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(54) DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF

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(57) **ABSTRACT**

In an organic EL display device, an improvement in the performance of a barrier film that blocks entry of a substance that causes degradation, such as moisture, into an organic electroluminescent element is achieved. The organic EL display device includes the barrier film, which is a stacked film including a barrier base material layer made of silicon oxide or silicon nitride and a base material coating layer in contact with an impregnated barrier base material layer. The barrier film blocks transmission of a substance that degrades the organic electroluminescent element. Nano-ink is applied on a surface of the barrier base material layer, and the barrier base material layer is impregnated with the nano-ink. The barrier base material layer subjected to the impregnation treatment serves as the impregnated barrier base material layer, while the nano-ink after impregnation serves as the base material coating layer.

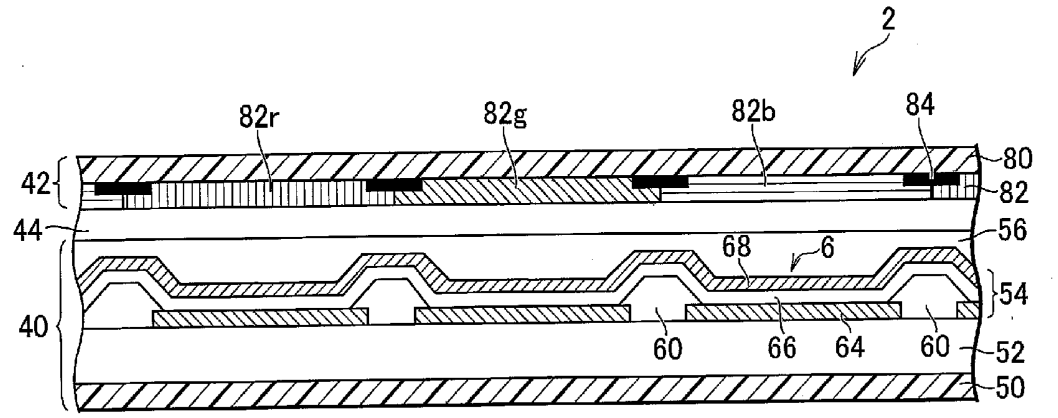


FIG. 1

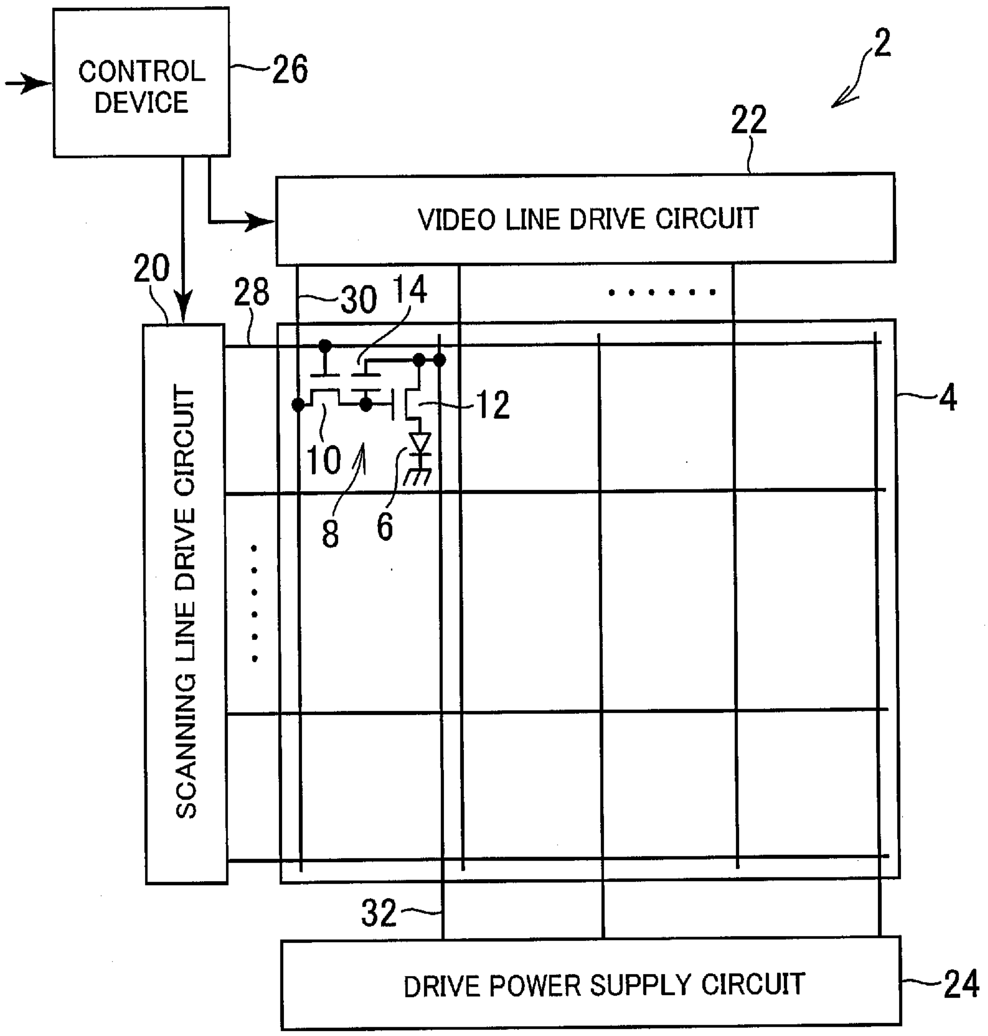

CONTROL DEVICE
26
2
22
VIDEO LINE DRIVE CIRCUIT
20
28
30
14
12
4
10
8
6
SCANNING LINE DRIVE CIRCUIT
32
DRIVE POWER SUPPLY CIRCUIT
24

