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(54) **ORGANIC EL DISPLAY DEVICE**

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CPC ***H01L 51/524*** (2013.01); ***H01L 51/5092*** (2013.01); ***H01L 51/5203*** (2013.01); ***H01L 27/3211*** (2013.01)

(57) **ABSTRACT**

Disclosed is an organic EL display device including: a base substrate (**10**); an organic EL element (**18**) provided over the base substrate (**10**); and a sealing film (**25***a*) covering the organic EL element (**18**). The sealing film (**25***a*) includes a plurality of buffer layers (**19***a*, **21***a*, **23***a*) each comprised of an inorganic film, and a buffer layer (**20***a*, **22***a*) comprised of an organic film and provided between adjacent two of the plurality of buffer layers (**19***a*, **21***a*, **23***a*). The buffer layer (**20***a*, **22***a*) includes, in its peripheral edge portion surrounding the organic EL element, a flat thin portion (**20***t*, **22***t*) which is thinner than the rest of the buffer layer (**20***a*, **22***a*) above the organic EL element (**18**).

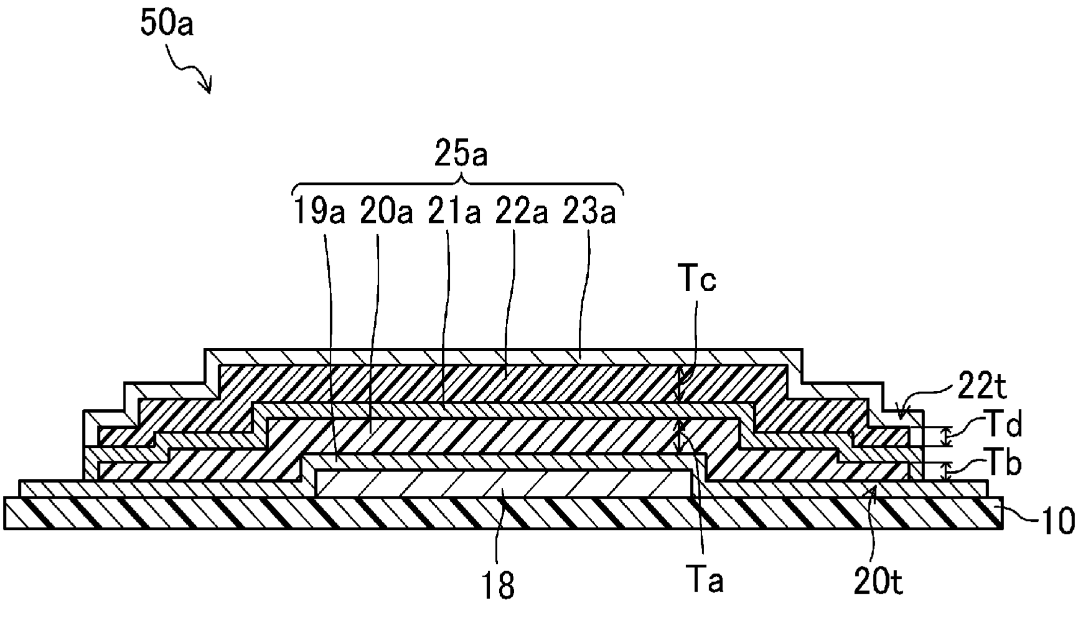
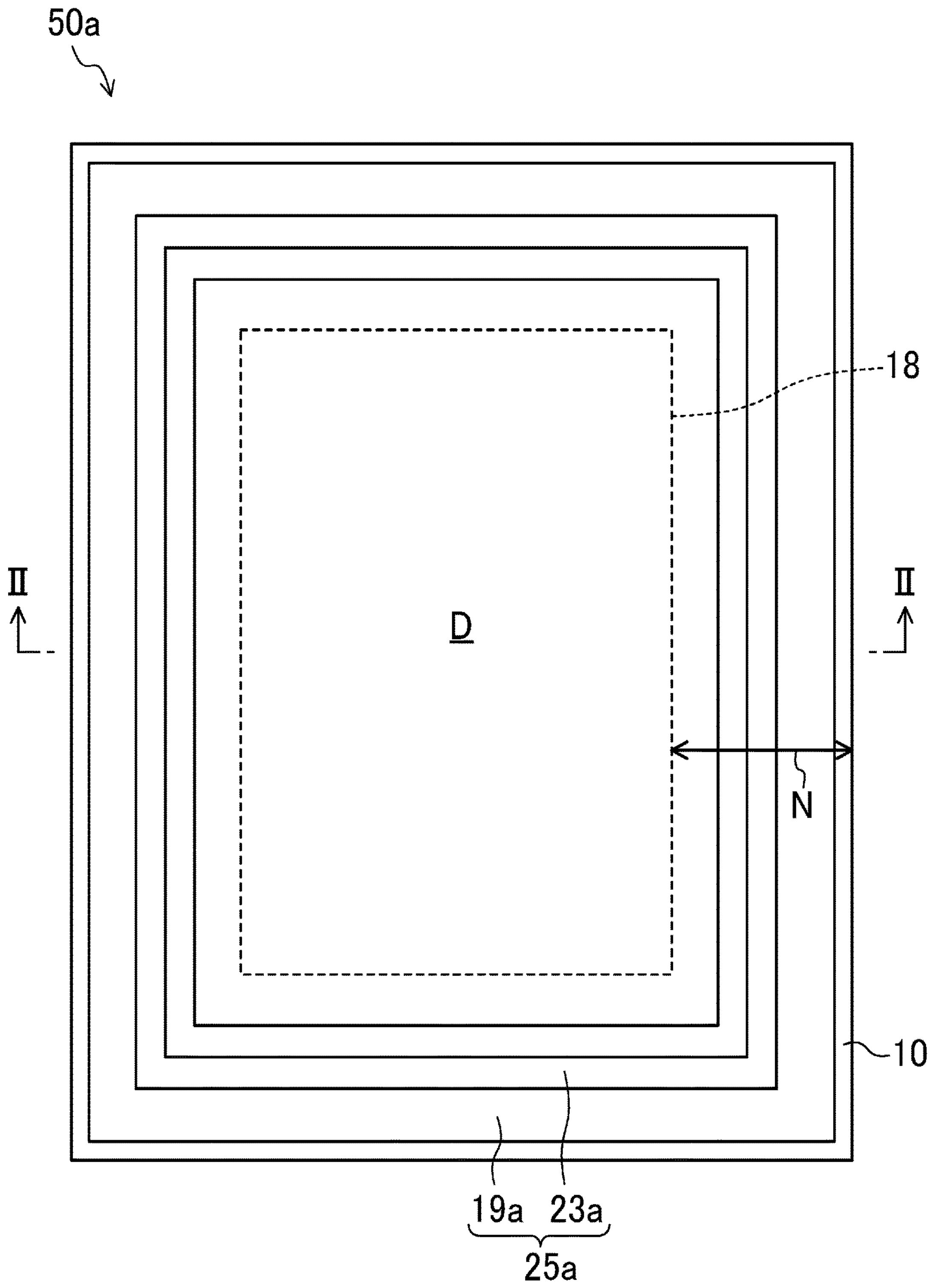


