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(12) **United States Patent**
Takahashi et al.

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(45) **Date of Patent: Jul. 14, 2020**

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(54) **DISPLAY DEVICE**

(71) Applicant: **Sharp Kabushiki Kaisha**, Sakai, Osaka (JP)

(72) Inventors: **Jumpei Takahashi**, Sakai (JP); **Tohru Sonoda**, Sakai (JP); **Takashi Ochi**, Sakai (JP); **Takeshi Hirase**, Sakai (JP); **Hisao Ochi**, Sakai (JP); **Tohru Senoo**, Sakai (JP); **Akihiro Matsui**, Sakai (JP)

(73) Assignee: **SHARP KABUSHIKI KAISHA**, Sakai (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/472,918**

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(86) PCT No.: **PCT/JP2017/034555**
§ 371 (c)(1),
(2) Date: **Jun. 24, 2019**

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PCT Pub. Date: **Mar. 28, 2019**

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(51) **Int. Cl.**
H01L 51/52 (2006.01)
H01L 27/32 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/5253*** (2013.01); ***H01L 27/3244*** (2013.01); *H01L 27/3211* (2013.01)

(58) **Field of Classification Search**
CPC H01L 51/5253; H01L 27/3244; H01L 27/3211
See application file for complete search history.

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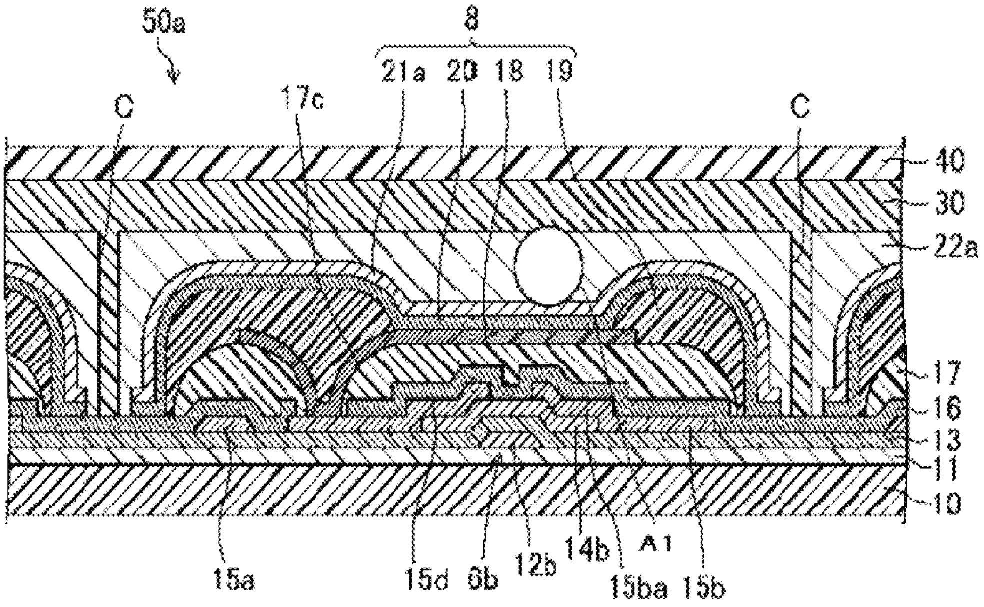
Primary Examiner — Nathan W Ha
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

An organic EL display device including: a base substrate; an organic EL element formed on the base substrate, and including a plurality of organic EL layers arranged in a matrix shape; and a sealing film formed on the organic EL element, wherein a plurality of subpixels are defined in association with the plurality of organic EL layers, and a plurality of grooves are formed in the sealing film through the interstices among the plurality of subpixels, and a foreign-matter contact portion configured to be in contact with a foreign matter existing on the organic EL element is formed in the sealing film.

20 Claims, 13 Drawing Sheets



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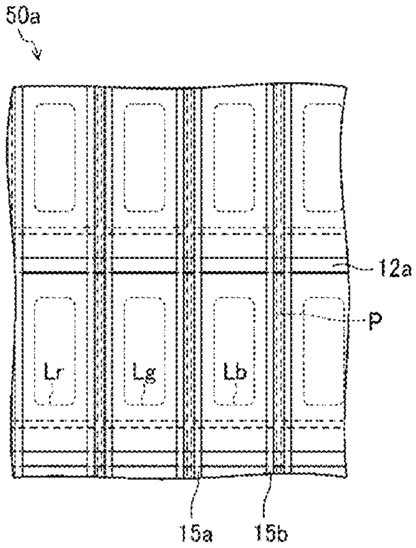


FIG. 1

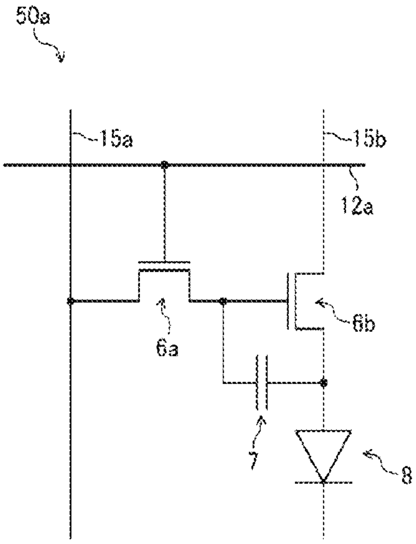
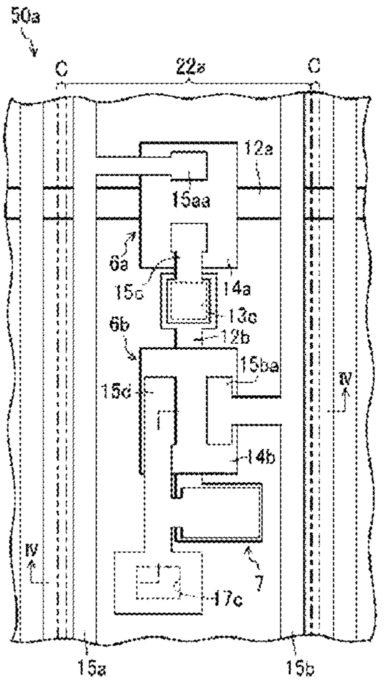


FIG. 2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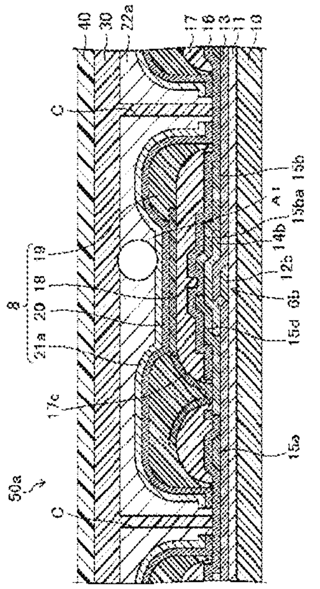
IV
17c
15a
15b

FIG. 3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21a
17c
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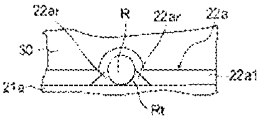
50a
C

FIG. 4

FIG. 5A



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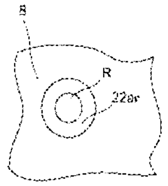

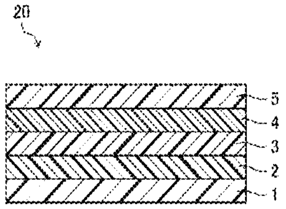

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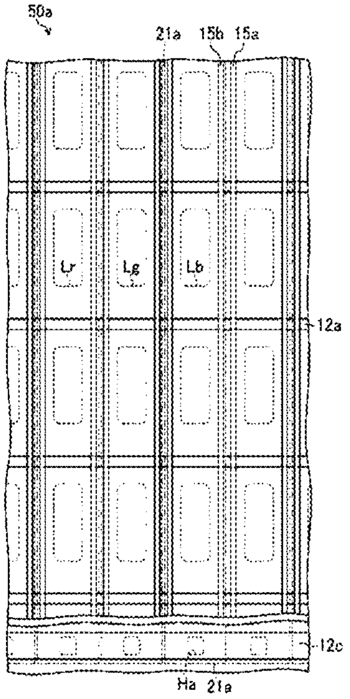

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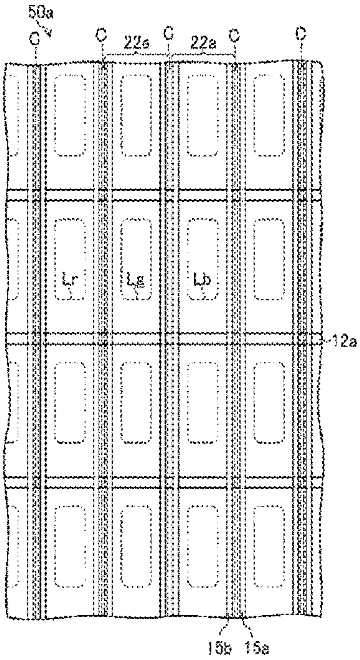

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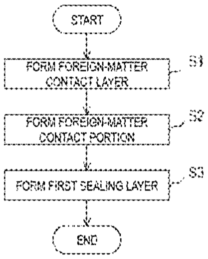
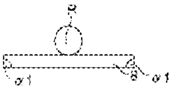


FIG. 9

FIG. 10A



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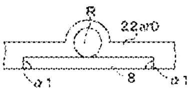
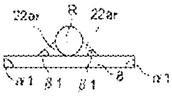


FIG. 10C



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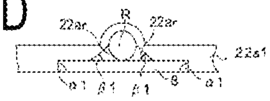

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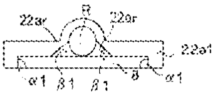

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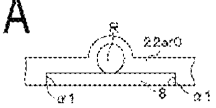

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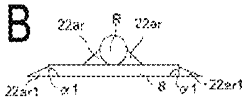

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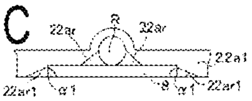

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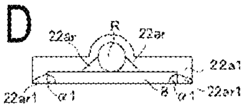


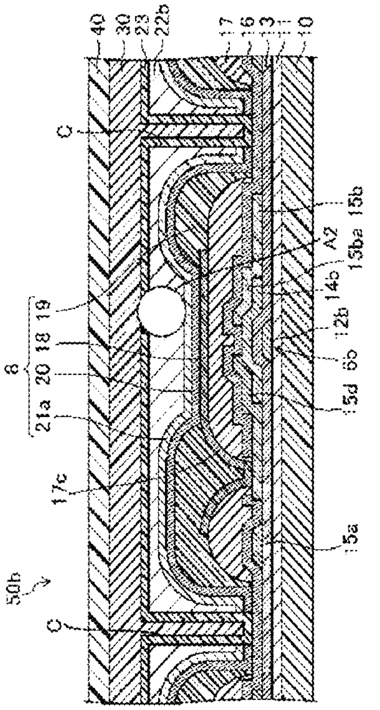
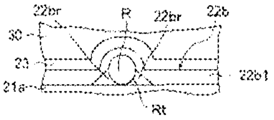


FIG. 12

FIG. 13A



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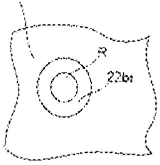

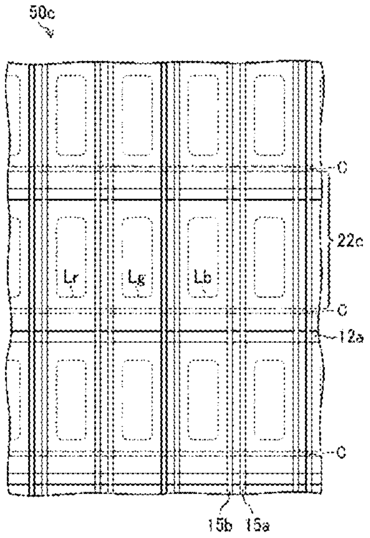

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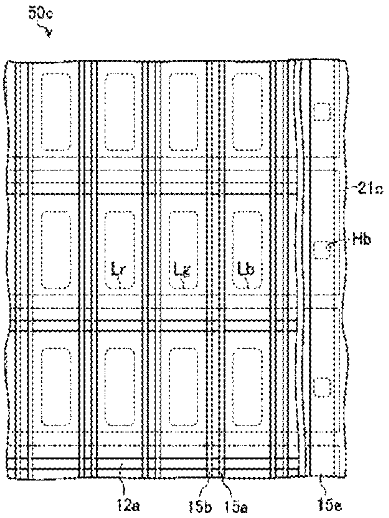
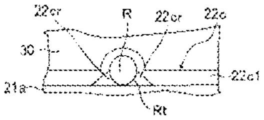


FIG. 15

FIG. 16A



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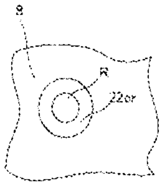

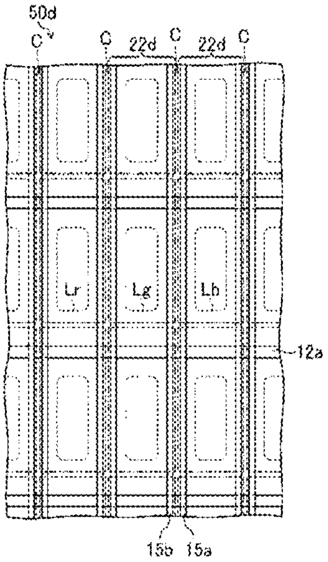

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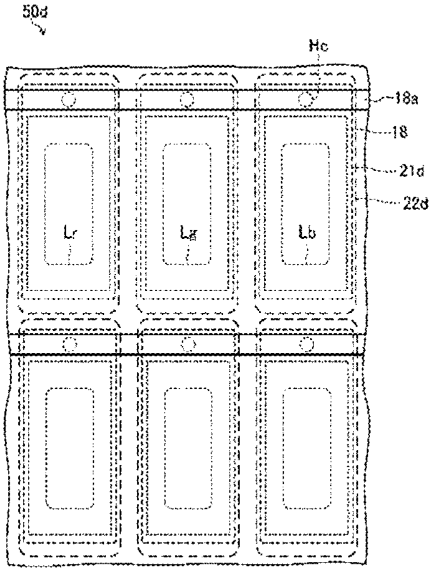
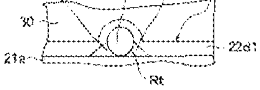


FIG. 18

FIG. 19A



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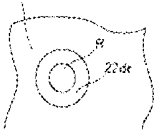


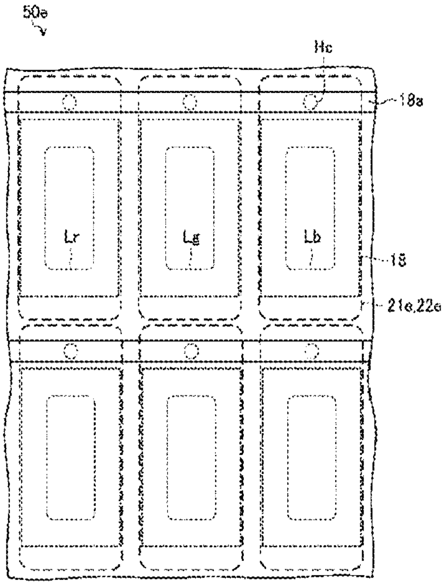
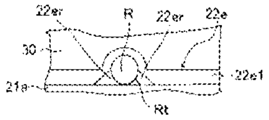


