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(54) **ORGANIC EL DEVICE, ORGANIC EL LIGHTING PANEL, ORGANIC EL LIGHTING APPARATUS, AND ORGANIC EL DISPLAY**

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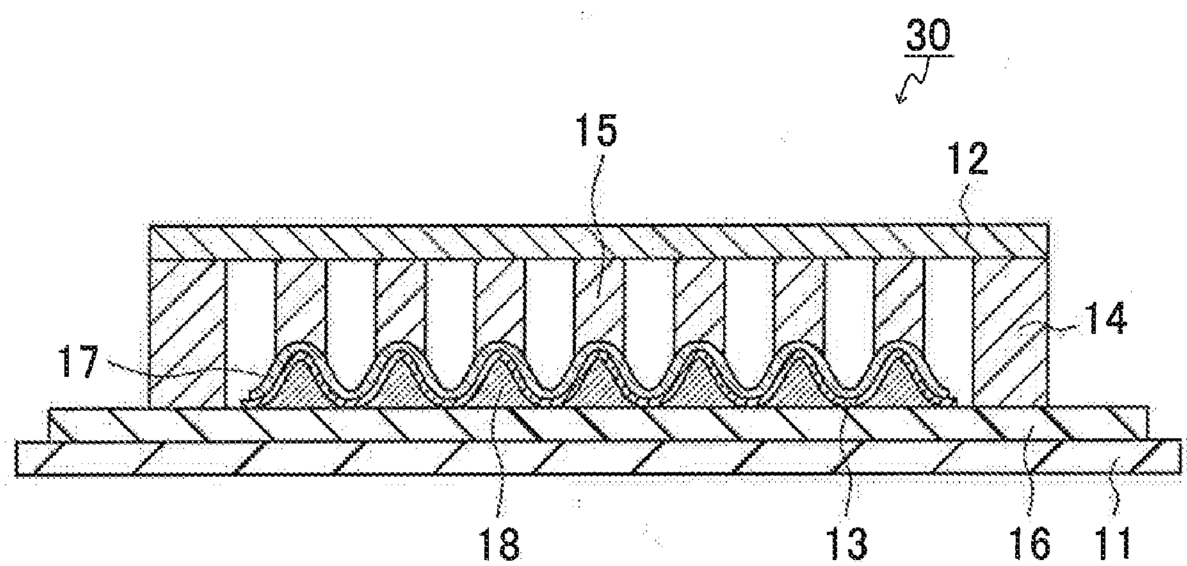
(57) **ABSTRACT**

The present invention provides an organic EL device that can prevent an organic EL layer(s) from being damaged when the organic EL device is bent. An organic EL device (**10**) of the present invention includes: a first substrate (**11**); a second substrate (**12**); one or more organic EL elements; and a sealing layer (**14**). Each of the one or more organic EL elements includes an organic EL layer (**13**) and a pair of electrodes (**16**, **17**). One surface of the first substrate (**11**) is a mounting surface on which the one or more organic EL elements are disposed. The first substrate (**11**) and the second substrate (**12**) are laminated in such a manner that the mounting surface of the first substrate (**11**) and one surface of the second substrate (**12**) face each other with the sealing layer (**14**) interposed therebetween. The sealing layer (**14**) seals a gap between the first substrate (**11**) and the second substrate (**12**) along an entire periphery of a region facing the second substrate (**12**) on the mounting surface of the first substrate (**11**) and an entire periphery of a region facing the first substrate (**11**) on the surface of the second substrate (**12**) facing the first substrate (**11**). The organic EL device further includes one or more supporting layers (**15**). The supporting layers (**15**) are disposed in such a manner that the supporting layers (**15**) connect the whole or part of a region without the one or more organic EL elements on the mounting surface of the first substrate (**11**) and a region facing the whole or part of the region without the one or more organic EL elements on the surface of the second substrate (**12**) facing the first substrate (**11**).



