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(54) OLED DISPLAY AND PRODUCTION METHOD THEREOF

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(57) **ABSTRACT**

An OLED display **10** of the present invention comprises: a device substrate **12;** an OLED device **14** formed on a surface of the device substrate **12;** an encapsulation substrate **22** which is placed opposite to the device substrate **12** and through which light emitted from the OLED device **14** passes; a sealant **24** which is provided between a marginal area of the device substrate **12** and a marginal area of the encapsulation substrate **22** for encapsulating the OLED device **14;** and an optically transparent desiccant layer **26** which is formed on a part of the encapsulation substrate **22** which is opposed to the OLED device **14.**

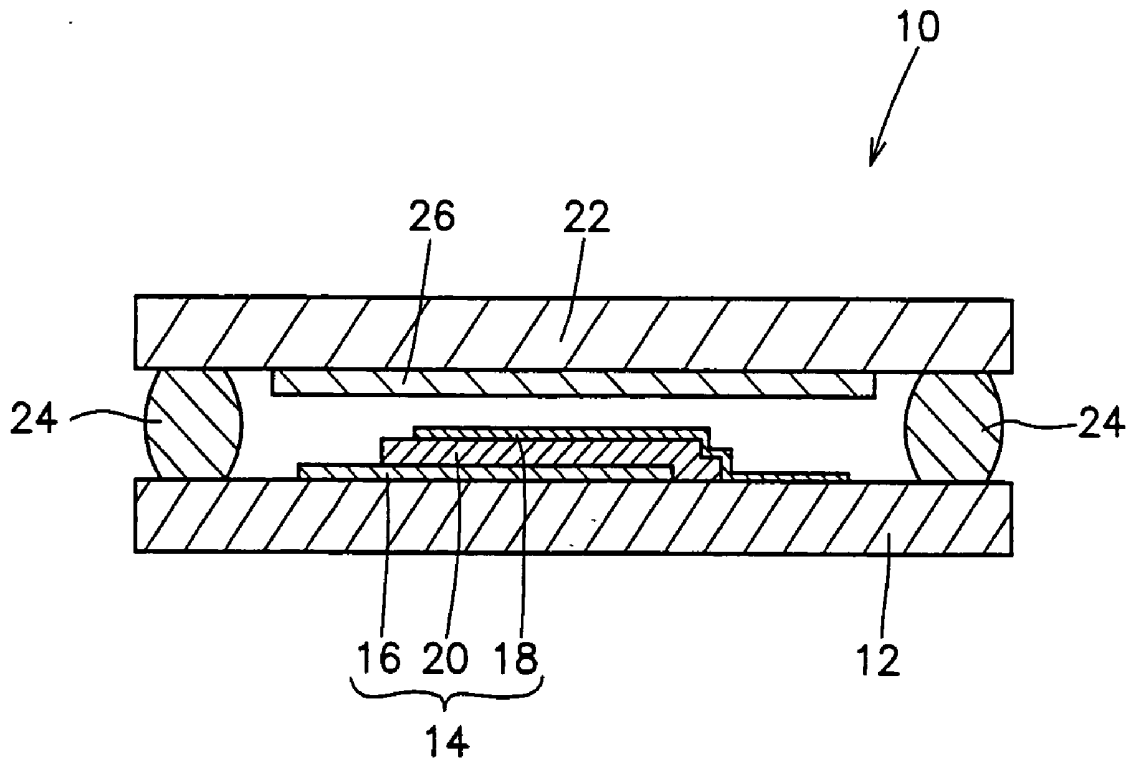


Fig. 1

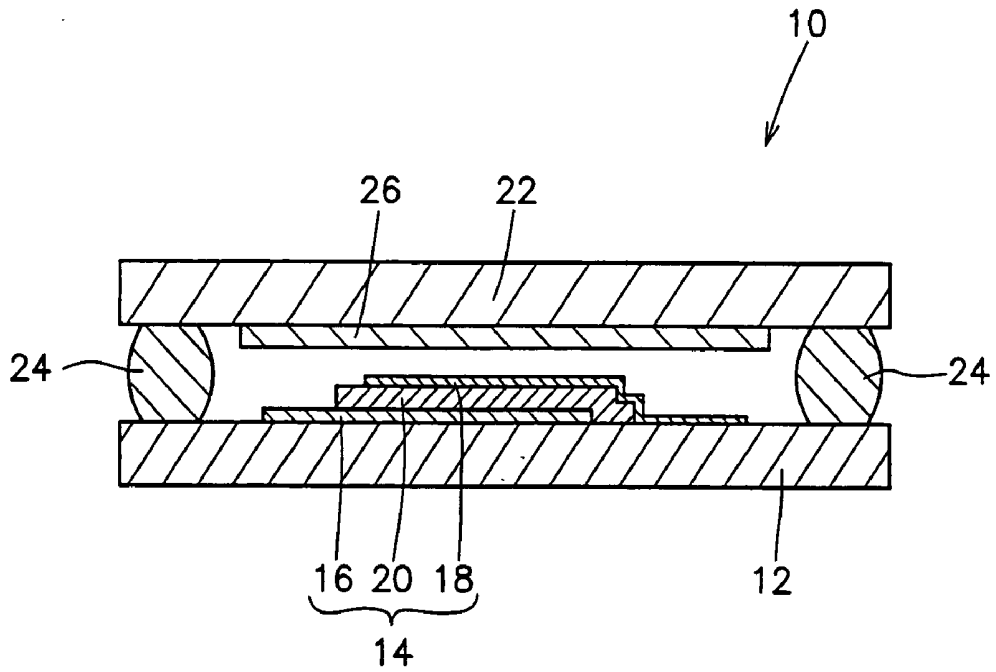


Fig. 2

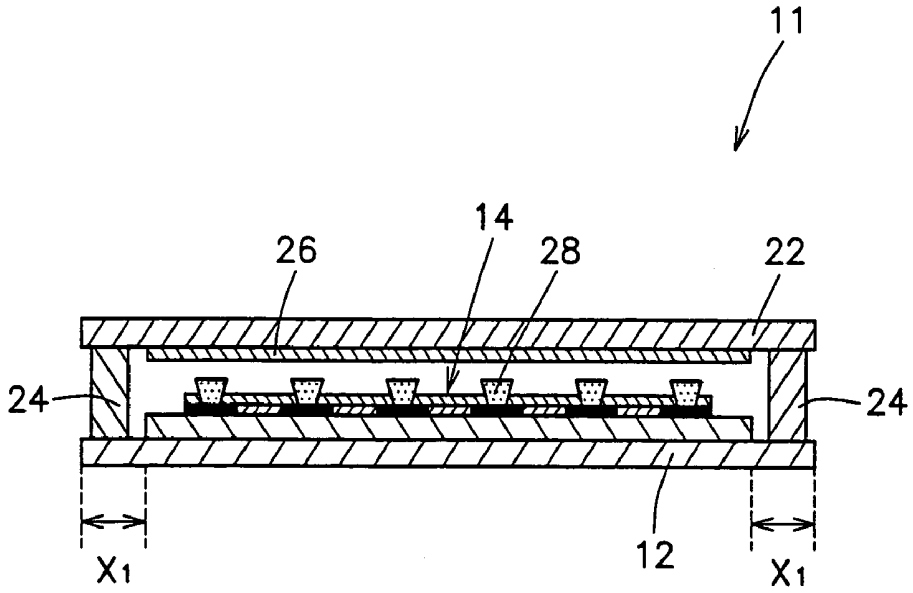
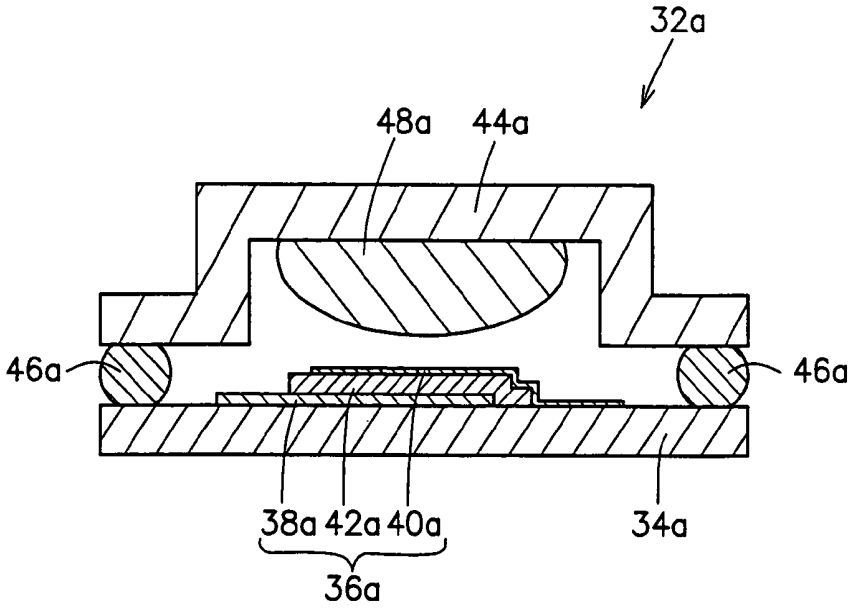
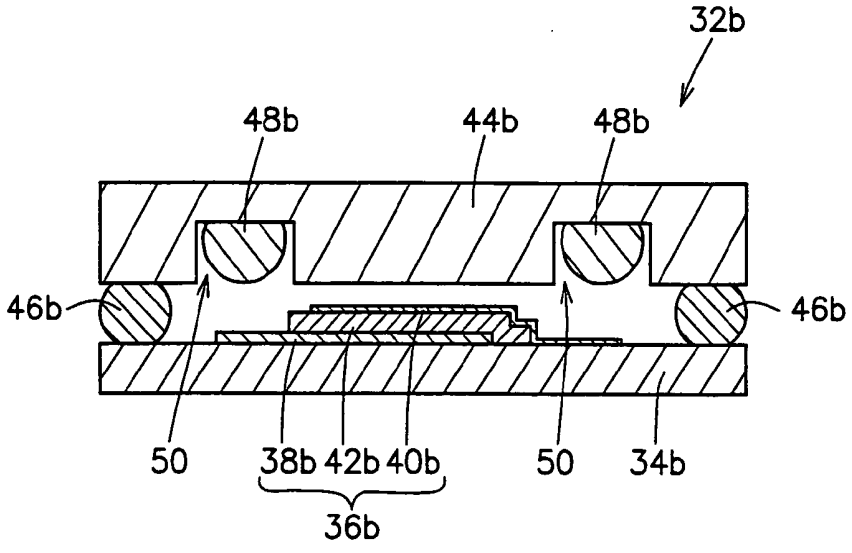


Fig. 3 (a)



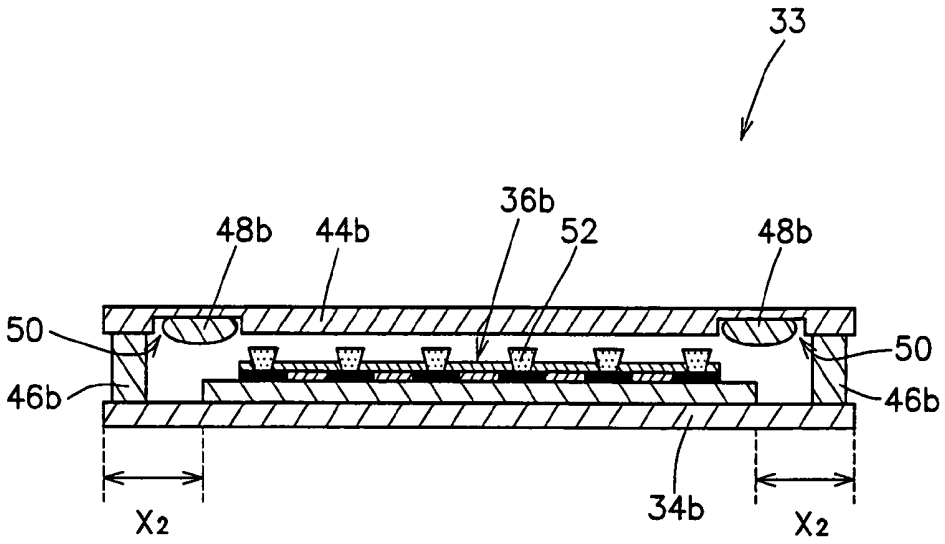
PRIOR ART

Fig. 3 (b)



