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Tsutsui et al.

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(54) **DISPLAY ELEMENT AND METHOD OF MANUFACTURING THE SAME**

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(22) Filed: **Jul. 17, 2001**

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(51) **Int. Cl.**[7] **H01J 9/00**; H05B 33/10
(52) **U.S. Cl.** **445/24**; 445/25
(58) **Field of Search** 313/503, 504, 313/506, 509, 512, 505; 445/24, 25; 257/99

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(57) **ABSTRACT**

There is provided a display element capable of efficiently emitting generated light externally and a method of manufacturing the display element, without damaging an organic electroluminescent layer. First, a transparent electrode protection material (**11**) is deposited on a first holding substrate (**10**); then organic electroluminescent light-emitting elements (**12**, **13**, **14**) are manufactured thereon; and then after sealing and holding with a sealing material (**15**) and a second holding substrate (**16**), the first holding substrate (**10**) and a transparent electrode protection material (**11**) are removed by etching or the like. According to the present invention, the removal of the first holding substrate (**10**) enables improvement of the emission rate generated in the electroluminescent layer (**13**), and improvement of brightness and contrast in the display element.

30 Claims, 3 Drawing Sheets

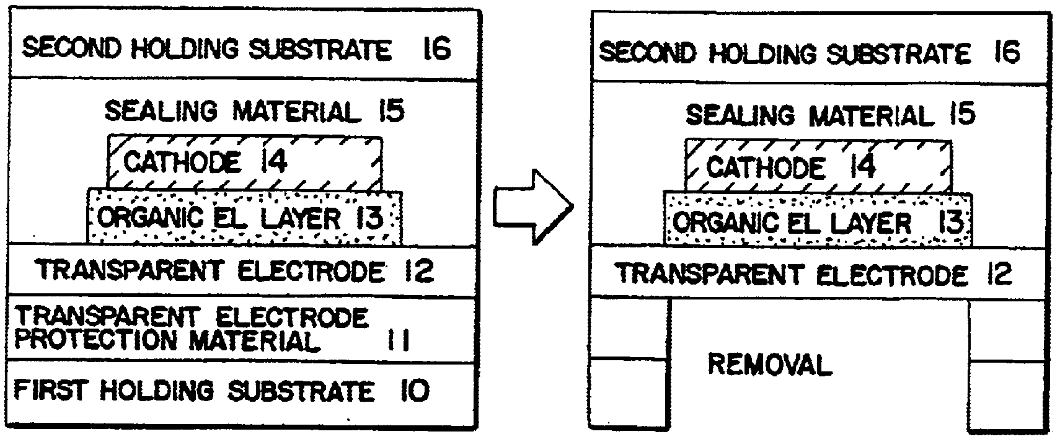


FIG. 1

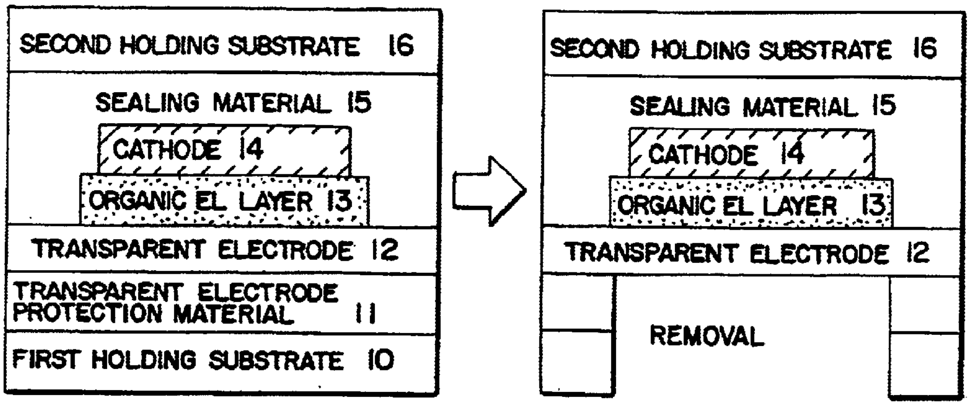


FIG. 2A

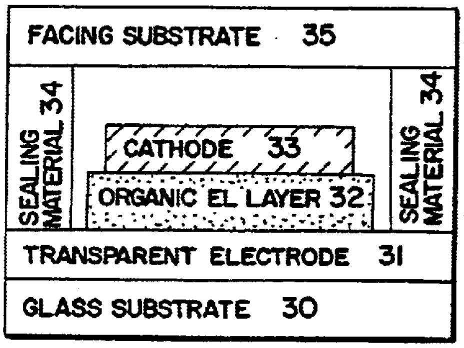


FIG. 2B

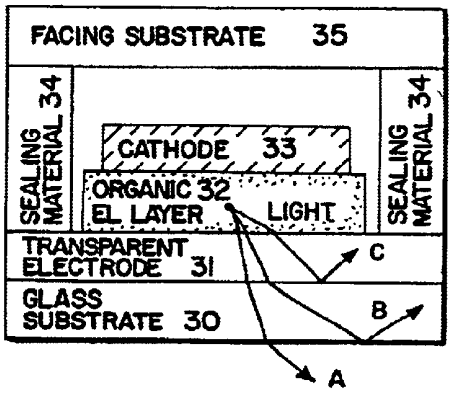


FIG. 2C

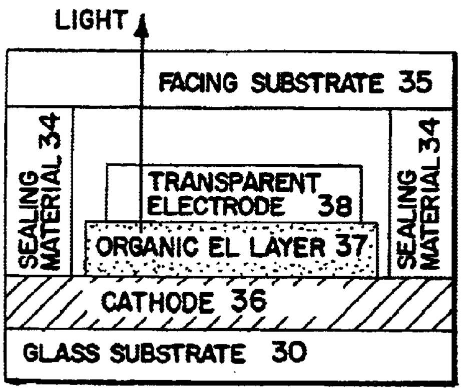
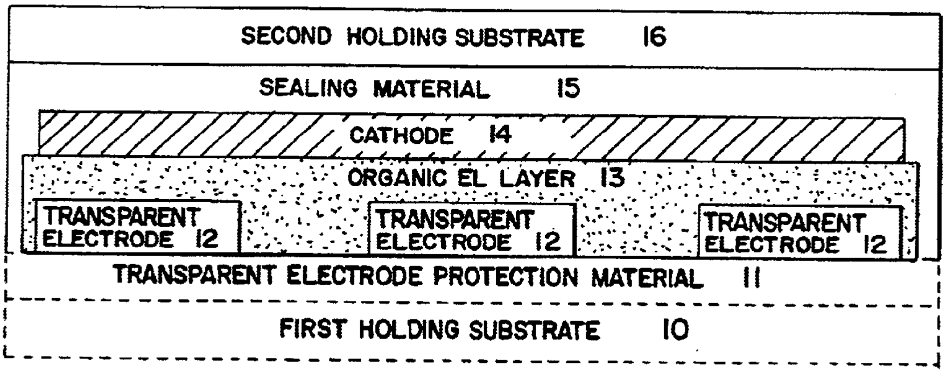


FIG. 3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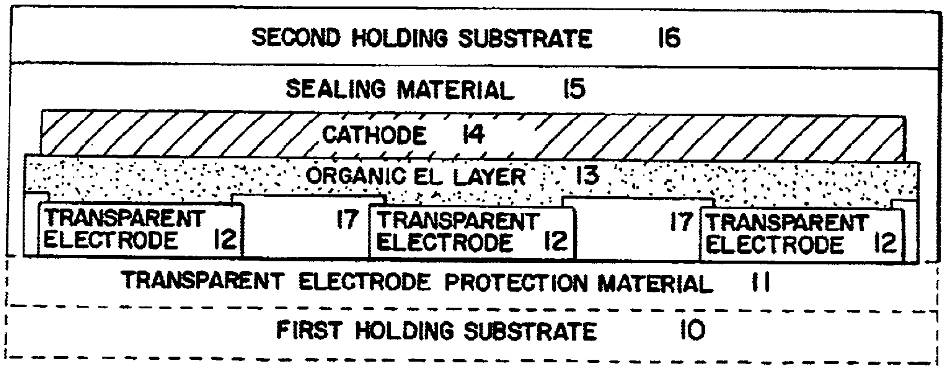
ORGANIC EL LAYER 13
TRANSPARENT ELECTRODE 12
TRANSPARENT ELECTRODE 12
TRANSPARENT ELECTRODE 12
TRANSPARENT ELECTRODE PROTECTION MATERIAL 11
FIRST HOLDING SUBSTRATE 10