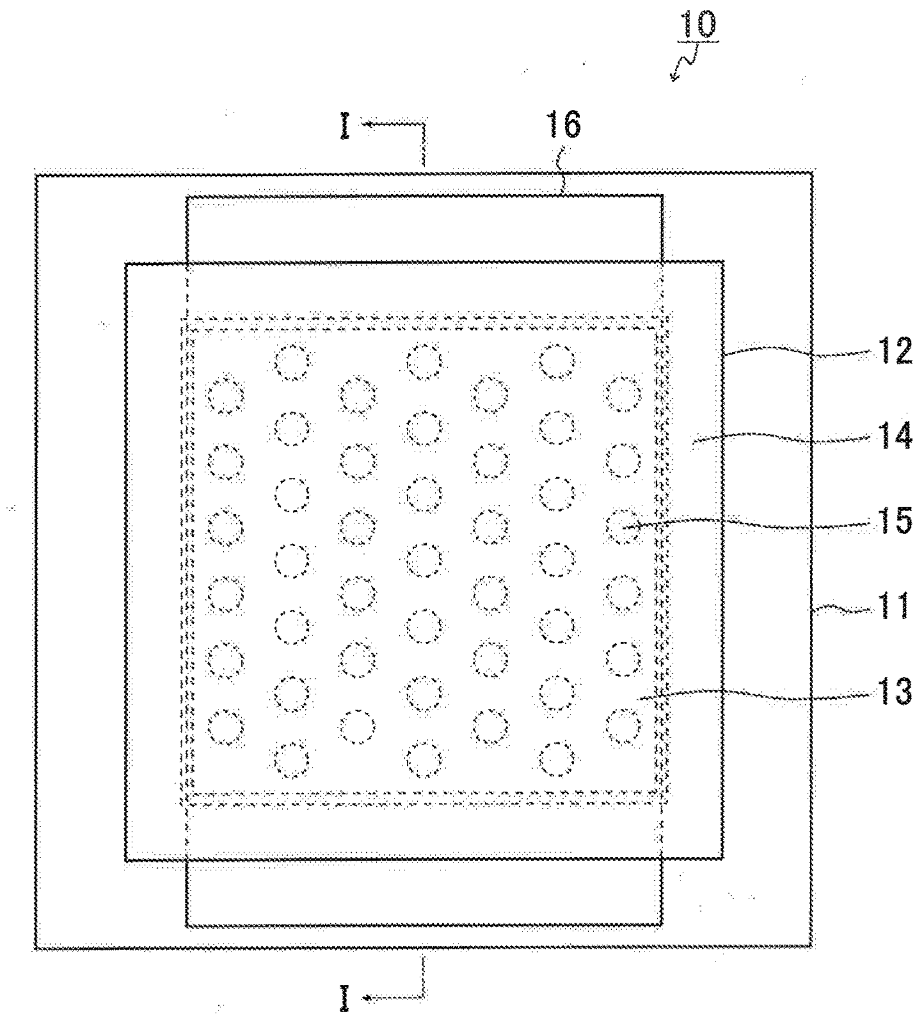


FIG. 1A

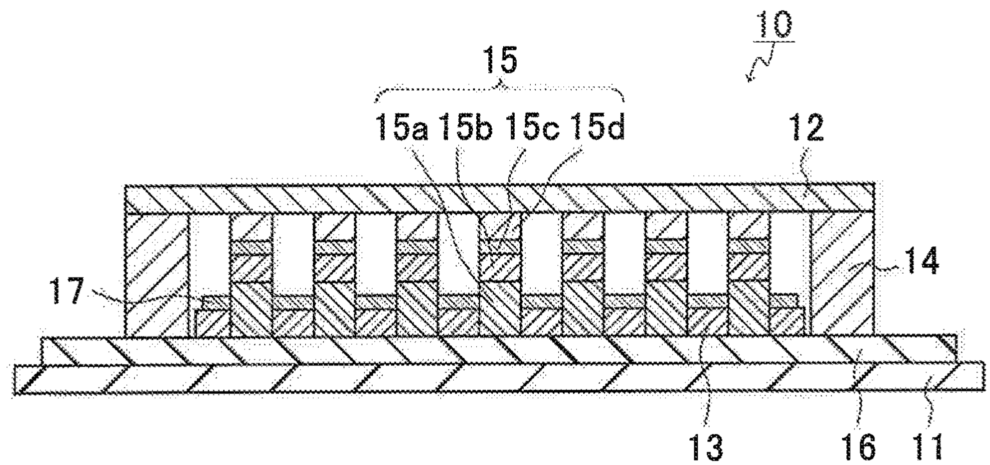


FIG. 1B

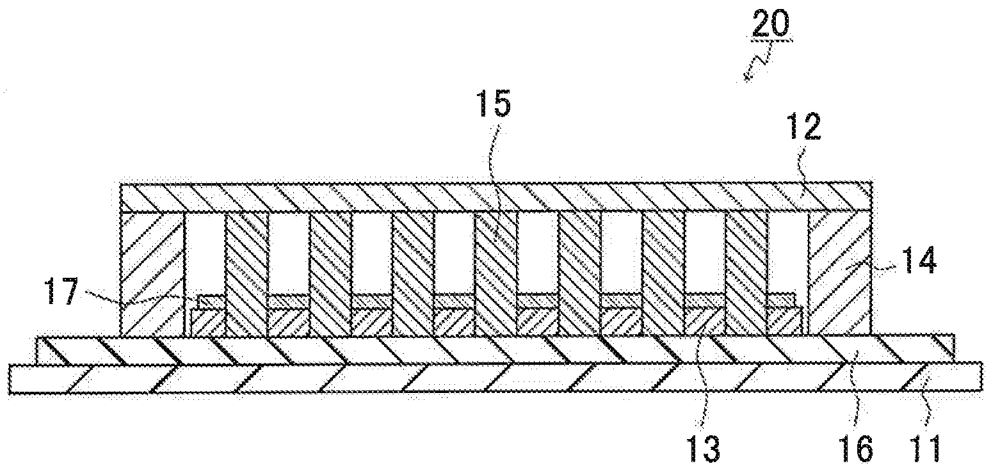


FIG. 2

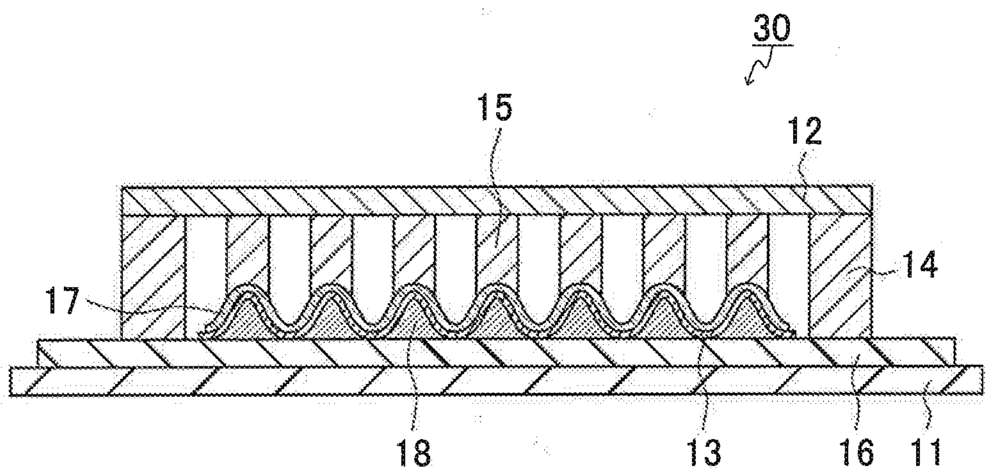


FIG. 3

ORGANIC EL DEVICE, ORGANIC EL LIGHTING PANEL, ORGANIC EL LIGHTING APPARATUS, AND ORGANIC EL DISPLAY

TECHNICAL FIELD

[0001] The present invention relates to an organic EL device, an organic EL lighting panel, an organic EL lighting apparatus, and an organic EL display.