PRIOR ART

Fig. 4



PRIOR ART

OLED DISPLAY AND PRODUCTION METHOD THEREOF

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a top-emission OLED (organic light emitting diode) display and a production method thereof.

[0003] 2. Description of Related Art

[0004] An LCD (liquid crystal display) and an OLED display are typical examples of a flat display. As shown in FIGS. **3**(*a*) and **3**(*b*), an OLED display **32***a*/**32***b* has an OLED device **36***a*/**36***b* on a device substrate **34***a*/**34***b,* and has a structure that the OLED device **36***a*/**36***b* is encapsulated by the device substrate **34***a*/**34***b,* an encapsulation cap or an encapsulation substrate **44***a*/**44***b* and a sealant **46***a*/**46***b* so as to protect the OLED device **36***a*/**36***b* from the ambient environment. A space is provided between the OLED device **36***a*/**36***b* and the encapsulation cap, between the OLED device **36***a*/**36***b* and the encapsulation substrate **44***a*/**44***b* and between the OLED device **36***a*/**36***b* and the sealant **46***a*/**46***b*. The OLED device **36***a*/**36***b* is composed of a bottom electrode **38***a*/**38***b,* a top electrode **40***a*/**40***b,* and an organic layer **42***a*/**42***b*. The organic layer **42***a*/**42***b* emits light.

[0005] There are two types of structures for the OLED display **32***a*/**32***b:* a bottom-emission structure and a top-emission structure. In the bottom-emission OLED display **32***a* shown in **FIG. 3**(*a*), the device substrate **34***a* and the bottom electrode **38***a* are transparent, and light is emitted through the bottom electrode **38***a* and the device substrate **34***a*. In the top-emission OLED display **32***b* shown in **FIG. 3**(*b*), the encapsulation substrate **44***b* is transparent, and light is emitted through the encapsulation substrate **44***b*. Conventionally, the bottom-emission OLED display **32***a* has achieved more widespread use.

[0006] The OLED device **36***a*/**36***b* is sensitive to moisture and oxygen. For this reason, a desiccant **48***a*/**48***b* is provided inside the OLED display **32***a*/**32***b,* and then the OLED device **36***a*/**36***b* is encapsulated to protect it from the ambient environment. In the bottom-emission OLED display **32***a,* it is not necessary that light passes through the encapsulation cap **44***a*. The encapsulation cap **44***a* can be made of metallic material which is not optically transparent. A room for the desiccant **48***a* can be relatively easily prepared. The desiccant **48***a* is packed in a baglike container and bonded to the encapsulation cap **44***a* with adhesive. However, a special apparatus for bonding the desiccant **48***a* is needed before encapsulating the OLED device **36***a,* which causes an increase in cost in mass production.

[0007] In the bottom-emission OLED display **32***a,* various circuits (not shown) are formed on the device substrate **34***a*. Therefore, an aperture ratio of the OLED display **32***a* is reduced. On the contrary, in the case of the top-emission OLED display, the aperture ratio is enlarged, but the placement of the desiccant **48***b* causes a big problem. For example, a recessed part **50** is formed in the encapsulation substrate **44***b* and the desiccant **48***b* packed in a baglike container is bonded to the recessed part **50**. However, an additional step of forming the recessed part **50** in the encapsulation substrate **44***b* is necessary, so that the production cost is increased.

