



US008421349B2

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

(10) **Patent No.:** **US 8,421,349 B2**  
(45) **Date of Patent:** **Apr. 16, 2013**

(54) **DISPLAY DEVICE WITH IMPROVED  
MOISTURE PREVENTION**

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(\*) 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.: **13/298,960**

(22) Filed: **Nov. 17, 2011**

(65) **Prior Publication Data**

US 2012/0062107 A1 Mar. 15, 2012

#### **Related U.S. Application Data**

(63) Continuation of application No. 11/193,864, filed on  
Jul. 29, 2005, now Pat. No. 8,080,936.

(30) **Foreign Application Priority Data**

Aug. 12, 2004 (JP) ..... 2004-235125

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

(52) **U.S. Cl.**  
USPC ..... **313/506**; 313/509

(58) **Field of Classification Search** ..... 313/498–512;  
428/690–691, 917; 438/26–29, 34, 82; 257/40,  
257/72, 98–100, 642–643, 759; 427/532–535,  
427/539

See application file for complete search history.

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*Primary Examiner* — Anh Mai

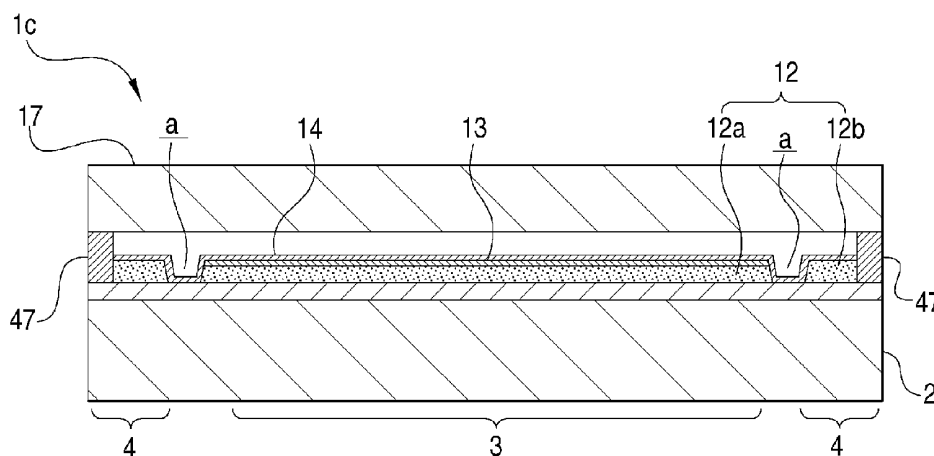
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(57) **ABSTRACT**

In a display device including, a display area having a plurality  
of organic EL devices on a substrate; a peripheral area having  
a driving circuit for the organic EL devices and surrounding  
the display area on the substrate; and an organic insulating  
film covering at least the driving circuit, the organic insulat-  
ing film has a separating groove which divides itself into the  
inner part and outer part at the periphery of the display area.