FIG. 1



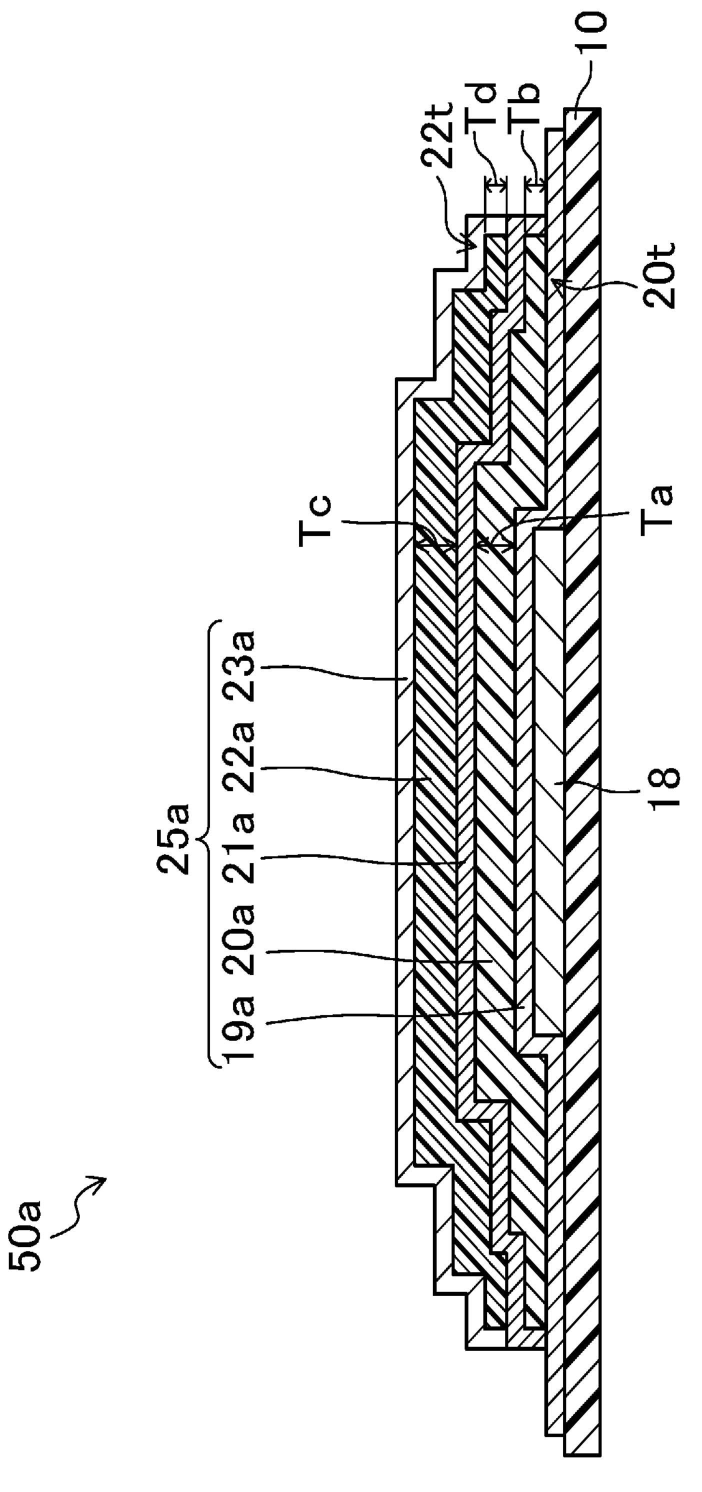


FIG. 2

FIG. 3

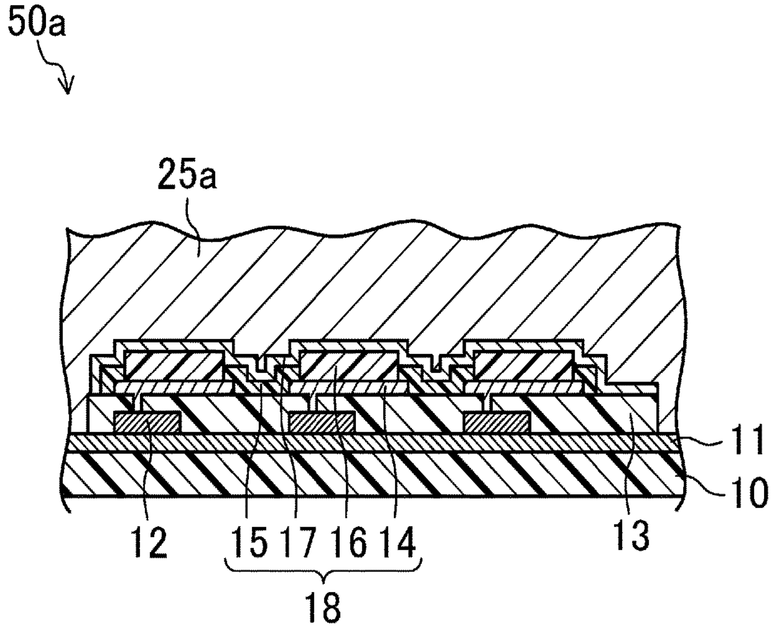


FIG. 4

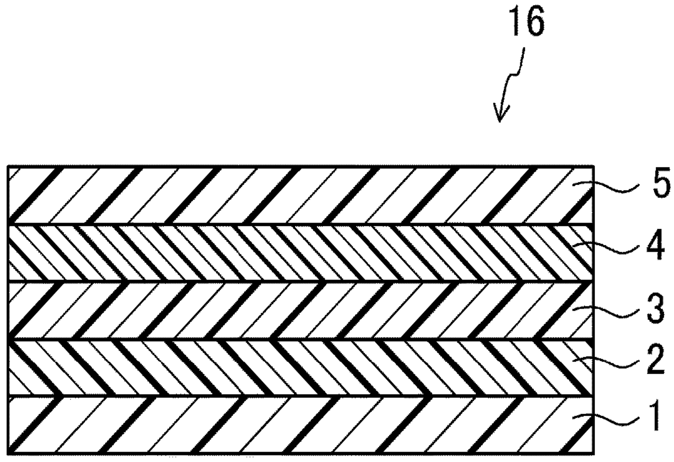


FIG. 5

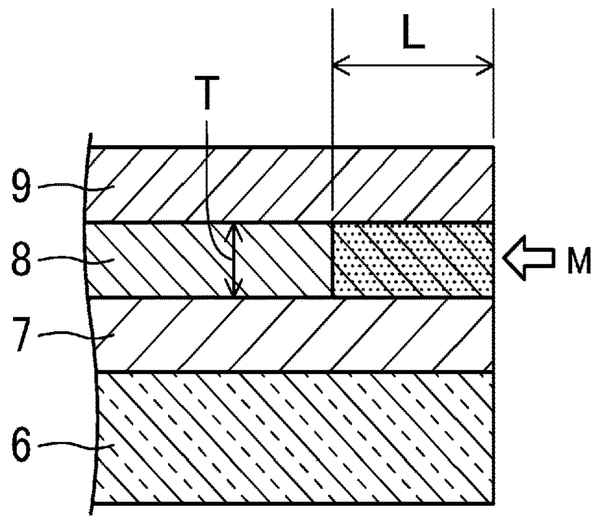
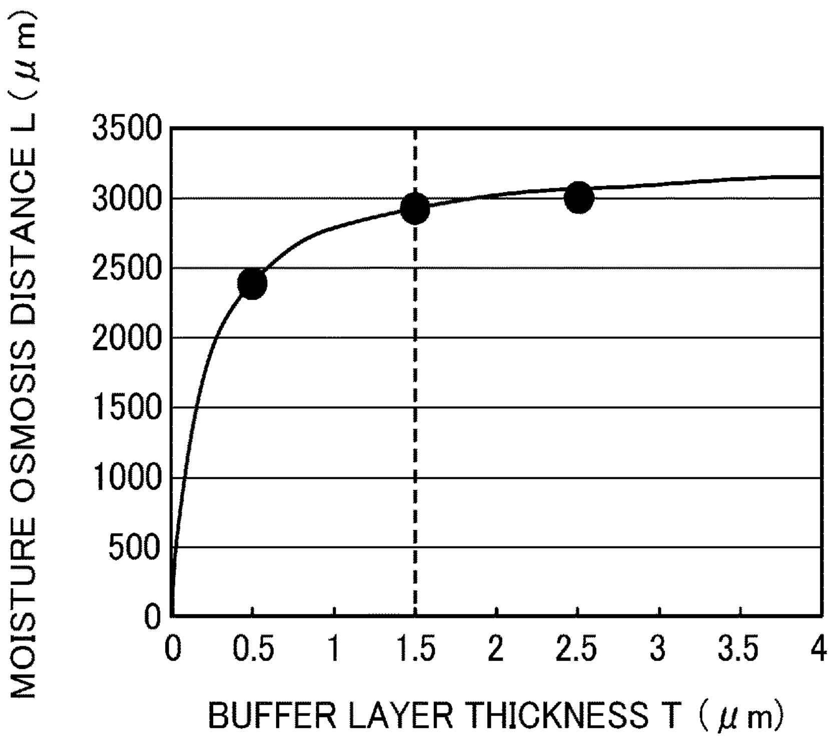

