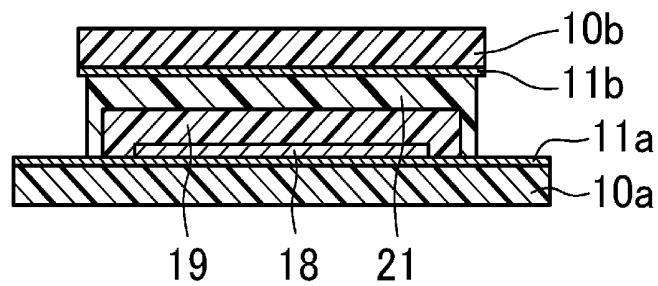


FIG.16



ORGANIC EL DISPLAY DEVICE

TECHNICAL FIELD

The present invention relates to an organic EL display device.

BACKGROUND ART

In recent years, self-luminous organic EL display devices including an organic electroluminescence (EL) element have received attention, as display devices alternative to liquid crystal display devices.

For example, Patent Document 1 discloses an organic electroluminescence display device (organic EL display device) including a display panel which includes an organic electroluminescence element (organic EL element) provided on a flexible substrate, and which has protective films bonded to its front and back surfaces with an adhesive.

CITATION LIST

Patent Documents

Patent Document 1: Japanese Unexamined Patent Publication No. 2013-254747

SUMMARY OF THE INVENTION

Technical Problem

The organic EL display device disclosed in Patent Document 1 described above includes a thin sealing film covering the organic EL element and other components, and a barrier film provided over the flexible substrate. The interface between the thin sealing film and the barrier film is exposed at an end face of the device. As a result, moisture or oxygen may enter the organic EL element via the exposed interface and may deteriorate the display capability of the organic EL element. Further, in the organic EL display device disclosed in Patent Document 1, if foreign matter exists on a surface of the barrier film or a surface of the organic EL element, it is likely that the foreign matter breaks through the thin sealing film to form a through hole. In such a case, moisture or oxygen may enter the organic EL element via the through hole formed in the thin sealing film, and may deteriorate the display capability of the organic EL element.

In view of the foregoing, it is therefore an object of the present invention to reduce the risk of deterioration of the display capability of an organic EL element caused by the entry of moisture or oxygen.

Solution to the Problem

To achieve the object, an organic EL display device of the present invention includes: a first resin substrate, a basecoat film provided on the first resin substrate; an organic EL element provided above the basecoat film; a first sealing film covering the organic EL element; a second resin substrate facing the first resin substrate, and provided closer to the first sealing film with an adhesive layer interposed between the second resin substrate and the first sealing film; and a second sealing film provided outside the first sealing film, and enhancing adhesion between the basecoat film and a stack including the first sealing film and the adhesive layer.

Advantages of the Invention

According to the present invention, a configuration in which the first and second sealing films protect the organic

EL element can reduce the risk of deterioration of the display capability of an organic EL element caused by the entry of moisture or oxygen.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view schematically showing a configuration of an organic EL display device according to a first embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along the line II-II in FIG. 1, and schematically showing the configuration of the organic EL display device.

FIG. 3 is a cross-sectional view taken along the line III-III in FIG. 1, and schematically showing the configuration of the organic EL display device.

FIG. 4 is a cross-sectional view showing an internal configuration of the organic EL display device according to the first embodiment of the present invention.

FIG. 5 is a cross-sectional view of an organic EL layer forming part of the organic EL display device according to the first embodiment of the present invention.

FIG. 6 is a first cross-sectional view showing a method for producing the organic EL display device according to the first embodiment of the present invention.

FIG. 7 is a second cross-sectional view showing the method for producing the organic EL display device according to the first embodiment of the present invention.

FIG. 8 is a cross-sectional view schematically showing a configuration of a variation of the organic EL display device according to the first embodiment of the present invention.

FIG. 9 is a cross-sectional view schematically showing a configuration of an organic EL display device according to a second embodiment of the present invention.

FIG. 10 is a first cross-sectional view showing a method for producing the organic EL display device according to the second embodiment of the present invention.

FIG. 11 is a second cross-sectional view showing the method for producing the organic EL display device according to the second embodiment of the present invention.

FIG. 12 is a third cross-sectional view showing the method for producing the organic EL display device according to the second embodiment of the present invention.

FIG. 13 is a plan view schematically showing a configuration of an organic EL display device according to a third embodiment of the present invention.

FIG. 14 is a cross-sectional view taken along the line XIV-XIV in FIG. 13, and schematically showing the configuration of the organic EL display device.

FIG. 15 is a first cross-sectional view showing a method for producing the organic EL display device according to the third embodiment of the present invention.

FIG. 16 is a second cross-sectional view showing the method for producing the organic EL display device according to the third embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will now be described in detail with reference to the drawings. Note that the present invention is not limited to the following embodiments.