**12 Claims, 6 Drawing Sheets**



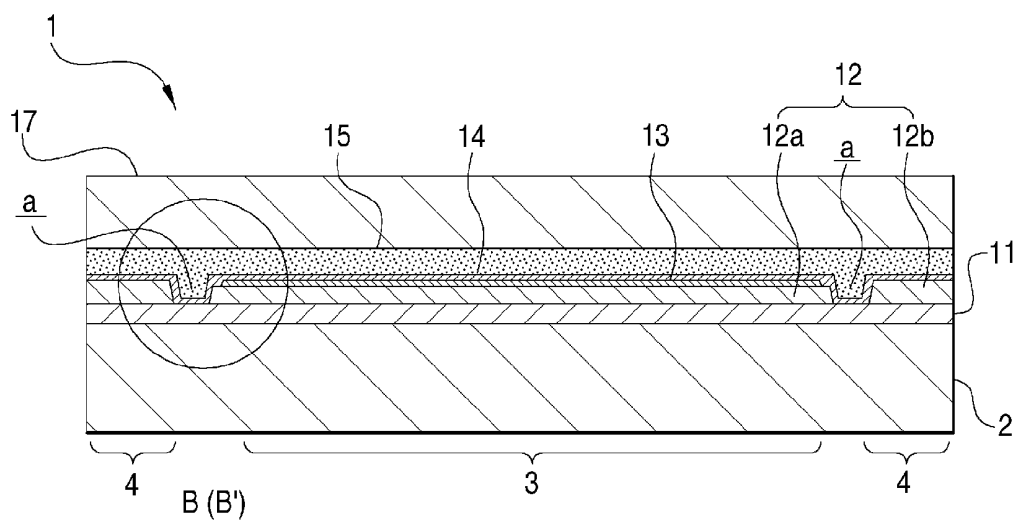
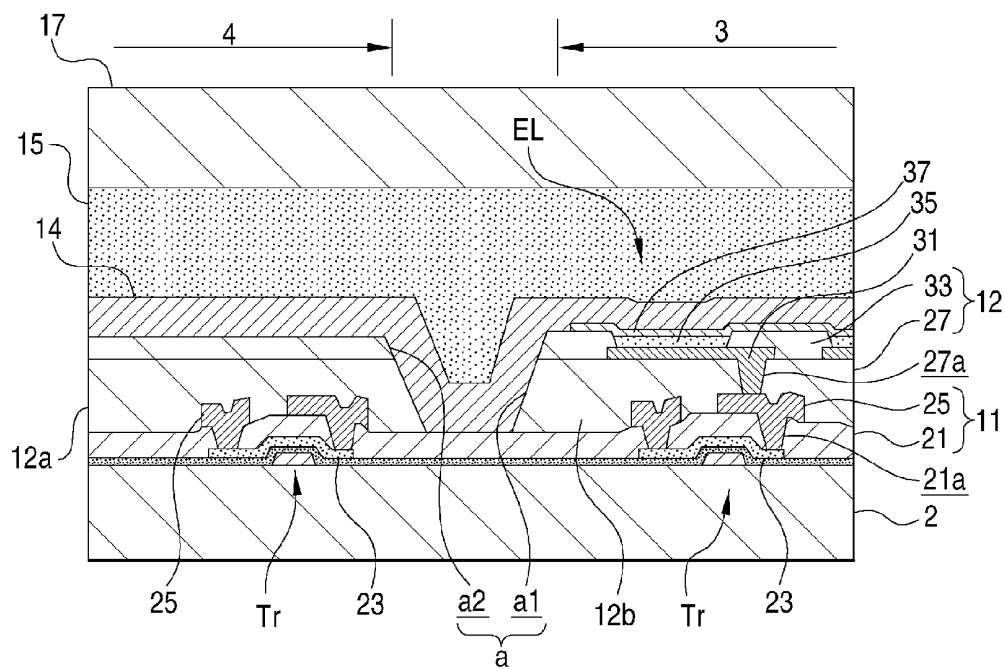