FIG. 20

FIG. 21A



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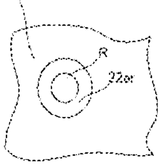

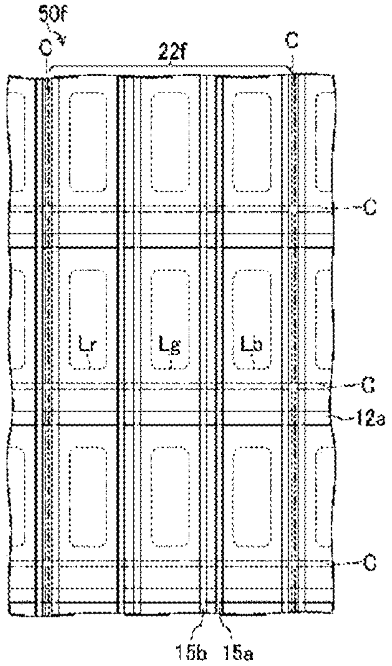
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FIG. 22

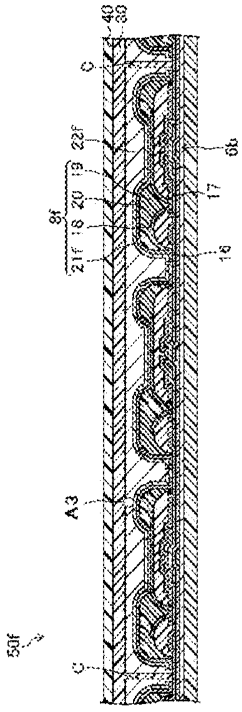
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FIG. 23

FIG. 24A

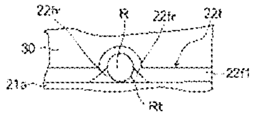
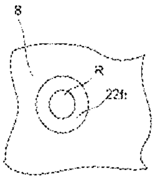


FIG. 24B



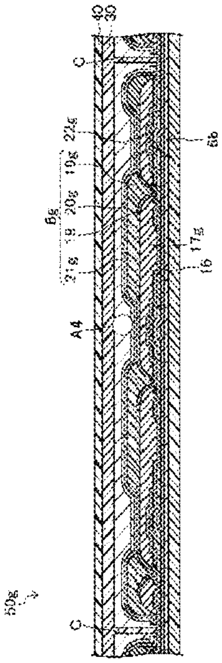


FIG. 25

FIG. 26A

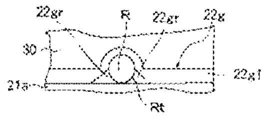
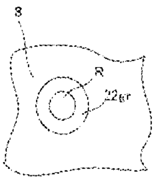


FIG. 26B



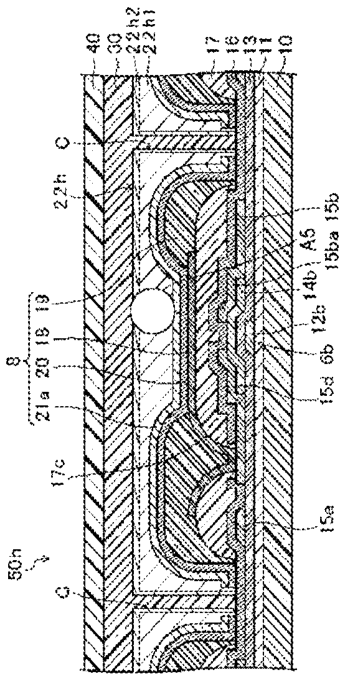
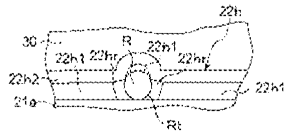


FIG. 27

FIG. 28A



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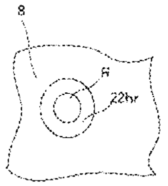


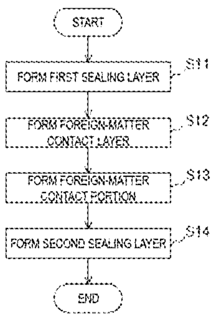
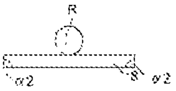


FIG. 29

FIG. 30A



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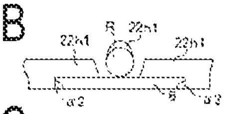

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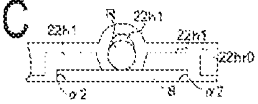

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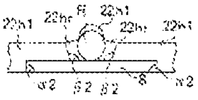


FIG. 30E

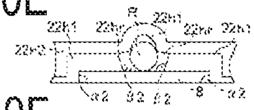


FIG. 30F

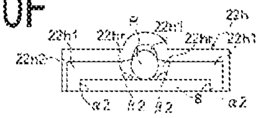


FIG. 31A

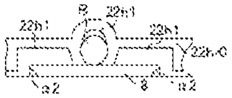


FIG. 31B

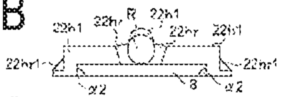


FIG. 31C

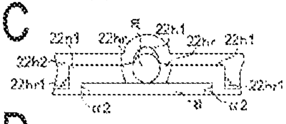
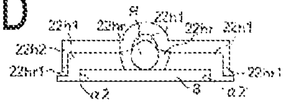


FIG. 31D



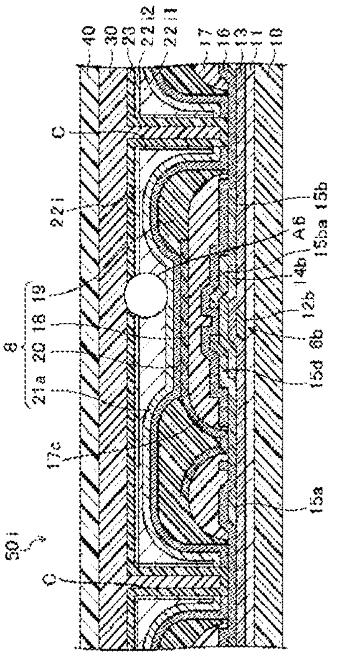


FIG. 32

FIG. 33A

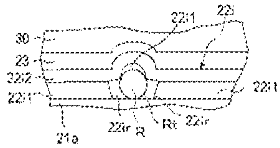
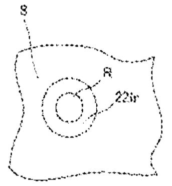


FIG. 33B



DISPLAY DEVICE

TECHNICAL FIELD

The disclosure relates to a display device and a method for manufacturing the same.

BACKGROUND ART

In recent years, organic electroluminescence (EL) display devices, which use organic EL elements and are of the self-luminous type, have attracted attention as a display device that can replace the liquid crystal display device. A general organic EL display device is provided with a sealing film covering the organic EL element to inhibit degradation of the organic EL element due to penetration of, for example, moisture and oxygen.

For example, PTL 1 discloses a method of manufacturing an organic EL element through a process of patterning the sealing film, which is achieved by performing a dry etching process using a metal mask to remove some part of the sealing film.

CITATION LIST

Patent Literature

PTL 1: JP 2007-73353 A

SUMMARY

Technical Problem

The sealing film includes, as a constituent, at least an inorganic film, which is fragile in nature. Hence, a stress, if applied to the inorganic film, tends to cause cracks in the inorganic film easily. Accordingly, a bending stress that is generated by bending an organic EL display device including a sealing film may result in cracks in the sealing film. The cracks impair the sealing ability of the sealing film, resulting in a less reliable organic EL display device.

The disclosure has been made in view of the problem mentioned above, and provides an organic EL display device that can be bent without causing cracks in the sealing film even in a case where a foreign matter exists on the organic EL element.

Solution to Problem

To achieve the above-described objective, a display device according to the disclosure includes: a base substrate; a display element formed on the base substrate and including a plurality of display layers arranged in a matrix shape; and a sealing film formed on the display element. In the display device, a plurality of subpixels are defined in association with the plurality of display layers, and in the sealing film: a plurality of grooves are formed through the interstices among the plurality of subpixels; and a foreign-matter contact portion configured to be in contact with a foreign matter existing on the display element is formed.

In addition, a display-device manufacturing method according to a different aspect of the disclosure is a method of manufacturing the display device including the steps of: forming a foreign-matter contact layer configured to cover the display element and a foreign matter existing on the display element; and forming the foreign-matter contact portion by ashing the foreign-matter contact layer.

In addition, a display-device manufacturing method according to a different aspect of the disclosure is a method of manufacturing the display device including the steps of: forming an inorganic film configured to cover the display element and a foreign matter existing on the display element; forming a foreign-matter contact layer configured to cover the inorganic film; and forming the foreign-matter contact portion by ashing the foreign-matter contact layer.

In addition, a display-device manufacturing method according to a different aspect of the disclosure is a method of manufacturing the display device, wherein the inorganic barrier film is formed by forming an aluminum oxide film by an atomic layer deposition method and the aluminum oxide covers the plurality of portions of the sealing film, which are separated.

Advantageous Effects of Disclosure

The sealing film provided on the display element includes the grooves to be formed between every two adjacent ones of the plurality of subpixels. Hence, the display device can be bent without causing cracks in the sealing film. In addition, the sealing film includes the foreign-matter contact portion configured to be in contact with a foreign matter that exists on the display element. Hence, a flawless sealing film can be formed even in a case where a foreign matter exists on the display element. In addition, the generation of the above-mentioned cracks can be prevented.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a plan view illustrating a pixel structure of an organic EL display device according to a first embodiment of the disclosure.

FIG. **2** is an equivalent circuit schematic of each of subpixels of the organic EL display device according to the first embodiment of the disclosure.

FIG. **3** is a plan view illustrating an interior structure of each subpixel of the organic EL display device according to the first embodiment of the disclosure.

FIG. **4** is a cross-sectional view of the organic EL display device taken along the line IV-IV in FIG. **3**.

FIG. **5**A is an enlarged view of a portion **A1** illustrated in FIG. **4** of a case where a foreign matter exists in the portion **A1**. FIG. **5**B is a plan view illustrating the foreign matter and the portion contacting the foreign matter (foreign-matter contact portion) illustrated in FIG. **5**A.

FIG. **6** is a cross-sectional view illustrating an organic EL layer included in the organic EL display device according to the first embodiment of the disclosure.

FIG. **7** is a plan view illustrating a second-electrode arrangement structure in the organic EL display device according to the first embodiment of the disclosure.

FIG. **8** is a plan view illustrating a sealing-film arrangement structure in the organic EL display device according to the first embodiment of the disclosure.

FIG. **9** is a flowchart describing steps of manufacturing main portions of the organic EL display device according to the first embodiment of the disclosure.

FIGS. **10**A to **10**E are diagrams describing a series of main steps of manufacturing the main portions of the organic EL display device according to the first embodiment of the disclosure.

FIGS. **11**A to **11**D are diagrams describing a series of main steps of manufacturing main portions of an organic EL display device according to Comparative Example 1.

FIG. **12** is a cross-sectional view illustrating an organic EL display device according to a second embodiment of the disclosure, and is a diagram corresponding to FIG. **4**.

FIG. **13**A is an enlarged view of a portion A**2** illustrated in FIG. **12** of a case where a foreign matter exists in the portion A**2**. FIG. **13**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **13**A.

FIG. **14** is a plan view illustrating a sealing-film arrangement structure in an organic EL display device according to a third embodiment of the disclosure.

FIG. **15** is a plan view illustrating a second-electrode arrangement structure in the organic EL display device according to the third embodiment of the disclosure.

FIG. **16**A is an enlarged schematic view illustrating a foreign matter existing in the organic EL display device according to the third embodiment of the disclosure and a portion around the foreign matter. FIG. **16**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **16**A.

FIG. **17** is a plan view illustrating a sealing-film arrangement structure in an organic EL display device according to a fourth embodiment of the disclosure.

FIG. **18** is a plan view illustrating a second-electrode connection structure in the organic EL display device according to the fourth embodiment of the disclosure.

FIG. **19**A is an enlarged schematic view illustrating a foreign matter existing in the organic EL display device according to the fourth embodiment of the disclosure and a portion around the foreign matter. FIG. **19**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **19**A.

FIG. **20** is a plan view illustrating a second-electrode connection structure in an organic EL display device according to a modified example of the fourth embodiment of the disclosure.

FIG. **21**A is an enlarged schematic view illustrating a foreign matter existing in the organic EL display device according to the Modified Example of the fourth embodiment of the disclosure and a portion around the foreign matter. FIG. **21**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **21**A.

FIG. **22** is a plan view illustrating a sealing-film arrangement structure in an organic EL display device according to a fifth embodiment of the disclosure.

FIG. **23** is a cross-sectional view illustrating the organic EL display device according to the fifth embodiment of the disclosure, and is a diagram corresponding to FIG. **4**.

FIG. **24**A is an enlarged view of a portion A**3** illustrated in FIG. **23** of a case where a foreign matter exists in the portion A**3**. FIG. **24**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **24**A.

FIG. **25** is a cross-sectional view illustrating an organic EL display device according to a modified example of the fifth embodiment of the disclosure, and is a diagram corresponding to FIG. **4**.

FIG. **26**A is an enlarged view of a portion A**4** illustrated in FIG. **25** of a case where a foreign matter exists in the portion A**4**. FIG. **26**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **26**A.

FIG. **27** is a cross-sectional view illustrating an organic EL display device according to a sixth embodiment of the disclosure, and is a diagram corresponding to FIG. **4**.

FIG. **28**A is an enlarged view of a portion A**5** illustrated in FIG. **27** of a case where a foreign matter exists in the portion A**5**. FIG. **28**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **28**A.

FIG. **29** is a flowchart describing steps of manufacturing main portions of the organic EL display device according to the sixth embodiment of the disclosure.

FIGS. **30**A to **30**F are diagrams describing a series of main steps of manufacturing the main portions of the organic EL display device according to the sixth embodiment of the disclosure.

FIGS. **31**A to **31**D are diagrams describing a series of main steps of manufacturing main portions of an organic EL display device according to Comparative Example 2.

FIG. **32** is a cross-sectional view illustrating an organic EL display device according to a seventh embodiment of the disclosure, and is a diagram corresponding to FIG. **4**.

FIG. **33**A is an enlarged view of a portion A**6** illustrated in FIG. **32** of a case where a foreign matter exists in the portion A**6**. FIG. **33**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **33**A.

DESCRIPTION OF EMBODIMENTS

Embodiments of the disclosure will be described below in detail with reference to the drawings. The disclosure is not limited to the embodiments described below. In addition, the following description will be based on a case where the disclosure is applied to an organic EL display device. In addition, in each of the drawings, the dimensions of constituent elements are not precisely illustrated as the actual dimensions of the constituent elements and the dimensional proportions of each of the constituent elements.