First Embodiment

FIGS. 1-8 show an organic EL display device according to a first embodiment of the present invention. Specifically, FIG. 1 is a plan view schematically showing a configuration

of the organic EL display device **30a** according to this embodiment. FIG. 2 is a cross-sectional view along the short side (i.e., taken along the line II-II in FIG. 1), schematically showing the configuration of the organic EL display device **30a**. FIG. 3 is a cross-sectional view along the long side (i.e., taken along the line III-III in FIG. 1), schematically showing the configuration of the organic EL display device **30a**. FIG. 4 is a cross-sectional view showing an internal configuration of the organic EL display device **30a**. FIG. 5 is a cross-sectional view of an organic EL layer **16** forming part of the organic EL display device **30a**. FIGS. 6 and 7 are first and second cross-sectional views along the long side, showing a method for producing the organic EL display device **30a**. FIG. 8 is a cross-sectional view schematically showing a configuration of an organic EL display device **30b**, which is a variation of the organic EL display device **30a**.

As shown in FIGS. 1-4, the organic EL display device **30a** includes a first resin substrate **10a** and a second resin substrate **10b** which face each other, and a flexible printed circuit (FPC) **25** connected to a side portion adjoining one side of the first resin substrate **10a**. Here, as shown in FIG. 1, the organic EL display device **30a** includes an organic EL element **18** which will be described later. The organic EL display device **18** has a rectangular shape in a plan view, and accordingly, defines a rectangular display region where images are displayed. The display region includes a plurality of pixels arranged in a matrix. For example, each pixel includes sub-pixels arranged adjacent to each other. The sub-pixels include a sub-pixel for gradation display in red, a sub-pixel for gradation display in green, and a sub-pixel for gradation display in blue. As shown in FIGS. 1-4, in the organic EL display device **30a**, the peripheral edge of the first resin substrate **10a** is located inside the peripheral edge of the second resin substrate **10b**.

As shown in FIGS. 2-4, a first basecoat film **11a** is provided on the first resin substrate **10a** and covers a surface (the upper surface in the figures) of the first resin substrate **10a**.

As shown in FIGS. 2-4, the organic EL element **18** is provided over the first basecoat film **11a**, with a plurality of thin film transistors (TFTs) **12** and an interlayer insulating film **13** interposed between the organic EL element **18** and the first basecoat film **11a**. Electrode terminals (not shown) are provided on a portion, of the first basecoat film **11a**, connected to the FPC **25** such that electric signals from the FPC **25** are inputted to the organic EL element **18** via the electrode terminals. Note that the schematic cross-sectional views of FIGS. 2 and 3 shows neither a configuration between the first basecoat film **11a** and the organic EL element **18**, nor an internal configuration of the organic EL element **18**.

As shown in FIGS. 2-4, a first sealing film **19** is provided on the organic EL element **18** and covers a surface of the organic EL element **18**.

As shown in FIGS. 2-4, a second basecoat film **11b** is provided on the second resin substrate **10b** and covers a surface (the lower surface in the figures) of the second resin substrate **10b**.

As shown in FIGS. 2-4, an adhesive layer **21** is provided between the first sealing film **19** and the second basecoat film **11b**. Here, as shown in FIGS. 2-4, the peripheral edge of the adhesive layer **21** is located inside the peripheral edge of the first resin substrate **10a**.

As shown in FIGS. 2-4, a second sealing film **23a** is provided over the second basecoat film **11b** and covers at least a portion of each of the adhesive layer **21**, the first resin substrate **10a**, and the first basecoat film **11a**. Specifically,

the second sealing film **23a** covers these components **21**, **10a**, and **11a**, except their portions connected or adjacent to the FPC **25**. The second sealing film **23a** is configured to enhance adhesion between the first basecoat film **11a**, and a stack including the first sealing film **19** and the adhesive layer **21**, and accordingly, to enhance adhesion between the first resin substrate **10a** over which the organic EL element **18** and the first sealing film **19** are formed, and the second resin substrate **10b**. As shown in FIG. 3, the adhesive layer **21**, the first resin substrate **10a**, and the first basecoat film **11a** are exposed without being covered with the second sealing film **23a** near the side portion adjoining the one side, of the first resin substrate **10a**, connected to the FPC **25**. Further, as shown in FIG. 1, the peripheral edge of the organic EL element **18** is more distant from the peripheral edge of the first sealing film **19** in the vicinity of the side, of the first resin substrate **10a**, connected to the FPC **25** than in the vicinities of the other three sides. Therefore, even though the adhesive layer **21** covering the first sealing film **19** is exposed without being covered with the second sealing film **23a**, the risk of deterioration of the display capability of the organic EL element **18** caused by the entry of moisture or oxygen can be reduced.

Each of the first and second resin substrates **10a** and **10b** has a rectangular shape in a plan view, and is configured as a plastic substrate made of, for example, polyimide resin.

Each of the first and second basecoat films **11a** and **11b** is configured as an inorganic insulating film such as a silicon dioxide film or a silicon nitride film.

As shown in FIG. 4, each TFT **12** is a switching element provided on the first basecoat film **11a** for a respective one of the sub-pixels. Here, each TFT **12** includes, for example: a gate electrode provided on the first basecoat film **11a**; a gate insulating film covering the gate electrode; a semiconductor layer provided on the gate insulating layer and overlapping with the gate electrode; and source and drain electrodes provided on the semiconductor layer and facing each other. Note that although each TFT **12** is configured as a bottom gate TFT as an example in this embodiment, each TFT **12** may be configured as a top gate TFT.