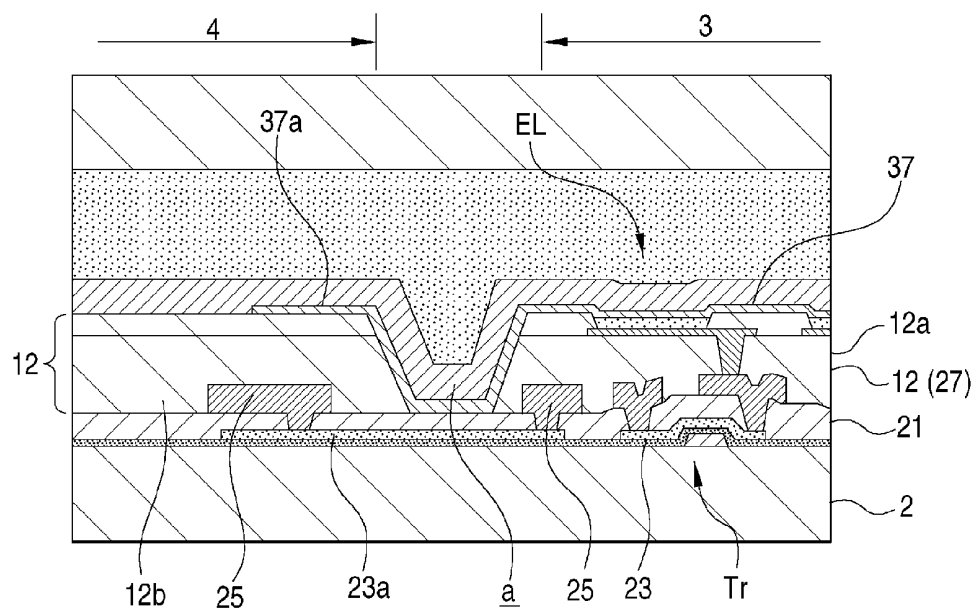
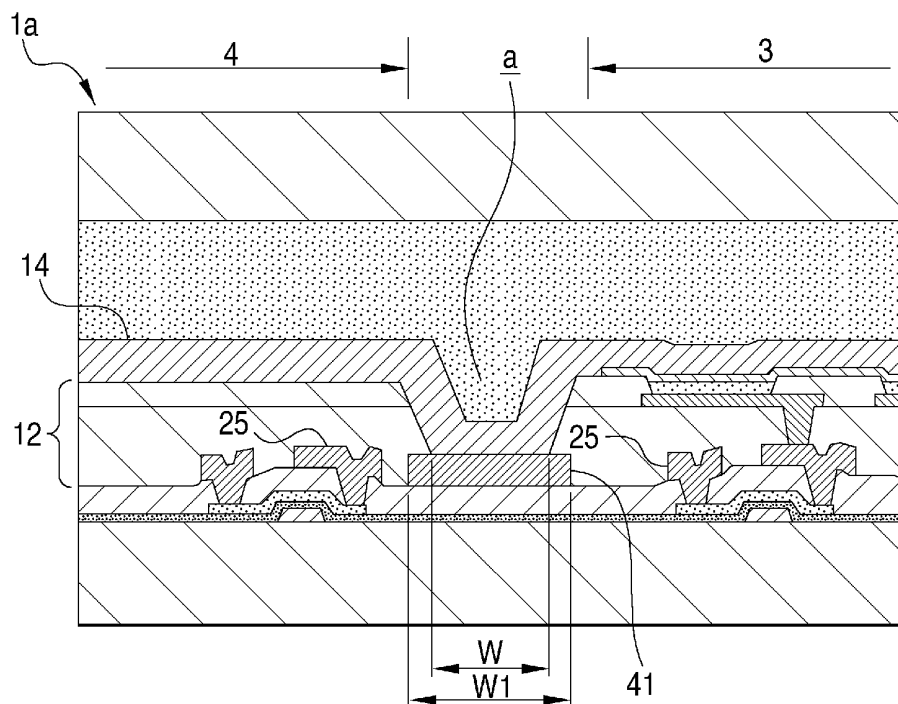
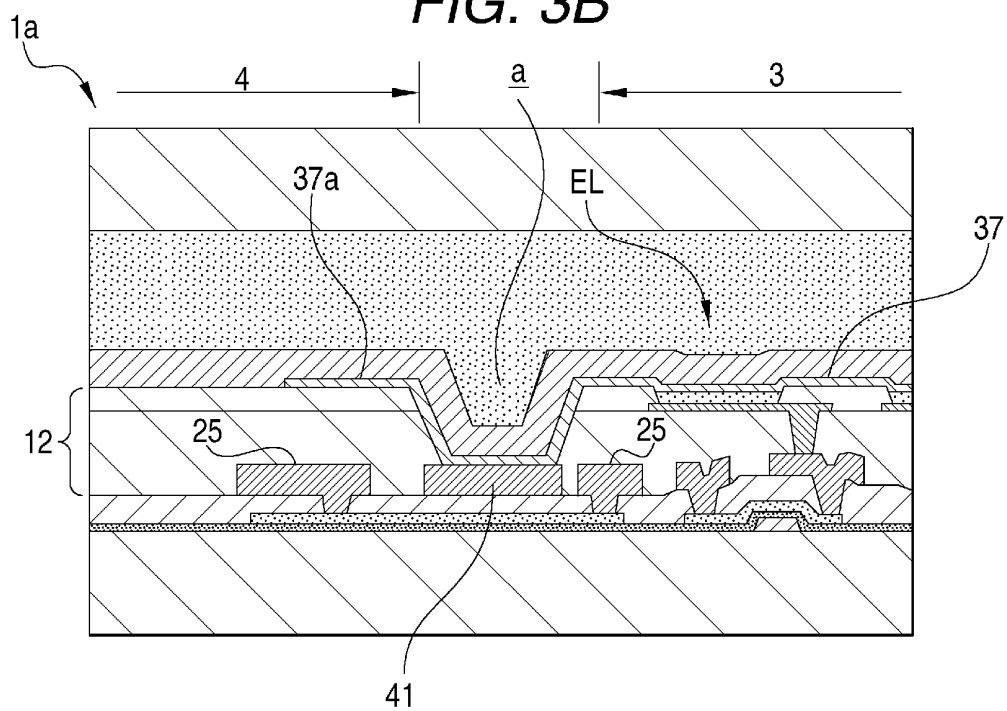