L
T
9
8
M
7
6

FIG. 6


MOISTURE OSMOSIS DISTANCE L (μm)
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
BUFFER LAYER THICKNESS T (μm)

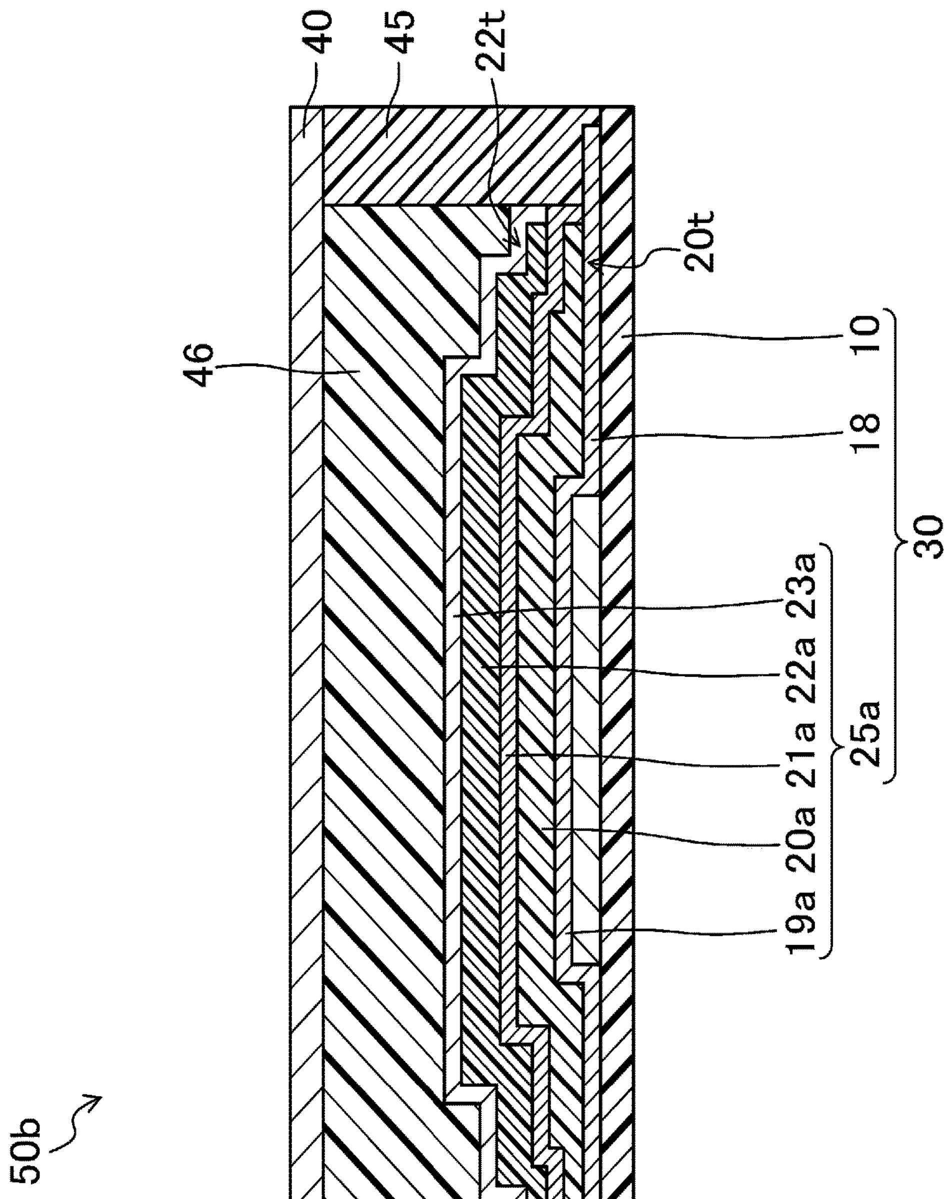
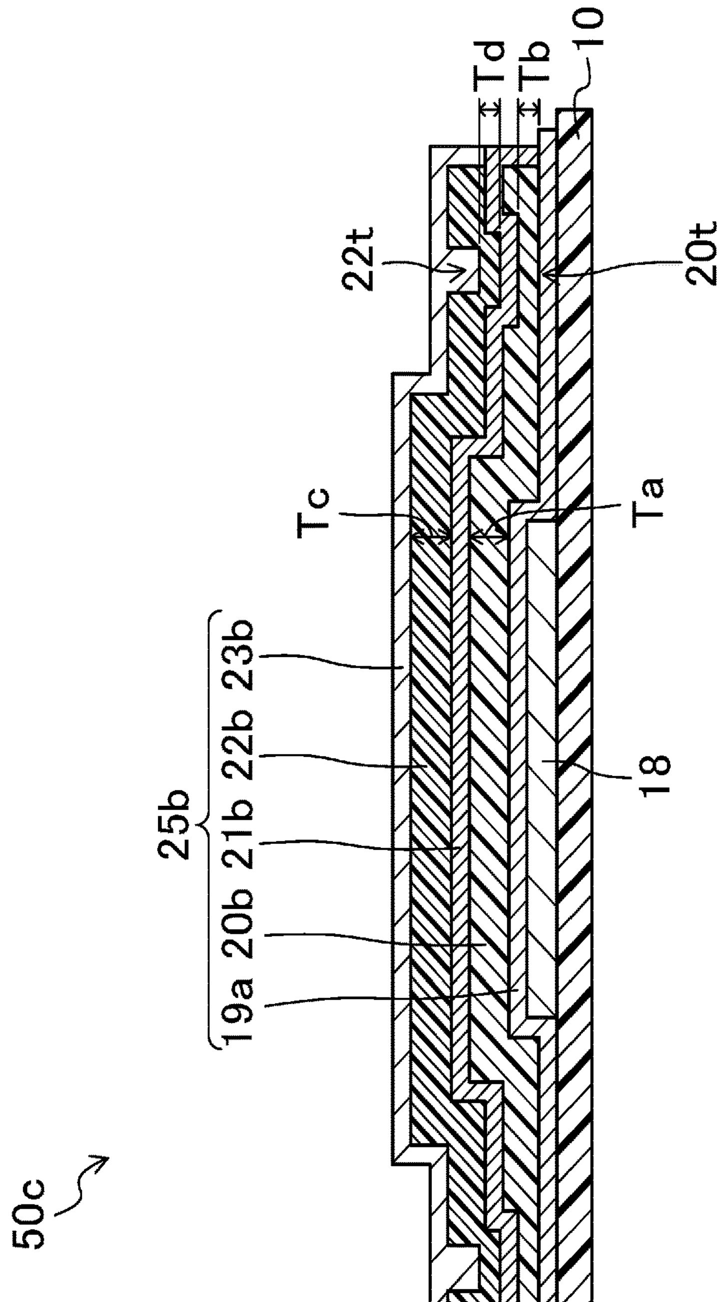


FIG. 7

FIG. 8



ORGANIC EL DISPLAY DEVICE

TECHNICAL FIELD

[0001] The present invention relates to an organic EL display device.