FIG.2

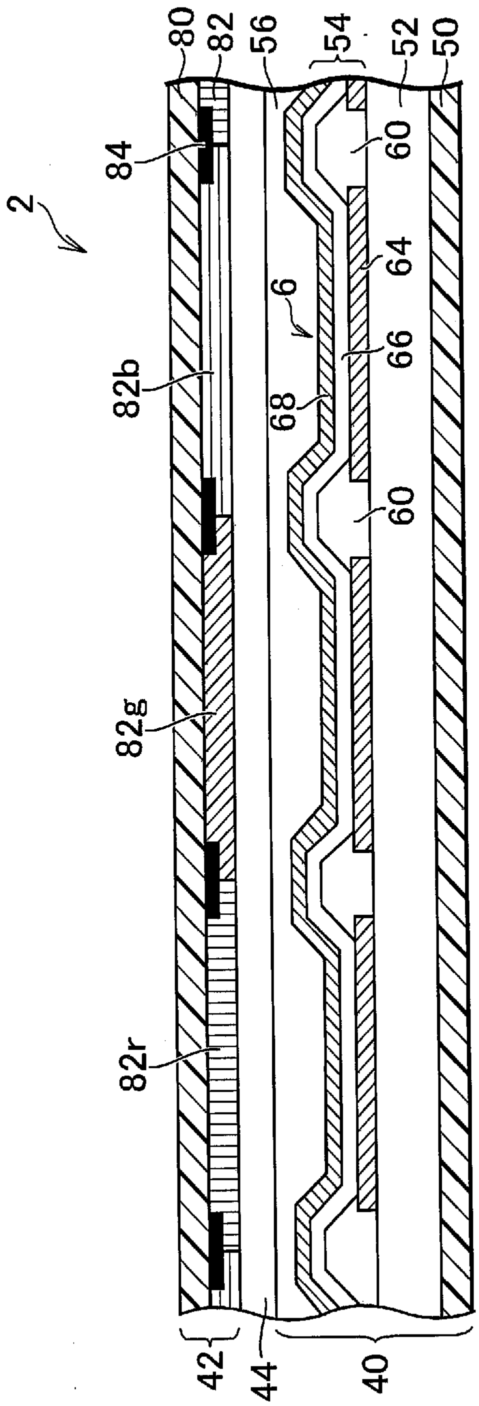


FIG.3A

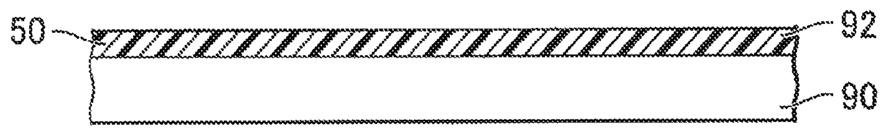


FIG.3B

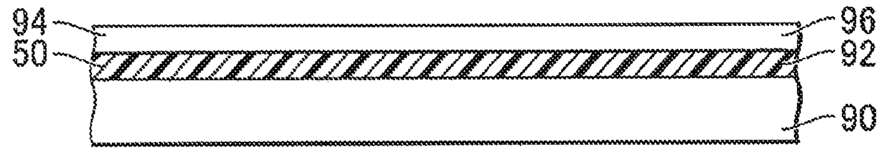


FIG.3C

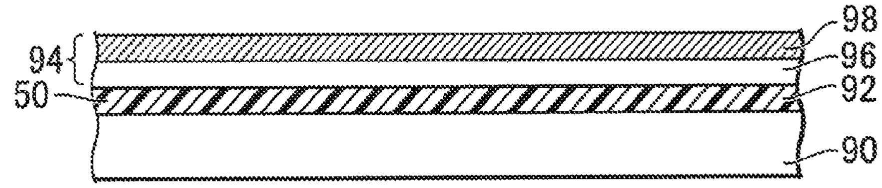


FIG.3D

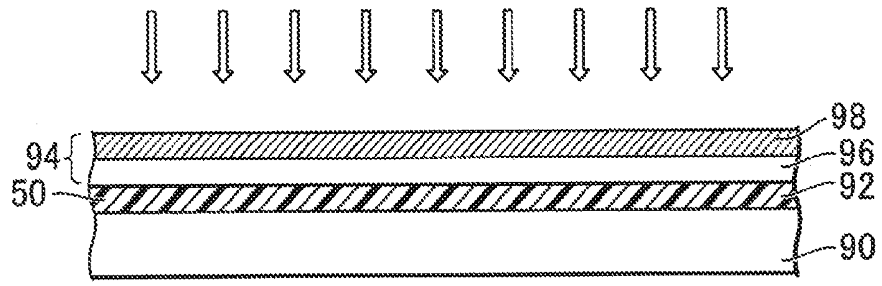


FIG.3E

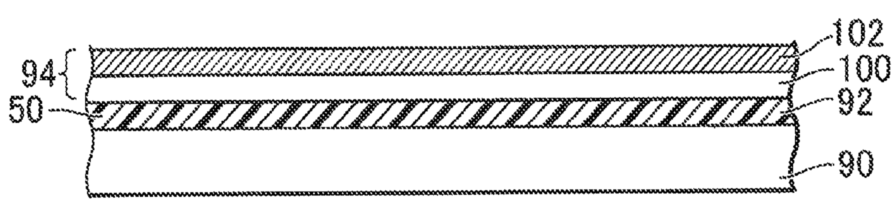


FIG.4A

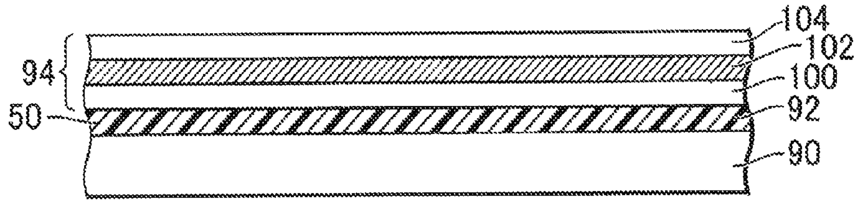


FIG.4B

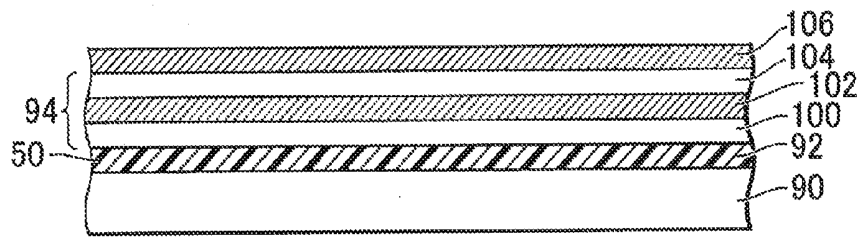


FIG.4C

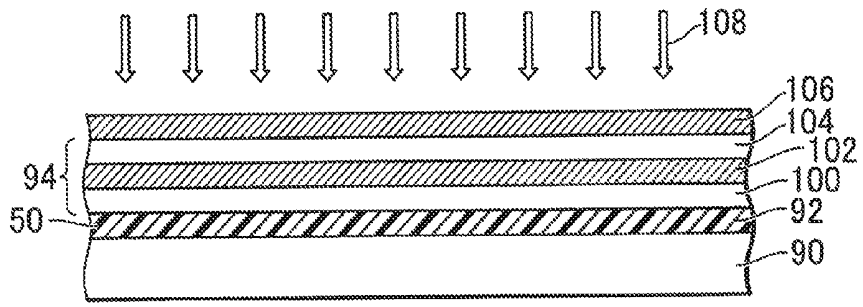


FIG.4D

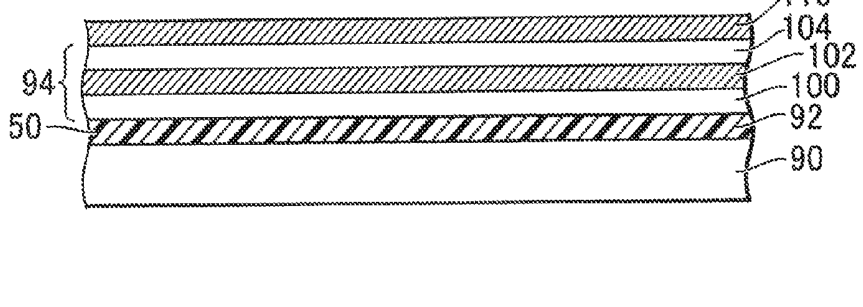


FIG.5A

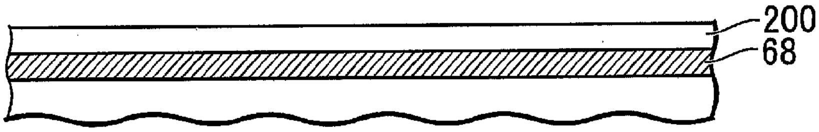


FIG.5B

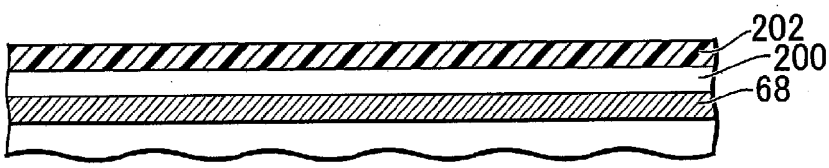
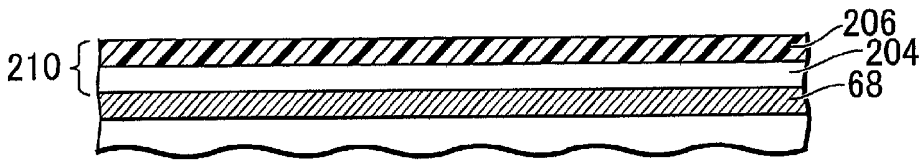


FIG.5C



DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority from Japanese application JP2014-154880 filed on Jul. 30, 2014, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a display device including an organic electroluminescent element and a manufacturing method thereof, and more particularly to a barrier film that blocks transmission of a substance degrading the organic electroluminescent element.

[0004] 2. Description of the Related Art

[0005] A flat panel display such as an organic electroluminescent (EL) display device includes a display panel including thin film transistors (TFTs) or organic light-emitting diodes (OLEDs) as organic electroluminescent elements formed on a substrate. Heretofore, a glass substrate has been used for the substrate of the display panel. In recent years, however, a flexible display is being developed in which polyimide as a resin film is used for the material of the substrate so that the display panel can be bent.

[0006] A protective film that protects the OLED whose characteristics are degraded by moisture or the like is provided in the organic EL display device. For example, the organic EL display device has a structure in which an element substrate on which the OLEDs and the like are formed and a counter substrate on which color filters and the like are formed are bonded together with a filling resin layer interposed therebetween. A sealing film having a moisture-proof function to protect the OLEDs against moisture contained in the filling layer is formed on the OLEDs. Moreover, in order to prevent entry of moisture from a polyimide film serving as a base material of the element substrate, a barrier film with low moisture permeability is provided between the polyimide film and the OLEDs. As the barrier film, a silicon oxide film or silicon nitride film that is stacked by a chemical vapor deposition (CVD) method, or an organic film that is deposited by a vapor deposition method is used.

SUMMARY OF THE INVENTION