FIG. 2A



**FIG. 2B**



*FIG. 3A**FIG. 3B*

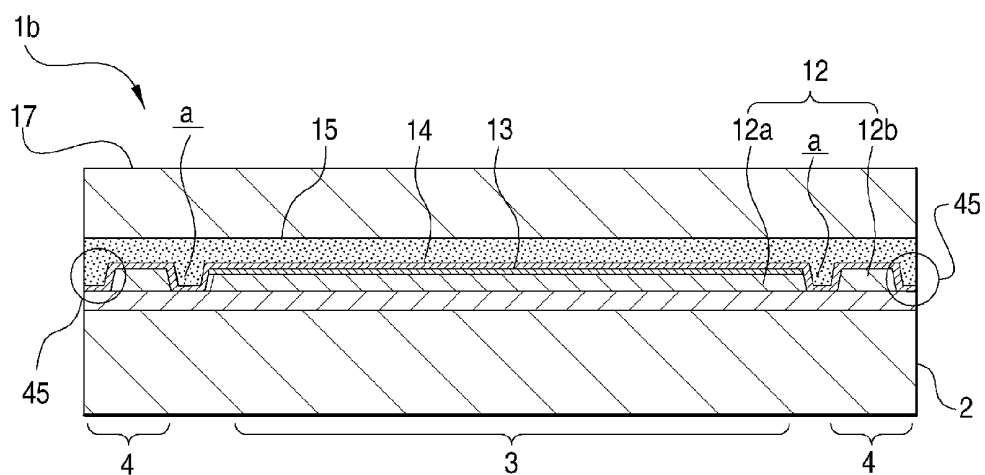


FIG. 5

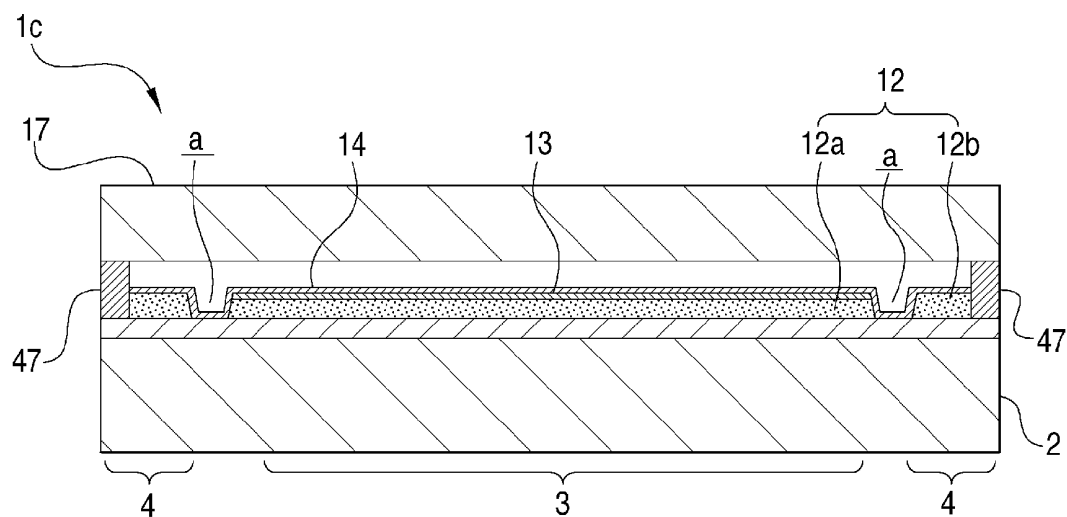
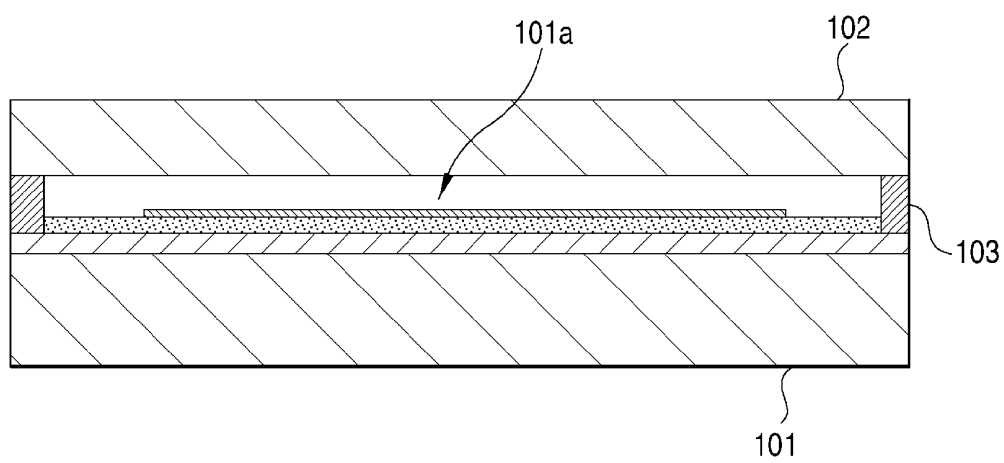
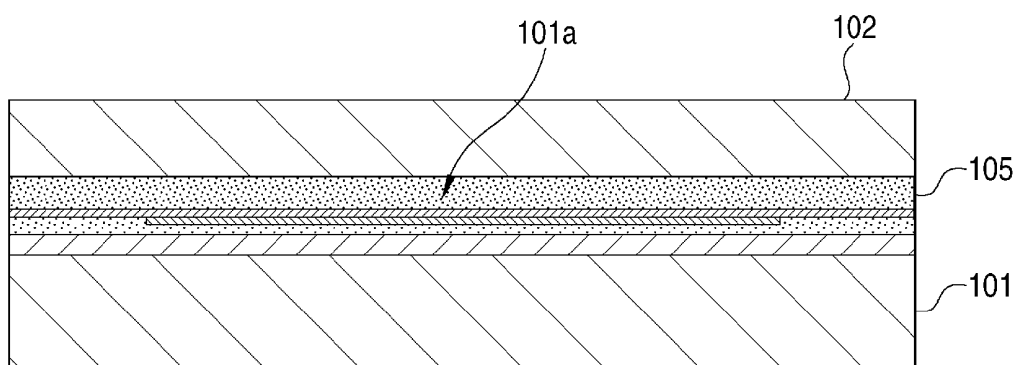


FIG. 6



*FIG. 7*

# DISPLAY DEVICE WITH IMPROVED MOISTURE PREVENTION

## RELATED APPLICATION DATA

This application is a continuation of U.S. patent application Ser. No. 11/193,864, filed Jul. 29, 2005, the entirety of which is incorporated herein by reference to the extent permitted by law. The present application claims priority to Japanese Patent JP2004-235125 filed in the Japanese Patent Office on Aug. 12, 2004, the entirety of which also is incorporated by reference herein to the extent permitted by law.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a display device and particularly relates to a display device suitable for the application to an organic EL display device.

### 2. Description of the Related Art

An organic EL device containing an organic material, electroluminescence (called EL hereinafter), is now popular as a light-emitting device, which can emit high intensity light through low-voltage direct-current driving. However, in such a device including organic EL devices (that is, an organic EL display device), moisture may deteriorate an organic layer of the device, which may lower the intensity of emitted light in each of the devices and/or may cause unstable light emission.

Conventionally as shown in FIG. 6, the organic EL devices on the substrate **101** are sealed by a cover member **102** and a sealant **103**. Also, a rigid carbon film may be further provided at the outside of the sealant **103**. Thus, the organic EL devices on the substrate **101** can be shielded from the outside, especially from moisture and oxygen which may cause the oxidation of the organic EL devices and prompt the deterioration of the devices (see Patent Document 1 below).