BACKGROUND ART

[0002] Self-luminous organic EL display devices including an organic electroluminescence (EL) element have recently received attention, as display devices alternative to liquid crystal display devices. For such organic EL display devices, a sealing structure has been proposed for reducing the deterioration of an organic EL element caused by entry of moisture, oxygen, and other substances. The sealing structure includes a sealing film covering the organic EL element and comprised of a stack of inorganic and organic films.

[0003] For example, Patent Document 1 discloses an organic EL display device including a sealing member (sealing film) formed by sequentially stacking a first barrier layer made of an inorganic material, a first buffer layer made of a resin material, a second barrier layer made of an inorganic material, a second buffer layer made of a resin material, and a third barrier layer made of an inorganic material.

CITATION LIST

Patent Documents

[0004] Patent Document 1: Japanese Unexamined Patent Publication No. 2006-4650

SUMMARY OF THE INVENTION

Technical Problem

[0005] Meanwhile, in the organic EL display device disclosed in Patent Document 1, the first, second, and third barrier layers each made of an inorganic material are stacked in a peripheral end portion of an array substrate forming part of the organic EL display device without interposing the first buffer layer made of a resin material between the first and second barrier layers, and the second buffer layer made of a resin material between the second and third layers. Therefore, stress caused by the first, second, and third barrier layers are not reduced by the first and second buffer layers in the peripheral end portion of the sealing member. Consequently, there may be the risk of deterioration of the sealing capability caused by, for example, delamination of the sealing member. In addition, in the peripheral end portion of the sealing member of the organic EL display device, if foreign matter exists at any of the interfaces between the first, second, and third barrier layers, the foreign matter is likely to break through the first, second, and third barrier layers because of the absence of the first and second buffer layers. This may deteriorate the sealing capability.

[0006] In view of the foregoing background, it is therefore an object of the present invention to reduce deterioration of sealing capability in a peripheral end portion of a sealing film.

Solution to the Problem

[0007] To achieve the above object, an organic EL display device of the present invention includes: a base substrate defining thereon a display region configured to display an image, and a non-display region surrounding the display region; an organic EL element provided in the display region of the base substrate; and a sealing film extending over the display region and the non-display region and covering the organic EL element, the sealing film including a plurality of barrier layers each comprised of an inorganic film, and a buffer layer comprised of an organic film and provided between adjacent two of the plurality of barrier layers. The buffer layer includes, in a peripheral edge portion of the buffer layer located in the non-display region surrounding the organic EL element, a flat thin portion which is thinner than the rest of the buffer layer located above the organic EL element.

Advantages of the Invention

[0008] According to the present invention, the buffer layer includes, in its peripheral edge portion located in the non-display region surrounding the organic EL element, the flat thin portion which is thinner than the rest of the buffer layer located above the organic EL element. This configuration can reduce deterioration of sealing capability in a peripheral end portion of the sealing film.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a plan view showing a schematic configuration for an organic EL display device according to a first embodiment of the present invention.

[0010] FIG. **2** is a cross-sectional view taken along line II-II in FIG. **1**, showing the schematic configuration for the organic EL display device.

[0011] FIG. **3** is a cross-sectional view showing an internal configuration for the organic EL display device according to the first embodiment of the present invention.

[0012] FIG. **4** is a cross-sectional view of an organic EL layer included in the organic EL display device according to the first embodiment of the present invention.

[0013] FIG. **5** is a cross-sectional view showing a model experiment on the organic EL display device according to the first embodiment of the present invention.

[0014] FIG. **6** is a graph showing a relationship between a buffer layer thickness and a moisture osmosis distance, which was determined in the model experiment on the organic EL display device according to the first embodiment of the present invention.

[0015] FIG. **7** is a cross-sectional view showing a schematic configuration for an organic EL display device according to a second embodiment of the present invention.

[0016] FIG. **8** is a cross-sectional view showing a schematic configuration for an organic EL display device according to a third embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0017] 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

[0018] FIGS. **1**-**6** show a display device according to a first embodiment of the present invention. Specifically, FIG. **1** is a plan view showing a schematic configuration for the organic EL display device **50***a* of this embodiment. FIG. **2** is a cross-sectional view taken along line II-II in FIG. **1**, showing the schematic configuration for the organic EL display device **50***a*. FIG. **3** is a cross-sectional view showing an internal configuration for the organic EL display device **50***a*. FIG. **4** is a cross-sectional view of an organic EL layer **16** included in the organic EL display panel **50***a*.

[0019] As shown in FIGS. **1** and **2**, the organic EL display device **50***a* includes: a transparent resin substrate **10** provided as a base substrate; an organic EL element **18** provided (indirectly) over the resin substrate **10**; and a sealing film **25***a* covering the organic EL element **18**. Here, as shown in FIG. **1**, in the organic EL display device **50***a*, the organic EL element **18** has a rectangular shape in a plan view, and accordingly, defines a rectangular display region D where images are displayed. The display region D includes a plurality of pixels arranged in a matrix. For example, each pixel includes a set of sub-pixels arranged adjacent to each other. The set of sub-pixels includes 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. **1**, the organic EL display device **50***a* defines therein a non-display region N in the shape of a frame surrounding the display region D. As shown in FIG. **3**, the organic EL display device **50***a* includes, between the resin substrate **10** and the organic EL element **18**, a basecoat film **11**, a plurality of TFTs **12**, and an interlayer insulating film **13** which are sequentially stacked in a direction away from the resin substrate **10**.

[0020] The first resin substrate **10** is a plastic substrate made of, for example, polyimide resin. The flexible, insulating, and transparent resin substrate is described as an example of the base substrate of this embodiment. Alternatively, the base substrate may be, for example, an insulating transparent glass substrate or an opaque, thin metal plate having electrical conductivity.

[0021] As shown in FIG. **3**, the basecoat film **11** is provided on the resin substrate **10**. Here, the basecoat film **11** is, for example, an inorganic insulating film such as a silicon dioxide film or a silicon nitride film.

[0022] As shown in FIG. **3**, each of the TFTs **12** is a switching element provided on the basecoat film **11** for an associated one of the sub-pixels. Here, each TFT **12** includes, for example: a gate electrode provided on the basecoat film **11**; a gate insulating film covering the gate electrode; a semiconductor layer provided over the gate insulating film and overlapping with the gate electrode; and source and drain electrodes provided over the semiconductor layer and facing each other. Note that each TFT **12** configured as a bottom gate TFT in this embodiment may be configured as a top gate TFT.

[0023] As shown in FIG. **3**, the interlayer insulating film **13** covers each TFT **12**, except for 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.

[0024] The organic EL element **18** is arranged in the display region D, and 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 FIG. **3**.

[0025] As shown in FIG. **3**, 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 illustrated in FIG. **3**, the first electrodes **14** are connected to the respective 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 preferably made of a material having a high work function. Non-limiting examples of materials for the first electrodes **14** include 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 (AtO_2), lithium (Li)/aluminum (Al), lithium (Li)/calcium (Ca)/aluminum (Al), or lithium fluoride (LiF)/calcium (Ca)/aluminum (Al). Furthermore, 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 the materials having a high work function include indium tin oxide (ITO) and indium zinc oxide (IZO).