BACKGROUND ART

[0002] An organic electro-luminescence (EL) device generally is configured as follows. The EL device includes one or more organic EL elements (each including an organic EL layer and a pair of electrodes), a substrate on which the organic EL element(s) is laminated, a sealing substrate, a sealing layer, and a filler. The sealing layer is disposed along outer edges of facing surfaces of the substrate and the sealing substrate, and the substrate and the sealing substrate are laminated with the sealing layer interposed therebetween. A gap between the substrate and the sealing substrate is filled with the filler.

[0003] In recent years, among various types of organic EL devices, a flexible organic EL device that can be bent is attracting attention. In the flexible organic EL device, substrates that are flexible (flexible substrates) are used as the substrate and the sealing substrates (Patent Document 1). However, when the flexible organic EL device is bent, the distance between the substrate and the sealing substrate in the thickness direction becomes shorter in the curved portion and the vicinity thereof. This may cause the inner surface of the sealing substrate to be in contact with the organic EL layer(s), resulting in damage to the organic EL layer(s). The damage to the organic EL layer(s) leads to a problem in that light emission is not obtained at the damaged portion.

[0004] Further, stress caused by the bending concentrates on the interface between the substrate and the sealing layer and the interface between the sealing substrate and the sealing layer, which may cause the sealing layer to peel off from the substrate or the sealing substrate.

CITATION LIST

Patent Document(s)

[0005] Patent Document 1: JP 2001-118674 A

BRIEF SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0006] With the foregoing in mind, it is an object of the present invention to provide an organic EL device that can prevent an organic EL layer(s) from being damaged when the organic EL device is bent.

Means for Solving Problem

[0007] In order to achieve the above object, the present invention provides an organic EL device including: a first substrate; a second substrate; one or more organic EL elements; and a sealing layer. Each of the one or more organic EL elements includes an organic EL layer and a pair of electrodes. One surface of the first substrate is a mounting surface on which the one or more organic EL elements are disposed. The first substrate and the second substrate are laminated in such a manner that the mounting surface of the first substrate and one surface of the second substrate face each other with the sealing layer interposed therebetween. The sealing layer seals a gap between the first substrate and the second substrate along an entire periphery of a region facing the second substrate on the mounting surface of the first substrate and an entire periphery of a region facing the first substrate on the surface of the second substrate facing the first substrate. The organic EL device further includes one or more supporting layers. The supporting layers are disposed in such a manner that the supporting layers connect the whole or part of a region without the one or more organic EL elements on the mounting surface of the first substrate and a region facing the whole or part of the region without the one or more organic EL elements on the surface of the second substrate facing the first substrate.

Effects of the Invention

[0008] According to the present invention, it is possible to provide an organic EL device that can prevent an organic EL layer(s) from being damaged when the organic EL device is bent.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. **1**A is a plan view showing an example of the configuration of an organic EL device of a first embodiment. FIG. **1**B is a sectional view of the organic EL device shown in FIG. **1**A, taken in the arrow direction of line I-I in FIG. **1**A.

[0010] FIG. **2** is a sectional view showing an example of the configuration of an organic EL device of a second embodiment.

[0011] FIG. **3** is a sectional view showing an example of the configuration of an organic EL device of a third embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0012] The organic EL panel, the organic EL lighting panel, the organic EL lighting apparatus, and the organic EL display according to the present invention will be described specifically below with reference to the accompanying drawings. It is to be noted, however, that the present invention is by no means limited by the following description. In FIGS. **1** to **3** to be described below, the same components are given the same reference numerals, and duplicate explanations thereof may be omitted. Also, in the drawings, the structure of each component may be shown in an simplified form as appropriate for the sake of convenience in illustration, and also, each component may be shown schematically with a dimension ratio and the like that are different from the actual dimension ratio and the like.

First Embodiment

[0013] The present embodiment is directed to an example of an organic EL device configured so that: each of supporting layers **15** is a laminate of two or more layers; the supporting layers **15** connect a first substrate **11** and a second substrate **12** via an anode **16** on the first substrate **11**; and part of a region without an organic EL element on a mounting surface of the first substrate **11** is a region where the supporting layers **15** are disposed. In this example, the supporting layers **15** are not disposed a region between the periphery of an organic EL layer **13** and a sealing layer **14**, which is other part of the region without the organic EL element. It is to be noted, however, that the present embodiment merely shows an example of the configuration of the organic EL device of the present invention, and the organic EL device of the present invention may be configured so that supporting layers are further provided in the region between the periphery of the organic EL layer and the sealing layer. FIGS. **1**A and **1**B shows the organic EL device of the present embodiment. FIG. **1**A is a plan view showing an example of the configuration of the organic EL device of the present embodiment, and FIG. **1**B is a sectional view of the organic EL device shown in FIG. **1**A, taken in the arrow direction of line **14** in FIG. **1**A. As shown in FIGS. **1**A and **1**B, the organic EL device **10** of the present embodiment includes the first substrate **11**, the second substrate **12**, the organic EL element, and the sealing layer **14**. The organic EL element includes the organic EL layer **13** and a pair of electrodes (an anode **16** and a cathode **17**). One surface of the first substrate **11** (the upper surface in FIG. **1**B) is a mounting surface on which the organic EL element is disposed. The first substrate **11** and the second substrate **12** are laminated in such a manner that the mounting surface of the first substrate **11** faces one surface of the second substrate **12** (the lower surface in FIG. **1**B) with the sealing layer **14** interposed therebetween. The sealing layer **14** seals a gap between the first substrate **11** and the second substrate **12** along an entire periphery of a region facing the second substrate **12** on the mounting surface of the first substrate **11** and an entire periphery of a region facing the first substrate **11** on the surface of the second substrate **12** facing the first substrate **11**. The organic EL device **10** of the present embodiment further includes one or more supporting layers **15** (in FIGS. **1**A and **1**B, the number of the supporting layers **15** is 45). As shown in FIG. **1**B, each of the supporting layers **15** is a laminate including a lower supporting layer **15***a*, a first intermediate supporting layer **15***b*, a second intermediate supporting layer **15***c*, and an upper supporting layer **15***d*. One surface of the lower supporting layer **15***a* (the lower surface in FIG. **1**B) is in contact with the anode **16**, and the other surface of the lower supporting layer **15***a* (the upper surface in FIG. **1**B) is in contact with one surface of the first intermediate supporting layer **15***b* (the lower surface in FIG. **1**B). The other surface of the first intermediate supporting layer **15***b* (the upper surface in FIG. **1**B) is in contact with one surface of the second intermediate supporting layer **15***c* (the lower surface in FIG. **1**B). The other surface of the second intermediate supporting layer **15***c* (the upper surface in FIG. **1**B) is in contact with one surface of the upper supporting layer **15***d* (the lower surface in FIG. **1**B), and the other surface of the upper supporting layer **15***d* (the upper surface in FIG. **1**B) is in contact with the surface of the second substrate **12** facing the first substrate **11**. With this configuration, the supporting layers **15** connect part of the region without the EL element on the mounting surface of the first substrate **11** and a region facing the part of the region without the organic EL element on the surface of the second substrate **12** facing the first substrate **11**. While the organic EL device **10** shown in FIGS. **1**A and **1**B is in a square shape, the shape of the organic EL device of the present invention is not limited thereto. Examples of the shape of the organic EL device of the present invention include: polygonal shapes other than the square shape, such as parallelogram shapes (including a rectangular shape and a rhombic shape) other than the square shape, a trapezoidal shape, a pentagonal shape, and a hexagonal shape; a circular shape; an oval shape; and shapes similar to these shapes (e.g., a substantially square shape or the like).