In FIG. 7, the cover member **102** is bonded via an adhesive **105** onto a device side **101a** of the substrate **101** having organic EL devices and/or a circuit.

Patent Document 1: JP-A-2002-93576

## SUMMARY OF THE INVENTION

However, in such devices, the spread of the moisture remaining within the display device is not completely prevented.

In particular, an inter-layer insulating film covering a driving circuit is made of an organic photo-sensitive material and allows water to pass through easily. Therefore, the moisture left within the display device easily spread via the inter-layer insulating film.

Accordingly, it is desirable to propose a display device which can prevent the deterioration of organic EL devices due to the spread of moisture remaining within the display device for higher long-term reliability.

According to an embodiment of the present invention, there is provided a display device including, a display area having a plurality of organic EL devices on a substrate; a peripheral area having a driving circuit for the organic EL devices and surrounding the display area on the substrate; and an organic insulating film covering at least the driving circuit, the organic insulating film has a separating groove which divides itself into the inner part and outer part at the periphery of the display area.

In such a device, the separating groove divides the organic insulating film into the inner part and outer part. Therefore, the deterioration of the organic EL devices due to moisture in

the display area can be reduced by preventing moisture in the outer part of the organic insulating film from moving into the inner part of the organic insulating film. The separating groove is preferably provided between the display area and the peripheral area, so that the moisture in the peripheral area is prevented from moving into the display area through the organic insulating film.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are diagrams showing a construction of a display device of a first embodiment;

FIGS. 2A and 2B are main part enlarged section views showing a construction of the display device of the first embodiment;

FIGS. 3A and 3B are main part enlarged section views showing a construction of a display device of a second embodiment;

FIGS. 4A and 4B are diagrams showing a construction of a display device of a third embodiment;

FIG. 5 is a schematic section view showing a construction of a display device of a fourth embodiment;

FIG. 6 is a schematic section view showing a construction of a display device in the past; and

FIG. 7 is a schematic section diagram showing another construction of a display device in the past.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of a display device of the invention will be described below in detail with reference to drawings.

### First Embodiment

FIG. 1A is a plan view showing a construction of a display device of a first embodiment, and FIG. 1B is a schematic section view taken at Line A-A' in FIG. 1A.

First of all, as shown in the plan view in FIG. 1A, a display device **1** is an organic EL display device including organic EL devices EL serving as light emitting elements. On a substrate (which is a supporting substrate here) **2**, the display device **1** includes a display area **3**, a peripheral area **4** surrounding the display area **3**, and an implemented area **5**. The substrate **2** is made of a transparent material such as glass. The display area **3** has a plurality of organic EL devices EL. An IC chip and/or a circuit substrate are implemented on the implemented area **5**.

In the display area **3**, each of pixels on the supporting substrate **2** has an organic EL device EL. When the display device **1** is an active-matrix display device, each pixel has an organic EL device and a pixel circuit (not shown) for driving the organic EL device. Each of the pixel circuits has a thin-film transistor serving as a switching element.

The peripheral area **4** surrounding the display area **3** has driving circuits (not shown) for transmitting a scan signal and/or a data signal to the organic EL devices EL. Each of the driving circuits includes a thin-film transistor. The driving circuits in the peripheral area **4** are connected to each other.

The implemented area **5** may have an array of terminals **6** for inputting an external signal to the driving circuits in the peripheral area **4**, for example.

The display device **1** including the display area **3**, peripheral area **4** and implemented area **5** as described above has the construction as shown in FIGS. 1A and 1B. In other words, a circuit-formed layer **11** (shown in the section view only) is provided on the supporting substrate **2**. The circuit-formed



layer 11 has the pixel circuits in the display area 3 and driving circuits in the peripheral area 4. An organic insulating film 12 covers the circuit-formed layer 11 on the supporting substrate 2. Here, the organic insulating film 12 serves as a flattening insulating film.

An EL layer 13 (shown in the section view only) is provided on the surface flattened by the organic insulating film 12. The EL layer 13 has a plurality of organic EL devices EL. An inorganic insulating film 14 (shown in the section view only) covers the organic EL devices EL (that is, EL layer 13) in the display area 3 and peripheral area 4. Notably, the implemented area 5 does not have the inorganic insulating film 14.

The display area 3 and peripheral area 4 covered by the inorganic insulating film 14 further have an adhesive layer 15 (shown in the section view only). The supporting substrate 2 is bonded to an opposite substrate 17 through the adhesive layer 15 so that the organic EL devices EL in the display area 3 can be sealed. The adhesive layer 15 contains an extremely low pervious material.

In the plan view in FIG. 1A, a part of the organic insulating film 12 and opposite substrate 17 is cut out for easy description.

In the display device 1 of the first embodiment having this layer structure as described above, the organic insulating film 12 has a separating groove a. The separating groove a separates the organic insulating film 12 into an inner part 12a and outer part 12b.

The separating groove a is a groove-shaped part resulting from the complete removal of the organic insulating film 12 and at least surrounds a part of the display area 3 and preferably surrounds the entire circumference of the display area 3. The separating groove a is further preferably provided between the display area 3 and the peripheral area 4 as shown in FIG. 1A.