As shown in FIG. 4, the interlayer insulating film **13** covers each TFT **12**, except a portion of the drain electrode of the TFT **12**. Here, the interlayer insulating film **13** is made of, for example, a transparent organic resin material such as acrylic resin.

As shown in FIG. 4, the organic EL element **18** includes a plurality of first electrodes **14**, an edge cover **15**, a plurality of organic EL layers **16**, and a second electrode **17** which are sequentially provided over the interlayer insulating film **13**. As shown in FIGS. 1 and 3, the organic EL element **18** is located close to a side of the first resin substrate **10a** (i.e., the right side in FIG. 1) which is opposite to the side connected to the FPC **25**.

As shown in FIG. 4, the plurality of first electrodes **14** are arranged in a matrix on the interlayer insulating film **13** such that each first electrode **14** corresponds to a respective one of the plurality of sub-pixels. Here, as shown in FIG. 4, the first electrodes **14** are connected to the drain electrodes of the TFTs **12** via contact holes formed in the interlayer insulating film **13**. The first electrodes **14** have the function of injecting holes (positive holes) into the organic EL layers **16**. To increase the efficiency in injecting positive holes into the organic EL layers **16**, the first electrodes **14** are beneficially made of a material having a high work function. Examples of materials for the first electrodes **14** include, but are not limited to, metal materials such as silver (Ag), aluminum (Al), vanadium (V), cobalt (Co), nickel (Ni),

tungsten (W), gold (Au), calcium (Ca), titanium (Ti), yttrium (Y), sodium (Na), ruthenium (Ru), manganese (Mn), indium (In), magnesium (Mg), lithium (Li), ytterbium (Yb), and lithium fluoride (LiF). The first electrodes **14** may also be made of an alloy of, for example, magnesium (Mg)/copper (Cu), magnesium (Mg)/silver (Ag), sodium (Na)/potassium (K), astatine (At)/astatine dioxide (AtO₂), lithium (Li)/aluminum (Al), lithium (Li)/calcium (Ca)/aluminum (Al), or lithium fluoride (LiF)/calcium (Ca)/aluminum (Al). The material for the first electrodes **14** may also be a conductive oxide such as tin oxide (SnO), zinc oxide (ZnO), indium tin oxide (ITO), and indium zinc oxide (IZO), for example. Moreover, the first electrodes **14** may be multilayers containing the above materials. Examples of materials having a high work function include, but are not limited to, indium tin oxide (ITO) and indium zinc oxide (IZO).

As shown in FIG. 4, the edge cover **15** is formed in a grid pattern to cover a peripheral portion of each first electrode **14**. Examples of materials for the edge cover **15** include, but are not limited to, an inorganic film of silicon dioxide (SiO₂), silicon nitride (SiN_x, where x is a positive number) such as Si₃N₄, or silicon oxynitride (SiNO), and an organic film of polyimide resin, acrylic resin, polysiloxane resin, or novolak resin.

As shown in FIG. 4, the plurality of organic EL layers **16** are each provided on a respective one of the first electrodes **14**, and are arranged in a matrix so as to correspond to the plurality of sub-pixels. Here, as shown in FIG. 5, each organic EL layer **16** includes a positive hole injection layer **1**, a positive hole transport layer **2**, a light-emitting layer **3**, an electron transport layer **4**, and an electron injection layer **5**, which are sequentially provided over the associated first electrode **14**.

The positive hole injection layer **1** is also called an anode buffer layer, and has the function of causing the energy levels of the first electrodes **14** and the organic EL layers **16** to approach each other and increasing the efficiency at which the first electrodes **14** inject positive holes into the organic EL layers **16**. Here, examples of materials for the positive hole injection layer **1** include, but are not limited to, triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyaryllalkane derivatives, pyrazoline derivatives, phenylenediamine derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives, hydrazone derivatives, and stilbene derivatives.

The positive hole transport layer **2** has the function of increasing the efficiency at which positive holes are transported from the first electrodes **14** to the organic EL layers **16**. Here, examples of materials for the positive hole transport layer **2** include, but are not limited to, porphyrin derivatives, aromatic tertiary amine compounds, styryl amine derivatives, polyvinylcarbazole, poly-p-phenylene vinylene, polysilane, triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyaryllalkane derivatives, pyrazoline derivatives, pyrazolone derivatives, phenylenediamine derivatives, arylamine derivatives, amine-substituted chalcone derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives, hydrazone derivatives, stilbene derivatives, hydrogenated amorphous silicon, hydrogenated amorphous silicon carbide, zinc sulfide, and zinc selenide.