[0008] As shown in **FIG. 4**, in the OLED display **33**, a plurality of OLED devices **36***b* are separated by ribs **52**, and the desiccant **48***b* has to be bonded only to non-display area on a marginal area of the encapsulation substrate **44***b*. Therefore, a frame area X_2 of the OLED display **33** becomes wider. However, in the case of a large-screen OLED display **33**, it is not sufficient that the desiccant **48***b* is provided to the marginal area of the encapsulation substrate **44***b,* because the desiccant **48***b* cannot exert its effect on all the OLED devices **36***b*. The desiccant **48***b* can be fixed to the encapsulation substrate **44***b* with resin. However, it is difficult to form a resin film of even thickness, and the resin reduces the effect of the desiccant **48***b*.

[0009] A patent document **1** discloses an OLED display with a desiccant layer formed on an encapsulation substrate. In the embodiments of this patent document, it is described that a transparent bottom electrode, an OLED layer, and a ytterbium top electrode are disposed on a glass substrate in this order. This structure is a well-known bottom emission structure. A desiccant layer on a counter substrate is produced from a porous film, so that the surface area of the desiccant layer becomes large. The desiccant layer is produced by spin coating or dip coating desiccant material and then by forming it into porous film by the sol-gel process. The desiccant layer having a wide surface area can have equal hygroscopic property to fine-powdered desiccant. Since the desiccant material is formed into film, the desiccant layer causes less particle contamination than the fine-powdered desiccant material.

[0010] However, since the desiccant layer is porous film, it becomes clouded. If such clouded layer is applied to the top-emission OLED display, the clouded porous film is provided on a path of light, so that the OLED display cannot be used as a display unit. Further, the porous film causes a diffused reflection of light, so that straight light which is required by a display unit cannot pass through the porous film. Furthermore, since the desiccant layer is formed by spin coating or dip coating desiccant material, the desiccant layer does not have even thickness and the light passing through the layer is not uniform. Therefore, the desiccant layer disclosed in the patent document **1** cannot be applied to the top-emission OLED display, and it can be used only in the bottom-emission OLED display.

[0011] A patent document **2** discloses an OLED device in which a mixed layer of a desiccant and a silicon compound is provided on an encapsulation substrate. In this case, a mixture of a desiccant and a silicon compound is applied to the encapsulation substrate and then hardened. However, since the desiccant and the silicon compound differ in refractive index, light may reflect diffusely. Since the mixed layer is provided on the encapsulation substrate only by applying the mixture to the encapsulation substrate and then hardening it, the surface of the mixed layer is rough and the rough surface may cause light to reflect diffusely. **FIG. 1** of the patent document **2** clearly shows that the mixed layer has a rough surface. Therefore, the OLED device of the patent document **2** is the one used in the bottom-emission OLED structure.

[0012] A patent document **3** discloses an OLED display in which an absorption layer prepared from a desiccant and a resin is formed on an encapsulation substrate. In this case, the absorption layer is formed by spreading a mixture of a

desiccant and a resin evenly on an encapsulation substrate by means of a doctor blade and then self-cooling it. However, the absorption layer is a mixed layer of the desiccant and the resin, so that their different refractive indexes may cause light to reflect diffusely. The OLED display of the patent document **3** is a bottom-emission OLED display.

[**0013**] [Document **1**] Japanese Unexamined Patent Publication No. (Patent Kokai No.) 2002-216951 (**FIG. 1**)

[**0014**] [Document **2**] Japanese Unexamined Patent Publication No. (Patent Kokai No.) 2000-277254 (**FIG. 1**)

[**0015**] [Document **3**] Japanese Unexamined Patent Publication No. (Patent Kokai No.) 2001-345175 (**FIG. 1** and **FIG. 2**)

SUMMARY OF THE INVENTION

[**0016**] An OLED display of the present invention comprises: a device substrate; an OLED device formed on a surface of the device substrate; an optically transparent encapsulation substrate which is placed opposite to the surface of the device substrate; a sealant which is provided between a marginal area of the device substrate and a marginal area of the encapsulation substrate which encapsulates the OLED device; and an optically transparent desiccant layer which is formed on a part of the encapsulation substrate through which light emitted from the OLED device passes. In the OLED display, the OLED device is encapsulated by the device substrate, the encapsulation substrate, and the sealant, and the optically transparent desiccant layer is formed on the encapsulation substrate through which the light emitted from the OLED device passes.