FIG. 2A shows an enlarged section view of Part B in the schematic section diagram in FIG. 1B, and FIG. 2B shows an enlarged section view of Part B' in the schematic section view in FIG. 1B. Note that Parts B and B' overlap one another in the depth direction in FIG. 1B. Detailed layer structures of the separating groove a and the surrounding will be described with reference to FIGS. 1A and 1B and based on the enlarged section views in FIGS. 2A and 2B.

As shown in FIG. 2A, the display area 3 and peripheral area 4 on the supporting substrate 2 have thin-film transistors Tr included in the pixel circuit and driving circuits, and an inorganic insulating film 21 covers the thin-film transistors Tr therein. A wiring 25 is provided on the inorganic insulating film 21. The wiring 25 is connected to a semiconductor layer 23 included in the sources and drains of the thin-film transistors Tr through connection holes 21a in the inorganic insulating film 21. The thin-film transistors Tr and wiring 25 are included in the pixel circuits of the display area 3 and the driving circuits of the peripheral area 4. These components described up to this point are included in the circuit-formed layer 11 described with reference to FIG. 1B.

A first organic insulating film 27 covers the wiring 25 on the inorganic insulating film 21. The first organic insulating film 27 contains a photo-sensitive compound and is coated as a flattening insulating film. The first organic insulating film 27 has a separating groove a1 between the display area 3 and the peripheral area 4 so that the display area 3 is surrounded. The separating groove a1 is formed by lithography processing.

The display area 3 on the first organic insulating film 27 has a plurality of organic EL devices EL. The organic EL devices EL have a lower electrode 31 connecting to the wiring 25 through a connection hole 27a in the first organic insulating

film 27. The lower electrode 31 is to be used as an anode (or cathode) and is patterned as a pixel electrode. The periphery of the lower electrode 31 is covered by a second organic insulating film 33 and is widely exposed at the center part only. The second organic insulating film 33 may contain a photo-sensitive compound, for example. Lithography processing is used to form an opening above the lower electrode 31 and a separating groove a2 over the separating groove a1 of the first organic insulating film 27.

Thus, according to the first embodiment, the first organic insulating film 27 and the second organic insulating film 33 are included in the organic insulating film 12 described with reference to FIGS. 1A and 1B. The separating groove a1 in the first organic insulating film 27 and the separating groove a2 in the second organic insulating film 33 form the separating groove a described with reference to FIGS. 1A and 1B.

An organic layer 35 including a light-emitting layer at least is patterned and stacked on the lower electrodes 31 exposing from the second organic insulating film 33. The light-emitting layer in the organic layer 35 contains an organic material, which emits light in response to the re-coupling of positive holes and electrons implanted to the light-emitting layer. An upper electrode 37 is provided on the patterned organic layer 35 and the second organic insulating film 33. Here, the upper electrode 37 is isolated from the lower electrode 31. The upper electrode 37 is to be used as a cathode (or anode), is provided as an electrode common to the organic EL devices EL and covers the display area 3.

Here, the EL layer 13 described with reference to FIG. 1B is the layer having a plurality of organic EL devices EL in the construction as described above.

The inorganic insulating film 14 and adhesive layer 15 cover the organic insulating film 12 and organic EL devices EL, and the opposite substrate 17 is provided thereon.

As shown in FIG. 2B, the upper electrode 37 for the organic EL devices EL has an end extending as an upper electrode wiring 37a in the peripheral area 4 and connecting, at predetermined positions, to the driving circuits in the peripheral area 4. Thus, the upper electrode wiring 37a extends to the peripheral area 4 across the separating groove a surrounding the display area 3. Therefore, securing an enough thickness of the organic insulating film 12 (that is, the first organic insulating film 27) is important for maintaining isolation between the wiring 25 in the display area 3 and the peripheral area 4 and the upper electrode wiring 37a.

At place where the upper electrode wiring 37a crosses the separating groove a, the wiring 25 in the display area 3 and the wiring 25 in the peripheral area 4 are connected through a connection wiring below the inorganic insulating film 21. In this case, for example, the semiconductor layer part of the same layer as the semiconductor layer 23 included in the thin-film transistors Tr may be a connection wiring 23a so that the connection wiring 23a can connect the wiring 25 in the display area 3 and the wiring 25 in the peripheral area 4. Thus, the wiring 25 in the display area 3 and the wiring 25 in the peripheral area 4 can be connected each other without a short circuit with respect to the electrode wiring 37a.

In display device 1, the separating groove a in the organic insulating film 12 surrounding the display area 3 divides the organic insulating film 12 into the inner part 12a and the outer part 12b, as described with reference to FIGS. 1A and 1B and 2A and 2B. Thus, the moisture existing in the part corresponding to the outer part 12b of the organic insulating film 12 does not enter into the inner part 12a through the organic insulating film 12. Therefore, the deterioration of the organic EL devices EL due to moisture can be prevented in the display area 3 positioned at the part covered by the inner part 12a.