When a voltage is applied from the first electrodes **14** and the second electrode **17**, positive holes and electrons are injected from the first and second electrodes **14** and **17** into the light-emitting layer **3**, in which the positive holes and the electrons are recombined with each other. The light-emitting layer **3** is made of a material having high luminous effi-

ciency. Examples of materials for the light-emitting layer **3** include, but are not limited to, metal oxinoid compounds (8-hydroxyquinoline metal complexes), naphthalene derivatives, anthracene derivatives, diphenylethylene derivatives, vinylacetone derivatives, triphenylamine derivatives, butadiene derivatives, coumarin derivatives, benzoxazole derivatives, oxadiazole derivatives, oxazole derivatives, benzimidazole derivatives, thiadiazole derivatives, benzothiazole derivatives, styryl derivatives, styrylamine derivatives, bis(styryl)benzene derivatives, tris(styryl)benzene derivatives, perylene derivatives, perinone derivatives, aminopyrene derivatives, pyridine derivatives, rodamine derivatives, acridine derivatives, phenoxazone, quinacridone derivatives, rubrene, poly-p-phenylene vinylene, and polysilane.

The electron transport layer **4** functions to efficiently move electrons to the light-emitting layer **3**. Here, examples of materials for the electron transport layer **4** include, but are not limited to, as organic compounds, oxadiazole derivatives, triazole derivatives, benzoquinone derivatives, naphthoquinone derivatives, anthraquinone derivatives, tetracyanoanthraquinodimethan derivatives, diphenquinone derivatives, fluorenone derivatives, silole derivatives, and metal oxinoid compounds.

The electron injection layer **5** has the function of causing the energy levels of the second electrode **17** and the organic EL layers **16** to approach each other and increasing the efficiency at which electrons are injected from the second electrode **17** into the organic EL layers **16**. This function contributes to reduction of the drive voltage of the organic EL element **18**. The electron injection layer **5** may also be called a cathode buffer layer. Here, examples of materials for the electron injection layer **5** include, but are not limited to, inorganic alkaline compounds such as lithium fluoride (LiF), magnesium fluoride (MgF₂), calcium fluoride (CaF₂), strontium fluoride (SrF₂), and barium fluoride (BaF₂), aluminum oxide (Al₂O₃), and strontium oxide (SrO).

As shown in FIG. 4, the second electrode **17** covers the organic EL layers **16** and the edge cover **15**. The second electrode **17** has the function of injecting electrons into the organic EL layers **16**. To increase the efficiency in injecting electrons into the organic EL layers **16**, the second electrode **17** is beneficially made of a material having a low work function. Here, examples of materials for the second electrode **17** include, but are not limited to, silver (Ag), aluminum (Al), vanadium (V), cobalt (Co), nickel (Ni), tungsten (W), gold (Au), calcium (Ca), titanium (Ti), yttrium (Y), sodium (Na), ruthenium (Ru), manganese (Mn), indium (In), magnesium (Mg), lithium (Li), ytterbium (Yb), or lithium fluoride (LiF). The second electrode **17** may also be made of an alloy of magnesium (Mg)/copper (Cu), magnesium (Mg)/silver (Ag), sodium (Na)/potassium (K), astatine (At)/astatine dioxide (AtO₂), lithium (Li)/aluminum (Al), lithium (Li)/calcium (Ca)/aluminum (Al), and lithium fluoride (LiF)/calcium (Ca)/aluminum (Al). The second electrode **17** may also contain a conductive oxide such as tin oxide (SnO), zinc oxide (ZnO), indium tin oxide (ITO), or indium zinc oxide (IZO). Moreover, the second electrode **17** may be multilayers containing the above materials. Examples of material having a low work function include, but are not limited to, magnesium (Mg), lithium (Li), lithium fluoride (LiF), magnesium (Mg)/copper (Cu), magnesium (Mg)/silver (Ag), sodium (Na)/potassium (K), lithium (Li)/aluminum (Al), lithium (Li)/calcium (Ca)/aluminum (Al), and lithium fluoride (LiF)/calcium (Ca)/aluminum (Al).

The first and second sealing films **19** and **23a** have the function of protecting the organic EL element **18** against

As shown in FIG. 6, an FPC **25** is then press-bonded to a portion, of the first basecoat film **11a**, corresponding to the side portion of the first resin substrate **10a**, via an anisotropic conductive film (ACF, not shown).

10a, connected to the FPC **25** or **25a**, the organic EL element **18** is located closer to the opposite side of the side portion connected to FPC **25** or **25a** of the first resin substrate **10a**. Consequently, the peripheral edge of the organic EL element **18** is spaced apart from the side portion connected to the FPC **25** or **25a**, and therefore, the risk of deterioration of the capability to seal the organic EL element **18** caused by the connection to the FPC **25** or **25a** can be reduced.

(5) Since the first sealing film **19** is located closer to the side portion, of the first resin substrate **10a**, connected to the FPC **25** or **25a**, the peripheral edge of the organic EL element **18** is more distant from the peripheral edge of the first sealing film **19** in the vicinity of the side portion, of the first resin substrate **10a**, connected to the FPC **25** or **25c** than in the vicinities of the other three sides of the first resin substrate **10a**. Therefore, even though the adhesive layer **21** covering the first sealing film **18** is exposed without being covered with the second sealing film **23a**, the risk of deterioration of the display capability of the organic EL element **18** caused by the entry of moisture or oxygen can be reduced.