[0007] Polyimide can be thermally decomposed at about 500° C. or more, which restricts the upper limit temperature in forming the barrier film on the polyimide film, and thus there is a problem that the characteristics of the barrier film may be limited. For example, when silicon oxide or silicon nitride is formed by a CVD method under this temperature limitation, a reduced film thickness tends to result in a porous film, so that the barrier performance may be insufficient. On the other hand, an increased film thickness can improve the barrier performance, but a time required for deposition is lengthened, so that productivity is reduced. Moreover, the heat resistance of an organic material used for the barrier film is relatively low. Therefore, when the temperature of a low-temperature polysilicon (LTPS) process for forming TFT is higher than the heat-resistant temperature of an organic material, it is difficult to form the barrier film on the polyimide film from the organic material. Moreover, the barrier film has poor adhesion to an organic film such as polyimide, so that detachment of the film easily occurs.

[0008] The invention achieves an improvement in the performance of a barrier film that blocks entry of a substance that causes degradation, such as moisture, into an organic electroluminescent element.

[0009] (1) A display device according to an aspect of the invention includes: a base material made of a resin material; an organic electroluminescent element provided on the base material; and a barrier film including a first layer and a second layer, the first layer containing silicon oxide or silicon nitride, the second layer being in contact with the first layer, the first layer containing a material of the second layer.

[0010] (2) A manufacturing method of a display device according to another aspect of the invention includes the steps of: forming an insulating layer made of silicon oxide or silicon nitride; forming, by application, a nano-ink layer on a surface of the insulating layer; and impregnating the insulating layer with at least a portion of the nano-ink layer.

[0011] (3) A manufacturing method of a display device according to still another aspect of the invention includes the steps of: forming an insulating layer made of silicon oxide or silicon nitride; forming, by application, an organic material layer on a surface of the insulating layer; and impregnating the insulating layer with at least a portion of the organic material layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a schematic view showing a schematic configuration of an organic EL display device according to a first embodiment of the invention.

[0013] FIG. **2** is a schematic partial cross-sectional view of a pixel array portion of the organic EL display device according to the first embodiment of the invention.