First Embodiment

FIG. **1** to FIG. **8** illustrate the first embodiment of an organic EL display device according to the disclosure. FIG. **1** is a plan view illustrating a pixel structure of an organic EL display device **50***a* according to the present embodiment. FIG. **2** is an equivalent circuit schematic of each of subpixels P of the organic EL display device **50***a*. FIG. **3** is a plan view illustrating an interior structure of each subpixel P of the organic EL display device **50***a*. FIG. **4** is a cross-sectional view of the organic EL display device **50***a* taken along the line IV-IV in FIG. **3**. FIG. **5**A is an enlarged view of a portion A**1** illustrated in FIG. **4** of a case where a foreign matter exists in the portion A**1**. FIG. **5**B is a plan view illustrating the foreign matter and the portion contacting the foreign matter (foreign-matter contact portion) illustrated in FIG. **5**A. FIG. **6** is a cross-sectional view illustrating an organic EL layer **20** included in the organic EL display device **50***a*. FIG. **7** is a plan view illustrating an arrangement structure of second electrodes **21***a* in the organic EL display device **50***a*. FIG. **8** is a plan view illustrating an arrangement structure of sealing film **22***a* in the organic EL display device **50***a*.

The organic EL display device **50***a* includes a display region that has a rectangular shape in a plan view. In the display region, a plurality of subpixels P (see FIG. **1**) are arranged in a matrix shape. As illustrated in FIG. **1**, the display region of the organic EL display device **50***a* includes: subpixels P each of which includes a red-color-light emitting region Lr configured to display a red-color grayscale; subpixel P each of which includes a green-color-light emitting region Lg configured to display a green-color grayscale; and subpixel P each of which includes a blue-color-light emitting region Lb configured to display a blue-color grayscale. The subpixels P of these three different colors are disposed side by side with one another. Each single pixel included in the display region of the organic EL display device **50***a* includes three mutually adjacent subpixels P: one including a red-color-light emitting region Lr; another including a green-color-light emitting region Lg; and the other including a blue-color-light emitting region Lb.

As illustrated in FIG. **4**, the organic EL display device **50***a* includes: a base substrate **10**; a plurality of organic EL elements **8**; a plurality of sealing films **22***a;* an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed as a display element over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17** (which will be described later). Each of the plurality of sealing films **22***a* is formed on the corresponding one of the organic EL elements **8**. The function layer **40** is formed over the plurality of sealing films **22***a* with the adhesive layer **30** provided in between.

As will be described later, each of the organic EL elements **8** included in the organic EL display device **50***a* has end portions each of which has a certain taper angle with respect to the base substrate **10**. The certain taper angle is not larger than a predetermined angle (the details of this taper angle will be described later).

The base substrate **10** is a plastic substrate made from a polyimide resin, for example.

The moisture-proof film **11** is formed on the base substrate **10**, and is made of a silicon oxide film, a silicon nitride film, and a silicon oxynitride film, for example. As illustrated in FIG. **2** and FIG. **3**, a plurality of gate lines **12***a* are formed on the moisture-proof film **11**. The gate lines **12***a* extend in parallel to one another, and each of the gate lines **12***a* extends in the horizontal direction in each of the above-mentioned drawings. In addition, as illustrated in FIG. **3** and FIG. **4**, in each of the subpixel P, a gate electrode **12***b* of a drive thin film transistor (drive TFT) **6***b* (which will be described later) is formed on the moisture-proof film **11**. The gate electrode **12***b* has an island shape extending in the vertical direction in FIG. **3**. In addition, as illustrated in FIG. **4**, a gate insulating film **13** is formed on the moisture-proof film **11** and covers the gate lines **12***a* and the gate electrodes **12***b.* The gate lines **12***a* and the gate electrodes **12***b* are formed of metal films made, for example, from aluminum, titanium, tungsten, tantalum, copper, or alloys thereof. In addition, the gate insulating film **13** is formed, for example, of a silicon oxide film, a silicon nitride film, or a silicon oxynitride film.

As illustrated in FIG. **3** and FIG. **4**, a first semiconductor layer **14***a* and a second semiconductor layer **14***b* are formed on the gate insulating film **13**. In each of the subpixels P, the first semiconductor layer **14***a* and the second semiconductor layer **14***b* are laid over the corresponding gate line **12***a* and the corresponding gate electrode **12***b,* respectively. In addition, as illustrated in FIG. **3** and FIG. **4**, a plurality of data lines **15***a* are formed on the gate insulating film **13**. The data lines **15***a* extend in parallel to one another in the vertical direction in FIG. **3**. In addition, as illustrated in FIG. **3** and FIG. **4**, a plurality of power source lines **15***b* are formed on the gate insulating film **13**. The power source lines **15***b* are adjacent to the corresponding data lines **15***a* and extend in parallel to one another. Note that the first semiconductor layer **14***a* and the second semiconductor layer **14***b* are made, for example, from amorphous silicon, low-temperature polysilicon, or In—Ga—Zn—O based oxide semiconductors.

As illustrated in FIG. **3**, in each of the subpixels P, a source electrode **15***aa* is formed on the gate insulating film **13** and the first semiconductor layer **14***a.* The source electrode **15***aa* extends, from the corresponding data line **15***a,* in the horizontal direction in FIG. **3**. In addition, as illustrated in FIG. **3**, in each of the subpixels P, an island-shaped drain electrode **15***c* is formed on the gate insulating film **13** and the first semiconductor layer **14***a.* The drain electrode **15***c* extends in the vertical direction in FIG. **3**. As illustrated in FIG. **3**, part of the gate line **12***a,* the gate insulating film **13**, the first semiconductor layer **14***a*, the source electrode **15***aa,* and drain electrode **15***c* together form a switching TFT **6***a.*

As illustrated in FIG. **3** and FIG. **4**, in each of the subpixels P, an island-shaped drain electrode **15***d* is formed on the gate insulating film **13** and the second semiconductor layer **14***b.* The drain electrode **15***d* extends in the vertical direction in FIG. **3**. In addition, as illustrated in FIG. **3** and FIG. **4**, a source electrode **15***ba* is formed on the gate insulating film **13** and the second semiconductor layer **14***b.* The source electrode **15***ba* extends, from the corresponding power source line **15***b,* in the horizontal direction in FIG. **3**. As illustrated in FIG. **3** and FIG. **4**, the gate electrode **12***b,* the gate insulating film **13**, the second semiconductor layer **14***b,* the source electrode **15***ba,* and the drain electrode **15***d* together form the drive TFT **6***b.* Note that the data lines **15***a,* the source electrode **15***aa,* the power source lines **15***b,* the source electrode **15***ba,* the drain electrode **15***c,* and drain electrode **15***d* are formed of metal films made, for example, from aluminum, titanium, tungsten, tantalum, copper, or alloys thereof. In addition, a passivation film **16** is formed on the gate insulating film **13**, and the plurality of interlayer insulating films **17** are formed on the gate insulating film **13** as illustrated in FIG. **4**. The passivation film **16** and the interlayer insulating films **17** cover the drive TFT **6***b* except its connection portion of the drain electrode **15***d,* and the switching TFT **6***a.* Note that passivation film **16** is formed, for example, of a silicon oxide film, a silicon nitride film, or a silicon oxynitride film. In addition, the plurality of interlayer insulating films **17** are formed, for example, extending in parallel to one another in the vertical direction in FIG. **3**. The interlayer insulating film **17** includes, for example, a transparent organic resin material, such as an acrylic resin. Note that as illustrated in FIG. **2** and FIG. **3**, the drain electrode **15***c* of the switching TFT **6***a* is connected to the gate electrode **12***b* of the drive TFT **6***b* via a contact hole **13***c* formed in the gate insulating film **13**. In addition, as illustrated in FIG. **2** and FIG. **3**, the gate electrode **12***b* of the drive TFT **6***b,* the drain electrode **15***d,* and the gate insulating film **13** located in between together form a capacitor **7**. In addition, as illustrated in FIG. **2** to FIG. **4**, the drain electrode **15***d* of the drive TFT **6***b* is connected to the organic EL element **8** via a contact hole **17***c* formed in the interlayer insulating film **17**.

As illustrated in FIG. **4**, the organic EL element **8** includes: a plurality of first electrodes **18**, a plurality of edge covers **19**, a plurality of organic EL layers **20**, and a plurality of second electrodes **21***a.* All of these components are formed in this order one upon another on and over the interlayer insulating films **17**.

The plurality of first electrodes **18** are formed as anode electrodes in individual subpixels P, and are arranged in a matrix shape on the interlayer insulating films **17**. In addition, as illustrated in FIG. **4**, in each of the subpixels P, the first electrode **18** is connected to the drain electrode **15***d* of the drive TFT **6***b* via the contact hole **17***c* formed in the interlayer insulating film **17**. The first electrode **18** functions to inject holes into the organic EL layer **20**. It is more preferable that the first electrodes **18** include a material having a large work function to improve the efficiency of hole injection into the organic EL layer **20**. Examples of materials that may be included in the first electrode **18** 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), and ytterbium (Yb). Further examples of materials that may be included in the first electrode **18** include alloys, examples of which include magnesium (Mg)-copper (Cu), magnesium (Mg)-silver (Ag), sodium (Na)-potassium (K), astatine (At)-astatine oxide (AtO_2), lithium (Li)-aluminum (Al), lithium (Li)-calcium (Ca)-aluminum (Al), and lithium fluoride (LiF)-calcium (Ca)-aluminum (Al). Further examples of materials that may be included in the first electrode **18** include electrically conductive oxides, examples of which include tin oxide (SnO), zinc oxide (ZnO), indium tin oxide (ITO), and indium zinc oxide (IZO). In addition, each of the first electrodes **18** may include a stack of two or more layers each of which is made of the above-mentioned materials, such as ITO/Ag, IZO/Ag, and IZO/Al. Note that some of the conductive oxides and the like materials have large work functions, and that examples of such materials include indium tin oxide (ITO) and indium zinc oxide (IZO).

The plurality of edge covers **19** are formed, for example, extending in parallel to one another in the vertical direction in FIG. **3**. In addition, as illustrated in FIG. **4**, the edge covers **19** are formed in a ladder shape and thus cover the edge portions of the first electrodes **18** of all the subpixels P that are arranged in a single vertical line in FIG. **3**. Note that each of the edge covers **19** may be, for example, an inorganic film or an organic film. Examples of materials that may be included in the inorganic film include silicon oxide (SiO_2), silicon nitride (SiNx (x is a positive number)) such as trisilicon tetranitride (Si_3N_4), and silicon oxynitride (SiNO). Examples of materials that may be included in the organic film include (photosensitive) polyimide resins, (photosensitive) acrylic resins, (photosensitive) polysiloxane resins, and novolak resins.

The plurality of organic EL layers **20** are included respectively in the individual subpixels P. The organic EL layers **20** are arranged in a matrix shape on the first electrodes **18** and edge covers **19**. In addition, in each of the subpixels P, the organic EL layer **20** covers the first electrode **18** exposed from the edge covers **19**. As illustrated in FIG. **6**, each of the organic EL layers **20** includes a hole injecting layer **1**, a hole transport layer **2**, a light-emitting layer **3**, an electron transport layer **4**, and an electron injecting layer **5**, which are arranged in the order stated over the first electrode **18**. In addition, each of the organic EL layers **20** is an example of the display layer mentioned in the scope of claims.

The hole injecting layer **1** is also referred to as an anode buffer layer, and functions to reduce the energy level difference between the first electrode **18** and the organic EL layer **20**, to improve the efficiency of hole injection into the organic EL layer **20** from the first electrode **18**. Examples of materials that may be included in the hole injecting 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.

The hole transport layer **2** functions to improve the efficiency of hole transport from the first electrode **18** to the organic EL layer **20**. Examples of materials that may be included in the hole transport layer **2** include porphyrin derivatives, aromatic tertiary amine compounds, styrylamine derivatives, polyvinylcarbazole, poly-p-phenylenevinylene, 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.

The light-emitting layer **3** is a region where the holes and the electrons recombine, when a voltage is applied via the first electrode **18** and the second electrode **21***a,* holes and electrons are injected from the first electrode **18** and the second electrode **21***a,* respectively. The light-emitting layer **3** includes a material having a high light emitting efficiency. Examples of materials that may be included in the light-emitting layer **3** include metal oxinoid compounds (8-hydroxyquinoline metal complexes), naphthalene derivatives, anthracene derivatives, diphenyl ethylene derivatives, vinyl acetone derivatives, triphenylamine derivatives, butadiene derivatives, coumarin derivatives, benzoxazole derivatives, oxadiazole derivatives, oxazole derivatives, benzimidazole derivatives, thiadiazole derivatives, benzothiazole derivatives, styryl derivatives, styrylamine derivatives, bisstyrylbenzene derivatives, trisstyrylbenzene derivatives, perylene derivatives, perinone derivatives, aminopyrene derivatives, pyridine derivatives, rhodamine derivatives, aquidine derivatives, phenoxazone, quinacridone derivatives, rubrene, poly-p-phenylenevinylene, and polysilane.

The electron transport layer **4** functions to facilitate migration of the electrons to the light-emitting layer **3** efficiently. Examples of materials that may be included in the electron transport layer **4** include organic compounds, example of which include oxadiazole derivatives, triazole derivatives, benzoquinone derivatives, naphthoquinone derivatives, anthraquinone derivatives, tetracyanoanthraquinodimethane derivatives, diphenoquinone derivatives, fluorenone derivatives, silole derivatives, and metal oxinoid compounds.

The electron injecting layer **5** functions to reduce the energy level difference between the second electrode **21***a* and the organic EL layer **20**, to improve the efficiency of electron injection into the organic EL layer **20** from the second electrode **21***a*. Because of this function, the driving voltage for the organic EL layer **20** can be reduced. The electron injecting layer **5** is also referred to as a cathode buffer layer. Examples of materials that may be included in the electron injecting 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).

As illustrated in FIG. **7**, the plurality of second electrodes **21***a* are formed extending in parallel to one another in the vertical direction in FIG. **7**. In addition, as illustrated in FIG. **7**, each of the second electrodes **21***a* has an elongated rectangular shape in a plan view and thus is laid over the organic EL layers **20** of all the subpixels P that are arranged in a single vertical line in FIG. **7**. To put it differently, each of the second electrodes **21***a* is electrically connected to the corresponding subpixels P arranged in a vertical single line in FIG. **7** and configured to display the grayscale of the same color. When one of the second electrodes **21***a* is connected to a particular subpixel P, that one of the second electrodes **21***a* is connected to none of the two subpixels P that are adjacent to the particular subpixel in the horizontal direction and that are configured to display the grayscale of different colors from the color of that particular subpixel P. In addition, as illustrated in FIG. **7**, in the non-display region, the second electrodes **21***a* are connected to a common wiring line **12***c* via contact holes Ha formed in a layered film of the gate insulating film **13** and the passivation film **16**. The common wiring line **12***c* is made of the same material as the material of the gate lines **12***a* and is formed in the same layer where the gate lines **12***a* are formed. The second electrode **21***a* functions to inject electrons into the organic EL layer **20**. It is more preferable that the second electrode **21***a* includes a material having a small work function to improve the efficiency of electron injection into the organic EL layer **20**. Examples of materials that may be included in the second electrode **21***a* 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), and ytterbium (Yb). Further examples of materials that may be included in the second electrode **21***a* include alloys, examples of which include magnesium (Mg)-copper (Cu), magnesium (Mg)-silver (Ag), sodium (Na)-potassium (K), astatine (At)-astatine oxide (AtO_2), lithium (Li)-aluminum (Al), lithium (Li)-calcium (Ca)-aluminum (Al), and lithium fluoride (LiF)-calcium (Ca)-aluminum (Al). Further examples of materials that may be included in the second electrode **21***a* include electrically conductive oxides, examples of which include tin oxide (SnO), zinc oxide (ZnO), indium tin oxide (ITO), and indium zinc oxide (IZO). The second electrode **21***a* may include a stack of two or more layers of any of the above-mentioned materials, such as ITO/Ag. Examples of materials having a small work function include magnesium (Mg), lithium (Li), 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).