FIG. 4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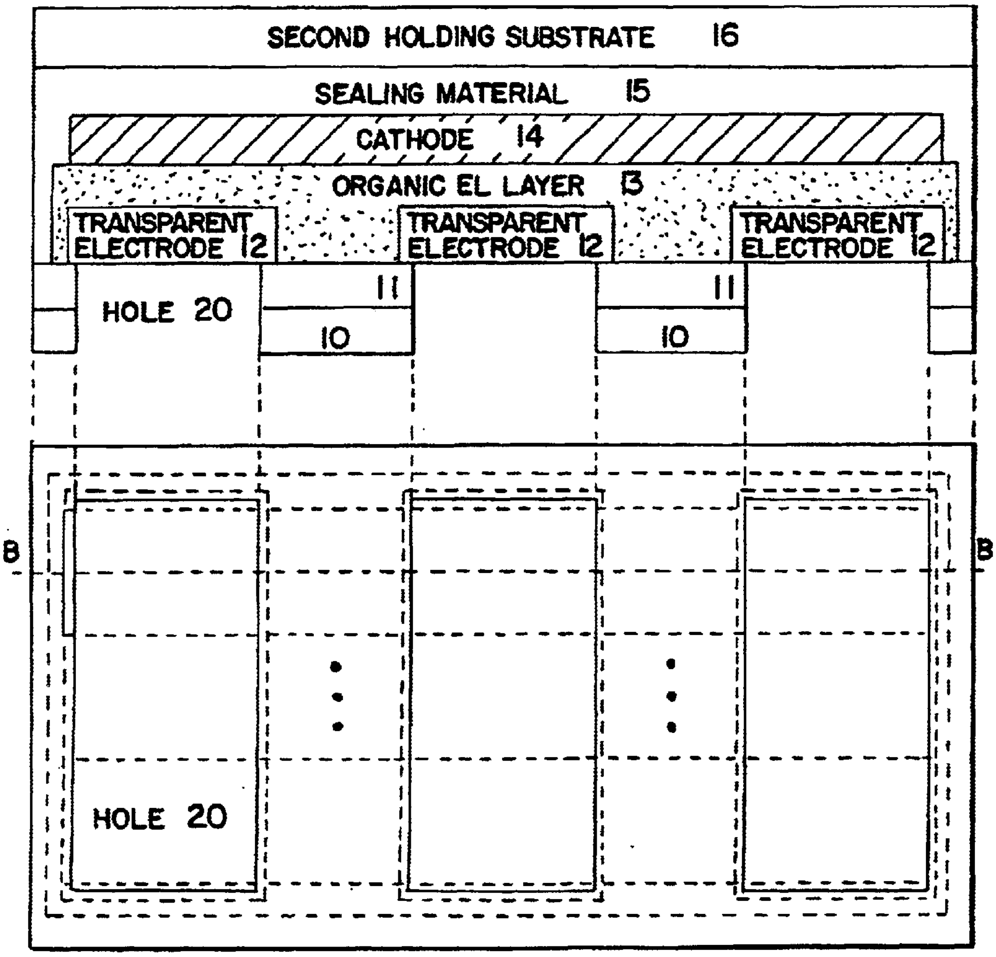
FIRST HOLDING SUBSTRATE 10

FIG. 5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TRANSPARENT ELECTRODE 12
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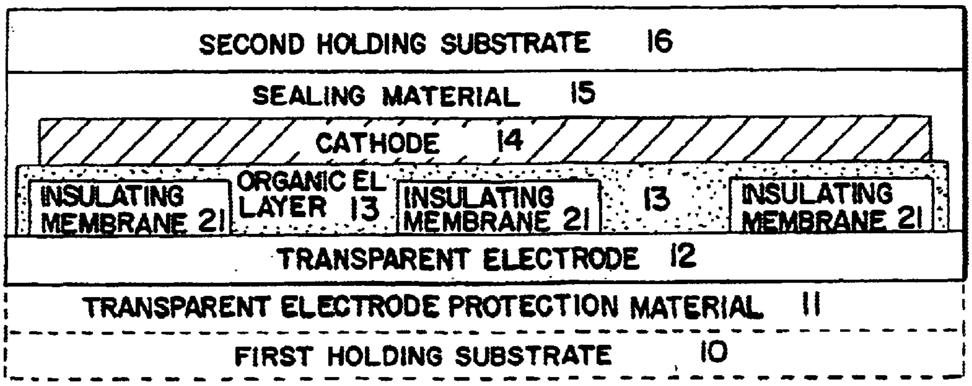
HOLE 20
11
10
11
10
B
B
HOLE 20

FIG. 6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INSULATING MEMBRANE 21
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INSULATING MEMBRANE 21
TRANSPARENT ELECTRODE 12
TRANSPARENT ELECTRODE PROTECTION MATERIAL 11
FIRST HOLDING SUBSTRATE 10

DISPLAY ELEMENT AND METHOD OF MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display element and a method of manufacturing a display element, and particularly, to a display element capable of efficiently emitting generated light externally and a method of manufacturing the display element.