Second Embodiment

FIGS. 9-12 show an organic EL display device according to a second embodiment of the present invention. Specifically, FIG. 9 is a cross-sectional view along the short side, schematically showing a configuration of an organic EL display device **30c** according to this embodiment. FIGS. 10, 11 and 12 are first, second, and third cross-sectional views along the short side, showing a method for producing the organic EL display device **30c**. In the following embodiments, components equivalent to those shown in FIGS. 1-8 are denoted by the same reference characters, and the detailed explanation thereof will be omitted.

In the first embodiment described above, the organic EL display devices **30a** and **30b** including the second sealing film **23a** that extends on the side surfaces of the adhesive layer **21** have been exemplified. On the other hand, the organic EL display device **30c** exemplified in this embodiment includes a resin layer **22** between an adhesive layer **21** and a second sealing film **23b**.

As shown in FIG. 9, the organic EL display device **30c** includes a first resin substrate **10a** and a second resin substrate **10b** which face each other, and an FPC **25** (not shown) connected to a side portion adjoining one side of the first resin substrate **10a**. Here, the organic EL display device **30c** includes an organic EL element **18**. The organic EL element **18** has a rectangular shape in a plan view, and accordingly, defines a rectangular display region where images are displayed. The display region includes a plurality of pixels arranged in a matrix. For example, each pixel includes sub-pixels arranged adjacent to each other. The sub-pixels include a sub-pixel for gradation display in red, a sub-pixel for gradation display in green, and a sub-pixel for gradation display in blue. As shown in FIG. 9, in the organic EL display device **30c**, the peripheral edge of the first resin substrate **10a** is located inside the peripheral edge of the second resin substrate **10b**.

As shown in FIG. 9, a first basecoat film **11a** is provided on the first resin substrate **10a** and covers a surface (the upper surface in the figures) of the first resin substrate **10a**.

As shown in FIG. 9, the organic EL element **18** is provided over the first basecoat film **11a** with a plurality of TFTs **12** (see FIG. 4) and an interlayer insulating film **13** (see FIG. 4) interposed between the organic EL element **18** and the first basecoat film **11a**.

As shown in FIG. 9, a first sealing film **19** is provided on the organic EL element **18** and covers a surface of the organic EL element **18**.

As shown in FIG. 9, a second basecoat film **11b** is provided on the second resin substrate **10b** and covers a surface (the lower surface in the figures) of the second resin substrate **10b**.

As shown in FIG. 9, the adhesive layer **21** is provided between the first sealing film **19** and the second basecoat film **11b**.

As shown in FIG. 9, the resin layer **22** is provided on the second basecoat film **11b** and covers at least a portion of each of the adhesive layer **21**, the first resin substrate **10a**, and the first basecoat film **11a**. Specifically, the resin layer **22** covers these components **21**, **10a**, and **11a**, except their portions connected to the FPC **25**. Here, the resin layer **22** is made of, for example, acrylic resin, and provided so as to prevent rupture of the second sealing film **23b** by covering, under its substantially even surface, a step on end surfaces between the adhesive layer **21** and a stack including the first resin substrate **10a** and the first basecoat film **11a**.

As shown in FIG. 9, the second sealing film **23b** is provided on the second basecoat film **11b** so as to cover the resin layer **22**. Here, the second sealing film **23b** has the function of protecting the organic EL element **18** against moisture and oxygen. Examples of materials for the second sealing film **23b** include, but are not limited to, inorganic materials such as silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), silicon nitride (SiN_x , where x is a positive number) such as Si_3N_4 , silicon carbonitride (SiCN), and silicon oxynitride (SiON), and organic materials such as acrylate, polyurea, parylene, polyimide, and polyamide.

The organic EL display device **30c** having the configuration described above is flexible, and configured to display images by appropriately causing, via the TFTs **12**, the light-emitting layers **3**, which are included in the organic EL layers **16** and correspond to the respective sub-pixels, to emit light.

It is now described, with reference to FIGS. 10-12, a method for producing the organic EL display device **30c** of this embodiment.

First, like the first embodiment described above, a first basecoat film **11a**, TFTs **12**, an interlayer insulating film **13**, an organic EL element **18** (including first electrodes **14**, an edge cover **15**, an organic EL layer **16** (including a positive hole injection layer **1**, a positive hole transport layer **2**, a light-emitting layer **3**, an electron transport layer **4**, and an electron injection layer **5**), and a second electrode **17**) and a first sealing film **19** are formed over a surface of a first resin substrate **10a**, as shown in FIG. 10. Thereafter, an FPC **25** is press-bonded to a portion, of the first basecoat film **11a**, corresponding to a side portion adjoining one side of the first resin substrate **10a**.