In particular, the separating groove **a** surrounding the display area **3** and between the display area **3** and the peripheral area **4** can prevent the entry of the moisture existing in the peripheral area **4** having the driving circuits into the display area **3** through the organic insulating film **12**. Therefore, even when moisture is absorbed to a foreign material (such as dust) caused in a process of manufacturing the driving circuits in the peripheral area **4**, the entry of the moisture into the display area **3** can be prevented, which can further prevent the deterioration of the organic EL devices more effectively. Preferably, the separating groove **a** is provided surrounding the display area **3** as closely as possible to the display area **3**. Thus, the volume of the inner part **12a** of the organic insulating film **12** can be reduced, and the amount of moisture that reaches to the organic EL devices EL through the part can be therefore reduced.

As a result, the long-term reliability of the display device **1** can be achieved since the deterioration of the organic EL devices EL due to moisture can be prevented.

#### Second Embodiment

FIGS. **3A** and **3B** are main part enlarged section views showing features in a display device according to a second embodiment. FIG. **3A** shows an enlarged section view corresponding to Part B in the schematic section view in FIG. **1B**, and FIG. **3B** shows an enlarged section view corresponding to Part B' in the schematic section view in FIG. **1B**. A display device **1a** according to the second embodiment shown in FIGS. **3A** and **3B** is different from the display device according to the first embodiment in that an inorganic layer **41** is provided at the bottom of the separating groove **a** for alleviating the degree of the level change due to the separating groove **a**. The other construction of the second embodiment is the same.

The inorganic layer **41** has a width **W1**, which is wider enough than the width **W** of the opening at the bottom of the separating groove **a**. The bottom of the separating groove **a** is configured to securely position on the inorganic layer **41** only so that the degree of the level change due to the separating groove **a** can be evenly alleviated. The inorganic layer **41** may be formed by patterning the same layer as that of the wiring **25** in the display area **3** and peripheral area **4**. In this case, the inorganic layer **41** may be patterned with sufficient isolation from the wiring **25**.

In particular, as shown in FIG. **3B**, the upper electrode wiring **37a** is connected and wired to the inorganic layer **41** containing the same material as that of the wirings **25** in the part where the upper electrode wiring **37a** extending from the upper electrode **37** for the organic EL devices EL crosses the separating groove **a**.

Note that the inorganic layer **41** may contain an insulating material. Also in this case, the inorganic layer **41** has the width **W1**, which is wider enough than the width **W** of the opening at the bottom of the separating groove **a**, and the bottom of the separating groove **a** is configured to securely position on the inorganic layer **41** only.

Since the separating groove **a** of the organic insulating film **12** is provided between the display area **3** and peripheral area **4** also in this construction, the deterioration of the organic EL devices EL due to moisture in the display area **3** can be prevented like the first embodiment.

Furthermore, this embodiment has the inorganic layer **41** at the bottom of the separating groove **a** so that the degree of the level change due to the separating groove **a** can be alleviated. Thus, the stress on the part covering the level change due to the separating groove **a** can be alleviated in the inorganic

insulating film **14** on the organic insulating film **12**. Therefore, the occurrence of a crack due to the stress can be prevented, which can prevent the entry of moisture through the crack.

The alleviation of the degree of the level change due to the separating groove **a** can easily secure the thickness of the upper electrode wiring **37a** extending to the peripheral area **4** across the separating groove **a**. Thus, the increase in resistant value and/or break of the upper electrode wiring **37a** can be prevented in the side walls of the separating groove **a**.

Notably, the inorganic layer **41** for alleviating the degree of the level change due to the separating groove **a** can be provided without any increase in number of steps when the inorganic layer **41** is formed by patterning the same layer as that of the wiring **25** in the display area **3** and peripheral area **4**.

#### Third Embodiment

FIG. **4A** is a plan view showing a construction of a display device according to a third embodiment, and FIG. **4B** is a schematic section view taken at Line A-A' in FIG. **4A**. A display device **1b** shown in FIGS. **4A** and **4B** is different from the display devices of the embodiments above in that a sealed area **45** resulting from the removal of the organic insulating film **12** is provided in the outermost circumference of the part having the opposite substrate **17** over the supporting substrate **2**, and the other construction is the same.

In other words, in the display device **1b**, the separating groove **a** resulting from the removal of the organic insulating film **12** is provided between the display area **3** and the peripheral area **4** so that the display area **3** is surrounded. The sealed area **45** resulting from the removal of the organic insulating film **12** is provided surrounding the separating groove **a** and the perimeter of the peripheral area **4**. The sealed area **45** is the outermost periphery of the part having the opposite substrate **17** over the supporting substrate **2** as described above. The outer part **12b** of the organic insulating film **12** separated by the separating groove **a** has the both side walls and top face completely covered by the inorganic insulating film **14** (shown in the section view only) on the organic insulating film **12** and are sealed by the adhesive layer (shown in the section view only). In other words, the organic insulating film **12** is not exposed to the outside in the part between the supporting substrate **2** and the opposite substrate **17**.

In display device **1b**, the deterioration of the organic EL devices EL due to moisture in the display area **3** can be prevented like the first embodiment since the separating groove **a** of the organic insulating film **12** is provided between the display area **3** and the peripheral area **4**.