[**0017**] A method of producing an OLED display according to the present invention comprises: preparing a device substrate and an encapsulation substrate; forming an OLED device on a surface of the device substrate; forming an optically transparent desiccant layer on a part of the encapsulation substrate through which light emitted from the OLED device passes and which is opposed to the surface of the device substrate; and encapsulating the OLED device by placing the device substrate and the encapsulation substrate opposite to each other in such a manner that the OLED device on the device substrate is opposed to the desiccant layer on the encapsulation substrate and by providing a sealant between a marginal area of the device substrate and a marginal area of the encapsulation substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0018**] **FIG. 1** is a cross sectional view of an OLED display of the present invention.

[**0019**] **FIG. 2** is a cross sectional view of an OLED display with a plurality of OLED devices.

[**0020**] **FIG. 3**(*a*) is a cross sectional view of a conventional bottom-emission OLED display and **FIG. 3**(*b*) is a cross sectional view of a conventional top-emission OLED display.

[**0021**] **FIG. 4** is a cross sectional view of a top-emission OLED display with a plurality of OLED devices.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[**0022**] Embodiments of the OLED display and the production method thereof according to the present invention will be described with reference to the drawings. The OLED display of the present invention is a top-emission OLED display.

[**0023**] As shown in **FIG. 1**, an OLED display **10** of the present invention comprises: a device substrate **12**; an OLED device **14** formed on a surface of the device substrate **12**; an optically transparent encapsulation substrate **22** which is placed opposite to the surface of the device substrate **12** and through which light emitted from the OLED device **14** passes; a sealant **24** which is provided between an marginal area of the device substrate **12** and a marginal area of the encapsulation substrate **22** for encapsulating the OLED device **14**; and an optically transparent desiccant layer **26** which is formed on a part of the encapsulation substrate **22** through which light emitted from the OLED device **14** passes.

[**0024**] Since the OLED display **10** of the present invention is a top-emission OLED display, the device substrate **12** may not necessarily be an optically transparent substrate. For example, the device substrate **12** may be made of plastic or glass. On the device substrate **12** are formed various circuits (not shown), on the circuits is formed a resin layer (not shown) for example, and on the resin layer is formed the OLED device **14**. It is noted that various circuits and resin layer are omitted from **FIG. 1** and the explanation of **FIG. 1**.

[**0025**] As a basic structure of the OLED device **14**, the organic layer **20** is sandwiched between the bottom electrode **16** and the top electrode **18**. In general, the bottom electrode **16** formed on the device substrate **12** is an anode. As the top electrode **18**, a transparent or translucent electrode is used. In many cases, the organic layer **20** is composed of a plurality of layers such as a hole injection layer, a hole transport layer, a light emission layer, an electron transport layer, and electron injection layer.

[**0026**] The encapsulation substrate **22** is a transparent substrate such as glass. The light emitted from the OLED device **14** passes through the encapsulation substrate **22**. A recessed part for putting the desiccant therein is not formed in the encapsulation substrate **22**. Since the encapsulation substrate is not additionally processed for the purpose of bonding the desiccant thereto, it is easy to bond the desiccant to the encapsulation substrate. The device substrate **12** and the encapsulation substrate **22** are placed opposite to each other in such a manner that the OLED device **14** on the device substrate **12** are opposed to the desiccant layer **26** on the encapsulation layer **22**, and the device substrate **12** and the encapsulation substrate **22** are connected by the sealant **24**. Thus, the OLED device **14** can be encapsulated to protect it from the ambient environment.

[**0027**] The desiccant layer **26** is formed from alkali metal oxide or alkali earth metal oxide. A thickness of the desiccant layer **26** is made uniform and the desiccant layer is made homogeneous so that the light can pass through the layer **26** without reflecting diffusely. The desiccant layer **26** is not formed by any one of the coating methods disclosed in the patent documents **1** to **3** or by a dip-coating method, but is formed by deposition in a vacuum or under a reduced pressure.