[0014] The organic EL device **10** of the present embodiment preferably is bendable, i.e., preferably is the so-called flexible organic EL device. To this end, it is preferable that the first substrate **11** and the second substrate **12** are flexible substrates.

[0015] It is preferable that the first substrate **11** transmits light emitted from the organic EL layer **13** at a high transmittance. The first substrate **11** preferably has a total light transmittance of at least 80%, more preferably at least 84%. Examples of the material of the first substrate **11** include: polyesters such as polyethylene naphthalate and polyethylene terephthalate; acrylic resins such as polymethyl methacrylate, polyethyl methacrylate, polymethyl acrylate, and polyethyl acrylate; polyether sulfone; and polycarbonates. When moisture permeation cannot be inhibited sufficiently by the first substrate **11** alone, it is preferable to form a barrier film for inhibiting the moisture permeation on the mounting surface of the first substrate **11**. The size (the length and the width) of the first substrate **11** is not particularly limited, and can be set as appropriate depending on a desired size of the organic EL device **10**, for example. The thickness of the first substrate **11** is not particularly limited, and is in the range from 20 to 300 μm, for example. In addition to or instead of the first substrate **11**, the second substrate **12** to be described below may be configured so as to transmit light emitted from the organic EL layer **13** at a high transmittance.

[0016] Examples of the material of the second substrate **12** include those described above as examples of the material of the first substrate **11**. Although it is not always necessary that the first substrate **11** and the second substrate **12** are formed of the same material, it is preferable that the first substrate **11** and the second substrate **12** are subjected to the same or substantially the same bending stress. The thickness of the second substrate **12** is not particularly limited, and is in the range from 20 to 300 μm, for example.

[0017] The organic EL element is a laminate in which the anode **16**, the organic EL layer **13**, and the cathode **17** are laminated in this order. In the organic EL device **10** of the present embodiment, the anode **16** is formed on the first substrate **11**. The lower supporting layers **15***a* are formed on the anode **16**. The organic EL layer **13** and the first intermediate supporting layers **15***b* are formed on the anode **16** and on the lower supporting layers **15***a*, respectively, using the same material. The cathode **17** and the second intermediate supporting layers **15***c* are formed on the organic EL layer **13** and on the first intermediate supporting layers **15***b*, respectively, using the same material. As a result, a region where the anode **16**, the organic EL layer **13**, and the cathode **17** are laminated serves as the organic EL element, and regions where the lower supporting layers **15***a* are interposed between the anode **16** and the first intermediate supporting layers **15***b*, i.e., regions where the supporting layers **15** are to be disposed, form part of the region without the organic EL element.

[0018] It is preferable that the anode **16** transmits light emitted from the organic EL layer **13** at a high transmittance. The anode **16** preferably has a total light transmittance of at least 85%. Examples of the material of the anode **16** include indium tin oxide and indium zinc oxide. While the anode **16**

in the organic EL device **10** shown in FIGS. **1**A and **1**B is in a rectangular shape, the organic EL device of the present embodiment is not limited thereto. The anode **16** may have any shape as long as voltage application to the organic EL layer **13** is possible. When there are a plurality of organic EL elements, a plurality of anodes **16** may be formed separately for the respective organic EL elements. However, it is preferable to form the anode **16** as a continuous film as shown in FIGS. **1**A and **1**B, for example. This can eliminate the necessity of patterning the anode **16** or can simplify the patterning of the anode **16**, so that the organic EL device **10** can be produced more easily at lower cost, for example. Also, it is possible to avoid trouble such as the occurrence of a short circuit in the organic EL element owing to roughness in the patterned peripheries of the anode **16**, for example. The thickness of the anode **16** is not particularly limited, and is in the range from 50 to 300 nm, for example. When the second substrate **12** is formed of a material with a high transmittance, the positions of the anode **16** and the cathode **17** to be described below are interchangeable.

[0019] As the organic EL layer **13**, a conventionally known and commonly used organic EL layer may be used. The organic EL layer **13** has, for example, a multilayer structure including, in sequence, a hole injection layer, a hole transport layer, a light emission layer containing an organic EL material, an electron transport layer, and an electron injection layer. The thickness of each layer included in the organic EL layer **13** is not particularly limited, and is in the range from 1 to 200 nm, for example. The thickness of the organic EL layer **13** as a whole is not particularly limited, and is in the range from 100 to 1000 nm, for example.