[0026] The edge cover **15** is formed in a grid pattern to cover a peripheral portion of each first electrode **14** as shown in FIG. **3**. Non-limiting examples of materials for the edge cover **15** include an inorganic film of silicon dioxide (SiO_2), silicon nitride (SiNx, where x is a positive number) such as Si_3N_4, and silicon oxynitride (SiNO), or an organic film of polyimide resin, acrylic resin, polysiloxane resin, and novolak resin.

[0027] As shown in FIG. **3**, the 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 sub-pixels. Here, as shown in FIG. **4**, 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 provided over the associated first electrode **14** in this order.

[0028] The positive hole injection layer **1** is also called an anode buffer layer, and has the function of bringing the energy levels of the first electrodes **14** and the organic EL layers **16** closer to each other and increasing efficiency in injection of positive holes from the first electrodes **14** into the organic EL layers **16**. Here, non-limiting examples of materials for the positive hole injection layer **1** include triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyarylalkane derivatives, pyrazoline derivatives, phenylenediamine derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives, hydrazone derivatives, and stilbene derivatives.

[0029] The positive hole transport layer **2** has the function of increasing an efficiency in transportation of positive holes from the first electrodes **14** to the organic EL layers **16**. Here, non-limiting examples of materials for the positive hole transport layer **2** include porphyrin derivatives, aromatic tertiary amine compounds, styryl amine derivatives, polyvinylcarbazole, poly-p-phenylene vinylene, polysilane, triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyarylalkane 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.

[0030] 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 efficiency. Non-limiting examples of materials for the light-emitting layer **3** include 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.

[0031] The electron transport layer **4** functions to efficiently move electrons to the light-emitting layer **3**. Here, non-limiting examples of materials for the electron transport layer **4** includes, as organic compounds, oxadiazole derivatives, triazole derivatives, benzoquinone derivatives, naphthoquinone derivatives, anthraquinone derivatives, tetracyanoanthraquinodimethane derivatives, diphenoquinone derivatives, fluorenone derivatives, silole derivatives, and metal oxinoid compounds.

[0032] The electron injection layer **5** has the function of bringing the energy levels of the second electrode **17** and the organic EL layers **16** closer to each other and increasing efficiency in injection of electron from the second electrode **17** into the organic EL layers **16**. This function contributes to reduction in the drive voltage of the organic EL element **18**. The electron injection layer **5** may also be called a cathode buffer layer. Here, non-limiting examples of materials for the electron injection layer **5** include inorganic alkaline compounds such as lithium fluoride (LiF), magnesium fluoride (MgF_2), calcium fluoride (CaF_2), strontium fluoride (SrF_2), and barium fluoride (BaF_2), aluminum oxide (Al_2O_3), and strontium oxide (SrO).

[0033] As shown in FIG. **3**, 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 efficiency in injecting electrons into the organic EL layers **16**, the second electrode **17** is preferably made of a material having a low work function. Here, non-limiting examples of materials for the second electrode **17** include 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 second electrode **17** may also be made of, for example, an alloy of magnesium (Mg)/copper (Cu), magnesium (Mg)/silver (Ag), sodium (Na)/potassium (K), astatine (At)/astatine dioxide (AtO_2), 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, for example, a conductive oxide such as tin oxide (SnO), zinc oxide (ZnO), indium tin oxide (ITO), and indium zinc oxide (IZO). Moreover, the second electrode **17** may be multilayers containing the above materials. Non-limiting examples of materials having a low work function include 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).

[0034] The sealing film **25***a* extends over the display region D and the non-display region N and covers the organic EL element **18**. The sealing film **25***a* has the function of protecting the organic EL element **18** against moisture and oxygen. As shown in FIG. **2**, the sealing film **25***a* includes a first barrier layer **19***a*, a first buffer layer **20***a*, a second barrier layer **21***a*, a second buffer layer **22***a*, and a third barrier layer **23***a*, which are stacked sequentially in a direction away from the organic EL element **18**.

[0035] Non-limiting examples of materials for the first, second, and third barrier layers **19***a*, **21***a*, and **23***a* include inorganic films such as a silicon dioxide (SiO_2) film, an aluminum oxide (Al_2O_3) film, a film of silicon nitride (SiN_x, where x is a positive number) such as Si_3N_4, and a silicon carbonitride (SiCN) film.

[0036] Non-limiting examples of materials for the first and second buffer layers **20***a* and **22***a* include organic films such as an acrylate film, a polyurea film, a parylene film, a polyimide film, and a polyamide film. Here, as shown in FIG. **2**, the first buffer layer **20***a* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **20***t* having a thickness Tb (e.g., about 0.5 to 1.5 μm), which is smaller than the thickness Ta (e.g., about 2.5 μm) of the rest of the first buffer layer **20***a* located above the organic EL element **18**. As shown in FIG. **2**, the second buffer layer **22***a* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **22***t* having a thickness Td (e.g., about 0.5 to 1.5 μm), which is smaller than the thickness Tc (e.g., about 2.5 μm) of the rest of the second buffer layer **22***a* located above the organic EL element **18**. Each of the first and second buffer layers **20***a* and **22***a* has, in its portion surrounding the organic EL element **18**, a stepped cross-sectional shape of which the height decreases outwardly, as shown in FIG. **2**. The thin portion **20***t* of the first buffer layer **20***a* and the thin portion **22***t* of the second buffer layer **22***a* surround the entire periphery of the organic EL element **18**. As shown in FIG. **2**, the thin portions **20***t* and **22***t* of the first and second buffer layers **20***a* and **22***a* overlap with each other in a plan view (i.e., as viewed in a substrate thickness direction). The thin portions **20***t* and **22***t* of the first and second buffer layers **20***a* and **22***a* each have a width raging from about 1.0 mm to about 3 mm, for example.

[0037] The organic EL display device **50***a* having the configuration described above is flexible, and capable of displaying an image by causing the light-emitting layer **3** of the organic EL layer **16** to appropriately emit light in each sub-pixel via the TFT **12**.

[0038] The organic EL display device **50***a* of this embodiment is produced in the following manner. First, a basecoat film **11**, TFTs **12**, an interlayer insulating film **13**, and an organic EL element **18** (including first electrodes **14**, an edge cover **15**, organic EL layers **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**) are formed, by a known method, over a surface of a resin substrate **10** made of, for example, polyimide resin. Next, organic and inorganic films are formed to cover the organic EL element **18** by chemical vapor deposition (CVD) or evaporation method, thereby forming a sealing film **25***a*. Here, during the deposition of the first and second buffer layers **20***a* and **22***a* forming part of the sealing film **25***a*, a film formation mask may be used to reduce the amount of material deposited in a peripheral edge portion located in a non-display region N surrounding the organic EL element **18**. Alternatively, a layer once deposited to a uniform thickness may be dry-etched such that a peripheral portion thereof located in the non-display region N surrounding the organic EL element **18** is thinned down. In this way, the thin portions **20***t* and **22***t* are formed.

[0039] Next, an experiment which was actually conducted will be described. FIG. **5** is a cross-sectional view showing the model experiment on the organic EL display device **50***a*. FIG. **6** is a graph showing a relationship between a buffer layer thickness T and a moisture osmosis distance L, which was determined through the model experiment on the organic EL display device **50***a*.