Next, for example, using the slit coating method, a thermosetting or UV curable adhesive is applied, at a thickness of about $5\text{ }\mu\text{m}$ to about $20\text{ }\mu\text{m}$, to a surface of the first sealing film **19** provided over the first resin substrate **10a** having the FPC **25** press-bonded thereto. Thereafter, a second resin substrate **10b** of polyimide resin, which is about $12\text{ }\mu\text{m}$ thick and which has, on its surface, a second basecoat film **11b** comprised of an about $1\text{ }\mu\text{m}$ thick silicon nitride film, is placed on a surface of the applied adhesive. The adhesive is then cured. In this manner, an adhesive layer **21** is formed and the second resin substrate **10b** is bonded to the first resin substrate **10a**, as shown in FIG. 11.

Further, a film of acrylic resin is formed on a surface of the second basecoat film **11b** by, for example, the vapor

deposition, such that the film covers the adhesive layer **21**, the first resin substrate **10a**, and the first basecoat film **11a** except their portions connected to the FPC **25**. In this manner, the resin layer **22** is formed.

Finally, a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), and a silicon nitride film (about 500 nm thick) are sequentially formed on the surface of the second basecoat film **11b** by, for example, the plasma CVD, such that the resultant films together cover the resin layer **22**. In this manner, a second sealing film **23b** is formed.

In the above manner, the organic EL display device **30c** of this embodiment can be produced.

As can be seen, the organic EL display device **30c** of this embodiment can provide the following advantage (6), in addition to the advantages (1)-(5) described above.

The advantage (1) is detailed here. The second sealing film **23b** that enhances the adhesion between the first basecoat film **11a** and the stack including the first sealing film **19** and the adhesive layer **21** is provided outside the first sealing film **19** covering the organic EL element **18**. Consequently, the capability to seal the peripheral edge of the organic EL element **18** is enhanced, and the risk of deterioration of the display capability of the organic EL element **18** caused by the entry of moisture or oxygen can be reduced. Further, even if foreign matter exists on a surface of the first basecoat film **10a** or a surface of the organic EL element **18**, and the foreign matter forms a through hole in the first sealing film **19**, the second sealing film **23b** secures the capability to seal the organic EL element **18**. Thus, the risk of deterioration of the display capability of the organic EL element **18** caused by the entry of moisture or oxygen can be reduced. Furthermore, the second sealing film **23b** and the resin layer **22** enhance the adhesion between layers of the multilayer structure forming the organic EL display device **30c**. This contributes to an increase in the physical strength of the organic EL display devices **30c** against, for example, bending and impact. Thus, the organic EL display device **30c** having high reliability can be achieved.

(6) The resin layer **22**, which is provided between the second sealing film **23b** and the stack including the adhesive layer **21**, the first basecoat film **11a**, and first resin substrate **10a**, covers the step between the adhesive layer **21** and the stack including the first resin substrate **10a** and the first basecoat film **11a** under its substantially even surface. As a result, damage to the second sealing film **23b** can be reduced.

Third Embodiment

FIGS. **13-16** show an organic EL display device according to a third embodiment of the present invention. Specifically, FIG. **13** is a plan view schematically showing a configuration of an organic EL display device **30d** of this embodiment. FIG. **14** is a cross-sectional view along the short side (i.e., taken along line XIV-XIV in FIG. **13**), schematically showing a configuration of the organic EL display device **30d**. FIGS. **15** and **16** are first and second cross-sectional views along the short side, showing a method for producing the organic EL display device **30d**.

The organic EL display devices **30a-30c** exemplified in the first and second embodiments described above are configured such that the peripheral edge of the first resin substrate **10a** is located inside the peripheral edge of the

second resin substrate **10b**. By contrast, the organic EL display device **30d** exemplified in this embodiment is configured such that the peripheral edge of a first resin substrate **10a** is located outside the peripheral edge of a second resin substrate **10b**.

As shown in FIGS. **13** and **14**, the organic EL display device **30d** includes the first resin substrate **10a** and the second resin substrate **10b** which face each other, and an FPC **25** connected to a side portion adjoining one side of the first resin substrate **10a**. Here, as shown in FIG. **13**, the organic EL display device **30d** includes an organic EL element **18**. The organic EL display device **18** has a rectangular shape in a plan view, and accordingly, defines a rectangular display region where images are displayed. The display region includes a plurality of pixels arranged in a matrix. For example, each pixel includes sub-pixels arranged adjacent to each other. The sub-pixels include a sub-pixel for gradation display in red, a sub-pixel for gradation display in green, and a sub-pixel for gradation display in blue. As shown in FIGS. **13** and **14**, in the organic EL display device **30d**, the peripheral edge of the first resin substrate **10a** is located outside the peripheral edge of the second resin substrate **10b**.

As shown in FIG. **14**, a first basecoat film **11a** is provided on the first resin substrate **10a** and covers a surface (the upper surface in the figures) of the first resin substrate **10a**. Note that although the configuration in which the first basecoat film **11a** is provided on a surface of the first resin substrate **10a** is exemplified in this embodiment, another inorganic film may be formed on the other side of the first resin substrate **10a** to enhance the capability to seal the organic EL element **18**.

As shown in FIG. **14**, the organic EL element **18** is provided over the first basecoat film **11a** with a plurality of TFTs **12** (see FIG. **4**) and an interlayer insulating film **13** (see FIG. **4**) interposed between the organic EL element **18** and the first basecoat film **11a**.