[0014] FIGS. **3**A to **3**E are schematic process flow views of steps for forming a stacked structure of a circuit portion in an OLED substrate of the organic EL display device according to the first embodiment of the invention.

[0015] FIGS. **4**A to **4**D are schematic process flow views of steps for forming the stacked structure of the circuit portion in the OLED substrate of the organic EL display device according to the first embodiment of the invention.

[0016] FIGS. **5**A to **5**C are schematic process flow views of steps for forming a sealing layer in an OLED substrate of an organic EL display device according to a second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Hereinafter, embodiments of the invention will be described based on the drawings.

[0018] The disclosure is illustrative only. Appropriate modifications that will readily occur to those skilled in the art and fall within the gist of the invention are of course included in the scope of the invention. In the drawings, the width, thickness, shape, and the like of each part may be schematically represented, compared to those in practicing aspects of the invention, for more clarity of description. However, they are illustrative only, and do not limit the interpretation of the invention. Moreover, in the specification and the drawings, elements similar to those described in relation to a previous drawing are denoted by the same reference numerals and signs, and a detailed description may be appropriately omitted.

First Embodiment

[0019] An organic EL display device is an active matrix display device, which is mounted as a display panel on a television set, a personal computer, a portable terminal, a mobile phone, or the like. FIG. **1** is a schematic view showing a schematic configuration of an organic EL display device **2** according to a first embodiment. The organic EL display device **2** includes a pixel array portion **4** that displays an image and a drive portion that drives the pixel array portion. The organic EL display device **2** is a flexible display, in which a resin film having flexibility, not a glass substrate, is used as a base material and a stacked structure of TFTs, OLEDs, and the like is formed on the base material.

[0020] In the pixel array portion **4**, OLEDs **6** and pixel circuits **8** are disposed in a matrix corresponding to pixels. The pixel circuit **8** includes a plurality of TFTs **10** and **12** and a capacitor **14**.

[0021] On the other hand, the drive portion includes a scanning line drive circuit **20**, a video line drive circuit **22**, a drive power supply circuit **24**, and a control device **26**, and drives the pixel circuit **8** to control light emission of the OLED **6**.

[0022] The scanning line drive circuit **20** is connected to scanning signal lines **28** each provided for alignment of pixels in the horizontal direction (pixel row). The scanning line drive circuit **20** sequentially selects the scanning signal lines **28** in response to a timing signal input from the control device **26**, and applies to the selected scanning signal line **28** a voltage to turn on the lighting TFT **10**.

[0023] The video line drive circuit **22** is connected to video signal lines **30** each provided for alignment of pixels in the vertical direction (pixel column). The video line drive circuit **22** receives a video signal from the control device **26**, and outputs, in synchronizing with selection of the scanning signal line **28** performed by the scanning line drive circuit **20**, a voltage in response to the video signal of the selected pixel row to each of the video signal lines **30**. The voltage is written via the lighting TFT **10** to the capacitor **14** in the selected pixel row. The drive TFT **12** supplies a current in response to the written voltage to the OLED **6**, whereby the OLED **6** of the pixel corresponding to the selected scanning signal line **28** emits light.

[0024] The drive power supply circuit **24** is connected to drive power lines **32** each provided in the pixel column, and supplies a current to the OLED **6** via the drive power line **32** and the drive TFT **12** of the selected pixel row.

[0025] An anode of the OLED **6** is connected to the drive TFT **12**. On the other hand, a cathode of the OLEDs **6** is basically connected to a ground potential. The cathode of the OLEDs **6** of all pixels is composed of a common electrode.

[0026] FIG. **2** is a schematic partial cross-sectional view of the pixel array portion **4** of the organic EL display device **2**, showing a cross-section along the horizontal direction of a display area. The organic EL display device **2** has a structure in which an OLED substrate **40** and a counter substrate **42** are bonded together with a filling material **44** interposed therebetween. In the embodiment, the pixel array portion is of a top emission-type, in which the OLEDs **6** serving as light-emitting portions are formed on the OLED substrate **40** and light generated by the OLED is emitted through the counter substrate **42**. That is, the light of the OLED is emitted upward in FIG. **2**. Moreover, a method for providing color display in the organic EL display device **2** shown in FIG. **2** is a color filter method, in which white light is generated in the OLEDs and RGB colors are obtained by transmitting the white light through color filters.

[0027] The OLED substrate **40** has a structure in which a circuit portion **52**, an OLED portion **54**, a sealing layer **56**, and the like are stacked on a base material **50** (panel base material) formed of a resin film. For example, a polyimide film can be used as the base material **50**.

[0028] The circuit portion **52** includes the pixel circuit **8**, the scanning signal line **28**, the video signal line **30**, and the drive power line **32**, all described above. Moreover, at least portions of the drive circuits **20** and **22**, the drive power supply circuit **24**, and the control device **26** can be configured as the circuit portion **52** on the OLED substrate **40** integrally with the pixel array portion. Although a detailed cross-sectional structure of the circuit portion **52** is not shown in FIG. **2**, the cross-sectional structure will be described later with reference to FIGS. **3**A to **3**E and FIGS. **4**A to **4**D.

[0029] The OLED portion **54** includes the OLEDs **6** each formed for each pixel and a bank **60** formed at pixel boundaries. The OLED **6** includes a lower electrode **64**, an organic layer **66**, and an upper electrode **68** stacked in this order. The organic layer **66** is configured to include a hole transport layer, a light-emitting layer, and an electron transport layer.

[0030] The lower electrode **64** and the upper electrode **68** constitute the anode and cathode of the OLED **6**, respectively. Light emission in the light-emitting layer is controlled by an electric signal applied between the anode and the cathode. As described above, the upper electrode **68** is basically formed common to the pixels in the entire display area, and a common voltage is applied from the drive portion to the upper electrode **68**. The lower electrode **64** (pixel electrode) is formed for each of the pixels, and supplied with a current in response to a video signal through the drive portion and the pixel circuit **8**.

[0031] The bank **60** is formed of an insulating layer between pixels, and electrically isolates the lower electrodes **64** from each other. The sealing layer **56** is stacked on the OLED portion **54**. The sealing layer **56** has a function of blocking transmission of moisture or the like contained in the filling material **44** and protecting the OLED.