As illustrated in FIG. **8**, the plurality of sealing films **22***a* are formed extending in parallel to one another in the vertical direction in FIG. **8**. In addition, as illustrated in FIG. **4** and FIG. **8**, the sealing films **22***a* are formed on the corresponding second electrodes **21***a*, respectively. Each of the sealing films **22***a* has an elongated rectangular shape in a plan view and thus covers the end faces of the organic EL layers **20** of all the subpixels P that are arranged in a single vertical line in FIG. **8**. In addition, as illustrated in FIG. **4** and FIG. **8**, the grooves C are formed between every two adjacent ones of the plurality of sealing films **22***a*. Each of the grooves C extends in the vertical direction in FIG. **8** between the corresponding two subpixels P (see also FIG. **3**). In addition, the sealing films **22***a* have a function to protect the organic EL layers **20** from moisture and oxygen.

In addition, for example, as illustrated in FIG. **5**A and FIG. **5**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***a* includes a first sealing layer **22***a***1** that is layered on the second electrode **21***a*, and also includes a foreign-matter contact portion **22***ar* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***a* is being manufactured, at least one foreign matter R exists in at least any one position on the organic EL element **8** in the organic EL display device **50***a* as illustrated in the enclosure **A1** in FIG. **4**. In this case, one foreign-matter contact portion **22***ar* is formed in the sealing film **22***a* for each place where a foreign matter R exists. In addition, the foreign-matter contact portion **22***ar* has a smaller taper angle than 90° with respect to the base substrate **10** as will be described in detail later.

In addition, as illustrated in FIG. **5**A, the foreign-matter contact portion **22***ar* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***a*, the foreign-matter contact portion **22***ar* and the first sealing layer **22***a***1** wrap up the foreign matter R. Note that the first sealing layer **22***a***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***a***1** is formed of an inorganic film, but that the first sealing layer **22***a***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***ar* includes one of the above-mentioned organic films. In addition, the foreign matter R is, for example, a glass piece or dust, such as a by-product of organic vapor deposition, that exists in a chamber (not illustrated) used in the manufacturing of various portions of the organic EL display device **50***a*.

The adhesive layer **30** is, for example, a UV-hardening-type adhesive, a thermosetting adhesive, an epoxy adhesive, an acrylic adhesive, or a polyolefin adhesive.

The function layer **40** is formed, for example, of a hard-coat film, a retardation plate, or a polarizing plate.

In a case where the organic EL display device **50***a* with the configuration described above displays images, in each of the subpixels P, a gate signal is inputted into the switching TFT **6***a* via the gate line **12***a* and thus the switching TFT **6***a* is turned ON. Then, in each of the subpixels P in the organic EL display device **50***a*, a predetermined voltage corresponding to a source signal is applied, via the data line **15***a*, to the gate electrode **12***b* of the drive TFT **6***b*. In addition, in each of the subpixels P of the organic EL display device **50***a*, the magnitude of the current from the power source line **15***b* is defined based on the voltage of the gate electrode **12***b* of the drive TFT **6***b*, and the current is supplied to the light-emitting layer **3** of the organic EL element **8**. In this way, the light-emitting layer **3** emits light. Note that in the organic EL display device **50***a*, even in a case where the switching TFT **6***a* is turned OFF, the voltage of the gate electrode **12***b* of the drive TFT **6***b* is maintained by the capacitor **7**. Hence, the emission of light by the light-emitting layer **3** continues until the gate signal for the next frame is inputted.

The organic EL display device **50***a* of the present embodiment can be manufactured in the following manner, for example.

Firstly, for example, on a surface of the base substrate **10** formed on a glass substrate, a moisture-proof layer **11**; TFT arrays including the switching TFTs **6***a*, the drive TFTs **6***b*, and the like; the passivation film **16**; and the interlayer insulating films **17** are formed by a well-known method.

Then, on the interlayer insulating films **17**, the first electrodes **18**, the edge covers **19**, the organic EL layers **20**, and the second electrodes **21***a* are formed sequentially by a well-known method, and thus, the organic EL elements **8** are formed.

In addition, after an inorganic film (which is to be the sealing film **22***a*) and a photoresist are formed on the second electrodes **21***a* by a well-known method, the inorganic film exposed from the photoresist is etched by use of buffered hydrofluoric acid, and thus the sealing films **22***a* are formed.

With reference to FIG. **9** and FIGS. **10**A to **10**E, a description will be given below about a specific method of forming the sealing films **22***a* of a case where a foreign matter R exists on the organic EL element **8**. FIG. **9** is a flowchart describing steps of manufacturing main portions of the organic EL display device **50***a* according to the first embodiment of the disclosure. FIGS. **10**A to **10**E are diagrams describing a series of main steps of manufacturing the main portions of the organic EL display device **50***a* according to the first embodiment of the disclosure. Note that the following description is based on a case where the foreign-matter contact portions **22***ar* are formed by use of an organic film whereas the first sealing layers **22***a***1** are formed by use of an inorganic film.

As illustrated in FIG. **9**, the foreign-matter contact layer made of an organic film is formed to cover the organic EL elements **8** by a well-known method (Step **S1**). Note that as illustrated in FIG. **10**A, in a case where a foreign matter R exists on the organic EL element **8**, the foreign-matter contact layer **22***ar***0** is formed on both the foreign matter R and the organic EL element **8** as illustrated in FIG. **10**B. Specifically, for example, a liquid organic material for the organic film is processed by a vapor deposition method to form the foreign-matter contact layer **22***ar***0** on both the foreign matter R and the organic EL element **8**. Then, the foreign-matter contact layer **22***ar***0** is subjected, for example, to a UV irradiation process, and thus the foreign-matter contact layer **22***ar***0** is hardened on both the foreign matter R and the organic EL element **8**.

In addition, as described earlier, in the organic EL element **8**, with respect to the base substrate **10** (FIG. **4**), the taper angle (denoted by "α1" in FIGS. **10**A to **10**E) of each end portion of the organic EL element **8** is set to an angle that is equal to or smaller than a predetermined angle (e.g., 30°). To put it differently, in the organic EL element **8**, the organic EL layer **20** and the second electrode **21***a* are formed with end faces of the organic EL layer **20** and the second electrode **21***a* having angles with respect to the base substrate **10** that are equal to or smaller than the predetermined angle in FIG. **4**, for example. Hence, in the present embodiment, the organic EL element **8** is prevented from being degraded by moisture (details of which will be described later).

Then, as illustrated in Step **S2** of FIG. **9**, by performing a known ashing process on the foreign-matter contact layer **22***ar***0**, the foreign-matter contact portion **22***ar* is formed on the organic EL element **8**. To put it differently, as a portion of the foreign-matter contact layer **22***ar***0** has not been removed due to the existence of the foreign matter R, that portion is formed as the foreign-matter contact portion **22***ar* by performing the ashing process as illustrated in FIG. **10**C. In addition, the foreign-matter contact portion **22***ar* is formed on the organic EL element **8** with the taper angle (denoted by "β1" in FIGS. **10**A to **10**E) of the foreign-matter contact portion **22***ar* with respect to the base substrate **10** being smaller than 90°. In addition, in a case where no foreign matter R exists on the organic EL element **8**, the foreign-matter contact layer **22***ar***0** is entirely removed by the ashing process, and thus no foreign-matter contact portion **22***ar* is formed in the sealing film **22***a*.

Then, a process of forming the first sealing layer **22***a***1** is performed as illustrated in Step **S3** of FIG. **9**. This formation process is performed by a well-known CVD method using, for example, an open mask or an FMM mask. Thus, as illustrated in FIG. **10**D, the first sealing layer **22***a***1** is formed to cover the organic EL element **8**, the foreign matter R, and the foreign-matter contact portion **22***ar*. Then, by performing a well-known etching process, the sealing films **22***a* for individual subpixels P are formed as illustrated in FIG. **10**E.

Lastly, the function layer **40** is affixed to the sealing film **22***a* via the adhesive layer **30**, and then the base substrate **10** is removed from the glass substrate by laser-light irradiation (e.g., see FIG. **4**).

Comparative Example 1 where the taper angle α**1** is larger than the predetermined angle has some problems, which are described specifically below with reference to FIGS. **11**A to **11**D. FIGS. **11**A to **11**D are diagrams describing a series of main steps of manufacturing main portions of an organic EL display device according to Comparative Example 1. Note that the following description is based on a case where the organic EL display device of Comparative Example 1 has a 90-degree taper angle α**1** of each end portion of the organic EL element **8** with respect to the base substrate **10**.

In the organic EL display device of Comparative Example 1, finishing the process in Step **S1** leaves the foreign-matter contact layer **22***ar***0** formed on the organic EL element **8** as illustrated in FIG. **11**A. Then, the ashing in Step **S2** leaves unremoved, as remaining portions **22***ar***1**, part of the organic film of the foreign-matter contact layer **22***ar***0** located in the end portions of the organic EL element **8** as illustrated in FIG. **11**B. These remaining portions **22***ar***1** are the result of the taper angle α**1** that is larger than the predetermined angle (e.g., 30°).

Then, finishing the process in Step **S3**, as illustrated in FIG. **11**C, the first sealing layer **22***a***1** is formed on both the foreign-matter contact portion **22***ar* and the remaining portions **22***ar***1**. Then, in a case where the sealing films are formed for individual subpixels P by a well-known etching process, the remaining portions **22***ar***1** may not be etched but exposed as illustrated in FIG. **11**D. In a case where the remaining portions **22***ar***1** are exposed as described above, the remaining portions **22***ar***1** may absorb moisture through the adhesive layer **30**, and the like. As a consequence, in Comparative Example 1, the moisture having been absorbed in remaining portions **22***r***1** may permeate the organic EL element **8** through the remaining portions **22***ar***1**. The moisture may degrade the organic EL element **8**.

In contrast, in the organic EL display device **50***a* of the present embodiment, each end portion of the organic EL element **8** has a taper angle α**1** that is equal to or smaller than the predetermined angle. Hence, finishing the ashing process leaves no remaining portions **22***ar***1** in the end portions of the organic EL element **8**, and thus the foreign-matter contact layer **22***ar***0** other than the foreign-matter contact portion **22***ar* can be removed by the ashing process. As a consequence, in the present embodiment, even in the case where a foreign matter R exists, consequences that are different from the consequences in Comparative Example 1 are produced. Specifically, the moisture is prevented from permeating the organic EL element **8** and the degradation of organic EL element **8** is prevented from being caused by the permeation of moisture. To put it differently, in the present embodiment, each end portion of the organic EL element **8** is formed to have the taper angle α**1** that leaves no remaining portions **22***ar***1** in the end portions of the organic EL element **8** after the ashing process on the foreign-matter contact layer **22***ar***0**.

The organic EL display device **50***a* of the present embodiment described above can have the following effects.

(1) In the sealing film **22***a,* the grooves C are formed between every two adjacent ones of the plurality of subpixels P. Hence, the organic EL display device **50***a* has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where the organic EL display device **50***a* is bent around a bent axis that is parallel to the data lines **15***a,* in the organic EL display device **50***a,* a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. To put it differently, the bending strain to be generated at the time of bending is determined to a certain amount c depending on the distance from the neutral surface (a surface that is neither stretched nor shrunk) and the bending radius. In a case where both a lower-rigidity portion and a higher-rigidity portion exist the same distance away from the neutral surface, the lower-rigidity portion has a larger strain ($\varepsilon 1$) and the higher-rigidity portion has a smaller strain ($\varepsilon 2$). Note that $\varepsilon=\varepsilon 1+\varepsilon 2$, meaning that the total strain ε is constant. Hence, in a case where there is no lower-rigidity portion ($\varepsilon 1=0$), $\varepsilon 2=\varepsilon$. In a case where there is a lower-rigidity portion, the strain in the higher-rigidity portion ($\varepsilon 2$) is obtained by subtracting the strain in the lower-rigidity portion from the total strain ε (i.e., $\varepsilon 2=\varepsilon-\varepsilon 1$), meaning that a smaller value $\varepsilon 2$ is obtained. Hence, as the sealing film **22***a* has a smaller strain, the generation of cracks in the sealing film **22***a* can be suppressed. Accordingly, when the organic EL display device **50***a* is bent, the generation of cracks in the sealing film **22***a* is suppressed. In addition, as the generation of cracks in the sealing film **22***a* can be suppressed, the sealing film **22***a* has an improved sealing performance, and thus the organic EL display device **50***a* becomes more reliable.

(2) In addition, the foreign-matter contact portion **22***ar* that contacts the foreign matter R existing on the organic EL element **8** is formed in the sealing film **22***a*. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing film **22***a* can be suppressed, and thus the organic EL display device **50***a* becomes more reliable. In addition, the foreign-matter contact portion **22***ar* is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, the foreign-matter contact portion **22***ar* can suppress the stress from the foreign matter R to the organic EL element **8** side when the organic EL display device **50***a* is bent. In addition, the existence of the foreign-matter contact portion **22***ar* in the sealing film **22***a* allows the first sealing layer **22***a***1** and thus the sealing film **22***a* to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

Second Embodiment

FIG. **12** to FIG. **13**B illustrate the second embodiment of an organic EL display device according to the disclosure. FIG. **12** is a cross-sectional view illustrating an organic EL display device **50***b* of the present embodiment, and is a diagram corresponding to FIG. **4**. FIG. **13**A is an enlarged view of a portion A2 illustrated in FIG. **12** of a case where a foreign matter exists in the portion A2. FIG. **13**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **13**A. In the following embodiments, parts identical to those in FIGS. **1** to **10** are designated by the same reference characters, and their detailed descriptions are omitted here.

The description of the first embodiment is based on the organic EL display device **50***a* where the end faces of the organic EL layer **20** are covered by the sealing film **22***a* whereas the description of the present embodiment is based on the organic EL display device **50***b* where the end faces of the organic EL layer **20** are covered by the inorganic barrier film **23**.

As illustrated in FIG. **12**, the organic EL display device **50***b* includes: a base substrate **10**; a plurality of organic EL elements **8**; a plurality of sealing films **22***b;* an inorganic barrier film **23**; an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22***b* is formed on the corresponding one of the organic EL elements **8**. The inorganic barrier film **23** covers the individual sealing films **22***b*. The function layer **40** is formed over inorganic barrier film **23** with the adhesive layer **30** provided in between.

In addition, for example, as illustrated in FIG. **13**A and FIG. **13**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***b* includes a first sealing layer **22***b***1** that is layered on the second electrode **21***a,* and also includes a foreign-matter contact portion **22***br* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***b* is being manufactured, at least one foreign matter R exists in at least any one position on the organic EL element **8** in the organic EL display device **50***b* as illustrated in the enclosure **A2** in FIG. **12**. In this case, one foreign-matter contact portion **22***br* is formed in the sealing film **22***b* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **13**A, the foreign-matter contact portion **22***br* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***b,* the foreign-matter contact portion **22***br* and the first sealing layer **22***b***1** wrap up the foreign matter R. Note that the first sealing layer **22***b***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***b***1** is formed of an inorganic film, but that the first sealing layer **22***b***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***br* includes one of the above-mentioned organic films.