As shown in FIG. **14**, a first sealing film **19** is provided on the organic EL element **18** and covers a surface of the organic EL element **18**.

As shown in FIG. **14**, a second basecoat film **11b** is provided on the second resin substrate **10b** and covers a surface (the lower surface in the figures) of the second resin substrate **10b**.

As shown in FIG. **14**, an adhesive layer **21** is provided between the first sealing film **19** and the second basecoat film **11b**.

As shown in FIG. **14**, a second sealing film **23c** is provided on the second basecoat film **11b** and covers the adhesive layer **21**, the second resin substrate **10b**, and the second basecoat film **11b**. Here, the second sealing film **23c** has the function of protecting the organic EL element **18** against moisture and oxygen. Examples of materials for the second sealing film **23c** include, but are not limited to, inorganic materials such as silicon dioxide (SiO₂), aluminum oxide (Al₂O₃), silicon nitride (SiN_x, where x is a positive number) such as Si₃N₄, silicon carbonitride (SiCN), and silicon oxynitride (SiON), and organic materials such as acrylate, polyurea, parylene, polyimide, and polyamide. The organic EL display device **30d** exemplified in this embodiment includes the second sealing film **23c** that extends on the side surfaces of the adhesive layer **21**. However, like the second embodiment described above, the organic EL display device **30d** may include a resin layer between the adhesive layer **21** and the second sealing film **23c** such that the resin layer covers, under its substantially even surface, a step

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between adhesive layer 21 and the stack including the second resin substrate 10b and the second basecoat film 11b.

The organic EL display device 30d having the configuration described above is flexible, and configured to display images by appropriately causing, via the TFTs 12, the light-emitting layers 3, which are included in the organic EL layers 16 and correspond to the respective sub-pixels, to emit light.

It is now described, with reference to FIGS. 15 and 16, a method for producing the organic EL display device 30d of this embodiment.

First, like the first embodiment described above, a first basecoat film 11a, TFTs 12, an interlayer insulating film 13, an organic EL element 18 (including first electrodes 14, an edge cover 15, an organic EL layer 16 (including a positive hole injection layer 1, a positive hole transport layer 2, a light-emitting layer 3, an electron transport layer 4, and an electron injection layer 5), and a second electrode 17) and a first sealing film 19 are formed over a surface of a first resin substrate 10a, as shown in FIG. 15. Thereafter, an FPC 25 is press-bonded to a portion, of the first basecoat film 11a, corresponding to a side portion adjoining one side of the first resin substrate 10a.

Next, for example, using the slit coating method, a thermosetting or UV curable adhesive is applied, at a thickness of about 5 μm to about 20 μm , to a surface of the first sealing film 19 provided over the first resin substrate 10a having the FPC 25 press-bonded thereto. Thereafter, a second resin substrate 10b of polyimide resin, which is about 12 μm thick and which has, on its surface, a second basecoat film 11b comprised of an about 1 μm thick silicon nitride film, is placed on a surface of the applied adhesive. The adhesive is then cured. In this manner, an adhesive layer 21 is formed and the second resin substrate 10b is bonded to the first resin substrate 10a, as shown in FIG. 16.

Further, a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), a silicon nitride film (about 500 nm thick), a silicon oxynitride film (about 500 nm thick), and a silicon nitride film (about 500 nm thick) are sequentially formed on a surface of the first basecoat film 11a by, for example, the plasma CVD, such that the resultant films together cover the resin layer 21, the second basecoat film 11b, and the second resin substrate 10b. In this manner, a second sealing film 23c is formed.

Note that according to the production method exemplified in this embodiment, the FPC 25 is press-bonded before bonding of the second resin substrate 10b. However, the press-bonding of the FPC 25 may follow the bonding of the second resin substrate 10b and the formation of the second sealing film 23c.

In the above manner, the organic EL display device 30d of this embodiment can be produced.

As can be seen, the organic EL display device 30d of this embodiment can provide the following advantage (7), in addition to the advantages (1) and (3) described above.

The advantage (1) is detailed here. The second sealing film 23c that enhances the adhesion between the first basecoat film 11a and the stack including the first sealing film 19 and the adhesive layer 21 is provided outside the first sealing film 19 covering the organic EL element 18. Consequently, the capability to seal the peripheral edge of the organic EL element 18 is enhanced, and the risk of deterioration of the display capability of the organic EL element 18 caused by the entry of moisture or oxygen can be reduced. Further, even if foreign matter exists on a surface of the first

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basecoat film 10a or a surface of the organic EL element 18, and the foreign matter forms a through hole in the first sealing film 19, the second sealing film 23c secures the capability to seal the organic EL element 18. Thus, the risk of the deterioration of display capability of the organic EL element 18 caused by the entry of moisture or oxygen can be reduced. Furthermore, the second sealing film 23c enhances the adhesion between layers of the multilayer structure forming the organic EL display device 30d. This contributes to an increase in the physical strength of the organic EL display devices 30d against, for example, bending and impact. Thus, the organic EL display device 30d having high reliability can be achieved.