[**0028**] For example, the desiccant layer **26** is made of CaO (calcium oxide) or BaO (barium oxide). The desiccant layer

26 is not formed from a mixture of a resin and desiccant, but is made from a single material like CaO or BaO. When the thickness of the desiccant layer **26** is about 200 nm, 90% or more of visible light can pass through the desiccant layer **26**. Therefore, even if the desiccant layer **26** is formed on a part of the encapsulation substrate **22** through which light passes, the OLED display of the present invention can be used as a display unit without problems.

[**0029**] Next, a method of producing the OLED display **10** will be described.

[**0030**] (1) The device substrate **12** and the encapsulation substrate **22** are prepared. As the encapsulation substrate **22**, an optically transparent substrate like a glass substrate is prepared.

[**0031**] (2) On the device substrate **12**, the OLED device **14** is formed. For example, the aforementioned layers that make up the OLED device **14** are formed by a known vacuum deposition method.

[**0032**] (3) The optically transparent desiccant layer **26** is formed on the encapsulation substrate **22** including a part through which the light emitted from the OLED device **14** passes and which is opposed to a surface of the device substrate **12** on which the OLED device **14** is formed. The desiccant layer **26** is formed by (A) depositing alkali metal or alkali earth metal on the encapsulation substrate **22** to form an alkali metal layer or an alkali earth metal layer and (B) oxidizing the alkali metal layer or the alkali earth metal layer. In the step (A), the alkali metal layer or the alkali earth metal layer is formed by depositing Ca or Ba by a vacuum deposition method or by a sputtering deposition method. In the step (B), CaO or BaO is formed. The desiccant layer **26** of a desired thickness may be formed by repeatedly performing the step (A) and the step (B).

[**0033**] Examples of the oxidizing step (B) include a step of exposing the alkali metal layer or the alkali earth metal layer to air. When the alkali metal layer or the alkali earth metal layer is exposed to air for oxidization, it absorbs moisture from the air. Therefore, it is necessary to evaporate the moisture. In order to evaporate the moisture, the oxidized alkali metal layer or the oxidized alkali earth metal layer is heated in a vacuum or in an inert gas. As an inert gas, nitrogen gas or argon gas is used.

[**0034**] (4) The device substrate **12** and the encapsulation substrate **22** are placed opposite to each other in such a manner that the OLED device **14** on the device substrate **12** is opposed to the desiccant layer **26** on the encapsulation substrate **22**, and the sealant **24** is provided between a marginal part of the device substrate **12** and a marginal part of the encapsulation substrate **22** so as to encapsulate the desiccant layer **26**. Encapsulating of the desiccant layer **26** is performed in a vacuum or in an inert gas. As an inert gas, nitrogen gas or argon gas is used. The reason why the desiccant layer **26** is encapsulated in an inert gas is because oxygen and moisture that deteriorate the OLED device **14** are prevented from getting into the OLED display **10** during the encapsulation process.

[**0035**] In this way, the OLED display **10** is produced as described above. The desiccant layer **26** is formed by depositing alkali metal or alkali earth metal on the encapsulation substrate **22** by a vacuum deposition method or a sputtering deposition method. Therefore, unlike the layer formed by a spin coating method or a dip coating method as described in the patent document **1**, the desiccant layer **26** of the present invention has a constant and uniform thickness and the light passing through the desiccant layer **26** does not reflect diffusely. It is difficult to form the desiccant layer by directly depositing alkali metal oxide or alkali earth metal oxide. However, in the present invention, alkali metal or alkali earth metal is deposited to form an alkali metal layer or an alkali earth metal layer and then oxidized, so that it is easy to form the desiccant layer. Further, unlike the desiccant layer described in the patent document **2** or **3**, the desiccant layer of the present invention is not a mixed layer of a resin and a desiccant, so that light does not reflect diffusely due to differences in refractive index.