[0032] The counter substrate **42** is, for example, a stacked body in which a color filter **82** and the like are stacked on a transparent base material **80** formed of a resin film. For example, a polyimide film can be used as the base material **80** similarly to the base material **50**. In the white light generated by the OLED, the color filter **82** selectively transmits light of a component corresponding to the color of a pixel. As the color filter **82**, for example, a color filter **82***r* that transmits a red wavelength band is disposed corresponding to an R pixel; a color filter **82***g* that transmits a green wavelength band is disposed corresponding to a G pixel; and a color filter **82***b* that transmits a blue wavelength band is disposed corresponding to a B pixel. A black matrix **84** is disposed at boundaries between the color filters **82***r*, **82***g*, and **82***b*.

[0033] The OLED substrate **40** and the counter substrate **42** are bonded together with the filling material **44** interposed therebetween such that the sealing layer **56** and the color filter **82** face each other. Specifically, the OLED substrate **40** and the counter substrate **42** are disposed to face each other with a gap provided therebetween, and a dam material (sealing material) (not shown) made of a resin is disposed in the gap so as to surround the display area, so that the gap in the display area is hermetically sealed. The filling material **44** made of a transparent resin fills the gap inside the dam material. Thereafter, the dam material and the filling material **44** are cured to bond the substrates together.

[0034] FIGS. **3**A to **3**E and FIGS. **4**A to **4**D are schematic process flow views of steps for forming the stacked structure of the circuit portion **52** in the OLED substrate **40**, showing partial cross-sectional views of the OLED substrate **40** in main steps. Hereinafter, steps up to the formation of the lower electrode **64** will be described with reference to FIGS. **3**A to **3**E and FIGS. **4**A to **4**D.

[0035] Since a resin film used as the base material **50** has flexibility, a glass substrate **90** is used as a support to maintain the base material **50** flat insteps for manufacturing the organic EL display device **2**. For example, a polyimide film **92** to be the base material **50** is formed by applying a raw material solution on a surface of the glass substrate **90** by spin coating, and imidizing the applied raw material solution by a heat treatment (FIG. **3**A).

[0036] On a surface of the polyimide film **92**, a barrier film **94** is formed as an under film of a polysilicon (p-Si) layer described later (FIGS. **3**B to **3**E and FIG. **4**A). The barrier film **94** is located between the polyimide film **92** and the OLED **6**, and blocks transmission of a substance that degrades the OLED **6**, such as moisture entering from the surface of the polyimide film **92**, after the glass substrate **90** is stripped.

[0037] In the embodiment, a barrier base material layer **96** is first stacked as the barrier film **94** on the surface of the polyimide film **92** (FIG. **3**B). The barrier base material layer **96** is, for example, silicon oxide (SiO_x) and deposited by a CVD method.

[0038] On a surface of the barrier base material layer **96**, nano-ink **98** containing aluminum (Al) or silver (Ag) nanoparticles is applied (FIG. **3**C). For example, the nano-ink **98** is applied by a spin-coating method, and subjected to drying under reduced pressure or the like after application so that the nano-ink **98** is less likely to flow.

[0039] Thereafter, a heat treatment is applied to a surface of the OLED substrate **40** on which the nano-ink **98** is applied, to fuse and bake the nano-ink layer (FIG. **3**D). Due to this, a base material coating layer **102** that covers the surface of the barrier base material layer **96** is formed, and at the same time, the barrier base material layer **96** can be impregnated with at least a portion of the nano-ink layer, so that an impregnated barrier base material layer **100** as a barrier base material layer that has been subjected to impregnation is formed under the base material coating layer **102** (FIG. **3**E). In the barrier base material layer **96**, voids of material particles, or a defect due to a foreign substance or the like that may exist on a deposited surface may exist. In contrast to this, since the voids or the like are closed by nanoparticles in the impregnated barrier base material layer **100**, the impregnated barrier base material layer **100** is less likely to transmit a substance that degrades the OLED **6**.

[0040] For example, the fusing and baking of the nano-ink **98** can be carried out by a flash lamp anneal (FLA) treatment. In the FLA treatment, for example, the temperature of an irradiated surface is increased by light irradiation for a short time, about one millisecond. In that case, a large temperature gradient is generated from the irradiated surface with respect to the depth direction. That is, since temperature rise in the lower layer can be suppressed while the nano-ink **98** is sufficiently heated, the thermal degradation of the polyimide film **92**, for example, can be avoided.

[0041] Moreover, the metal contained in the nano-ink **98** may be oxidized by baking in an oxygen atmosphere. Due to this, the binding of SiO_x constituting the barrier base material to the metal with which the impregnated barrier base material layer **100** is impregnated may be strengthened in the impregnated barrier base material layer **100**. Further, when, for example, the barrier base material layer is impregnated with Al, aluminum oxide having higher strength is formed by oxidization, and thus the strength of the impregnated barrier base material layer **100** is increased. It is desirable during the treatment in the oxygen atmosphere that the main body of the polyimide film **92** is not damaged. Accordingly, it would be better to stop the oxidation treatment when the oxidation reaches the vicinity of the interface of the polyimide film **92**.

[0042] As described above, even when thin SiO_x is used as the barrier base material layer **96**, barrier performance is improved through impregnation, and therefore, the barrier film **94** can basically adopt a structure composed only of the impregnated barrier base material layer **100** and the base material coating layer **102**. However, in the barrier film **94** of the embodiment, an additional barrier layer **104** made of silicon nitride (SiN_y) is further stacked on a surface of the base material coating layer **102**, so that the barrier performance is further enhanced (FIG. **4**A). For example, SiN_y for forming the additional barrier layer **104** is deposited by a CVD method. In this case, when alkali metal ions such as sodium (Na) contained in the glass substrate **90** are diffused into p-Si constituting the channel of a TFT, the characteristics of the TFT are degraded. Even when an alkali-free glass substrate is used for the glass substrate **90**, a small amount of alkali metal ions may exist in the alkali-free glass substrate. The SiN_y film constituting the additional barrier layer **104** prevents the alkali metal ions from diffusing from the glass substrate **90** into the p-Si layer.

[0043] On a surface of the under film including the barrier film **94** described above, an amorphous silicon (a-Si) film. **106** is formed by, for example, a CVD method (FIG. **4**B). Although the a-Si film **106** is stacked on a surface of the SiN_y film constituting the additional barrier layer **104** in FIG. **4**B, a SiO_x film may be further stacked as an under film on the additional barrier layer **104**, and the a-Si film **106** may be stacked on a surface of the SiO_x film. The SiO_x film may improve the characteristics of the interface relative to p-Si.