[0020] The material of the cathode **17** is aluminum or silver, for example. Also, the cathode **17** may be formed of a material with a high transmittance, examples of which include those described above as examples of the material of the anode **16**. For example, when the first substrate **11**, the second substrate **12**, the anode **16**, and the cathode **17** are all formed of materials with a high transmittance, it is possible to produce the organic EL device **10** that is transparent as a whole. The thickness of the cathode **17** is not particularly limited, and is in the range from 50 to 300 nm, for example.

[0021] Examples of the material of the sealing layer **14** include ultraviolet-curable adhesives and thermosetting adhesives, such as epoxy resins and acrylic resins. The sealing layer **14** is formed so that the thickness thereof is slightly greater than the total thickness of the organic EL layer **13** and the cathode **17**. The thickness of the sealing layer **14** is in the range from 1 to 100 μm, for example.

[0022] Each of the supporting layers **15** in the organic EL device **10** shown in FIGS. **1**A and **1**B is in a columnar shape. It is to be noted, however, that the organic EL device **10** of the present embodiment is not limited thereto, and each of the supporting layers **15** may be in a polygonal columnar shape such as a hexagonal columnar shape, for example. Although the supporting layer **15** in a grid pattern may be formed such that the organic EL element is divided into segments by the supporting layer **15** and the segments are surrounded by the supporting layer **15**, it is preferable to dispose the columnar supporting layers **15** so as to form a dot pattern in a plan view, as shown in FIG. **1**A, for example. With this configuration, for example, the contact area between the first substrate **11** and the second substrate **12** can be made smaller as compared with the case where the supporting layer **15** in a grid pattern is formed, which allows the organic EL device **10** to have higher flexibility and also to have a larger light emission region as described below. The cross-sectional area per supporting layer **15** in the in-plane direction of the mounting surface of the first substrate **11** preferably corresponds to the area of a circle with an average diameter of not less than 5 **82** m and not more than 300 μm, more preferably a circle with an average diameter of not less than 8 μm and not more than 100 μm. The above-described cross-sectional area per supporting layer **15** preferably is in the range from 15 to 80000 μm^2, more preferably from 50 to 8000 μm^2.

[0023] In the in-plane direction of the mounting surface of the first substrate **11**, the density of the supporting layers **15** in a region surrounded by the sealing layer **14** preferably is in the range from 10 to 10000 supporting layers/cm^2. By setting the density in the above-described range, it is possible to more suitably prevent the surface of the second substrate **12** facing the first substrate **11** from coming into contact with the organic EL layer **13** when the organic EL device **10** is bent. As a result, the damage to the organic EL layer **13** can be prevented more suitably. It is more preferable that the density is in the range from 100 to 400 supporting layers/cm^2. On the mounting surface of the first substrate **11**, a light emission region in the region surrounded by the sealing layer **14** preferably is at least 80%, more preferably at least 90%. The light emission region is a region provided with the organic EL element.

[0024] The lower supporting layers **15***a* preferably are insulating layers. The material of the lower supporting layers **15***a* may be a resin or an inorganic compound, and examples of the material of the lower supporting layers **15***a* include those described above as examples of the materials of the first substrate **11** and the second substrate **12**. The thickness of the lower supporting layers **15***a* is not particularly limited. The lower supporting layers **15***a* preferably has an average thickness in the range from not less than 0.2 μm and not more than 100 μm, more preferably an average thickness in the range from not less than 1 μm and not more than 30 μm.

[0025] Each of the first intermediate supporting layers **15***b* has the same configuration as the organic EL layer **13**, as described above.

[0026] The material and the thickness of the second intermediate supporting layers **15***c* are the same as those described above for the cathode **17**.

[0027] It is preferable that the upper supporting layers **15***d* are formed of the same material as the sealing layer **14**. The thickness of the upper supporting layers **15***d* is not particularly limited. For example, as shown in FIG. **1**B, the thickness of the upper supporting layers **15***d* may be a value obtained by subtracting, from the thickness of the sealing layer **14**, the thicknesses of the lower supporting layers **15***a*, the first intermediate supporting layers **15***b*, and the second intermediate supporting layers **15***c*. Alternatively, the upper supporting layers **15***d* may have the same thickness as the sealing layer **14**, or may have any other thickness.

[0028] In the organic EL device **10** of the present embodiment, gaps (blank spaces in FIG. **1**B) that are present between the first substrate **11** and the second substrate **12** and surrounded by the sealing layer **14** may be filled with a filler. The filler may be an inert gas, for example. By using, as the filler, a mixture obtained by mixing a desiccant such as calcium oxide with silicone, it is possible to more suitably prevent the surface of the second substrate **12** facing the first substrate **11** from coming into contact with the organic EL layer **13** when the organic EL device **10** is bent. As a result, the damage to the organic EL layer **13** can be prevented more suitably.

[0029] Next, a method for producing the organic EL device **10** of the present embodiment will be described with reference to an illustrative example. It is to be noted, however, that this production method is merely illustrative, and the organic EL device **10** of the present embodiment may be produced by any method.

[0030] First, the anode **16** is formed on the mounting surface of the first substrate **11**. The anode **16** can be formed by, for example, forming a film of the above-described material of the anode **16** according to a conventionally known method such as sputtering or chemical vapor deposition (CVD) with the use of a shadow mask. The anode **16** also can be formed by uniformly applying the above-described material of the anode **16** on the mounting surface of the first substrate **11** to form a film and patterning the thus-formed film into a desired shape by photolithography.

[0031] Next, the lower supporting layers **15***a* are formed on the anode **16**. The lower supporting layers **15***a* can be formed in the same manner as the anode **16** using the above-described material of the lower supporting layers **15***a*, for example. The lower supporting layers **15***a* also can be formed by applying the above-described material of the lower supporting layers **15***a* by dispensed coating, ink-jet coating, or printing such as screen printing, flexographic printing, or gravure printing.