As illustrated in FIG. **12**, the inorganic barrier film **23** is in contact with the perimeter edge surface of each organic EL layer **20** and with the perimeter edge surface of each sealing film **22***b*. In addition, the inorganic barrier film **23** is formed, for example, of an aluminum oxide film formed by an atomic layer deposition (ALD) method. Note that the atomic layer deposition method is a film formation method where reaction products are deposited one layer of atoms after another by repeating a cycle including an adsorption and reaction process of molecules of film-formation materials (precursors) on a surface of a substrate placed in a vacuum chamber, and a subsequent purging process by use of an inert gas to remove excess of molecules. The film formed by the atomic layer deposition method is very thin (approximately 10 nm), but is uniform and has an excellent coatability.

The organic EL display device **50***b* with the above-described configuration, as in the case of the organic EL display device **50***a* of the first embodiment, is configured to display images by making the light-emitting layers **3** of the organic EL layers **20** in each of the subpixels P emit light appropriately.

The organic EL display device **50***b* of the present embodiment can be manufactured by modifying the manufacturing method described in the first embodiment. Specifically, a conductive film that is to be the second electrodes **21***a* and inorganic film that is to be the sealing films **22***b* are formed on the entire substrate where organic EL layers **20**. Then, the conductive film and the inorganic film are etched by use of buffered hydrofluoric acid and thus are patterned to form second electrodes **21***a* and sealing films **22***b*. In addition, by an ALD method an inorganic barrier film **23** is formed to cover the sealing film **22***b*. Then, as in the manufacturing method described in the first embodiment, a process of affixing the function layer **40** via the adhesive layer **30** and the subsequent processes are performed.

The organic EL display device **50***b* of the present embodiment described above can have the following effect (3), in addition to the above-described effects (1) and (2).

Now, a detail description will be given below about the item (1). In the sealing film **22***b*, the grooves C are formed between every two adjacent ones of the plurality of subpixels P. Hence, the organic EL display device **50***b* has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where the organic EL display device **50***b* is bent around a bent axis that is parallel to the data lines **15***a*, in the organic EL display device **50***b*, a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as the sealing film **22***b* has a smaller strain, the generation of cracks in the sealing film **22***b* can be suppressed. Accordingly, when the organic EL display device **50***b* is bent, the generation of cracks in the sealing film **22***b* is suppressed. In addition, as the generation of cracks in the sealing film **22***b* can be suppressed, the sealing film **22***b* has an improved sealing performance, and thus the organic EL display device **50***b* becomes more reliable.

(2) In addition, the foreign-matter contact portion **22***br* that contacts the foreign matter R existing on the organic EL element **8** is formed in the sealing film **22***b*. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing film **22***b* can be suppressed, and thus the organic EL display device **50***b* becomes more reliable. In addition, the foreign-matter contact portion **22***br* is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, the foreign-matter contact portion **22***br* can suppress the stress from the foreign matter R to the organic EL element **8** side when the organic EL display device **50***b* is bent. In addition, the existence of the foreign-matter contact portion **22***br* in the sealing film **22***b* allows the first sealing layer **22***b***1** and thus the sealing film **22***b* to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

(3) Even in a case where the perimeter edge surface of each organic EL layer **20** and at least a part of the perimeter edge surface of the sealing film **22***b* overlap each other, the inorganic barrier film **23** covering each of the sealing films **22***b* can prevent the organic EL element **8** from being degraded. In addition, the inorganic barrier film **23** is thinner than and has a better coatability than the sealing film **22***b*. Hence, the sealing ability can be prevented from being impaired while the flexibility of the organic EL display device **50***b* can be improved.

Third Embodiment

FIG. **14** to FIG. **16**B illustrate the third embodiment of an organic EL display device according to the disclosure. FIG. **14** is a plan view illustrating an arrangement structure of sealing films **22***c* in an organic EL display device **50***c* according to the present embodiment. In addition, FIG. **15** is a plan view illustrating an arrangement structure of second electrodes **21***c* in the organic EL display device **50***c*. In addition, FIG. **16**A is an enlarged schematic view illustrating a foreign matter existing in the organic EL display device **50***c* according to the third embodiment of the disclosure and a portion around the foreign matter. FIG. **16**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **16**A.

The description in Embodiment 1 is based on a case of the organic EL display device **50***a* where the sealing films **22***a* extend in parallel to the data lines **15***a* whereas the description in the second embodiment is based on a case of the organic EL display device **50***b* where the sealing films **22***b* extend in parallel to the data lines **15***a*. The description in the present embodiment is based on a case of the organic EL display device **50***c* where the sealing films **22***c* extend in parallel to gate lines **12***a*.

The organic EL display device **50***c* includes: a base substrate **10**; a plurality of organic EL elements **8**; the plurality of sealing films **22***c*; an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22***c* is formed on the corresponding one of the organic EL elements **8**. The function layer **40** is formed over the plurality of sealing films **22***c* with the adhesive layer **30** provided in between.

The organic EL element **8** includes: a plurality of first electrodes **18**, a plurality of edge covers **19**, a plurality of organic EL layers **20**, and a plurality of second electrodes **21***c*. All of these components are formed in this order one upon another on and over the interlayer insulating films **17**. Note that as illustrated in FIG. **15**, the plurality of second electrodes **21***c* are formed extending in parallel to one another in the horizontal direction in FIG. **15**. In addition, as illustrated in FIG. **15**, each of the second electrodes **21***c* has an elongated rectangular shape in a plan view and thus is laid over the organic EL layers **20** of all the subpixels P that are arranged in a single horizontal line in FIG. **15**. To put it differently, each of the second electrodes **21***c* is electrically connected to the corresponding subpixels P arranged in a horizontal single line in FIG. **15** and configured to display the grayscale of different colors from one another. When one of the second electrodes **21***c* is connected to a particular subpixel P, that one of the second electrodes **21***c* is connected to none of the two subpixels P that are adjacent to the particular subpixel in the horizontal vertical and that are configured to display the grayscale of the same color as the color of that particular subpixel P. In addition, as illustrated in FIG. **15**, in the non-display region, the second electrodes **21***c* are connected to a common wiring line **15***e* via contact holes Hb formed in the passivation film **16**. The common wiring line **15***e* is made of the same material as the material of the data lines **15***a* and is formed in the same layer where the data lines **15***a* are formed. The second electrode **21***c* functions to inject electrons into the organic EL layer **20**, and is made from the same material as the material for the second electrode **21***a* described in the first embodiment.

As illustrated in FIG. **14**, the plurality of sealing films **22***c* are formed extending in parallel to one another in the horizontal direction in FIG. **14**. In addition, the sealing films **22***c* are formed on the corresponding second electrodes **21***c*, respectively. Each of the sealing films **22***c* has an elongated rectangular shape in a plan view and thus covers the end faces of the organic EL layers **20** of all the subpixels P that are arranged in a single horizontal line in FIG. **14**. In addition, as illustrated in FIG. **14**, the grooves C are formed between every two adjacent ones of the plurality of sealing films **22***c*. Each of the grooves C extends in the horizontal direction in FIG. **14** between the corresponding two subpixels P. In addition, the sealing films **22***c* have a function to protect the organic EL layers **20** from moisture and oxygen.

In addition, for example, as illustrated in FIG. **16**A and FIG. **16**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***c* includes a first sealing layer **22***c***1** that is layered on the second electrode **21***a*, and also includes a foreign-matter contact portion **22***cr* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***c* is being manufactured, at least one foreign matter R exists in at least any one position on the second electrode **21***a* (on the organic EL element **8**) in the organic EL display device **50***c* as illustrated in FIG. **16**A. In this case, one foreign-matter contact portion **22***cr* is formed in the sealing film **22***c* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **16**A, the foreign-matter contact portion **22***cr* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***c*, the foreign-matter contact portion **22***cr* and the first sealing layer **22***c***1** wrap up the foreign matter R. Note that the first sealing layer **22***c***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***c***1** is formed of an inorganic film, but that the first sealing layer **22***c***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***cr* includes one of the above-mentioned organic films.

The organic EL display device **50***c* with the above-described configuration, as in the case of the organic EL display device **50***a* of the first embodiment, is configured to display images by making the light-emitting layers **3** of the organic EL layers **20** in each of the subpixels P emit light appropriately.

The organic EL display device **50***c* of the present embodiment can be manufactured by a modified version of the manufacturing method described earlier in the first embodiment. In the present embodiment, the pattern shape used in the formation of the second electrode **21***a* and sealing film **22***a* is modified to form the second electrode **21***c* and the sealing film **22***c*.

The organic EL display device **50***c* of the present embodiment described above can have the above-described effects (1) and (2).

Now, a detail description will be given below about the item (1). In the sealing film **22***c*, the grooves C are formed between every two adjacent ones of the plurality of subpixels P. Hence, the organic EL display device **50***c* has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where the organic EL display device **50***c* is bent around a bent axis that is parallel to the gate lines **12***a*, in the organic EL display device **50***c*, a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as the sealing film **22***c* has a smaller strain, the generation of cracks in the sealing film **22***c* can be suppressed. Accordingly, when the organic EL display device **50***c* is bent, the generation of cracks in the sealing film **22***c* is suppressed. In addition, as the generation of cracks in the sealing film **22***c* can be suppressed, the sealing film **22***c* has an improved sealing performance, and thus the organic EL display device **50***c* becomes more reliable.

(2) In addition, the foreign-matter contact portion **22***cr* that contacts the foreign matter R existing on the organic EL element **8** is formed in the sealing film **22***c*. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing film **22***c* can be suppressed, and thus the organic EL display device **50***c* becomes more reliable. In addition, the foreign-matter contact portion **22***cr* is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, the foreign-matter contact portion **22***cr* can suppress the stress from the foreign matter R to the organic EL element **8** side when the organic EL display device **50***c* is bent. In addition, the existence of the foreign-matter contact portion **22***cr* in the sealing film **22***c* allows the first sealing layer **22***c***1** and thus the sealing film **22***c* to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

Fourth Embodiment

FIG. **17** to FIG. **21**B illustrate the fourth embodiment of an organic EL display device according to the disclosure. FIG. **17** is a plan view illustrating an arrangement structure of sealing films **22***d* in an organic EL display device **50***d* according to the present embodiment. In addition, FIG. **18** is a plan view illustrating an arrangement structure of second electrodes **21***d* in the organic EL display device **50***d*. In addition, FIG. **19**A is an enlarged schematic view illustrating a foreign matter existing in the organic EL display device **50***d* according to the fourth embodiment of the disclosure and a portion around the foreign matter. FIG. **19**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **19**A. In addition, FIG. **20** is a plan view illustrating a connection structure for second electrodes **22***e* in an organic EL display device **50***e* of a modified example of the organic EL display device **50***d*. In addition, FIG. **21**A is an enlarged schematic view illustrating a foreign matter existing in the modified example of the organic EL display device **50***d* according to the fourth embodiment of the disclosure and a portion around the foreign matter. FIG. **21**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **21**A.

The descriptions in the first to third embodiments are based on cases of organic EL display devices **50***a* to **50***c*, respectively, where the plurality of sealing films **22***a*, **22***b*, and **22***c*, respectively, extend in parallel to one another. The description in the present embodiment is based on a case of the organic EL display device **50***d* where the plurality of sealing films **22***d* are arranged in a matrix shape.

The organic EL display device **50***d* includes: a base substrate **10**; a plurality of organic EL elements **8**; the plurality of sealing films **22***d*; an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22***d* is formed on the corresponding one of the organic EL elements **8**. The function layer **40** is formed over the plurality of sealing films **22***c* with the adhesive layer **30** provided in between.

The organic EL element **8** includes: a plurality of first electrodes **18**, a plurality of edge covers **19**, a plurality of organic EL layers **20**, and a plurality of second electrodes **21***d*. All of these components are formed in this order one upon another on and over the interlayer insulating films **17**. Note that the plurality of second electrodes **21***d* are arranged in a matrix shape as illustrated in FIG. **18**. In addition, as illustrated in FIG. **18**, each of the second electrodes **21***d* has a rectangular shape in a plan view and is laid over the organic EL layer **20** of the corresponding one of the subpixels P. To put it differently, when one of the second electrodes **21***d* is electrically connected to a particular subpixel P, that one of the second electrodes **21***d* is electrically connected to none of the two subpixels P that are adjacent in the vertical direction to the particular subpixel P in FIG. **18** and that are configured to display the grayscale of the same color. In addition, when one of the second electrodes **21***d* is electrically connected to a particular subpixel P, that one of the second electrodes **21***a* is connected to none of the two subpixels P that are adjacent in the horizontal direction to the particular subpixel P in FIG. **18** and that are configured to display the grayscale of different colors from the color of that particular subpixel P. In addition, as illustrated in FIG. **18**, the second electrodes **21***d* are connected to one of common wiring lines **18***a* via contact holes Hc formed in the edge covers **19**. The common wiring lines **18***a* are made of the same material as the material of the first electrodes **18** and is formed in the same layer where the first electrodes **18** are formed. The second electrode **21***d* functions to inject electrons into the organic EL layer **20**, and is made from the same material as the material for the second electrode **21***a* described in the first embodiment. Note that the common wiring lines **18***a* are laid over the corresponding gate lines **12***a*.

The plurality of sealing films **22***d* are arranged in a matrix shape as illustrated in FIG. **17** and FIG. **18**. In addition, as illustrated in FIG. **17** and FIG. **18**, the sealing films **22***d* are formed on the corresponding second electrodes **21***d*, respectively. Each of the sealing films **22***d* has a rectangular shape in a plan view and thus covers the end faces of the organic EL layer **20** of the corresponding one of the subpixels P. In addition, as illustrated in FIG. **17**, the grooves C extending between every two subpixels P are formed in a matrix shape. In addition, the sealing films **22***d* have a function to protect the organic EL layers **20** from moisture and oxygen.

In addition, for example, as illustrated in FIG. **19**A and FIG. **19**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***d* includes a first sealing layer **22***d***1** that is layered on the second electrode **21***a*, and also includes a foreign-matter contact portion **22***dr* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***d* is being manufactured, at least one foreign matter R exists in at least any one position on the second electrode **21***a* (on the organic EL element **8**) in the organic EL display device **50***d* as illustrated in FIG. **19**A. In this case, one foreign-matter contact portion **22***dr* is formed in the sealing film **22***d* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **19**A, the foreign-matter contact portion **22***dr* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***d*, the foreign-matter contact portion **22***dr* and the first sealing layer **22***d***1** wrap up the foreign matter R. Note that the first sealing layer **22***d***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***d***1** is formed of an inorganic film, but that the first sealing layer **22***d***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***dr* includes one of the above-mentioned organic films.

The organic EL display device **50***d* with the above-described configuration, as in the case of the organic EL display device **50***a* of the first embodiment, is configured to display images by making the light-emitting layers **3** of the organic EL layers **20** in each of the subpixels P emit light appropriately.