[0040] As shown in FIG. **5**, a SiNx film having a thickness of 0.5 μm, a SiCN film having a thickness of 0.5 μm, 1.5 μm, or 2.5 μm, and a SiNx film having a thickness of 0.5 μm were sequentially formed over a 0.7 mm thick glass substrate **6** by CVD. In this manner, three specimens each included a first barrier layer **7**, a buffer layer **8**, and a second barrier layer **9** were prepared, which differed in the thickness of the buffer layer **8**.

[0041] The three specimens were allowed to stand in a constant temperature/humidity bath set at a temperature of 80° C. and a relative humidity of 85% for 336 hours. Thereafter, an end of the glass substrate **6** of each specimen was observed with a microscope to determine a moisture osmosis distance L. Specifically, as shown in FIG. **5**, the length of an area of the buffer layer **8** which was discolored due to absorption of moisture M (i.e. the dotted area in the figure) was measured from the end surface of the glass substrate **6** at three different points, and the average of the measurements was taken to be determined as the moisture osmosis distance L.

[0042] FIG. **6** shows the results of the experiment. The results demonstrate that the moisture osmosis distance L increases in a logarithmic function manner with respect to the thickness T of the buffer layer **8**, and that the moisture osmosis distance L steeply decreases when the thickness T of the buffer layer **8** is about 1.5 μm or less. Thus, it has been conjectured that in the three-layer stack including the first barrier layer **7**, the buffer layer **8**, and the second barrier layer **9**, the speed at which the osmosis of moisture M progresses depends on the thickness of the buffer layer **8**.

[0043] As can be seen, the organic EL display device **50***a* of this embodiment can provide the following advantages.

[0044] (1) The sealing film **25***a*, which covers the organic EL element **18** arranged in the display region D of the resin substrate **10**, extends over the display region D and the non-display region N, and includes the first barrier layer **19***a*, a second barrier layer **21***a*, and a third barrier layer **23***a* that are each comprised of an inorganic film. The sealing film **25***a* also includes the first buffer layer **20***a*, which is comprised of an organic film and sandwiched between the adjacent first and second barrier layers **19***a* and **21***a*. The sealing film **25***a* further includes the second buffer layer **22***a*, which is comprised of an organic film and sandwiched between the adjacent second and third barrier layers **21***a* and **23***a*. The first buffer layer **20***a* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **20***t* of which the thickness Tb is smaller than the thickness Ta of the rest of the first buffer layer **20***a* located above the organic EL element **18**. The second buffer layer **22***a* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **22***t* of which the thickness Td is smaller than the thickness Tc of the rest of the second buffer layer **22***a* located above the organic EL element **18**. Thus, also in the peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, the thin portion **20***t* of the first buffer layer **20***a* is arranged between the first and second barrier layers **19***a* and **21***a*, and the thin portion **22***t* of the second buffer layer **22***a* is arranged between the second and third barrier layers **21***a* and **23***a*. As a result, stress caused by the first, second, and third barrier layers **19***a*, **21***a*, and **23***a* can be reduced by the first and second buffer layers **20***a* and **22***a*. This can reduce the risk of delamination of the sealing film **25***a* and similar inconveniences. In the peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, if foreign matter exists at any of the interfaces between the first, second, and third barrier layers **19***a*, **21***a*, and **23***a*, the interposition of the thin portion **20***t* of the first buffer layer **20***a* and the thin portion **22***t* of the second buffer layer **22***a* makes it difficult for the foreign matter to break through the first, second, and third barrier layers **19***a*, **21***a*, and **23***a*. Further, the thicknesses Tb and Td of the first and second buffer layers **20***a* and **22***a* in the peripheral edge portion located in the non-display region N surrounding the organic EL element **18** are smaller than the thicknesses Ta and Tc of the first and second buffer layers **20***a* and **22***a* above the organic EL element **18**. This configuration can reduce the speed at which the osmosis of moisture M progresses from a peripheral end portion of the sealing film **25***a*. Thus, the configuration described above can reduce the risk of delamination of the sealing film **25***a* in its peripheral end portion, the risk of breaking through of the peripheral end portion of the sealing film **25***a* by foreign matter, and the risk of increase in the speed at which the osmosis of moisture M progresses from the peripheral end portion of the sealing film **25***a*, thereby enabling reduction of deterioration of the sealing capability of the peripheral end portion of the sealing film **25***a*.

[0045] (2) The thin portions **20***t* and **22***t* of the first and second buffer layers **20***a* and **22***a* each surround the entire periphery of the organic EL element **18**. This configuration makes it possible to reduce the deterioration of the sealing capability of the peripheral end portion of the sealing film **25***a* along the entire periphery.

[0046] (3) The first and second buffer layers **20***a* and **22***a* include the thin portions **20***t* and **22***t*, respectively. This configuration can reduce the deterioration of the sealing capability of the peripheral end portion of the sealing film **25***a* more effectively than in a case where only one of the first and second buffer layers **20***a* and **22***a* includes a thin portion.

[0047] (4) The thin portions **20***t* and **22***t* of the first and second buffer layers **20***a* and **22***a* overlap with each other. Therefore, the thin portions **20***t* and **22***t* can be formed at a low cost if a single film formation mask or a single etching mask is shared.

[0048] (5) Each of the first and second buffer layers **20***a* and **22***a* has, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a stepped cross-sectional shape of which the height decreases outwardly. This configuration can reduce the width of the peripheral edge portion located in the non-display region N surrounding the organic EL element **18**.

Second Embodiment

[0049] FIG. **7** is a plan view showing a schematic configuration for an organic EL display device **50***b* of this embodiment. In the embodiments below, components equivalent to those illustrated in FIGS. **1-6** are denoted by the same reference characters, and the detailed explanation thereof will be omitted.

[0050] In the first embodiment, the organic EL display devices **50***a* including no sealing substrate has been exemplified. In this embodiment, an organic EL display device **50***b* including a sealing substrate **40** is exemplified.

[0051] As shown in FIG. **7**, the organic EL display device **50***b* includes: an element substrate **30** and the sealing substrate **40** facing each other; a frame-shaped sealing material **45** provided between the element substrate **30** and the sealing substrate **40**; and a sealing resin layer **46** provided in a region surrounded by the sealing material **45** between the element substrate **30** and the sealing substrate **40**.

[0052] As shown in FIG. **7**, the element substrate **30** has substantially the same configuration as that of the organic EL display device **50***a* of the first embodiment. Note that although the element substrate **30** exemplified in this embodiment has substantially the same configuration as that of the organic EL display device **50***a* of the first embodiment, the element substrate **30** may alternatively be configured as an organic EL display device **50***c* of a third embodiment, which will be described later.

[0053] The sealing substrate **40** includes, for example, a resin substrate and a basecoat film provided on the resin substrate. Here, the resin substrate of the sealing substrate **40** has substantially the same configuration as that of the resin substrate **10** of the first embodiment. The basecoat film of the sealing substrate **40** has substantially the same configuration as that of the basecoat film **11** of the first embodiment.

[0054] The sealing material **45** is provided so as to bond a peripheral portion of the element substrate **30** to a peripheral portion of the sealing substrate **40**. Non-limiting examples of materials for the sealing material **45** include epoxy resin, acrylic resin, polyimide resin, and phenol resin which are UV curable and/or thermosetting.

[0055] The sealing resin layer **46** functions as a getter (i.e., has the function of adsorbing oxygen, moisture, and other substances). Non-limiting examples of materials for the sealing resin layer **46** include epoxy resin and silicon resin which are thermosetting. Moreover, the sealing resin layer **46** contains, for example, a metal oxide such as calcium oxide (CaO), barium oxide (BaO), and aluminum oxide (Al_2O_3), and active carbon, silica gel, and zeolite.