[**0036**] The aforementioned explanation can also be applied to the case where a plurality of OLED devices **14** are formed on the device substrate **12**. As shown in **FIG. 2**, a plurality of OLED devices **14** are separated by ribs **28**, and the desiccant layer **26** is formed over the whole surface of the encapsulation substrate **22**. Compared to the desiccant **48***b* shown in **FIG. 4** as prior art, the desiccant layer **26** can exert its effect evenly on all the OLED devices **14**. Further, the desiccant is not bonded to the marginal area of the encapsulation substrate, so that a frame area X_1 is narrower than the frame area X_2 shown in **FIG. 4**. Thus the OLED display **11** can be effectively downsized.

[**0037**] While the embodiments of the present invention have thus been described with reference to the drawings, it should be understood that the present invention be not limited to the embodiments shown in the drawings. Various changes, modifications, and imnprovements can be made to the embodiments on the basis of knowledge of those skilled in the art without departing from the scope of the present invention. This application claims priority from Japanese Patent Application No. 2003-209068, which is incorporated herein by reference.

What is claimed is:

1. An OLED display comprising:

a device substrate;

an OLED device formed on a surface of the device substrate;

an optically transparent encapsulation substrate placed opposite to the surface of the device substrate;

a sealant which encapsulates the OLED device, said sealant provided between a marginal area of the device substrate and a marginal area of the encapsulation substrate; and

an optically transparent desiccant layer on at least a part of the encapsulation substrate through which light emitted from the OLED device passes.

2. The OLED display according to claim 1, wherein said desiccant layer is formed from alkali metal oxide or alkali earth metal oxide.

3. A method of producing an OLED display, comprising:

preparing a device substrate and an encapsulation substrate;

forming an OLED device on a surface of the device substrate;

forming an optically transparent desiccant layer on a part of the encapsulation substrate through which light emitted from the OLED device passes, said part of the encapsulation substrate opposed to the surface of the device substrate; and

encapsulating the OLED device by placing the device substrate and the encapsulation substrate opposite to each other in such a manner that the OLED device on the device substrate is opposed to the desiccant layer on the encapsulation substrate and by providing a sealant between a marginal area of the device substrate and a marginal area of the encapsulation substrate.

4. The method of producing an OLED display according to claim 3, wherein said step of forming an optically transparent desiccant layer comprises:

depositing alkali metal or alkali earth metal on the encapsulation substrate to form an alkali metal layer or an alkali earth metal layer; and

oxidizing the alkali metal layer or the alkali earth metal layer.

5. The method of producing an OLED display according to claim 4, wherein said oxidizing step comprises:

exposing the alkali metal layer or the alkali earth metal layer to air; and

after said exposing step, heating the oxidized alkali metal layer or the oxidized alkali earth metal layer in a vacuum or in an inert gas.

6. The method of producing an OLED display according to claim 4, wherein said encapsulating step is performed in a vacuum or in an inert gas.

7. The method of producing an OLED display according to claim 4, wherein said depositing step is performed using a vacuum deposition method or a sputtering deposition method.

8. The method of producing an OLED display according to claim 7, wherein said encapsulating step is performed in a vacuum or in an inert gas.

* * * * *

专利名称(译)	OLED显示器及其制造方法		
公开(公告)号	US20050046349A1	公开(公告)日	2005-03-03
申请号	US10/926260	申请日	2004-08-25
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IPC分类号	H05B33/04 G09F9/00 G09F9/30 H01J1/62 H01L51/50 H01L51/52 H05B33/10 H05B33/14		
CPC分类号	H01L2251/5315 H01L51/5237 H01L51/5259		
优先权	2003209068 2003-08-27 JP		
外部链接	Espacenet USPTO		

摘要(译)

本发明的OLED显示器10包括：器件基板12;形成在器件基板12的表面上的OLED器件14;封装基板22，与器件基板12相对放置，OLED器件14发出的光通过该封装基板22;密封剂24，设置在器件基板12的边缘区域和封装基板22的边缘区域之间，用于封装OLED器件14;光学透明的干燥剂层26形成在封装基板22的与OLED器件14相对的部分上。