The organic EL display device **50***d* of the present embodiment can be manufactured by a modified version of the manufacturing method described earlier in the first embodiment. In the present embodiment, the pattern shape used in the formation of the second electrode **21***a* and sealing film **22***a* is modified to form the second electrode **21***d* and the sealing film **22***d*. Note that according to the method of manufacturing the organic EL display device **50***d* in the present embodiment, the second electrodes **21***d* and the sealing films **22***d* are separately formed. It is, however, allowed to manufacture an organic EL display device **50***e* by forming the second electrodes **21***e* and sealing films **22***e* simultaneously (see FIG. **20**). Specifically, as in the case of the manufacturing method described earlier in the second embodiment, a conductive film that is to be the second electrodes **21***e* and an inorganic film that is to be the sealing films **22***e* are formed on the entire substrate where organic EL layers **20**. Then, the conductive film and the inorganic film are etched by use of buffered hydrofluoric acid and thus are patterned to form second electrodes **21***e* and sealing films **22***e*. Note that not only the second electrodes **21***e* and the sealing films **22***e* but also the organic EL layers **20** may be formed by performing an etching process using the buffered hydrofluoric acid. Then, the perimeter edge surface of each of the plurality of organic EL layers **20** and the perimeter edge surface of the corresponding one of the sealing films **22***e* that have been divided into the plurality units may be laid one upon the other.

In addition, for example, as illustrated in FIG. **21**A and FIG. **21**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***e* includes a first sealing layer **22***e***1** that is layered on the second electrode **21***a,* and also includes a foreign-matter contact portion **22***er* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***e* is being manufactured, at least one foreign matter R exists in at least any one position on the second electrode **21***a* (on the organic EL element **8**) in the organic EL display device **50***e* as illustrated in FIG. **21**A. In this case, one foreign-matter contact portion **22***er* is formed in the sealing film **22***e* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **21**A, the foreign-matter contact portion **22***er* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***e,* the foreign-matter contact portion **22***er* and the first sealing layer **22***e***1** wrap up the foreign matter R. Note that the first sealing layer **22***e***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***e***1** is formed of an inorganic film, but that the first sealing layer **22***e***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***er* includes one of the above-mentioned organic films.

The organic EL display devices **50***d* and **50***e* of the present embodiment described above can have the above-described effects (1) and (2).

Now, a detail description will be given below about the item (1). In each of the sealing films **22***d* and **22***e*, the grooves C are formed in a lattice pattern, extending between every two adjacent ones of the plurality of subpixels P. Hence, each of the organic EL display devices **50***d* and **50***e* has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where each of the organic EL display devices **50***d* and **50***e* is bent around a bent axis that is parallel to the gate lines **12***a* or the data lines **15***a,* in each of the organic EL display devices **50***d* and **50***e,* a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as each of the sealing films **22***d* and **22***e* has a smaller strain, the generation of cracks in each of the sealing films **22***d* and **22***e* can be suppressed. Accordingly, when each of the organic EL display devices **50***d* and **50***e* is bent, the generation of cracks in each of the sealing films **22***d* and **22***e* is suppressed. In addition, as the generation of cracks in each of the sealing films **22***d* and **22***e* can be suppressed, each of the sealing films **22***d* and **22***e* has an improved sealing performance, and thus the organic EL display devices **50***d* and **50***e* become more reliable.

(2) In addition, the foreign-matter contact portion **22***dr* and **22***er* each of which contacts the foreign matter R existing on the organic EL element **8** are formed respectively in the sealing films **22***d* and **22***e*. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing films **22***d* and **22***e* can be suppressed, and thus the organic EL display devices **50***d* and **50***e* become more reliable. In addition, each of the foreign-matter contact portions **22***dr* and **22***er* is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, each of the foreign-matter contact portions **22***dr* and **22***er* can suppress the stress from the foreign matter R to the organic EL element **8** side when each of the organic EL display device **50***d* and **50***e* is bent. In addition, the existence of each of the foreign-matter contact portions **22***dr* and **22***er* in the corresponding one of the sealing films **22***d* and **22***e* allows the first sealing layer **22***d***1** and thus the sealing film **22***d* as well as the first sealing layer **22***e***1** and thus the sealing film **22***e* to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

Fifth Embodiment

FIG. **22** to FIG. **26**B illustrate the fifth embodiment of an organic EL display device according to the disclosure. FIG. **22** is a plan view illustrating an arrangement structure of sealing films **22***f* in an organic EL display device **50***f* according to the present embodiment. FIG. **23** is a cross-sectional view illustrating the organic EL display device **50***f,* and is a diagram corresponding to FIG. **4**. FIG. **24**A is an enlarged view of a portion A3 illustrated in FIG. **23** of a case where a foreign matter exists in the portion A3. FIG. **24**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **24**A. FIG. **25** is a cross-sectional view illustrating an organic EL display device **50***g* according to a modified example of the organic EL display device **50***f,* and is a diagram corresponding to FIG. **4**. FIG. **26**A is an enlarged view of a portion A4 illustrated in FIG. **25** of a case where a foreign matter exists in the portion A4. FIG. **26**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **26**A.

The description in the fourth embodiment is based on a case of the organic EL display device **50***d* where one of the sealing films **22***d* is formed for the corresponding one of all the subpixels P. The description in the present embodiment is based on a case of the organic EL display device **50***f* where each of the sealing films **22***f* is formed for the corresponding three subpixels P that are adjacent to one another. Note that the description of the present embodiment is based on a case of the organic EL display device **50***f* where three subpixels P that are adjacent to one another together form a single pixel and where each sealing film **22***f* is formed for the corresponding one of the pixels thus formed. In an alternative configuration, a single pixel is formed by two subpixels P or more than three subpixels P that are adjacent to each other, and a sealing film is formed for each of the pixels thus formed.

As illustrated in FIG. **23**, the organic EL display device **50***f* includes: a base substrate **10**; a plurality of organic EL elements **8***f;* the plurality of sealing films **22***f;* an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8***f* is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22***f* is formed on the corresponding one of the organic EL elements **8**. The function layer **40** is formed over the plurality of sealing films **22***f* with the adhesive layer **30** provided in between.

As illustrated in FIG. **23**, the organic EL element **8***f* includes: a plurality of first electrodes **18**, a plurality of edge covers **19**, a plurality of organic EL layers **20**, and a plurality of second electrodes **21***f*. All of these components are formed in this order one upon another on and over the interlayer insulating films **17**. Note that the plurality of second electrodes **21***f* are formed extending in parallel to one another in the vertical direction in FIG. **22**. In addition, each of the second electrodes **21***f* has an elongated rectangular shape in a plan view and thus is laid over the organic EL layers **20** of all the subpixels that are arranged in three vertical lines in FIG. **22** that are adjacent in horizontal direction in FIG. **22** to one another. Note that as illustrated in FIG. **23**, each of the second electrodes **21***f* covers the end faces of the organic EL layers **20** of the subpixels P arranged in the inner-side one of the three adjacent lines of the subpixels P. In addition, in the non-display region, the second electrodes **21***f* are connected to a common wiring line via contact holes formed in a layered film of the gate insulating film **13** and the passivation film **16**. The common wiring line is made of the same material as the material of the gate lines **12***a* and is formed in the same layer where the gate lines **12***a* are formed. Note that the second electrode **21***f* functions to inject electrons into the organic EL layer **20**, and is made from the same material as the material for the second electrode **21***a* described in the first embodiment.

As illustrated in FIG. **22**, the plurality of sealing films **22***f* are formed extending in parallel to one another in the vertical direction in FIG. **22**. In addition, as illustrated in FIG. **22** and FIG. **23**, each of the sealing films **22***f* has an elongated rectangular shape in a plan view and thus covers the second electrodes **21***f* and the end faces of the organic EL layers **20** exposed from the second electrodes **21***f*. In addition, as illustrated in FIGS. **22** and **23**, in the plurality of sealing films **22***f*, the grooves C arranged in a lattice pattern are formed extending in both vertical and horizontal directions in FIG. **22**. Each of the grooves C extends between the corresponding two subpixels P. In addition, the sealing films **22***f* have a function to protect the organic EL layers **20** from moisture and oxygen.

In addition, for example, as illustrated in FIG. **24**A and FIG. **24**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***f* includes a first sealing layer **22***f***1** that is layered on the second electrode **21***a*, and also includes a foreign-matter contact portion **22***fr* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***f* is being manufactured, at least one foreign matter R exists in at least any one position on the second electrode **21***a* (on the organic EL element **8**) in the organic EL display device **50***f* as illustrated in FIG. **24**A. In this case, one foreign-matter contact portion **22***fr* is formed in the sealing film **22***f* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **24**A, the foreign-matter contact portion **22***fr* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***f*, the foreign-matter contact portion **22***fr* and the first sealing layer **22***f***1** wrap up the foreign matter R. Note that the first sealing layer **22***f***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***f***1** is formed of an inorganic film, but that the first sealing layer **22***f***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***fr* includes one of the above-mentioned organic films.

The organic EL display device **50***f* with the above-described configuration, as in the case of the organic EL display device **50***a* of the first embodiment, is configured to display images by making the light-emitting layers **3** of the organic EL layers **20** in each of the subpixels P emit light appropriately.

The organic EL display device **50***f* of the present embodiment can be manufactured by a modified version of the manufacturing method described earlier in the first embodiment. In the present embodiment, the pattern shape used in the formation of the second electrode **21***a* and sealing film **22***a* is modified to form the second electrode **21***f* and the sealing film **22***f*.

Note that the description in the present embodiment is based on a case of the organic EL display device **50***f* including the interlayer insulating films **17** and the edge covers **19**, both of which are separated for each one of the subpixels P adjacent to one another in the direction in which the gate lines **12***a* extend. An alternative organic EL display device **50***g* may include edge covers **19***g* which are separated for each three subpixels adjacent to one another in the direction in which the gate lines **12***a* extend.

Specifically, as illustrated in FIG. **25**, the organic EL display device **50***g* includes: a base substrate **10**; a plurality of organic EL elements **8***g*; the plurality of sealing films **22***g*; an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8***g* is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22***g* is formed on the corresponding one of the organic EL elements **8***g*. The function layer **40** is formed over the plurality of sealing films **22***g* with the adhesive layer **30** provided in between.

As illustrated in FIG. **25**, the organic EL element **8***g* includes: a plurality of first electrodes **18**, a plurality of edge covers **19***g*, a plurality of organic EL layers **20***g*, and a plurality of second electrodes **21***g*. All of these components are formed in this order one upon another on and over the interlayer insulating films **17***g*.

As illustrated in FIG. **25**, the plurality of interlayer insulating film **17***g* are formed on the passivation film **16**, and extend in parallel to one another in, for example, the vertical direction in FIG. **22**. In addition, each of the interlayer insulating films **17***g* has an elongated rectangular shape in a plan view, and thus is laid over all the subpixels P that are arranged in vertical three lines that are adjacent, in the horizontal direction in FIG. **22**, to one another, for example. The interlayer insulating film **17***g* includes, for example, a transparent organic resin material, such as an acrylic resin.

The plurality of edge covers **19***g* are formed, for example, extending in parallel to one another in the vertical direction in FIG. **22**. In addition, as illustrated in FIG. **25**, the edge covers **19***g* are arranged in a lattice pattern with n rows and 3 columns (where n is the number of the gate lines **12***a*), for example, and thus cover the edge portions of the first electrodes **18** of all the subpixels P that are arranged in vertical three lines that are adjacent, in the horizontal direction in FIG. **22**, to one another. Note that each of the edge covers **19***g* may be, for example, an inorganic film or an organic film. Examples of materials that may be included in the inorganic film include silicon oxide (SiO_2), silicon nitride (SiNx (x is a positive number)) such as trisilicon tetranitride (Si_3N_4), and silicon oxynitride (SiNO). Examples of materials that may be included in the organic film include (photosensitive) polyimide resins, (photosensitive) acrylic resins, (photosensitive) polysiloxane resins, and novolak resins.

The plurality of organic EL layers **20***g* are included respectively in the individual subpixels P. The organic EL layers **20***g* are arranged in a matrix shape on the first electrodes **18** and the edge covers **19***g*. In addition, in each of the subpixels P, the organic EL layer **20***g* covers the first electrode **18** exposed from the edge covers **19***g*. As in the case of the organic EL layer **20** described earlier in the first embodiment, each of the organic EL layers **20***g* includes a hole injecting layer **1**, a hole transport layer **2**, a light-emitting layer **3**, an electron transport layer **4**, and an electron injecting layer **5**, which are arranged in the order stated over the first electrode **18**.

The plurality of second electrodes **21***g* are formed extending in parallel to one another in the vertical direction in FIG. **22**, for example. In addition, each of the second electrodes **21***g* has an elongated rectangular shape in a plan view and thus is laid over the organic EL layers **20***g* of all the subpixels that are arranged in three vertical lines in FIG. **22** that are adjacent in horizontal direction in FIG. **22** to one another, for example. Note that as illustrated in FIG. **25**, each of the second electrodes **21***g* covers the end faces of the organic EL layers **20***g* of the subpixels P arranged in the inner-side one of the three adjacent lines of the subpixels P. In addition, in the non-display region, the second electrodes **21***g* are connected to a common wiring line via contact holes formed in a layered film of the gate insulating film **13** and the passivation film **16**. The common wiring line is made of the same material as the material of the gate lines **12***a* and is formed in the same layer where the gate lines **12***a* are formed. Note that the second electrode **21***g* functions to inject electrons into the organic EL layer **20***g*, and is made from the same material as the material for the second electrode **21***a* described in the first embodiment.

The plurality of sealing film **22***g* are formed extending in parallel to one another in the vertical direction in FIG. **22**, for example. In addition, as illustrated in FIG. **22** and FIG. **25**, each of the sealing films **22***g* has an elongated rectangular shape in a plan view and thus covers the second electrodes **21***g* and the end faces of the organic EL layers **20***g* exposed from the second electrodes **21***g*. In addition, as in the case of the sealing films **22***f,* in the plurality of sealing films **22***g,* the grooves C arranged in a lattice pattern are formed extending in both vertical and horizontal directions in FIG. **22**. Each of the grooves C extends between the corresponding two subpixels P. In addition, the sealing films **22***g* have a function to protect the organic EL layers **20***g* from moisture and oxygen.

In addition, for example, as illustrated in FIG. **26**A and FIG. **26**B, in a case where a foreign matter R exists on the second electrode **21***a* (on the organic EL element **8**), the sealing film **22***g* includes a first sealing layer **22***g***1** that is layered on the second electrode **21***a,* and also includes a foreign-matter contact portion **22***gr* that is configured to contact the foreign matter R. To put it differently, suppose a case where while an organic EL display device **50***g* is being manufactured, at least one foreign matter R exists in at least any one position on the second electrode **21***a* (on the organic EL element **8**) in the organic EL display device **50***g* as illustrated in FIG. **26**A. In this case, one foreign-matter contact portion **22***gr* is formed in the sealing film **22***g* for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **26**A, the foreign-matter contact portion **22***gr* is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22***g,* the foreign-matter contact portion **22***gr* and the first sealing layer **22***g***1** wrap up the foreign matter R. Note that the first sealing layer **22***g***1** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where the first sealing layer **22***g***1** is formed of an inorganic film, but that the first sealing layer **22***g***1** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22***gr* includes one of the above-mentioned organic films.