[0032] When the lower supporting layers **15***a* are formed by photolithography, the lower supporting layers **15***a* can be formed by, for example, forming a photoresist film on the anode **16** and patterning the thus-formed photoresist film by photolithography. The photoresist may be either a negative photoresist or a positive photoresist. For example, the photoresist may be a negative photoresist such as an acrylic resin, novolac, or polyimide. The photolithography is preferable because it is possible to form a tine pattern of a 10-μm scale, and further, light emitted from the organic EL layer **13** is not blocked if a transparent acrylic resin is used as the photoresist.

[0033] When the lower supporting layers **15***a* are formed by printing, the printing process may be repeated a plurality of times until the lower supporting layers **15***a* have a desired thickness. When the lower supporting layers **15***a* are formed by printing, the cross-sectional area per lower supporting layer **15***a* in the in-plane direction of the mounting surface of the first substrate **11** is larger as compared with the case where the lower supporting layers **15***a* are formed by photolithography. However, printing brings about the following advantages: the thickness can be increased easily; a wider range of material selection is allowed; and printing requires simple forming steps and a simple apparatus, so that the lower supporting layers **15***a* can be formed with high efficiency at low cost.

[0034] Next, the organic EL layer **13** and the first intermediate supporting layers **15***b* are formed at the same time on the anode **16** and on the lower supporting layers **15***a*, respectively, using the same material. By forming the organic EL layer **13** and the first intermediate supporting layers **15***b* at the same time using the same material as described above, it is possible to eliminate the necessity of patterning these components or simplify the patterning of these components, so that the organic EL device **10** can be produced more easily, for example. The same applies to the cathode **17** and the second intermediate supporting layers **15***c* to be described below. The organic EL layer **13** and the first intermediate supporting layers **15***b* can be formed using a conventionally known material by a conventionally known method, such as vacuum deposition by resistance heating, molecular beam epitaxy (MBE), or laser ablation, with the use of a shadow mask, for example. When the organic EL layer **13** and the first intermediate supporting layers **15***b* are formed using a polymeric material, the organic EL layer **13** and the first intermediate supporting layers **15***b* can be formed on the anode **16** and the lower supporting layer **15***a*, respectively, by applying the polymeric material in the liquid form by printing such as inkjet printing. It is also possible to apply the polymeric material in the form of a photosensitive coating solution by spin coating or slit coating and to form the organic EL layer **13** and the first intermediate supporting layers **15***b* on the anode **16** and on the lower supporting layer **15***a*, respectively, by photolithography.

[0035] Next, the cathode **17** and the second intermediate supporting layers **15***c* are formed at the same time on the organic EL layer **13** and on the first intermediate supporting layer **15***b*, respectively, using the same material. The cathode **17** and the second intermediate supporting layers **15***c* can be formed using the above-described material of the cathode **17** by a conventionally known method such as vacuum deposition or sputtering, for example.

[0036] Next, the sealing layer **14** and the upper supporting layers **15***d* are formed at the same time on the anode **16** and on the second intermediate supporting layer **15***d*, respectively, using the same material as described above. Thereafter, the second substrate **12** is bonded to the upper surfaces of the sealing layer **14** and the upper supporting layers **15***d* with an adhesive or by fusion. Through the above-described process, the organic EL device **10** of the present embodiment can be obtained.

[0037] With the configuration of the organic EL device **10** of the present embodiment in which the supporting layers **15** are disposed so as to connect part of a region without the EL element on the mounting surface of the first substrate **11** and a region facing the part of the region without the organic EL element on the surface of the second substrate **12** facing the first substrate **11**, it is possible to prevent the distance between the first substrate **11** and the second substrate **12** in the thickness direction from becoming shorter when the organic EL device **10** is bent, whereby the organic EL layer **13** can be prevented from being damaged when the organic EL device **10** is bent. Further, by disposing the columnar supporting layers **15** so as to form a dot pattern in a plan view as shown in FIG. **1**A, the bending stress applied when the organic EL device **10** is bent is distributed, so that it is possible to prevent the sealing layer **14**, the lower supporting layers **15***a*, and the upper supporting layers **15***d* from peeling off from the first substrate **11** or the second substrate **12**.

[0038] The organic EL device **10** of the present embodiment can be used in a wide range of applications, such as, for example, an organic EL lighting panel, an organic EL lighting apparatus, and an organic EL display, as described below.

Second Embodiment

[0039] The present embodiment is directed to an example of an organic EL device configured so that: each of supporting layers **15** has a single layer structure; the supporting layers **15** connect a first substrate **11** and a second substrate **12** via an anode **16** on the first substrate **11**; and part of a region without an organic EL element on a mounting surface of the first substrate **11** is a region not provided with an organic EL layer **13**. FIG. **2** is a sectional view showing an example of the configuration of the organic EL device of the present embodiment. As shown in FIG. **2**, the organic EL device **20** of the present embodiment has the same configuration as the organic EL device **10** of the first embodiment, except that each of the supporting layers **15** has a single layer structure.

[0040] Examples of the material of the supporting layers **15** include those described above as examples of the materials of the lower supporting layers **15***a* and the sealing layer **14** in the first embodiment. The thickness of the supporting layers **15** is not particularly limited. For example, the supporting layers **15** may have the same thickness as a sealing layer **14** as in the example shown in FIG. **2**, or may have any other thickness.

[0041] Next, a method for producing the organic EL device **20** of the present embodiment will be described with reference to an illustrative example. It is to be noted, however, that this production method is merely illustrative, and the organic EL device **20** of the present embodiment may be produced by any method.

[0042] First, the anode **16** is formed on the mounting surface of the first substrate **11** in the same manner as in the first embodiment. When there are a plurality of organic EL elements, a plurality of anodes **16** may be formed separately for the respective organic EL elements. However, it is preferable to form the anode **16** as a continuous film as shown in FIG. **2**, for example. This can eliminate the necessity of patterning the anode **16** or can simplify the patterning of the anode **16**, so that the organic EL device **20** can be produced more easily at lower cost, for example. Also, it is possible to avoid trouble such as the occurrence of a short circuit in the organic EL element owing to roughness in the patterned peripheries of the anode **16**, for example. The same applies to the third embodiment.