[0044] The a-Si film **106** is processed by LTPS annealing (FIG. **4**C). Specifically, fusing and crystallization of the a-Si film **106** are carried out by irradiation with excimer laser light **108**, so that a p-Si film **110** is formed (FIG. **4**D).

[0045] Subsequently, the p-Si film **110** is patterned using a photolithography technique, so that the p-Si film **110** at places to be used in the circuit portion **52** is selectively left. For example, atop gate-type TFT is formed using the p-Si film **110**. Specifically, a semiconductor region serving as the channel portion, source portion, and drain portion of the TFT is formed of the p-Si film **110**. A gate electrode is disposed on the channel portion of the TFT via a gate insulating film. The gate electrode is formed by patterning a metal film formed by sputtering or the like. Moreover, an impurity is introduced by ion implantation into the p-Si serving as the source portion and drain portion of the TFT, and further, a source electrode and a drain electrode that are electrically connected to the source portion and the drain portion are formed. Wires such as the scanning signal line **28**, the video signal line **30**, and the drive power line **32** shown in FIG. **1** are formed using metal layers or the like forming the gate electrode, the source electrode, and the drain electrode.

[0046] After the formation of the source electrode, the drain electrode, and the like, an inter-layer insulating film is stacked by, for example, a CVD method. The stacked structure from the barrier base material layer **96** to the inter-layer insulating film corresponds to the circuit portion **52** shown in FIG. **2**.

[0047] A conductor film is formed on a surface of the circuit portion **52**, that is, on the inter-layer insulating film, and the lower electrode **64** is formed by patterning the conductor film. If the drive TFT **12** shown in FIG. **1** is an n-channel TFT, the lower electrode **64** is electrically connected to the source electrode of the drive TFT **12** via a contact hole formed in the inter-layer insulating film.

[0048] The lower electrode **64** can be formed of, for example, a transparent electrode material such as indium tin oxide (ITO). An ITO film can be deposited by a reactive sputtering method using a mixed gas of $Ar+O_2$. Moreover, the lower electrode **64** can also be formed using another transparent electrode material, for example, indium zinc oxide (IZO), tin oxide, zinc oxide, indium oxide, or an aluminum oxide composite oxide.

[0049] The organic EL display device **2** of the embodiment is of a top emission-type as described above, and the lower electrode **64** can adopt a two-layered structure in which a transparent conductive film is stacked on a reflective layer formed of a material having a high optical reflectance. For example, the reflective layer can be formed of Al, Ag, or the like, and reflects light from the light-emitting layer toward a display surface, that is, the counter substrate **42** side.

[0050] As shown in FIG. **2**, after the formation of the lower electrode **64**, a photosensitive acrylic resin, for example, is applied on the lower electrode **64** and patterned by a photolithography technique to form the bank **60** at the pixel boundaries. The lower electrode **64** is exposed in a pixel effective area surrounded by the bank **60**. After the formation of the bank **60**, the layers constituting the organic layer **66** are sequentially stacked on the lower electrode **64**. The upper electrode **68** is formed on the organic layer **66** using a transparent electrode material. For example, IZO is deposited as the upper electrode **68** by a reactive sputtering method using a mixed gas of $Ar+O_2$. Then, for example, a SiN_y film is deposited as the sealing layer **56** by a CVD method.

[0051] The OLED substrate **40** is manufactured in this manner. As previously described, the pixel array portion **4** is produced by bonding the OLED substrate **40** and the counter substrate **42** together. After the OLED substrate **40** and the counter substrate **42** are bonded together, the glass substrate **90** is stripped.

[0052] In the organic EL display device **2** as described above, the barrier film **94** including the impregnated barrier base material layer **100** is formed between the base material **50** and the OLED **6** of the OLED substrate **40**. As previously described, since the pores (pinholes) that may exist in the barrier base material layer **96** are closed by the nanoparticles filling therein in the impregnated barrier base material layer **100**, the impregnated barrier base material layer **100** is less likely to transmit a substance that degrades the OLED **6**. With this improved resistance to transmission due to the impregnation of the nano-ink **98** or the filling of nanoparticles, it is not necessary to increase the thickness of the barrier base material layer **96** in order to obtain the resistance to transmission. That is, the impregnated barrier base material layer **100** can be formed to be relatively thin. The reduced film thickness contributes to a reduction in process load; while the impregnation of the film with the nano-ink **98** can not only improve a barrier property but also provide a sufficient bending strength even with the reduced film thickness. Further, since the pores (pinholes) of the barrier base material layer **96** are filled, the uniformity of stress in a plane of the impregnated barrier base material layer **100** is improved. Therefore, a change, such as the occurrence of a defect in the impregnated barrier base material layer **100** due to a temperature change, is less likely to occur in a subsequent manufacturing process, so that productivity is improved. At the same time, with the improved uniformity of stress, the occurrence of warpage can be suppressed upon handling a large-sized substrate.

[0053] In the embodiment described above, the barrier base material layer **96** made of SiO_x is stacked on the polyimide film **92**. Since a SiO_x film has flexibility compared to a SiN_y film, the impregnated barrier base material layer **100** using SiO_x functions as a stress buffer layer between the polyimide film **92** and the layer on the impregnated barrier base material layer **100**, which is preferable in terms of constituting a flexible display.

[0054] On the other hand, the barrier film **94** may be formed using the impregnated barrier base material layer **100** that is obtained from the barrier base material layer **96** made of SiN_y. Moreover, the additional barrier layer **104** may be a SiO_x film instead of a SiN_y film. Moreover, the additional barrier layer **104** may be located under the impregnated barrier base material layer **100**. Moreover, the barrier film **94** can adopt a structure not including the additional barrier layer **104** as described above. In the embodiment described above, however, since the p-Si film **110** is formed on the barrier film **94**, a base suitable for the growth of the p-Si film **110** is needed under the p-Si film **110**. Moreover, when the base material coating layer **102** has conductivity, for example, when the base material coating layer **102** is made of Al or Ag applied as nano-ink, or silver oxide obtained by subjecting the Ag to an oxidation treatment, consideration such as providing an insulating film on the base material coating layer **102** is given so that the base material coating layer **102** does not contact the conductive member of the circuit portion **52**, such as the p-Si film **110**. An oxide of aluminum is an insulator, and therefore, consideration is not especially needed in this point of view.