The organic EL display devices **50***f* and **50***g* of the present embodiment described above can have the above-described effects (1) and (2).

Now, a detail description will be given below about the item (1). In each of the sealing films **22***f* and **22***g,* the grooves C are formed in a lattice pattern, extending between every two adjacent ones of the plurality of subpixels P. Hence, each of the organic EL display devices **50***f* and **50***g* has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where each of the organic EL display devices **50***f* and **50***g* is bent around a bent axis that is parallel to the gate lines **12***a* or the data lines **15***a,* in each of the organic EL display devices **50***f* and **50***g,* a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as each of the sealing films **22***f* and **22***g* has a smaller strain, the generation of cracks in each of the sealing films **22***f* and **22***g* can be suppressed. Accordingly, when each of the organic EL display devices **50***f* and **50***g* is bent, the generation of cracks in each of the sealing films **22***f* and **22***g* is suppressed. In addition, as the generation of cracks in each of the sealing films **22***f* and **22***g* can be suppressed, each of the sealing films **22***f* and **22***g* has an improved sealing performance, and thus the organic EL display devices **50***f* and **50***g* become more reliable.

(2) In addition, the foreign-matter contact portion **22***fr* and **22***gr* each of which contacts the foreign matter R existing on the organic EL element **8** are formed respectively in the sealing films **22***f* and **22***g*. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing films **22***f* and **22***g* can be suppressed, and thus the organic EL display devices **50***f* and **50***g* become more reliable. In addition, each of the foreign-matter contact portions **22***fr* and **22***gr* is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, each of the foreign-matter contact portions **22***fr* and **22***gr* can suppress the stress from the foreign matter R to the organic EL element **8** side when each of the organic EL display device **50***f* and **50***g* is bent. In addition, the

existence of each of the foreign-matter contact portions **22*fr*** and **22*gr*** in the corresponding one of the sealing films **22*f*** and **22*g*** allows the first sealing layer **22*f*1** and thus the sealing film **22*f*** as well as the first sealing layer **22*g*1** and thus the sealing film **22*g*** to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

Sixth Embodiment

FIG. **27** to FIG. **28**B illustrate the sixth embodiment of an organic EL display device according to the disclosure. FIG. **27** is a cross-sectional view illustrating an organic EL display device **50*h*** according to the sixth embodiment of the disclosure, and is a diagram corresponding to FIG. **4**. FIG. **28**A is an enlarged view of a portion **A5** illustrated in FIG. **27** of a case where a foreign matter exists in the portion A**5**. FIG. **28**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **28**A.

The description of the first embodiment is based on the organic EL display device **50*a*** including the sealing film **22*a*** including: the foreign-matter contact layer **22*ar*0** formed first; and the first sealing layer **22*a*1** formed after that. The description of the present embodiment is based on a case of the organic EL display device **50*h*** including a sealing film **22*h*** including: a first sealing layer **22*h*1** formed first; a foreign-matter contact layer **22*hr*0** formed secondly; and a second sealing layer **22*h*2** formed after that.

As illustrated in FIG. **27**, the organic EL display device **50*h*** includes: a base substrate **10**; a plurality of organic EL elements **8**; the plurality of sealing films **22*h*;** an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22*h*** is formed on the corresponding one of the organic EL elements **8**. The function layer **40** is formed over the plurality of sealing films **22*h*** with the adhesive layer **30** provided in between.

As in the cases of each of the embodiments described so far, each of the organic EL elements **8** included in the organic EL display device **50*h*** has end portions each of which has a certain taper angle with respect to the base substrate **10**. The certain taper angle is not larger than a predetermined angle (the details of this taper angle will be described later).

As in the case of the sealing films **22*a*** in the first embodiment, the plurality of sealing films **22*h*** are formed extending in parallel to one another. In addition, as illustrated in FIG. **27**, each of the sealing films **22*h*** has an elongated rectangular shape in a plan view. Each of the sealing films **22*h*** is formed on the second electrode **21*a*** and thus is laid over the second electrode **21*a*.** In addition, as illustrated in FIG. **27**, in the plurality of sealing films **22*h*,** grooves C extending between every two mutually adjacent subpixels P are formed.

In addition, for example, as illustrated in FIG. **28**A and FIG. **28**B, in a case where a foreign matter R exists on the second electrode **21*a*** (on the organic EL element **8**), each of the sealing films **22*h*** includes: a first sealing layer **22*h*1** that is layered on both the second electrode **21*a*** and the foreign matter R; a foreign-matter contact portion **22*hr*** that is configured to contact the foreign matter R; and a second sealing layer **22*h*2** that is layered on both the first sealing layer **22*h*1** and the foreign-matter contact layer **22*hr*.** To put it differently, suppose a case where while an organic EL display device **50*h*** is being manufactured, at least one foreign matter R exists in at least any one position on the organic EL element **8** in the organic EL display device **50*h*** as illustrated in the enclosure A**5** in FIG. **27**. In this case, one foreign-matter contact portion **22*hr*** is formed in the sealing film **22*h*** for each place where a foreign matter R exists. In addition, the foreign-matter contact portion **22*hr*** has a larger taper angle than 90° with respect to the base substrate **10** as will be described in detail later.

In addition, as illustrated in FIG. **28**A, the foreign-matter contact portion **22*hr*** is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22*h*,** the foreign-matter contact portion **22*hr*,** the first sealing layer **22*h*1**, and second sealing layer **22*h*2** wrap up the foreign matter R. Note that each of the first sealing layer **22*h*1** and the second sealing layer **22*h*2** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where each of the first sealing layer **22*h*1** and the second sealing layer **22*h*2** is formed of an inorganic film, but that each of the first sealing layer **22*h*1** and the second sealing layer **22*h*2** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22*hr*** includes one of the above-mentioned organic films.

With reference to FIG. **29** and FIGS. **30**A to **30**F, a description will be given below about a specific method of forming the sealing films **22*h*** of a case where a foreign matter R exists on the organic EL element **8**. FIG. **29** is a flowchart describing steps of manufacturing main portions of the organic EL display device **50*h*** according to the sixth embodiment of the disclosure. FIGS. **30**A to **30**F are diagrams describing a series of main steps of manufacturing the main portions of the organic EL display device **50*h*** according to the sixth embodiment of the disclosure. Note that the following description is based on a case where the foreign-matter contact portions **22*hr*** are formed by use of an organic film whereas the first sealing layers **22*h*1** and the second sealing layer **22*h*2** are formed by use of an inorganic film.

As illustrated in Step **S11** of FIG. **29**, a process of forming the first sealing layer **22*h*1** as an inorganic film is performed as the first one of all the components in the sealing film **22*h*.** For example, this formation process is performed by a well-known CVD method using, for example, an open mask or an FMM mask. Thus, the first sealing layer **22*h*1** is formed on the organic EL element **8**. Note that as illustrated in FIG. **30**A, in a case where a foreign matter R exists on the organic EL element **8**, the first sealing layer **22*h*1** is formed on the organic EL element **8** with a gap left between itself and the foreign matter R, and is also formed on the foreign matter R, as illustrated in FIG. **30**B.

In addition, as described earlier, in the organic EL element **8**, with respect to the base substrate **10** (FIG. **27**), the taper angle (denoted by "$\alpha 2$" in FIGS. **30**A to **30**F) of each end portion of the organic EL element **8** is set to an angle that is equal to or smaller than a predetermined angle (e.g., 30°). To put it differently, in the organic EL element **8**, the organic EL layer **20** and the second electrode **21*a*** are formed with end faces of the organic EL layer **20** and the second electrode **21*a*** having angles with respect to the base substrate **10** that are equal to or smaller than the predetermined angle in FIG. **27**, for example. Hence, in the present embodiment, the organic EL element **8** is prevented from being degraded by moisture (details of which will be described later).

Then, as illustrated in Step S12 of FIG. **29**, the foreign-matter contact layer made of an organic film is formed to cover the organic EL elements **8** and the first sealing layer **22*h*1** by a well-known method. Specifically, as illustrated in FIG. **30**C, the foreign-matter contact layer **22*hr*0** covers the first sealing layer **22*h*1**, and fills the gap left between the foreign matter R and the first sealing layer **22*h*1** on the organic EL element **8**. Specifically, for example, a liquid organic material for the organic film is processed by a vapor deposition method to form the foreign-matter contact layer **22*hr*0** on the foreign matter R, the organic EL element **8**, and the first sealing layer **22*h*1**. Then, the foreign-matter contact layer **22*hr*0** is subjected, for example, to a UV irradiation process, and thus the foreign-matter contact layer **22*hr*0** is hardened on the foreign matter R, the organic EL element **8**, and the first sealing layer **22*h*1**. In addition, the foreign-matter contact portion **22*hr*** is formed on the organic EL element **8** with the taper angle (denoted by "β2" in FIGS. **30**D to **30**F) of the foreign-matter contact portion **22*hr*** with respect to the base substrate **10** being larger than 90°, for example.

Then, as illustrated in Step S13 of FIG. **29**, by performing a known ashing process on the foreign-matter contact layer **22*hr*0**, the foreign-matter contact portion **22*hr*** is formed on the organic EL element **8**. To put it differently, as a portion of the foreign-matter contact layer **22*hr*0** has not been removed due to the existence of the foreign matter R, that portion is formed as the foreign-matter contact portion **22*hr*** by performing the ashing process as illustrated in FIG. **30**D. To put it differently, the foreign-matter contact portion **22*hr*** is formed by allowing some portions of the foreign-matter contact layer **22*hr*0** located around the foreign matter R and filling the gap to be left not removed (see also FIG. **28**B). In addition, in a case of no foreign matter R existing on the organic EL element **8**, the first sealing layer **22*h*1** is formed to cover the entire surfaces of the organic EL element **8** without any such gaps as described above. The foreign-matter contact layer **22*hr*0** is completely removed by the ashing process, and thus no foreign-matter contact portion **22*hr*** is formed in the sealing film **22*h***.

Then, a process of forming the second sealing layer **22*h*2** is performed as illustrated in Step S14 of FIG. **29**. This formation process is performed by a well-known CVD method using, for example, an open mask or an FMM mask. Thus, as illustrated in FIG. **30**E, the second sealing layer **22*h*2** is formed to cover the first sealing layer **22*h*1** and the foreign-matter contact portion **22*hr***. Then, by performing a well-known etching process, the sealing films **22*h*** for individual subpixels P are formed as illustrated in FIG. **30**F.

Comparative Example 2 where the taper angle α**2** is larger than the predetermined angle has some problems, which are described specifically below with reference to FIGS. **31**A to **31**D. FIGS. **31**A to **31**D are diagrams describing a series of main steps of manufacturing main portions of an organic EL display device according to Comparative Example 2. Note that the following description is based on a case where the organic EL display device of Comparative Example 2 has a 90-degree taper angle α**2** of each end portion of the organic EL element **8** with respect to the base substrate **10**.

In the organic EL display device of Comparative Example 2, finishing the process in Step S12 leaves the foreign-matter contact layer **22*hr*0** formed on the organic EL element **8** and the first sealing layer **22*h*1** as illustrated in FIG. **31**A. Then, the ashing in Step S**13** leaves unremoved, as remaining portions **22*hr*1**, part of the organic film of the foreign-matter contact layer **22*hr*0** located in the end portions of the organic EL element **8** as illustrated in FIG. **31**B. These remaining portions **22*hr*1** are the result of the taper angle α**2** that is larger than the predetermined angle (e.g., 30°).

Then, finishing the process in Step S**14**, as illustrated in FIG. **31**C, the second sealing layer **22*h*2** is formed on the first sealing layer **22*h*1**, the foreign-matter contact portion **22*hr*** and the remaining portions **22*hr*1**. Then, in a case where the sealing films are formed for individual subpixels P by a well-known etching process, the remaining portions **22*hr*1** may not be etched but exposed as illustrated in FIG. **31**D. In a case where the remaining portions **22*hr*1** are exposed as described above, the remaining portions **22*hr*1** may absorb moisture through the adhesive layer **30**, and the like. As a consequence, in Comparative Example 2, in a case where a foreign matter R exists near the remaining portion **22*hr*1**, the moisture having been absorbed in remaining portions **22*hr*1** may permeate the organic EL element **8** through the remaining portions **22*hr*1** and the remaining portion **22*hr*1**. The moisture may degrade the organic EL element **8**.

In contrast, in the organic EL display device **50*h*** of the present embodiment, each end portion of the organic EL element **8** has a taper angle α**2** that is equal to or smaller than the predetermined angle. Hence, finishing the ashing process leaves no remaining portions **22*hr*1** in the end portions of the organic EL element **8**, and thus the foreign-matter contact layer **22*hr*0** other than the foreign-matter contact portion **22*hr*** can be removed by the ashing process. As a consequence, in the present embodiment, even in the case where a foreign matter R exists, consequences that are different from the consequences in Comparative Example 2 are produced. Specifically, the moisture is prevented from permeating the organic EL element **8** and the degradation of organic EL element **8** is prevented from being caused by the permeation of moisture. To put it differently, in the present embodiment, each end portion of the organic EL element **8** is formed to have the taper angle α**2** that leaves no remaining portions **22*hr*1** in the end portions of the organic EL element **8** after the ashing process on the foreign-matter contact layer **22*hr*0**.

The organic EL display device **50*h*** of the present embodiment described above can have the following effect (4), in addition to the above-described effects (1) and (2).

Now, a detail description will be given below about the item (1). In the sealing film **22*h***, the grooves C are formed between every two adjacent ones of the plurality of subpixels P. Hence, the organic EL display device **50*h*** has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where the organic EL display device **50*h*** is bent around a bent axis that is parallel to the gate lines **12*a***, in the organic EL display device **50*h***, a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as the sealing film **22*h*** has a smaller strain, the generation of cracks in the sealing film **22*h*** can be suppressed. Accordingly, when the organic EL display device **50*h*** is bent, the generation of cracks in the sealing film **22*h*** is suppressed. In addition, as the generation of cracks in the sealing film **22*h*** can be suppressed, the sealing film **22*h*** has an improved sealing performance, and thus the organic EL display device **50*h*** becomes more reliable.

(2) In addition, the foreign-matter contact portion **22*hr*** that contacts the foreign matter R existing on the organic EL element **8** is formed in the sealing film **22*h***. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing film **22*h*** can be suppressed, and thus the organic EL display device **50*h*** becomes more reliable. In addition, the foreign-matter contact portion **22*hr*** is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. Hence, the foreign-matter contact portion **22*hr*** can suppress the stress from the foreign matter R to the organic EL element **8** side when the organic EL display device **50*h*** is bent. In addition, the existence of the foreign-matter contact portion **22*hr*** in the sealing film **22*h*** allows the second sealing layer **22*h*2** and thus the sealing film **22*h*** to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

(4) The sealing film **22*h*** includes: the first sealing layer **22*h*1** that is formed before the foreign-matter contact layer **22*hr*0**; and the second sealing layer **22*h*2** that is formed after the foreign-matter contact layer **22*hr*0**. Hence, the sealing performance of the sealing film **22*h*** can be enhanced easily. In addition, the first sealing layer **22*h*1** is formed before the foreign-matter contact layer **22*hr*0** is formed, and an ashing process is performed after the formation of the foreign-matter contact layer **22*hr*0**. Hence, the damages that would otherwise be given to the organic EL element **8** by the ashing process can be reduced significantly.