2. Description of the Related Art

Conventionally, in the case of display elements which use, for example, an organic electroluminescent element or the like as a light emitting element, the organic electroluminescent element is typically formed over a glass substrate. FIGS. **2A** to **2C** are explanatory diagrams showing constructions and operations of a conventional display element. FIG. **2A** is an explanatory diagram showing an example construction of a first conventional element. Note, however, that in the diagram, each layer is depicted in an exaggerated fashion and differs from actual relative proportions.

The EL (electroluminescent) elements referred to in this specification include triplet-based light emission elements and/or singlet-based light emission devices, for example.

The conventional sequence for forming the film coating is to sputter a transparent electrode **31** (e.g., ITO: indium oxide-tin oxide alloy) on a glass substrate **30**, and then an organic electroluminescent layer **32** is formed by vapor deposition or by spin coating onto the substrate **31**, and a cathode **33** is evaporated. After that, sealing material **34** is used to adhere a facing substrate **35** to prevent deterioration of the organic electroluminescent layer **32** and the cathode **33** due to the atmosphere.

FIG. **2B** is an explanatory diagram showing an optical path in the first conventional example element. In the above-mentioned conventional structure the cathode material of the cathode **33** is a metal. Therefore, light emerges from the substrate **30** side (FIG. **2B**, optical path A), but, due to differences in the refraction indices of each of the layers, the light cannot escape from the front surface of the element at a angle greater than the critical angle (FIG. **2B**, optical paths B and C). Therefore, the emergence ratio of the light is $1/(2n^2)$; where n is the refraction index of the luminous layer **32** (approximately 1.6). Therefore, there was a problem that 80% of the light generated was guided inside the glass substrate **30** and escaped sideways.

In order to avoid this problem, a method has been proposed for forming the film coating on the glass substrate in the reverse sequence starting with the cathode. FIG. **2C** is an explanatory diagram showing a structure of a second conventional example element. The sequence for forming the film coatings was, first, to vapor deposit a cathode **36** on the glass substrate **30**. Then, after vapor depositing or spin coating an organic electroluminescent layer **37** for film coating, a transparent electrode **38** such as that of ITO was formed by sputtering. In this case it was necessary to sputter a transparent conducting film **38** such as that of ITO onto the electroluminescent film **37**, but there was a problem that the organic electroluminescent layer **37** was altered due to damage suffered and increased temperature experienced during sputtering.

SUMMARY OF THE INVENTION

An object of the present invention is to solve the above-mentioned problems in the prior art, and provide a display

element and a method of manufacturing a display element capable of effectively emitting generated light externally, without damaging the organic electroluminescent layer.

The present invention is characterized in that, after a light emitting element is manufactured in the same sequence as the first conventional example element (FIG. **2A**) and sealed, a holding substrate for forming a transparent electrode is removed by means of etching or the like.

According to the present invention, the holding substrate for forming the transparent electrode is removed, with the result that the emission rate generated at the electroluminescent layer is improved, and the brightness and contrast of the display element are improved.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is an explanatory diagram showing a structure of a first embodiment of a display element in accordance with the present invention;

FIGS. **2A** to **2C** are explanatory diagrams showing constructions and operations of a conventional display element; and

FIG. **3** is an explanatory diagram showing problems arising in the case of a simple matrix construction; and

FIG. **4** is an explanatory diagram showing a construction of a second embodiment of a display element in accordance with the present invention; and

FIG. **5** is an explanatory diagram showing a construction of a third embodiment of a display element in accordance with the present invention; and

FIG. **6** is an explanatory diagram showing a construction of a fourth embodiment of a display element in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, detailed explanation is made of the embodiments of the present invention.