[0043] Next, the supporting layers **15** are formed on the anode **16** using the above-described material of the supporting layers **15** in the same manner as the lower supporting layers **15***a* in the first embodiment. The supporting layers **15** are formed in such a manner that the supporting layers **15** have the same thickness as the sealing layer **14** to be formed subsequently.

[0044] Next, in the same manner as in the first embodiment, the organic EL layer **13** is formed on a region on the anode **16** excluding portions where the supporting layers **15** have been formed.

[0045] Next, the cathode **17** is formed only on the organic EL layer **13** in the same manner as in the first embodiment.

[0046] Next, the sealing layer **14** is formed on the anode **16**, and the second substrate **12** is bonded to the upper surfaces of the sealing layer **14** and the supporting layers **15** with an adhesive or by fusion. Through the above-described process, the organic EL device **20** of the present embodiment can be obtained.

[0047] The organic EL device **20** of the present embodiment also can exhibit the same effect as the organic EL device **10** of the first embodiment. The organic EL device **20** of the present embodiment also can be used in the same applications as the organic EL device **10** of the first embodiment.

Third Embodiment

[0048] The present embodiment is directed to an example of an organic EL device configured so that: part of a region without an organic EL element on a mounting surface of a first substrate **11** is provided with a pair of electrodes (an anode **16** and a cathode **17**) and an organic EL layer **13**, and insulating layers **18** are provided between the pair of electrodes (the anode **16** and the cathode **17**). FIG. **3** is a sectional view showing an example of the configuration of the organic EL device of the present embodiment. As shown in FIG. **3**, the organic EL device **30** of the present embodiment has the same configuration as the organic EL device **10** of the first embodiment, except that: the insulating layers **18** are formed at the positions of the lower supporting layers **15***a*; the organic EL layer **13** is formed as a continuous film; the cathode **17** is formed as a continuous film on the organic EL layer **13**; and supporting layers **15** are formed at the positions of the upper supporting layers **15**. In the organic EL device **30** of the present embodiment, a region where the anode **16**, the organic EL layer **13**, and the cathode **17** are laminated serves as the organic EL element, and regions where the anode **16**, the insulating layers **18**, the organic EL layer **13**, and the cathode **17** are laminated form part of a region without the organic EL element.

[0049] The insulating layers **18** are patterned so that each insulating layer **18** has an inverted V-shape with smooth slopes. The cross-sectional area of the base part of the inverted V-shape per insulating layer **18** in the in-plane direction of the mounting surface of the first substrate **11** preferably corresponds to the area of a circle with an average diameter of not less than 5 μm and not more than 300 μm, more preferably a circle with an average diameter of not less than 8 μm and not more than 100 μm. The above-described cross-sectional area of the base part of the inverted V-shaped insulating layer **18** preferably is in the range from 15 to 80000 μm^2, more preferably from 50 to 8000 μm^2. The thickness (height) of the insulating layers **18** is not particularly limited. The insulating layers **18** preferably have an average thickness in the range from not less than 0.2 μm and not more than 100 μm, more preferably in the range from not less than 1 μm and not more than 30 μm. Examples of the material of the insulating layers **18** include those described above as examples of the material of the lower supporting layers **15***a* in the first embodiment and photoresist Materials that allow tine patterning of a 10-μm scale (e.g., acrylic resins, novolac, and polyimide).

[0050] Examples of the material of the supporting layers **15** include those described above as examples of the material of the upper supporting layers **15***d* in the first embodiment. The thickness of the supporting layers **15** is not particularly limited. For example, as shown in FIG. **3**, the thickness of the supporting layers **15** may be a value obtained by subtracting, from the thickness of the sealing layer **14**, the thicknesses of the insulating layers **18**, the organic EL layer **13**, and the cathode **17**. Alternatively, the supporting layers **15** may have the same thickness as the sealing layer **14**, or may have any other thickness.

[0051] Next, a method for producing the organic EL device **30** of the present embodiment will be described with reference to an illustrative example. It is to be noted, however, that this production method is merely illustrative, and the organic EL device **30** of the present embodiment may be produced by any method.

[0052] First, the anode **16** is formed on the mounting surface of the first substrate **11** in the same manner as in the first embodiment.

[0053] Next, the insulating layers **18** are formed on the anode **16** using the above-described material of the insulating layers **18** in the same manner as the lower supporting layers **15***a* in the first embodiment. At this time, the insulating layers **18** can he formed into the inverted V-shapes with smooth slopes easily by adjusting the temperature at which the insulating layers **18** are formed so that the above-described material of the insulating layers **18** has a desired viscosity.

[0054] Next, the organic EL layer **13** is formed on the anode **16** and the insulating layers **18** in the same manner as in the first embodiment, except that the organic EL layer **13** is formed as a continuous film.

[0055] Next, the cathode **17** is formed as a continuous film on the organic EL layer **13** in the same manner as in the first embodiment.

[0056] Next, the sealing layer **14** and the supporting layers **15** are formed at the same time on the anode **16** and on the cathode **17**, respectively, using the same material. Thereafter, the second substrate **12** is bonded to the upper surfaces of the sealing layer **14** and the supporting layers **15** with an adhesive or by fusion. Through the above-described process, the organic EL device **30** of the present embodiment can be obtained. For example, by disposing the columnar supporting layers **15** so as to form a dot pattern in a plan view as in the first embodiment, the contact area between the first substrate **11** and the second substrate **12** can be made smaller as compared with the case where the supporting layer **15** in a grid pattern is formed, which allows the organic EL device **30** to have higher flexibility and also to have a larger light emission region, for example.