Seventh Embodiment

FIG. **32** to FIG. **33**B illustrate the seventh embodiment of an organic EL display device according to the disclosure. FIG. **32** is a cross-sectional view illustrating an organic EL display device **50*i*** according to the seventh embodiment of the disclosure, and is a diagram corresponding to FIG. **4**. FIG. **33**A is an enlarged view of a portion A6 illustrated in FIG. **32** of a case where a foreign matter exists in the portion A**6**. FIG. **33**B is a plan view illustrating the foreign matter and the foreign-matter contact portion illustrated in FIG. **33**A.

The description of the sixth embodiment is based on the organic EL display device **50*h*** where the end faces of the organic EL layer **20** are covered by the sealing film **22*h*** whereas the description of the present embodiment is based on the organic EL display device **50*i*** where the end faces of the organic EL layer **20** are covered by the inorganic barrier film **23**.

As illustrated in FIG. **32**, the organic EL display device **50*i*** includes: a base substrate **10**; a plurality of organic EL elements **8**; a plurality of sealing films **22*i*;** an inorganic barrier film **23**; an adhesive layer **30**; and a function layer **40**. Each of the organic EL elements **8** is formed over the base substrate **10**, and in between are structures from a moisture-proof film **11** to interlayer insulating films **17**. Each of the plurality of sealing films **22*i*** is formed on the corresponding one of the organic EL elements **8**. The inorganic barrier film **23** covers the individual sealing films **22*i***. The function layer **40** is formed over inorganic barrier film **23** with the adhesive layer **30** provided in between.

In addition, for example, as illustrated in FIG. **33**A and FIG. **33**B, in a case where a foreign matter R exists on the second electrode **21*a*** (on the organic EL element **8**), each of the sealing films **22*i*** includes: a first sealing layer **22*i*1** that is layered on both the second electrode **21*a*** and the foreign matter R; a foreign-matter contact portion **22*ir*** that is configured to contact the foreign matter R; and a second sealing layer **22*i*2** that is layered on both the first sealing layer **22*i*1** and the foreign-matter contact layer **22*ir*.** To put it differently, suppose a case where while an organic EL display device **50*i*** is being manufactured, at least one foreign matter R exists in at least any one position on the organic EL element **8** in the organic EL display device **50*i*** as illustrated in the enclosure A**6** in FIG. **31**. In this case, one foreign-matter contact portion **22*ir*** is formed in the sealing film **22*i*** for each place where a foreign matter R exists.

In addition, as illustrated in FIG. **33**A, the foreign-matter contact portion **22*ir*** is configured to surround the foreign matter R and to contact at least a surface portion Rt of the foreign matter R located on the organic EL element **8** side of the foreign matter R. In addition, in the sealing film **22*i*,** the foreign-matter contact portion **22*ir*,** the first sealing layer **22*i*1**, and second sealing layer **22*i*2** wrap up the foreign matter R. Note that each of the first sealing layer **22*i*1** and the second sealing layer **22*i*2** is formed, for example, of a single layer film or a layered film of inorganic materials such as a silicon oxide film, a silicon nitride film, and a silicon oxynitride film. Note that the present embodiment is based on a case where each of the first sealing layer **22*i*1** and the second sealing layer **22*i*2** is formed of an inorganic film, but that each of the first sealing layer **22*i*1** and the second sealing layer **22*i*2** may be a layered film including not only one or more of the above-mentioned inorganic films and an organic film that is layered on the inorganic film. The organic film may be formed from acrylate, polyurea, parylene, polyimide, polyamide, or the like. In addition, the foreign-matter contact portion **22*ir*** includes one of the above-mentioned organic films.

The organic EL display device **50*i*** of the present embodiment described above can have the above-described effects (1), (2), (3), and (4).

Now, a detail description will be given below about the item (1). In the sealing film **22*i*,** the grooves C are formed between every two adjacent ones of the plurality of subpixels P. Hence, the organic EL display device **50*i*** has a smaller rigidity at portions between two adjacent ones of the plurality of subpixels P where the grooves C are formed. Hence, in a case where the organic EL display device **50*i*** is bent around a bent axis that is parallel to the gate lines **12*a*,** in the organic EL display device **50*i*,** a larger bending strain is generated in the outer portions of the subpixel P where the grooves C are formed whereas a smaller bending strain is generated in the inner portions of the subpixel P where no grooves C are formed. Hence, as the sealing film **22*i*** has a smaller strain, the generation of cracks in the sealing film **22*i*** can be suppressed. Accordingly, when the organic EL display device **50*i*** is bent, the generation of cracks in the sealing film **22*i*** is suppressed. In addition, as the generation of cracks in the sealing film **22*i*** can be suppressed, the sealing film **22*i*** has an improved sealing performance, and thus the organic EL display device **50*i*** becomes more reliable.

(2) In addition, the foreign-matter contact portion **22*ir*** that contacts the foreign matter R existing on the organic EL element **8** is formed in the sealing film **22*i***. Hence, even in the case where a foreign matter R exists on the organic EL element **8**, the generation of cracks in the sealing film **22*i*** can be suppressed, and thus the organic EL display device **50*i*** becomes more reliable. In addition, the foreign-matter contact portion **22*ir*** is formed to contact at least the surface portion Rt of the foreign matter R located on the organic EL

element **8** side of the foreign matter R. Hence, the foreign-matter contact portion **22***ir* can suppress the stress from the foreign matter R to the organic EL element **8** side when the organic EL display device **50***i* is bent. In addition, the existence of the foreign-matter contact portion **22***ir* in the sealing film **22***i* allows the first sealing layer **22***i***1** and thus the sealing film **22***i* to be formed without causing faults. Hence, even in the case where a foreign matter R exists, the sealing performance for the organic EL element **8** can be prevented from being impaired, and thus the organic EL element **8** can be more reliable.

(3) Even in a case where the perimeter edge surface of each organic EL layer **20** and at least a part of the perimeter edge surface of the sealing film **22***i* overlap each other, the inorganic barrier film **23** covering each of the sealing films **22***i* can prevent the organic EL element **8** from being degraded. In addition, the inorganic barrier film **23** is thinner than and has a better coatability than the sealing film **22***i*. Hence, the sealing ability can be prevented from being impaired while the flexibility of the organic EL display device **50***i* can be improved. In addition, even in a case where the remaining portion is formed in an end portion of the organic EL element **8**, the remaining portion is covered by the inorganic barrier film **23**. Hence, the sealing film **22***i* of the present embodiment can prevent cracks from being caused by the remaining portion. This effect is not obtainable from the sixth embodiment.

(4) The sealing film **22***i* includes: the first sealing layer **22***i***1** that is formed before the foreign-matter contact layer to form the foreign-matter contact portion **22***ir*; and the second sealing layer **22***i***2** that is formed after the foreign-matter contact layer. Hence, the sealing performance of the sealing film **22***i* can be enhanced easily. In addition, the first sealing layer **22***i***1** is formed before the foreign-matter contact layer is formed, and an ashing process is performed after the formation of the foreign-matter contact layer **22**. Hence, the damages that would otherwise be given to the organic EL element **8** by the ashing process can be reduced significantly.

Other Embodiments

The descriptions of the embodiments provided so far are based on cases of organic EL display devices each of which includes a sealing film with grooves formed though the sealing film in the thickness direction. The disclosure may be applied to an organic EL display device including a sealing film with grooves formed in the sealing film but not therethrough in the thickness direction.

In addition, the description in each of the embodiments is based on a case of an organic EL display device where the sealing films are patterned by removing some portions of the inorganic film that is to be the sealing films and the portions to be removed are located between the subpixels. In addition, the flexibility of the organic EL display device may be enhanced by patterning not only the sealing films but also the moisture-proof films and the gate insulating films. To this end some portions of the inorganic film that is to be the moisture-proof films and some portions of the inorganic film that is to be the gate insulating films may be removed, and the portions to be removed are located between the subpixels.

In the embodiments described above, the example of the organic EL layer including the five-layer structure including the hole injecting layer, the hole transport layer, the light-emitting layer, the electron transport layer, and the electron injecting layer is given. It is also possible that, for example, the organic EL layer may include a three-layer structure including a hole injection-cum-transport layer, a light-emitting layer, and an electron transport-cum-injection layer.

In the embodiments described above, the example of the organic EL display devices include the first electrode as an anode and the second electrode as a cathode. However, the disclosure is also applicable to an organic EL display device, in which the layers of the structure of the organic EL layer are in the reverse order, with the first electrode being a cathode and the second electrode being an anode.

In the embodiments described above, the example of the organic EL display devices include the element substrate in which, the electrode of the TFT connected to the first electrode is the drain electrode. However, the disclosure is also applicable to an organic EL display device including an element substrate, in which the electrode of the TFT connected to the first electrode is referred to as the source electrode.

In addition, the description provided so far is based on a case where the disclosure is applied to an organic EL display device as an exemplar flexible display device. The disclosure is not limited to such a display device, and is applicable to any display device including a display element that is flexible and bendable. There are display elements of different types: display elements configured to control the brightness and/or transmittance by use of the electric current; and display elements configured to control the brightness and/or transmittance by use of the voltage. Some exemplar current-control display elements include: EL display devices such as organic EL (Electro Luminescence) display devices including Organic Light Emitting Diodes (OLEDs) and inorganic EL display devices including inorganic light emitting diodes; and Quantum dot Light Emitting Diode (QLED) display devices including (Quantum dot Light Emitting Diodes (QLEDs)). In addition, some exemplar voltage-control display elements include liquid crystal display elements.

INDUSTRIAL APPLICABILITY

As has been described so far, the disclosure is useful for a display device, such as a flexible organic EL display device.

REFERENCE SIGNS LIST

C	Groove
P	Subpixel
8	Organic EL element (display element)
10	Base substrate
12*c*, **15***e*, and **18***a*	Common wiring line
20, **20***g*	Organic EL layer (display layer)
21*a*, **21***c* to **21***g*	Second electrode (cathode electrode)
22*a* to **22***i*	Sealing film
22*a***1** to **22***i***1**	First sealing layer
22*h***2** to **22***i***2**	Second sealing layer
22*ar* to **22***ir*	Foreign-matter contact layer
23	Inorganic barrier film
50*a* to **50***i*	Organic EL display device (display device)
R	Foreign matter

The invention claimed is:

1. A display device comprising:

a base substrate;

a display element formed on the base substrate and including a plurality of display layers arranged in a matrix shape; and

a sealing film formed on the display element,

wherein a plurality of subpixels are defined in association with the plurality of display layer,
in the sealing film,
a plurality of grooves are formed through the interstices among the plurality of subpixels, and
a foreign-matter contact portion configured to be in contact with a foreign matter existing on the display element is formed,
the sealing film further includes a first sealing layer formed on the display element,
in the sealing film, the foreign-matter contact portion and the first sealing layer wrap up the foreign matter, and
in the foreign-matter contact portion, a taper angle with respect to the base substrate is smaller than 90°.

2. The display device according to claim **1**,
wherein the foreign-matter contact portion is positioned on a display-element side of the foreign matter and is configured to surround the foreign matter.

3. The display device according to claim **1**,
wherein in the display element, a taper angle of an end portion of the display element with respect to the base substrate is equal to or smaller than a predetermined angle.

4. The display device according to claim **1**,
wherein the foreign-matter contact portion is an organic film.

5. The display device according to claim **1**,
wherein the sealing film is separated into a plurality of portions by the grooves.

6. The display device according to claim **5**,
wherein the plurality of portions of the sealing film, which are separated, cover perimeter edge surfaces of the plurality of display layers.

7. The display device according to claim **5**, further comprising an inorganic barrier film configured to cover the plurality of portions of the sealing film, which are separated,
wherein the perimeter edge surfaces of the plurality of display layers overlap at least part of perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

8. The display device according to claim **7**,
wherein the perimeter edge surfaces of the plurality of display layers overlap the perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

9. The display device according to claim **7**,
wherein the inorganic barrier film is in contact with the perimeter edge surfaces of the plurality of display layers and the perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

10. A display device comprising:
a base substrate;
a display element formed on the base substrate and including a plurality of display layers arranged in a matrix shape; and
a sealing film formed on the display element,
wherein a plurality of subpixels are defined in association with the plurality of display layer,
in the sealing film,
a plurality of grooves are formed through the interstices among the plurality of subpixels, and
a foreign-matter contact portion configured to be in contact with a foreign matter existing on the display element is formed,
the sealing film further includes: a first sealing layer; and a second sealing layer formed on the first sealing layer and the foreign-matter contact portion,
in the sealing film, the foreign-matter contact portion, the first sealing layer, and the second sealing layer wrap up the foreign matter, and
in the foreign-matter contact portion, a taper angle with respect to the base substrate is larger than 90°.

11. The display device according to claim **10**,
wherein the foreign-matter contact portion is positioned on a display-element side of the foreign matter and is configured to surround the foreign matter.

12. The display device according to claim **10**,
wherein the sealing film is separated into a plurality of portions by the grooves.

13. The display device according to claim **12**,
wherein the plurality of portions of the sealing film, which are separated, cover perimeter edge surfaces of the plurality of display layers.

14. The display device according to claim **12**, further comprising an inorganic barrier film configured to cover the plurality of portions of the sealing film, which are separated,
wherein the perimeter edge surface of the plurality of display layers overlap at least part of perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

15. The display device according to claim **14**,
wherein the perimeter edge surfaces of the plurality of display layers overlap the perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

16. The display device according to claim **15**,
wherein the inorganic barrier film is in contact with the perimeter edge surfaces of the plurality of display layers and the perimeter edge surfaces of the plurality of portions of the sealing film, which are separated.

17. A display device comprising:
a base substrate;
a display element formed on the base substrate and including a plurality of display layers arranged in a matrix shape; and
a sealing film formed on the display element,
wherein a plurality of subpixels are defined in association with the plurality of display layer,
in the sealing film,
a plurality of grooves are formed through the interstices among the plurality of subpixels, and
a foreign-matter contact portion configured to be in contact with a foreign matter existing on the display element is formed
the sealing film is separated into a plurality of portions by the grooves, and
the plurality of portions of the sealing film, which are separated, are configured to cover perimeter edge surfaces of the plurality of display layer.

18. The display device according to claim **17**,
wherein the foreign-matter contact portion is positioned on a display-element side of the foreign matter and is configured to surround the foreign matter.

19. The display device according to claim **17**,
wherein the sealing film further includes a first sealing layer formed on the display element, and
in the sealing film, the foreign-matter contact portion and the first sealing layer wrap up the foreign matter.

20. The display device according to claim **17**,
wherein in the display element, a taper angle of an end portion of the display element with respect to the base substrate is equal to or smaller than a predetermined angle.

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专利名称(译)	显示装置		
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摘要(译)

一种有机EL显示装置,包括:基底;以及 有机EL元件,其形成在基底基板上,并且包括以矩阵形状排列的多个有机EL层。 形成在有机EL元件上的密封膜,其中与多个有机EL层相关联地限定多个子像素,并且通过多个子像素之间的间隙在密封膜中形成多个凹槽,并且 在密封膜上形成有与有机EL元件上存在的异物接触的异物接触部。