Embodiment 1

FIG. **1** is an explanatory diagram showing a construction of and a method of manufacturing a first embodiment of a display element in accordance with the present invention. The sequence for depositing an organic electroluminescent display element in the first embodiment of the present invention is, first, to deposit a transparent electrode protection material **11** onto of a first holding substrate **10** made of glass, for example. After sputtering a transparent electrode **12** on the transparent electrode protection material **11**, an organic electroluminescent layer **13** is formed by vapor depositing or by spin coating, and cathode **14** is vapor deposited. After that, a sealing material **15** is used to adhere a second holding substrate **16**. Then, the first holding substrate **10** and the transparent electrode protection material are etched and removed in sequence.

(The First Holding Substrate)

The first holding substrate **10** may be formed of a metal, an inorganic substrate or a polymer other than glass, as far as the first holding substrate **10** thus formed has excellent surface smoothness (i.e. the surface smoothness roughly equivalent to that of standard glass substrates having transparent electrodes). However, the substrate is needed to be removed partially or entirely after sealing by using the second holding substrate **16**, for example. The first holding substrate **10** is removed last; therefore, provided that the substrate is strong enough to hold the light emitting elements (**12–14**) until the time of sealing, then the thinner the substrate is the better. The etching of the first holding substrate **10** can be conducted and the substrate may be entirely removed without patterning, or it is possible, for example, to remove only a portion of the light-emitting portion. Examples of usable materials for the first holding substrate **10** are shown in Chart 1.

Chart 1

Material		Etchant
Glass, inorganic substances	Silica glass	Hydrofluoric acid, Fluoric nitric acid
	Titanium oxide	Thermal condensed sulfuric acid; Sodium hydroxide
	Silicon	Hydrofluoric acid, Fluoric nitric acid
Metal	Aluminum	Hydrochloric acid, Rare sulfuric aid, Nitric acid
	Titanium	Hydrofluoric acid
Polymer	PMMA	Toluene, Chloroform
	Polycarbonate	Chloroform, Acetone, DMF

(The Transparent Electrode Protection Material)

For the transparent electrode protection material **11** formed to the first holding substrate **10** by, for example, spin coating, it is preferable to use a material that resists the etchant (etching material) of the first holding substrate **10**, and can resist the heat and light (i.e., plasma light from the sputter, etc.) when the transparent electrode **12** is deposited and formed.

The role of the transparent electrode protection material **11** is to act as an etching stopper when the first holding substrate **10** is etched. Therefore, it is not necessary for the transparent electrode protection material **11** to be present when the first holding substrate **10** is to be etched in the case either when an etchant can be used which will not melt the transparent electrode **12**, or when complete time control for the etching is possible.

The transparent electrode protection material **11** is preferably a material which can be removed after etching the first holding substrate **10**. The transparent electrode protection material **11** can also be non-transparent if it can be removed completely. Further, it is not necessary for the transparent electrode protection material **11** to be transparent in the case when the transparent electrode protection material **11** is to be removed in the thickness direction. However, it is preferable that light not be absorbed in the visible light area. Chart 2 shows materials that can be used for the transparent electrode protection material **11**.

Chart 2

Material	Etchant
Norbornen polymer	Toluene, Chloroform
Polystyrene	Toluene, THF
Polycarbonate	Chloroform, Acetone, DMF
Copper phthalocyanine	Chloroform, Acetone
Resist material	Acetone
Acryl	(O_2 Plasma dry etching)

(The Transparent Electrode)

The transparent electrode **12** is made of ITO, for example, and has a film thickness of 80 nm–150 nm, for example. Further, in order to minimize guided waves in the film, it is preferable that the transparent electrode **12** itself be thin. Note that for the transparent electrode **12**, the organic electroluminescent layer **13**, and the cathode **14** of metal or the like, it is possible to adopt and use exactly the same materials and depositing methods as for the organic electroluminescent light-emitting element in the conventional and known art.

(The Sealing Material)

For the sealing material, it is preferable to use a material which can resist the etchant for the first substrate and the transparent electrode protection material. In the case that a non-resisting material is used, the first holding substrate and the transparent electrode protection material are etched after protecting bare parts of the sealing material for the side face of the substrate. Materials such as epoxy resin, optical curing epoxy resin, optical curing acrylic resin can be used for the sealing material.

(The Second Holding Substrate)

It is desirable that the etchant used for the second holding substrate **16** be different from that used for the first holding substrate **10**. In the case that the second holding substrate **16** has resistance against the etchant for the first holding substrate **10**, consideration does not have to be made for the protecting of the second holding substrate **16** when etching the first holding substrate **10**, so the process is simple and easy. The second substrate **16** is no necessary in the case that strength can be maintained merely by means of the sealing material **15** after the etching of the first holding substrate **10** and the transparent electrode protection material **11**.