[0055] For the nano-ink **98**, those containing carbon as nanoparticles can be used. Moreover, the barrier base material layer **96** may be impregnated with an organic material such as an acrylic resin, instead of the nano-ink **98**, to form the impregnated barrier base material layer **100**. For example, a thermoplastic resin can be used as the organic material, and the barrier base material layer **96** can be impregnated with the resin that has been thermally fused. The organic material may be, for example, a material that is polymerized and cured by ultraviolet irradiation or the like, such as a synthetic resin, a monomer, or an oligomer. In this case, the material melted by heat or dissolved by a solvent is subjected to an impregnation treatment, and then, a polymerization treatment is carried out.

[0056] The barrier film **94** described above includes the base material coating layer **102** in contact with the barrier base material layer **96** containing SiO_x or SiN_y, and the material of the base material coating layer **102** is contained in the barrier base material layer **96**. Here, the barrier film **94** can adopt a structure in which the nano-ink **98** or an organic material deposited on the barrier base material layer **96** does not necessarily form the base material coating layer **102** on the surface of the impregnated barrier base material layer **100** after the impregnation treatment. That is, the nano-ink or the organic material completely penetrates into the impregnated barrier base material layer **100**, so that an area where the nano-ink **98** or the organic material is not left may exist on the surface of the impregnated barrier base material layer **100**.

[0057] The TFT is of a top gate-type in the embodiment, but the TFT may have another structure. For example, the TFT may be of a bottom gate-type.

Second Embodiment

[0058] The barrier film including the impregnated barrier base material layer described in the first embodiment can be provided at a position at which the barrier film is integrated with the sealing layer **56** (sealing film) of the organic EL display device **2**. Specifically, the barrier film can be provided at a position in contact with an upper or lower surface of the sealing layer **56** separately from the sealing layer **56**, and in addition, the sealing layer **56** itself can be configured as the barrier film. Similarly to the sealing layer **56**, the barrier film favorably blocks transmission of moisture or the like contained in the filling material **44**, and protects the OLEDs.

[0059] In a second embodiment, an organic EL display device **2** in which a sealing layer **56** itself is configured as a barrier film including an impregnated barrier base material layer will be described. The organic EL display device **2** of the embodiment has a structure substantially common with that of the organic EL display device **2** of the first embodiment described above, so that FIG. **1** and FIG. **2** can be referred to for the schematic structure of the organic EL display device **2** of the second embodiment. Hereinafter, the organic EL display device **2** according to the second embodiment will be described mainly on differences from the first embodiment; while components similar to those of the organic EL display device **2** of the first embodiment are denoted by the same reference numerals and signs, and the description thereof is basically omitted.

[0060] FIGS. **5A** to **5C** are schematic process flow views of steps for forming the sealing layer **56** in an OLED substrate **40**, showing partial cross-sectional views of the OLED substrate **40** in main steps.

[0061] On a surface of an upper electrode **68**, a SiN_y film is deposited as a barrier base material layer **200** by, for example, a CVD method (FIG. **5A**).

[0062] On a surface of the barrier base material layer **200**, an organic material film **202** is formed (FIG. **5B**). The organic material film **202** is made of, for example, a UV-curable acrylic resin and formed by deposition by a vapor deposition method, or by applying an acrylic resin dissolved in an organic solvent by a spin-coating method.

[0063] Thereafter, a heat treatment is applied to a surface of the OLED substrate **40** on which the organic material film **202** is formed, to fuse the acrylic resin, so that the barrier base material layer **200** is impregnated with at least a portion of the acrylic resin. Due to this, an impregnated barrier base material layer **204** as the barrier base material layer **200** impregnated with the acrylic resin and a base material coating layer **206** as the acrylic resin left on a surface of the impregnated barrier base material layer **204** are formed. After the impregnation treatment, ultraviolet irradiation (UV irradiation) is carried out to cure the base material coating layer **206** and the acrylic resin in the impregnated barrier base material layer **204**. Due to this, a barrier film **210** including the impregnated barrier base material layer **204** and the base material coating layer **206** is formed as the sealing layer **56** (FIG. **5C**).

[0064] A SiN_y film basically has high resistance to transmission of moisture or the like compared to a SiO_x film. However, holes may be formed when the film thickness of the SiN_y film is thin, and also, a defect may occur due to a foreign substance or the like that may exist on a deposited surface. In contrast to this, since the holes or the like are closed by the organic material filling therein in the impregnated barrier base material layer **204**, the impregnated barrier base material layer **204** is less likely to transmit a substance that degrades the OLED **6**.

[0065] For example, the thermal fusion of the organic material film **202** can be carried out by the FLA treatment. For example, when the organic material film **202** is deposited by a vapor deposition apparatus, the apparatus can adopt a structure in which a deposition chamber includes a transparent window made of silica glass or the like and the organic material film **202** can be irradiated with light from the outside of the window. The FLA treatment and the UV irradiation treatment are carried out through the window. Incidentally, in the FLA treatment of the embodiment, ultraviolet light is removed through a filter to prevent polymerization. In this apparatus, the formation, FLA treatment, and UV irradiation treatment of the organic material film **202** can be carried out without taking the OLED substrate **40** out of the deposition chamber (vacuum treatment chamber), so that preferred productivity can be realized. Further, by configuring the apparatus such that another CVD step before or after the deposition of the organic material film **202**, for example, the formation of the barrier base material layer **200** is carried out in the same deposition chamber, or in another deposition chamber connected to the above-mentioned deposition chamber without breaking the vacuum, an improvement in productivity can be further achieved.

[0066] The organic material film **202** can be formed of a non-UV-curable material, and also can be formed of a material other than an acrylic resin. Since the pixel array portion **4** is of a top emission-type in the embodiment, the sealing layer **56** needs to transmit light. Accordingly, the material is selected so that the impregnated barrier base material layer **204** and the base material coating layer **206** become transparent.

[0067] For example, the organic material film **202** can be made of a fluorine resin such as perfluoro alkoxy alkane (PFA) or ethylene-tetrafluoroethylene copolymer (ETFE). Moreover, the organic material film **202** may be formed of a monomer or an oligomer, which is subjected to an impregnation treatment and then polymerized to form a synthetic resin such as an acrylic resin. Moreover, the impregnated barrier base material layer **204** may be formed by impregnating the barrier base material layer **200** with nano-ink instead of the organic material film **202**. For example, since aluminum oxide has a broad transmission wavelength region from the ultraviolet region to the infrared, the barrier film **210**, which is transparent, can be formed such that Al nano-ink is applied on the barrier base material layer and subjected to fusion, impregnation, and oxidation by the FLA treatment or the like.