(7) The second sealing film 23c is provided to cover the adhesive layer 21 and the second resin substrate 10b. Specifically, the second sealing film 23c surrounds the four sides of the organic EL element 18, and the FPC 25 is connected to a portion outside the second sealing film 23c. This configuration contributes to enhancement of the capability to seal the organic el element 18 even though the FPC 25 is press-bonded to the first resin substrate 10a.

Other Embodiments

In each of the above embodiments, the organic EL layer has been exemplified as a layer having a stacked structure of the five layers, namely, the positive hole injection layer, a positive hole transport layer, the light-emitting layer, the electron transport layer, and the electron injection layer. However, the organic EL layer may have a stacked structure of three layers including a positive hole injection and transport layer, a light-emitting layer, and an electron transport and injection layer, for example.

In each of the above embodiments, the organic EL display device in which the first electrode functions as the anode and the second electrode functions as the cathode has been exemplified. However, the present invention is applicable to an organic EL display device which has an inverted stacked structure of the organic EL element and in which the first electrode functions as the cathode and the second electrode functions as the anode.

In each of the above embodiments, the organic EL display device including the element substrate in which an electrode of the TFT connected to the first electrode is denoted as the drain electrode has been exemplified. However, the present invention is applicable to an organic EL display device including an element substrate in which the electrode of the TFT connected to the first electrode is called a source electrode.

The organic EL display device exemplified in each of the above embodiments is configured such that the total thickness of the upper components provided above the organic EL element differs from the total thickness of the lower components provided below the organic EL element. However, the organic EL display device may be configured such that the upper components and the lower components have a similar total thickness, and the organic EL element is accordingly located at a neutral plane to which substantially no stress is applied when the organic EL display device is curved. This configuration contributes to an increase in the flexibility of the organic EL display device.

INDUSTRIAL APPLICABILITY

As can be seen from the foregoing description, the present invention is useful for an organic EL display device.

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DESCRIPTION OF REFERENCE CHARACTERS

10a First Resin Substrate

10b Second Resin Substrate

11a First Basecoat Film

11b Second Basecoat Film

18 Organic EL Element

19 First Sealing Film

21 Adhesive Layer

22 Resin Layer

23a-23c Second Sealing Film

25 Flexible Printed Circuit (FPC)

25a First Flexible Printed Circuit (First FPC)

30a-30d Organic EL Display Device

The invention claimed is:

1. An organic EL display device comprising:

a first resin substrate;

a basecoat film provided on the first resin substrate;

an organic EL element provided over the basecoat film;

a first sealing film covering the organic EL element;

a second resin substrate facing the first resin substrate, and
provided closer to the first sealing film with an adhesive
layer interposed between the second resin substrate and
the first sealing film; anda second sealing film provided outside the first sealing
film, and enhancing adhesion between the basecoat film
and a stack including the first sealing film and the
adhesive layer, whereinin a plan view, a peripheral edge of the first resin substrate
is located inside a peripheral edge of the second resin
substrate,

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the second sealing layer covers at least a portion of each
of the adhesive layer, the first resin substrate, and the
basecoat film,in the plan view, a peripheral edge of the adhesive layer
is located inside the peripheral edge of the first resin
substrate, anda resin layer is provided between the second sealing film
and a stack including the adhesive layer and the first
resin substrate such that the resin layer covers a step
between the adhesive layer and the first resin substrate.2. The organic EL display device of claim 1, wherein
the first resin substrate has a rectangular shape in the plan
view,a flexible printed circuit is connected to a side portion
adjoining one side of the first resin substrate,the adhesive layer, the first resin substrate, and the
basecoat film are exposed without being covered with
the second sealing film near the side portion adjoining
the one side of the first resin substrate, andthe organic EL element provided over the basecoat film is
located closer to an opposite side of the one side of the
first resin substrate.3. The organic EL display device of claim 2, wherein the
first sealing film is located closer to a side opposite to the one
side of the first resin substrate.4. The organic EL display device of claim 1, wherein
another basecoat film is provided on a surface, of the second
resin substrate, facing the adhesive layer.

* * * * *

专利名称(译)	有机EL显示装置		
公开(公告)号	US10249694	公开(公告)日	2019-04-02
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[标]申请(专利权)人(译)	夏普株式会社		
申请(专利权)人(译)	夏普株式会社		
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IPC分类号	H01L27/32 H01L51/52 H01L51/00 H05B33/04 H01L51/50		
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摘要(译)

公开了一种有机EL显示装置，其包括：第一树脂基板 10。在第一树脂基材上提供的底涂层膜 11 在底涂膜 11 上提供有机EL元件 18，覆盖有机EL的第一密封膜 19 元素 18；第二树脂基板 10b 面向第一树脂基板 10a，并且设置得更靠近第一密封膜 19，其中粘合剂层 21 介于第二树脂基板 10b 和第一密封膜之间 19 的；和设置在第一密封膜 19 外部的第二密封膜 23，并增强底涂层膜之间的粘合性 11 a 和包括第一密封膜 19 和粘合剂层 21 的叠层。