Materials such as, for example, sheet glass, sheet metals such as aluminum, polyethylene, polycarbonate, polyimide or other polymer sheets can be used for the material of the second holding substrate **16**. Note, however, that plastics may be used for the sealing material and the second holding substrate so that a flexible display element can be manufactured.

The construction of a display element, according to the first embodiment as shown in FIG. **1**, is such that the transparent electrode **12** is exposed. Therefore, almost all of the light that was guided into the glass substrate **30** in conventional display elements (FIG. **2**B, optical path B) is emitted externally through the transparent electrode. Thus, the emission rate is improved as compared with the conventional display element.

Embodiment 2

Next, explanation is made of a second embodiment. FIG. **3** is an explanatory diagram showing problems arising in the case of a simple matrix construction. When a plurality of pixels address independently, as they do in a simple matrix construction, patterning of the transparent electrode **12** becomes necessary. In this case, there is the problem that the organic electroluminescent layer **13** comes into direct contact with the etchant during the etching of the transparent electrode protection material **11** and, moreover, the light emission side of the organic electroluminescent layer **13** is partially exposed to the atmosphere.

FIG. **4** is an explanatory diagram showing a construction according to the second embodiment of the display element of the present invention in the case when the present invention is constructed in a simple matrix construction. In the case that it is desired that the organic electroluminescent layer **13** be protected from the etchant for the transparent electrode protection material **11**, that exposure of the organic electroluminescent layer **13** to the atmosphere be prevented, an organic electroluminescent protection material **17** is deposited on the portions where the transparent electrode **12** was not formed after patterning the transparent electrode **12**. In order to prevent tearing of the cathode **14**, the thickness of the organic electroluminescent protection material **17** is preferably less than the combined thickness of the transparent electrode **12** and the organic electroluminescent layer **13**, for example, 150 nm. Such materials as, for example, silica glass, acrylic resin, polyimide resin, etc. can be used as the material of the protection material **17**.

Embodiment 3

Next, explanation is made of a third embodiment. FIG. **5** is an explanatory diagram showing a construction of a third embodiment of the display element of the present invention when the display element of the present invention is constructed in a simple matrix construction. In the case that the organic electroluminescent protection material **17** is not used, parts of the first holding substrate **10** and the transparent electrode protection material **11** are etched and the first holding substrate **10** and the transparent electrode protection material **11** are removed only where the transparent electrode **12** exists, so as not to expose the organic electroluminescent layer **13**.

FIG. **5** is an example in which the first holding substrate **10** and the transparent electrode protection material **11** on the transparent electrode **12** are removed in the shape of a line, and holes **20** are formed. The upper diagram is a cross-sectional view along the line B—B, and the lower diagram is a diagram viewing the display element from the side of the first holding substrate **10**. The lower diagram is an abbreviated depiction. The simple matrix is constructed by positioning tens or hundreds of cathodes **14** and transparent electrodes **12** in a grid. The holes **20** do not have to be provided in a line shape, but can also be provided in a rectangle (or square) shape only where the cathode **14** and the transparent electrodes **12** overlap.

When the display element is constructed as shown in FIG. **5**, the first substrate **10** and the transparent electrode protection material **11** surround the light-emitting area. Therefore, the contrast of the display element can be improved by either the first substrate **10** or the transparent electrode protection material **11** being black, for example.

Embodiment 4

FIG. **6** is an explanatory diagram showing a construction of a fourth embodiment of the display element of the present invention. Embodiment 4 is a method of controlling the light-emitting location without patterning the transparent electrode. Embodiment 4 is a method of sandwiching SiO_2, a resist, or other such insulating film **21** at the portions where it is not desired that light be emitted from the electrode **12** that has been formed to the entire surface. In this case, in order that the insulating membranes **21** do not tear the organic electroluminescent layer **13** at the time when the organic electroluminescent layer **13** is deposited and formed, it is desirable to form the insulating membranes **21** at a thickness of 100 nm or less. When the display element is constructed according to this method, electronic current potential screening is performed across the entire surface of the transparent electrode **12**. The light-emitting region, therefore, is not controlled in parts. Instead, patterning methods for fixed, still images or for plane emission are used.