[0057] The organic EL device **30** of the present embodiment also can exhibit the same effect as the organic EL device **10** of the first embodiment. The organic EL device **30** of the present embodiment also can be used in the same applications as the organic EL device **10** of the first embodiment. Further, in the organic EL device **30** of the present embodiment, the organic EL layer **13** is a continuous film. This can eliminate the necessity of patterning the organic EL layer **13** or can simplify the patterning of the organic EL layer **13**, so that the organic EL device **30** can be produced easily.

Fourth Embodiment

[0058] In the present embodiment, the organic EL lighting panel according to the present invention will be described. The organic EL panel of the present invention is characterized in that it includes the organic EL device of any of the first to third embodiments. Other configurations or conditions are by no means limited, and may be the same as those in conventionally known organic EL lighting panels, for example.

Fifth Embodiment

[0059] In the present embodiment, the organic EL lighting apparatus according to the present invention will be described. The organic EL lighting apparatus of the present invention is characterized in that it includes the organic EL device of any of the first to third embodiments or the organic EL lighting panel of the fourth embodiment. Other configurations or conditions are by no means limited, and may be the same as those in conventionally known organic EL lighting apparatuses, for example.

Sixth Embodiment

[0060] In the present embodiment, the organic EL display according to the present invention will be described. The organic EL display of the present invention is characterized in that it includes the organic EL device of any of the first to third embodiments or the organic EL lighting panel of the fourth embodiment. Other configurations or conditions are by no means limited, and may he the same as those in conventionally known organic EL displays, for example.

[0061] While the present invention has been described above with reference to exemplary embodiments, the present invention is by no means limited thereto. Various changes and modifications that may become apparent to those skilled in the art may be made in the configuration and specifics of the present invention without departing from the scope of the present invention.

[0062] This application claims priority from Japanese Patent Application No. 2015-129146 filed on Jun. 26, 2015. The entire disclosure of this Japanese patent application is incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[0063] According to the present invention, it is possible to provide an organic EL device that can prevent an organic EL layer(s) from being damaged when the organic EL device is bent. The organic EL device of the present invention can be used in a wide range of applications, such as an organic EL lighting panel, an organic EL lighting apparatus, and an organic EL display, for example.

EXPLANATION OF REFERENCE NUMERALS

[0064] **10**, **20**, **30**: organic EL device
[0065] **11**: first substrate
[0066] **12**: second substrate
[0067] **13**: organic EL layer
[0068] **14**: sealing layer
[0069] **15**: supporting layer
[0070] **16**: anode
[0071] **17**: cathode
[0072] **18**: insulating layer

1. An organic EL device comprising:

a first substrate;

a second substrate;

one or more organic EL elements; and

a sealing layer,

each of the one or more organic EL elements comprising an organic EL layer and a pair of electrodes,

one surface of the first substrate being a mounting surface on which the one or more organic EL elements are disposed,

the first substrate and the second substrate being laminated in such a manner that the mounting surface of the first substrate and one surface of the second substrate face each other with the sealing layer interposed therebetween,

the sealing layer sealing a gap between the first substrate and the second substrate along an entire periphery of a region facing the second substrate on the mounting surface of the first substrate and an entire periphery of a region facing the first substrate on the surface of the second substrate facing the first substrate,

wherein the organic EL device further comprises one or more supporting layers, and

the supporting layers are disposed in such a manner that the supporting layers connect the whole or part of a region without the one or more organic EL elements on the mounting surface of the first substrate and a region facing the whole or part of the region without the one or more organic EL elements on the surface of the second substrate facing the first substrate.

2. The organic EL device according to claim **1**, wherein the supporting layer is a laminate of two or more layers.

3. The organic EL device according to claim **2**, wherein the supporting layer is the laminate, and at least one layer included in the laminate has the same composition as the sealing layer.

4. The organic EL device according to claim **1**, wherein the supporting layer has a single layer structure.

5. The organic EL device according to any one of claims **1** to **4**, wherein

the supporting layer is an insulating layer.

6. The organic EL device according to any one of claims **1** to **5**, wherein

a cross-sectional area per supporting layer in an in-plane direction of the mounting surface of the first substrate is in a range from 15 to 80000 μm^2.

7. The organic EL device according to any one of claims **1** to **6**, wherein

in an in-plane direction of the mounting surface of the first substrate, the density of the supporting layers in a region surrounded by the sealing layer is in a range from 10 to 10000 supporting layers/cm^2.

8. The organic EL device according to any one of claims **1** to **7**, wherein

in an in-plane direction of the mounting surface of the first substrate, a light emission region in a region surrounded by the sealing layer is at least 80%.

9. The organic EL device according to any one of claims **1** to **8**, wherein

the organic EL element is a laminate in which an electrode layer as one of the pair of electrodes, the organic EL layer, and another electrode layer as the other one of the pair of electrodes are laminated in this order in a direction in which the first substrate and the second substrate face each other.

10. The organic EL device according to claim **9**, wherein

in the organic EL element, the electrode layer on the first substrate side is an anode and the electrode layer on the second substrate side is a cathode.

11. The organic EL device according to any one of claims **1** to **10**, wherein

the whole or part of the region without the one or more organic EL elements on the mounting surface of the first substrate is a region where the one or more supporting layers are disposed.

12. The organic EL device according to any one of claims **1** to **10**, wherein

the whole or part of the region without the one or more organic EL elements on the mounting surface of the first substrate is a region provided with the pair of electrodes and the organic EL layer with an insulating layer interposed between the pair of electrodes.

13. The organic EL device according to any one of claims **1** to **12**, wherein

the first substrate and the second substrate are flexible substrates.

14. The organic EL device according to any one of claims **1** to **13**, wherein

a gap between the first substrate and the second substrate in a region surrounded by the sealing layer is filled with a filler.

15. An organic EL lighting panel comprising:

the organic EL device according to any one of claims **1** to **14**.

16. An organic EL lighting apparatus comprising:

the organic EL device according to any one of claims **1** to **14** or the organic EL lighting panel according to claim **15**.

17. An organic EL display comprising:

the organic EL device according to any one of claims **1** to **14** or the organic EL lighting panel according to claim **15**.

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