[0056] The organic EL display device **50***b* having the configuration described above is flexible, and capable of displaying an image by causing the light-emitting layer **3** of the organic EL layer **16** to appropriately emit light in each sub-pixel via the TFT **12**.

[0057] The organic EL display device **50***b* having the configuration described above can be produced in the following process.

[0058] First, a sealing resin is applied to a surface of the organic EL display device **50***a* produced by the production method according to the first embodiment, i.e., to a surface of the element substrate **30** by, for example, the dispending method, in a frame shape, and a filler resin is dropped onto and placed in the inside of the sealing resin.

[0059] Subsequently, the element substrate **30** on which the sealing resin and the filler resin have been arranged is bonded to the sealing substrate **40** in a reduced-pressure atmosphere. Thereafter, the reduced-pressure atmosphere is released, thereby applying a pressure to the outer surfaces of the element substrate **30** and the sealing substrate **40**.

[0060] Further, for example, the sealing resin sandwiched between the element substrate **30** and the sealing substrate **40** is irradiated with UV light. Thereafter, the sealing resin and the filler resin are cured by heating the irradiated panel, thereby forming the sealing material **45** and the sealing resin layer **46**.

[0061] As can be seen, the organic EL display device **50***b* of this embodiment can provide the following advantage (6), in addition to the advantages (1)-(5) described above.

[0062] (6) Provision of the sealing substrate **40** facing the element substrate **30**, the sealing material **45** between the element substrate **30** and the sealing substrate **40**, and the sealing resin layer **46** surrounded by the sealing material **45** between the element substrate **30** and the sealing substrate **40** can reduce deterioration of the organic EL element **18**, and enhance the reliability of the organic EL display device **50***b*.

Third Embodiment

[0063] FIG. **8** is a cross-sectional view showing a schematic configuration for an organic EL display device **50***c* of this embodiment.

[0064] In the first and second embodiments, the organic EL display devices **50***a* and **50***b* each including the buffer layers having a stepped cross-sectional shape in its end portion have been exemplified. In this embodiment, an organic EL display device **50***c* is exemplified which includes buffer layers having a cross-sectional shape in which a thin portion forms a constriction.

[0065] As shown in FIG. **8**, the organic EL display device **50***c* includes: a transparent resin substrate **10** provided as a base substrate; an organic EL element **18** provided (indirectly) over the resin substrate **10**; and a sealing film **25***b* covering the organic EL element **18**.

[0066] The sealing film **25***b* extends over a display region D and a non-display region N and covers the organic EL element **18**. The sealing film **25***b* has the function of protecting the organic EL element **18** against moisture and oxygen. As shown in FIG. **8**, the sealing film **25***b* includes a first barrier layer **19***a*, a first buffer layer **20***b*, a second barrier layer **21***b*, a second buffer layer **22***b*, and a third barrier layer **23***b*, which are staked sequentially in a direction away from the organic EL element **18**.

[0067] Non-limiting examples of the materials for the second and third barrier layers **21***b* and **23***b* include inorganic films such as a silicon dioxide (SiO_2) film, an aluminum oxide (Al_2O_3) film, a film of silicon nitride (SiN_x, where x is a positive number) such as Si_3N_4, and a silicon carbonitride (SiCN) film.

[0068] Non-limiting examples of the materials for the first and second buffer layers **20***b* and **22***b* include organic films such as an acrylate film, a polyurea film, a parylene film, a polyimide film, and a polyamide film. Here, as shown in FIG. **8**, the first buffer layer **20***b* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **20***t* having a thickness Tb (e.g., about 0.5 to 1.5 μm) which is smaller than the thickness Ta (e.g., about 2.5 μm) of the rest of the first buffer layer **20***b* located above the organic EL element **18**. As shown in FIG. **8**, the second buffer layer **22***b* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a flat thin portion **22***t* having a thickness Td (e.g., about 0.5 to 1.5 μm) which is smaller than the thickness Tc (e.g., about 2.5 μm) of the rest of the second buffer layer **22***b* located above the organic EL element **18**. Thus, when viewed in section, each of the first and second buffer layers **20***b* and **22***b* has, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a constriction formed by the thin portion **20***t* or **22***t*, in other words, a groove having, for example, a U- or V-shaped cross section. The thin portions **20***t* and **22***t* of the first and second buffer layers **20***b* and **22***b* each surround the entire periphery of the organic EL element **18**. As shown in FIG. **8**, the thin portions **20***t* and **22***t* of the first and second buffer layers **20***b* and **22***b* overlap with each other in a plan view (i.e., as viewed in a substrate thickness direction). The thin portions **20***t* and **22***t* of the first second buffer layers **20***b* and **22***b* each has a width ranging from about 0.1 mm to about 3 mm.

[0069] The organic EL display device **50***c* having the configuration described above is flexible, and capable of displaying an image by causing the light-emitting layer **3** of the organic EL layer **16** to appropriately emit light in each sub-pixel via the TFT **12**.

[0070] The organic EL display device **50***c* having the configuration above described can be produced by the production method of the organic EL display device **50***a* described in the first embodiment, and by changing the thickness arrangement in the formation of the inorganic and organic films.

[0071] As can be seen, the organic EL display device **50***c* of this embodiment can provide the following advantage (7), in addition to the advantages (1)-(4) described above.

[0072] The advantage (1) will be detailed below. The sealing film **25***b*, which covers the organic EL element **18** arranged in the display region D of the resin substrate **10**, extends over the display region D and the non-display region N and includes the first barrier layer **19***a*, a second barrier layer **21***b*, and a third barrier layer **23***b* that are each comprised of an inorganic film. The sealing film **25***b* also includes the first buffer layer **20***b*, which is comprised of an organic film and sandwiched between the adjacent first and second barrier layers **19***a* and **21***b*. The sealing film **25***b* further includes the second buffer layer **22***b*, which is comprised of an organic film and sandwiched between the adjacent second and third barrier layers **21***b* and **23***b*. The first buffer layer **20***b* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, the flat thin portion **20***t* of which the thickness Tb is smaller than the thickness Ta of the rest of the first buffer layer **20***b* located above the organic EL element **18**. The second buffer layer **22***b* includes, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, the flat thin portion **22***t* of which the thickness Td is smaller than the thickness Tc of the rest of the second buffer layer **22***b* located above the organic EL element **18**. Thus, also in the peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, the thin portion **20***t* of the first buffer layer **20***b* and the thin portion **22***t* of the second buffer layer **22***b* are arranged between the adjacent first and second barrier layers **19***a* and **21***b*, and between the adjacent second and third barrier layers **21***b* and **23***b*, respectively. As a result, stress caused by the first, second, and third barrier layers **19***a*, **21***b*, and **23***b* can be reduced by the first and second buffer layers **20***b* and **22***b*. This can reduce the risk of delamination of the sealing film **25***b* and similar inconveniences. In the peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, if foreign matter exists at any of the interfaces between the first, second, and third barrier layers **19***a*, **21***b*, and **23***b*, the interposition of the thin portion **20***t* of the first buffer layer **20***b* and the thin portion **22***t* of the second buffer layer **22***b* makes it difficult for the foreign matter to break through the first, second, and third barrier layers **19***a*, **21***b*, and **23***b*. Further, the thicknesses Tb and Td of the first and second buffer layers **20***b* and **22***b* in the peripheral edge portion located in the non-display region N surrounding the organic EL element **18** are smaller than the thicknesses Ta and Tc of the first and second buffer layers **20***b* and **22***b* above the organic EL element **18**. This configuration can reduce the speed at which the osmosis of moisture M progresses from the peripheral end portion of the sealing film **25***a*. Thus, the configuration described above can reduce the risk of delamination of the sealing film **25***b* in the peripheral end portion, the risk of breaking through of the peripheral end portion of the sealing film **25***b* by foreign matter, and the risk of increase in the speed at which the osmosis of moisture M progresses from the peripheral end portion of the sealing film **25***b*, thereby enabling reduction of deterioration of the sealing capability of the peripheral end portion of the sealing film **25***b*.