Next, explanation is made of specific examples of combinations of materials used for each layer and of manufacturing processes. Materials Example 1 is an example in which glass is used for the first holding substrate **10**, polystyrene is used for the transparent electrode protection material **11**, and aluminum is used for the second holding substrate **16**, for the display element of Embodiment 1.

Materials Example 1

1. The transparent electrode protection material (polystyrene) is spin coated onto the first holding substrate (glass).

2. The transparent electrode (ITO) is sputtered onto the substrate described in 1.

3. The organic electroluminescent layer is produced on the substrate described in 2.

4. After sealing the organic electroluminescent layer on the substrate described in 3, the substrate is held by means of the second holding substrate (aluminum).

5. The first holding substrate of the substrate described in 4 is melted by means of hydrofluoric acid.

6. The polystyrene of the substrate described in 5 is melted by means of toluene.

Materials Example 2 is an example in which aluminum is used for the first holding substrate **10**, polycarbonate is used for the transparent electrode protection material **11**, and glass is used for the second holding substrate **16**, for the display element of Embodiment 2.

Materials Example 2

1. The transparent electrode protection material (polycarbonate) is spin coated onto the first holding substrate (aluminum).

2. The transparent electrodes (ITO) are sputtered onto the substrate described in 1.

3. The transparent electrodes on the substrate described in 2 are patterned.

4. The organic electroluminescent protection material (SiO_2) is sputtered onto the substrate described in 3, and the exposed portions of the transparent electrode protection material are coated. After forming the film layer, the SiO_2 coating covering the transparent electrodes is reverse-sputtered, and surfaces of the transparent electrodes are exposed.

5. The organic electroluminescent layer is produced on the substrate described in 4.

6. After sealing the organic electroluminescent layer on the substrate described in 5, the substrate is held by means of the second holding substrate (glass).

7. The first holding substrate (aluminum) described in 6 is melted by means of hydrochloric acid.

8. The polycarbonate of the substrate described in 7 is melted by means of toluene.

Materials Example 3 is an example in which, glass is used for the first holding substrate **10**, acryl is used for the transparent electrode protection material **11**, and titanium oxide is used for the second holding substrate **16**, for the display element of Embodiment 3.

Materials Example 3

1. The transparent electrode protection material (acryl) is spin coated onto the first holding substrate (glass).

2. The transparent electrodes (ITO) are sputtered onto the first substrate described in 1.

3. The transparent electrodes on the substrate described in 2 are patterned.

4. The organic electroluminescent layer is produced on the substrate described in 3.

5. After sealing the organic electroluminescent layer on the substrate described in 4, the substrate is held by means of the second holding substrate (titanium oxide).

6. The first holding substrate (glass) of the substrate described in 5 is patterned with the resists, and after etching

only the portions where the transparent electrodes are arranged, the resists are then removed.

7. The acryl of the substrate described in 6 is removed by means of O_2 plasma only where the first holding substrate was removed.

In the present invention, the construction described above enables the first holding substrate to be removed and, if the transparent electrode or electrodes are thin enough, light is not wave-guided. An effect is thereby produced such that the emission rate from the electroluminescent layer is improved. Further, by raising the emission ratio, there is also an effect such that the same brightness as is obtained from standard elements can be obtained with lower voltage, and greater longevity and energy-saving are also made possible.

Further, the method of the present invention also produces the effect that it is not necessary to be concerned with the damage that was mentioned in connection with the prior art and that is suffered when the transparent electrode film is sputtered or otherwise deposited on the organic electroluminescent layer according to the method that begins by forming the cathode.

Additionally, there was the problem that in the case when the plastic substrate was used to manufacture the display element, the temperature during the deposition of the transparent electrode or electrodes had to be kept low. However, with the present invention, it is possible to realize a polymer second holding substrate without concern for the temperature.

What is claimed is:

1. A method of manufacturing a display device, comprising:

forming a light-emitting element over a substrate for emitting light on a side of the substrate;

holding said light-emitting element from an opposite side of said substrate; and

removing at least a portion of said substrate completely through a thickness direction,

wherein said light-emitting element comprises a transparent electrode, an organic electroluminescent layer and a cathode.

2. A method according to claim **1**, wherein said substrate comprises a holding substrate and a transparent electrode protection material layer.

3. A method of manufacturing a display device, comprising:

forming a light emitting element over a first substrate;

holding the light emitting element by using a second substrate over the light emitting element; and

removing at least a portion of the first substrate completely through a thickness direction by etching,

wherein the step of forming the light emitting element comprises:

forming at least a first electrode;

forming an electroluminescence layer over the first electrode; and

forming a second electrode over the electroluminescence layer.