[0068] Moreover, the barrier film **210** may be formed using, as the barrier base material layer **200**, another inorganic material film such as a SiO_x film. Further, the barrier film **210** can be configured to include, in addition to the impregnated barrier base material layer **204** using a SiO_x film, an additional barrier layer formed of a SiN_y film stacked on a surface of the base material coating layer **206**.

Modified Examples

[0069] The barrier film including the impregnated barrier base material layer described in the embodiments can be provided at a position other than the positions shown in the first and second embodiments.

[0070] For example, the barrier film can be provided on a filling-material-side surface of the counter substrate **42** to be bonded on the sealing layer **56** via the filling material **44**.

[0071] Moreover, when, for the purpose of protecting a surface of the base material **80** for example, a film using polyethylene terephthalate (PET) as a base material and subjected to, for example, a hard coating treatment is attached to the surface, the film can be a film with the barrier film formed on a rear surface thereof.

[0072] The barrier films described in the embodiments and modified examples can be used together.

[0073] In the embodiments, the organic EL display device has been illustrated as an example of the disclosure. However, the barrier film can be adopted, for preventing the degradation of a structure due to permeation of moisture or the like, also in other display devices such as a liquid crystal display device, another self-luminous-type display device, and an electronic paper-type display device including an electrophoretic element or the like. Moreover, it is needless to say that the display device is applicable, without particular limitation, to from middle- and small-sized display devices to a large-sized display device.

[0074] Various altered and modified examples within the range of the idea of the invention will occur to those skilled in the art, and it is understood that the altered and modified examples also belong to the scope of the invention. For example, when those skilled in the art appropriately add or remove a component or change the design of a component in the embodiments described above, or add or omit a step or change the conditions of a step in the embodiments described above, those are included in the scope of the invention as long as they include the gist of the invention.

[0075] Moreover, it is understood that as to other operational effects brought about by the aspects described in the embodiments, an operational effect that is apparent from the description of the specification or that will appropriately occur to those skilled in the art is of course brought about by the invention.

[0076] While there have been described what are at present considered to be certain embodiments of the invention, it will be understood that various modifications may be made thereto, and it is intended that the appended claims cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A display device comprising:
a base material made of a resin material;
an organic electroluminescent element provided on the base material; and
a barrier film including a first layer and a second layer, the first layer containing silicon oxide or silicon nitride, the second layer being in contact with the first layer, the first layer containing a material of the second layer.

2. The display device according to claim **1**, wherein
the first layer is impregnated with the material of the second layer.

3. The display device according to claim **1**, wherein
the first layer contains pores, and
the pores are filled with the material of the second layer.

4. The display device according to claim **3**, wherein
each of the pores is a void of particles made of the silicon oxide or the silicon nitride.

5. The display device according to claim **3**, wherein
each of the pores is a defect existing in the first layer.

6. The display device according to claim **3**, wherein
the material of the second layer contained in the first layer is a nanoparticle.

7. The display device according to claim **1**, wherein
the material of the second layer contains, as a main component, any one of aluminum, silver, an acrylic resin, a fluorine resin, and carbon.

8. The display device according to claim **1**, wherein
the barrier film is located on the base material.

9. The display device according to claim **1**, further comprising, between the base material and the organic electroluminescent element, a circuit portion including a thin film transistor, wherein
the barrier film is located between the base material and the circuit portion.

10. The display device according to claim **1**, wherein
the organic electroluminescent element includes a lower electrode, a light-emitting layer, and an upper electrode, and
the barrier film is located on a side of the organic electroluminescent element opposite to the base material and is in contact with the upper electrode.

11. The display device according to claim **1**, further comprising a counter base material facing the base material, wherein
a filling material is disposed between the base material and the counter base material, and
the barrier film is located between the counter base material and the filling material.

12. The display device according to claim **1**, wherein
the barrier film includes a third layer containing silicon oxide or silicon nitride on a side of the second layer opposite to the first layer.

13. A manufacturing method of a display device, comprising the steps of:
forming an insulating layer made of silicon oxide or silicon nitride;
forming, by application, a nano-ink layer on a surface of the insulating layer; and
impregnating the insulating layer with at least a portion of the nano-ink layer.

14. The manufacturing method according to claim **13**, wherein
the nano-ink layer contains, as a main component, any one of aluminum, silver, and carbon.

15. The manufacturing method according to claim **13**, further comprising the step of forming a base material made of a resin material, wherein
the insulating film is formed in contact with the base material.

16. The manufacturing method according to claim **13**, further comprising the steps of:
forming a base material made of a resin material; and
forming, on the base material, an organic EL layer including a lower electrode, a light-emitting layer, and an upper electrode, wherein

the insulating film is located on a side of the organic EL layer opposite to the base material and is formed in contact with the upper electrode.

17. A manufacturing method of a display device, comprising the steps of:

forming an insulating layer made of silicon oxide or silicon nitride;

forming, by application, an organic material layer on a surface of the insulating layer; and

impregnating the insulating layer with at least a portion of the organic material layer.

18. The manufacturing method according to claim **17**, wherein

the organic material layer contains, as a main component, an acrylic resin or a fluorine resin.

19. The manufacturing method according to claim **17**, further comprising the step of forming a base material made of a resin material, wherein

the insulating film is formed in contact with the base material.

20. The manufacturing method according to claim **17**, further comprising the steps of:

forming a base material made of a resin material; and

forming, on the base material, an organic EL layer including a lower electrode, a light-emitting layer, and an upper electrode, wherein

the insulating film is located on a side of the organic EL layer opposite to the base material and is formed in contact with the upper electrode.

* * * * *

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申请(专利权)人(译)	日本展示INC.		
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摘要(译)

在有机EL显示装置中，实现了阻挡膜的性能的改进，所述阻挡膜阻止引起诸如湿气的降解的物质进入有机电致发光元件。有机EL显示装置包括阻挡膜，该阻挡膜是包括由氧化硅或氮化硅制成的阻挡基底材料层和与浸渍的阻挡基底材料层接触的基底材料涂层的叠层膜。阻挡膜阻挡降解有机电致发光元件的物质的透射。将纳米油墨涂布在阻挡基材层的表面上，并用纳米油墨浸渍阻挡基材层。经过浸渍处理的阻挡基材层用作浸渍的阻挡基材层，而浸渍后的纳米油墨用作基材涂层。