Furthermore, in the display device **1b** of the third embodiment, the sealed area **45** resulting from the removal of the organic insulating film **12** and being provided at the outer edges of the supporting substrate **2** and opposite substrate **17** can prevent the entry of moisture from the outside of the display device **1b**. Thus, the deterioration of the organic EL devices EL due to moisture in the display area **3** can be more securely prevented, and the corrosion of a metallic material due to moisture, for example, can be also prevented in the peripheral area **4**.

#### Fourth Embodiment

FIG. **5** is a schematic section view showing a construction of a display device according to a fourth embodiment. A display device **1c** in FIG. **5** is different from the display device of the third embodiment in that a hollow part exists between

the supporting substrate 2 and the opposite substrate 17, and the other construction is the same.

In other words, in the display device 1c, an adhesive sealant 47 is provided between the supporting substrate 2 and the opposite substrate 17 surrounding the separating groove a between the display area 3 and the peripheral area 4 and the perimeter of the peripheral area 4, resulting from the removal of the organic insulating film 12. The sealant 47 bonds the opposite substrate 17 to the supporting substrate 2 and seals the hollow part between the supporting substrate 2 and the opposite substrate 17.

Also in the display device 1c of the fourth embodiment, the deterioration of the organic EL devices EL due to moisture in the display area 3 can be prevented, and the reliability can be improved since the separating groove a of the organic insulating film 12 is provided between the display area 3 and the peripheral area 4.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A display device comprising:

a first substrate having a display area and a peripheral area surrounding the display area, the display area including a plurality of light emitting devices, and the peripheral area including driving circuitry for the light emitting devices;

an organic insulating film disposed over the first substrate within the display area and the peripheral area;

a separation groove in the organic insulating film, the separation groove provided between the display area and the peripheral area and surrounding the display area, the separation groove dividing the organic insulating film into an inner part disposed within the display area and an outer part disposed within the peripheral area;

an inorganic insulating film covering the inner and outer parts of the organic insulating film and lining an inside of the separation groove; and

a sealed area provided apart from the separation groove, the sealed area being in an outermost portion of the peripheral area and surrounding a main portion of the peripheral area,

wherein,

no organic insulating film is present in the sealed area and the sealed area is separated from the separation groove by the outer part of the organic insulating film, the outer part of the organic insulating film having (i) a first sidewall on the side of the sealed area, (ii) a second sidewall on the side of the separation groove, and (iii) a top face, both the first and second sidewalls and the top face being completely covered by the inorganic insulating film, and

the sealed area includes the inorganic insulating film directly covered by an adhesive layer for bonding the first substrate to a second substrate.

2. The display device according to claim 1, wherein the light emitting devices are organic electroluminescence (EL) devices.

3. The display device according to claim 1, wherein a first wiring is disposed in the display area and a second wiring is disposed in the peripheral area, the first and second wirings being connected by a third wiring disposed under the organic insulating film.

4. The display device according to claim 1, wherein an inorganic layer is provided directly under a bottom portion of the separation groove so as to reduce a level change due to the separation groove.

5. The display device according to claim 2, wherein:

the organic insulating film is further includes a first organic insulating film and a second organic insulating film,

the first organic insulating film is provided as a flattening insulating film covering a circuit layer formed on the first substrate, the circuit layer including (i) the driving circuitry in the peripheral area and (ii) pixel circuits in the display area, and

the second organic insulating film covers the first organic insulating film.

6. The display device according to claim 2, wherein an upper electrode for the organic EL devices extends to the peripheral area.

7. The display device according to claim 2, further including an EL layer including the organic EL devices, the EL layer being provided on the organic insulating film and covered by the inorganic insulating film.

8. The display device according to claim 5, wherein an upper electrode for the organic EL devices is provided between the second organic insulating film and the inorganic insulating film and extends to the peripheral area.

9. The display device according to claim 5, wherein the pixel circuits include thin-film transistors.

10. The display device according to claim 8, wherein the upper electrode has an end that extends from the display area, across the separation groove along sidewalls and a floor of the separation groove, and to the peripheral area, a portion of the upper electrode within the separation groove being covered by the inorganic insulating film lining the separation groove.

11. The display device according to claim 4, wherein the inorganic layer includes an insulating material.

12. The display device according to claim 4, wherein the inorganic layer is made of the same material as that of a first wiring disposed in the display area and a second wiring disposed in the peripheral area.

\* \* \* \* \*

专利名称(译)	显示装置具有改善的防潮性		
公开(公告)号	<a href="#">US8421349</a>	公开(公告)日	2013-04-16
申请号	US13/298960	申请日	2011-11-17
[标]申请(专利权)人(译)	索尼公司		
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发明人	FUJIMURA, HIROSHI INO, MASUMITSU ASANO, MITSURU YUMOTO, AKIRA IWASE, YUICHI		
IPC分类号	H01L51/52		
CPC分类号	H05B33/04 H01L51/5237 H01L27/3244		
审查员(译)	MAI , ANH		
优先权	2004235125 2004-08-12 JP		
其他公开文献	US20120062107A1		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

## 摘要(译)

在显示装置中，包括：在基板上具有多个有机EL器件的显示区域；外围区域，具有用于有机EL器件的驱动电路并围绕基板上的显示区域；有机绝缘膜至少覆盖驱动电路，有机绝缘膜具有分离槽，该分离槽将自身分成显示区域周边的内部和外部。