[0073] The advantage (2) will be detailed below. The thin portions **20***t* and **22***t* of the first and second buffer layers **20***b* and **22***b* each surround the entire periphery of the organic EL element **18**. This configuration makes it possible to reduce the deterioration of the sealing capability of the peripheral end portion of the sealing film **25***b* along the entire periphery.

[0074] The advantage (3) will be detailed below. The first and second buffer layers **20***b* and **22***b* include the thin portions **20***t* and **22***t*, respectively. This configuration can reduce the deterioration of the sealing capability of the peripheral end portion of the sealing film **25***b* more effectively than in a case where only one of the first and second buffer layers **20***b* and **22***b* has a thin portion.

[0075] The advantage (4) will be detailed below. The thin portions **20***t* and **22***t* of the first and second buffer layers **20***b* and **22***b* overlap with each other. Therefore, the thin portions **20***t* and **22***t* can be formed at a low cost if a single film formation mask or a single etching mask is shared.

[0076] (7) Each of the first and second buffer layers **20***b* and **22***b* has, in its peripheral edge portion located in the non-display region N surrounding the organic EL element **18**, a cross-sectional shape in which the thin portion **20***t* or **22***t* forms a constriction. The constrictions formed by the thin portions **20***t* and **22***t* can reduce the speed at which the osmosis of moisture M progresses from the peripheral end portion of the sealing film **25***b*.

Other Embodiments

[0077] In each of the above embodiments, the organic EL display device in which the thin portion of the first buffer layer overlaps with the thin portion of the second buffer layer has been exemplified. Alternatively, the present invention is applicable to an organic EL display device in which the thin portion of the first buffer layer does not overlap with the thin portion of the second buffer layer.

[0078] In each of the above embodiments, the organic EL display device in which each of the first and second buffer layers includes the thin portion has been exemplified. Alternatively, the present invention is applicable to an organic EL display device in which either one of the first and second buffer layers has the thin portion.

[0079] In each of the above embodiments, the organic EL display device including the five-layer sealing film that is comprised of the third barrier layer, the second buffer layer, the second barrier layer, the first buffer layer, and the first barrier layer has been exemplified. Alternatively, the present invention is applicable to an organic EL display device including a differently-structured sealing film in which a single buffer layer is sandwiched between two barrier layers, such as a three-layer sealing film comprised of, for example, a second barrier layer, a buffer layer, and a first barrier layer.

[0080] Moreover, 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. Alternatively, 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.

[0081] 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. Alternatively, the present invention is applicable to an organic EL display device in which the stacked structure of the organic EL element is inverted, the first electrode functions as the cathode, and the second electrode functions as the anode.

[0082] 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. Alternatively, 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.

INDUSTRIAL APPLICABILITY

[0083] As can be seen from the foregoing description, the present invention is useful for an organic EL display device.

DESCRIPTION OF REFERENCE CHARACTERS

[0084] D Display Region
[0085] N Non-Display Region
[0086] **10** Resin Substrate (Base Substrate)
[0087] **18** Organic EL Element
[0088] **19***a* First Barrier Layer
[0089] **20***a*, **20***b* First Buffer Layer
[0090] **20***t* Thin Portion
[0091] **21***a*, **21***b* Second Barrier Layer
[0092] **22***a*, **22***b* Second Buffer Layer
[0093] **22***t* Thin Portion
[0094] **23***a*, **23***b* Third Barrier Layer
[0095] **25***a*, **25***b* Sealing Film
[0096] **30** Element Substrate
[0097] **40** Sealing Substrate
[0098] **45** Sealing Material
[0099] **46** Sealing Resin Layer
[0100] **50***a*-**50***c* Organic EL Display Device

1. An organic EL display device comprising:
a base substrate defining thereon a display region configured to display an image, and a non-display region surrounding the display region;
an organic EL element provided in the display region of the base substrate; and
a sealing film extending over the display region and the non-display region and covering the organic EL element,
the sealing film including a plurality of barrier layers each comprised of an inorganic film, and a buffer layer comprised of an organic film and provided between adjacent two of the plurality of barrier layers, wherein
the buffer layer includes, in a peripheral edge portion of the buffer layer located in the non-display region surrounding the organic EL element, a flat thin portion which is thinner than the rest of the buffer layer located above the organic EL element.

2. The organic display device of claim **1**, wherein
the thin portion surrounds an entire periphery of the organic EL element.

3. The organic display device of claim **1**, wherein
the plurality of barrier layers include three different barrier layers,
the buffer layer includes two different buffer layers, and each of the two buffer layers includes the thin portion.

4. The organic display device of claim **3**, wherein
the thin portions of the two buffer layers overlap with each other.

5. The organic display device of claim **1**, wherein
the buffer layer has, in the peripheral edge portion of the buffer layer located in the non-display region surrounding the organic EL element, a stepped cross-sectional shape of which a height decreases outwardly.

6. The organic display device of claim **1**, wherein
the buffer layer has, in the peripheral edge portion of the buffer layer located in the non-display region surround-

ing the organic EL element, a cross-sectional shape in which the thin portion forms a constriction.

7. The organic display device of claim **1**, further comprising:

a sealing substrate facing the sealing film on the base substrate; and

a sealing material provided in a frame shape between an element substrate and the sealing substrate to bond the element substrate and the sealing substrate together, the element substrate including the base substrate, the organic EL element, and the sealing film.

8. The organic display device of claim **7**, wherein

a sealing resin layer is provided in a region surrounded by the sealing material provided between the element substrate and the sealing substrate.

9. The organic display device of claim **1**, wherein

the plurality of barrier layers is comprised of a first barrier layer, a second barrier layer, and a third barrier layer which are staked sequentially in a direction away from the organic EL element,

the buffer layer is comprised of a first buffer layer between the first and second barrier layers, and a second buffer layer between the second and third barrier layers, and

each of the first and second buffer layers has, in the peripheral edge portion of the buffer layer located in the non-display region surrounding the organic EL element, a cross-sectional shape in which the thin portion forms a constriction.

10. The organic display device of claim **9**, wherein

each of the first and second buffer layers has a thin portion surrounding an entire periphery of the organic EL element.

11. The organic display device of claim **9**, wherein

each of the first and second buffer layers has a thin portion, and the thin portions of the first and second buffer layers overlap with each other in a plan view.

* * * * *

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[标]申请(专利权)人(译)	夏普株式会社		
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摘要(译)

本发明公开了一种有机EL显示装置，包括：基础基板（ 10 ）;在基础衬底（ 10 ）上提供有机EL元件（ 18 ）;和覆盖有机EL元件的密封膜（ 25 ）（ 18 ）。密封膜（ 25 ）包括多个缓冲层（ 19 21 a， 23 a ）每个都包含无机薄膜和缓冲层（ 20 a， 22 a 由有机薄膜组成，并提供在多个缓冲层中相邻的两个之间（ 19 a， 21 a， 23 a ）。缓冲层（ 20 a 22 ）包括在其围绕有机EL元件的外围边缘部分中，一个扁平的薄部分（ 20 22 ），它比缓冲层的其余部分更薄有机EL元件（ 18 ）上方（ 20 a， 22 a ）。