4. A method according to claim **3**, wherein the electrolumiescence layer comprises an organic material.

5. A method according to claim **3**, wherein the first electrode is an anode.

6. A method according to claim **3**, wherein the first electrode is transparent.

7. A method according to claim **3**,

wherein a plurality of the first electrodes are formed in the step of forming at least a first electrode,

wherein the method further comprises forming a plurality of layers for protecting the electroluminescence layer between the plurality of first electrodes before forming the electroluminescence layer over the plurality of first electrodes.

8. A method according to claim **3**, further comprising an insulating layer over the first electrode.

9. A method according to claim **3**, further comprising forming a layer as an etching stopper between the first substrate and the first electrode.

10. A method according to claim **9**, further comprising removing the layer as an etching stopper after the step of removing at least the portion of the first substrate.

11. A method according to claim **10**, wherein the first substrate and the layer as an etching stopper is removed in a region under the first electrode.

12. A method of manufacturing a display device, comprising:

forming a light emitting element over a first substrate;

holding the light emitting element by using a second substrate over the light emitting element; and

removing one portion or a plurality of portions of the first substrate,

wherein the step of forming the light emitting element comprises:

forming at least a first electrode;

forming an electroluminescence layer over the first electrode; and

forming a second electrode over the electroluminescence layer.

13. A method according to claim **12**, wherein the electrolumiescence layer comprises an organic material.

14. A method according to claim **12**, wherein the first electrode is an anode.

15. A method according to claim **12**, wherein the first electrode is transparent.

16. A method according to claim **12**, further comprising an insulating layer over the first electrode.

17. A method according to claim **12**,

wherein a plurality of first electrodes are formed in the step of forming at least a first electrode,

wherein the first substrate is removed in a plurality of portions under the first electrodes.

18. A method according to claim **17**,

wherein the method further comprises forming a plurality of layers for protecting the electroluminescence layer between the plurality of first electrodes before forming the electroluminescence layer over the plurality of first electrodes.

19. A method according to claim **12**, further comprising forming a layer as an etching stopper between the first substrate and the first electrode.

20. A method according to claim **19**, further comprising removing the layer as an etching stopper after the step of removing the portion of the first substrate.

21. A method according to claim **20**, wherein the first substrate and the layer as an etching stopper is removed in a region under the first electrode.

22. A method of manufacturing a display device, comprising:

forming a light-emitting element over a first substrate;

disposing a sealing material on the first substrate;

adhering a second substrate on the sealing material; and

removing at least a portion of the first substrate completely through a thickness direction of the first substrate, wherein the light-emitting element comprises:

a first electrode;

an electroluminescence layer over the first electrode; and

a second electrode over the electroluminescence layer.

23. A method according to claim **22**, wherein the electrolumiescence layer comprises an organic material.

24. A method according to claim **22**, wherein the first electrode is an anode.

25. A method according to claim **22**, wherein the first electrode is transparent.

26. A method according to claim **22**, further comprising forming an insulating layer over a portion of the first electrode.

27. A method according to claim **22**, wherein at least the portion of the first substrate is removed by etching.

28. A method according to claim **27**, further comprising forming a layer as an etching stopper between the first substrate and the first electrode.

29. A method according to claim **28**, further comprising removing the layer as an etching stopper after the step of removing at least the portion of the first substrate.

30. A method according to claim **29**, wherein the first substrate and the layer as an etching stopper is removed in a region under the first electrode.

* * * * *

专利名称(译)	显示元件及其制造方法
公开(公告)号	US6866555
公开(公告)日	2005-03-15
申请号	US09/907133
申请日	2001-07-17
[标]申请(专利权)人(译)	株式会社半导体能源研究所
申请(专利权)人(译)	半导体能源研究所有限公司.
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摘要(译)

提供一种能够在外部有效地发射所产生的光的显示元件和制造该显示元件的方法，而不损坏有机电致发光层。首先，在第一保持基板（10）上沉积透明电极保护材料（11）;然后在其上制造有机电致发光元件（12,13,14）;然后，在用密封材料（15）和第二保持基板（16）密封和保持之后，通过蚀刻等去除第一保持基板（10）和透明电极保护材料（11）。根据本发明，去除第一保持基板（10）能够改善在电致发光层（13）中产生的发光率，并改善显示元件中的亮度和对比度。