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(54) **MANUFACTURING METHOD OF OLED DISPLAY PANEL**

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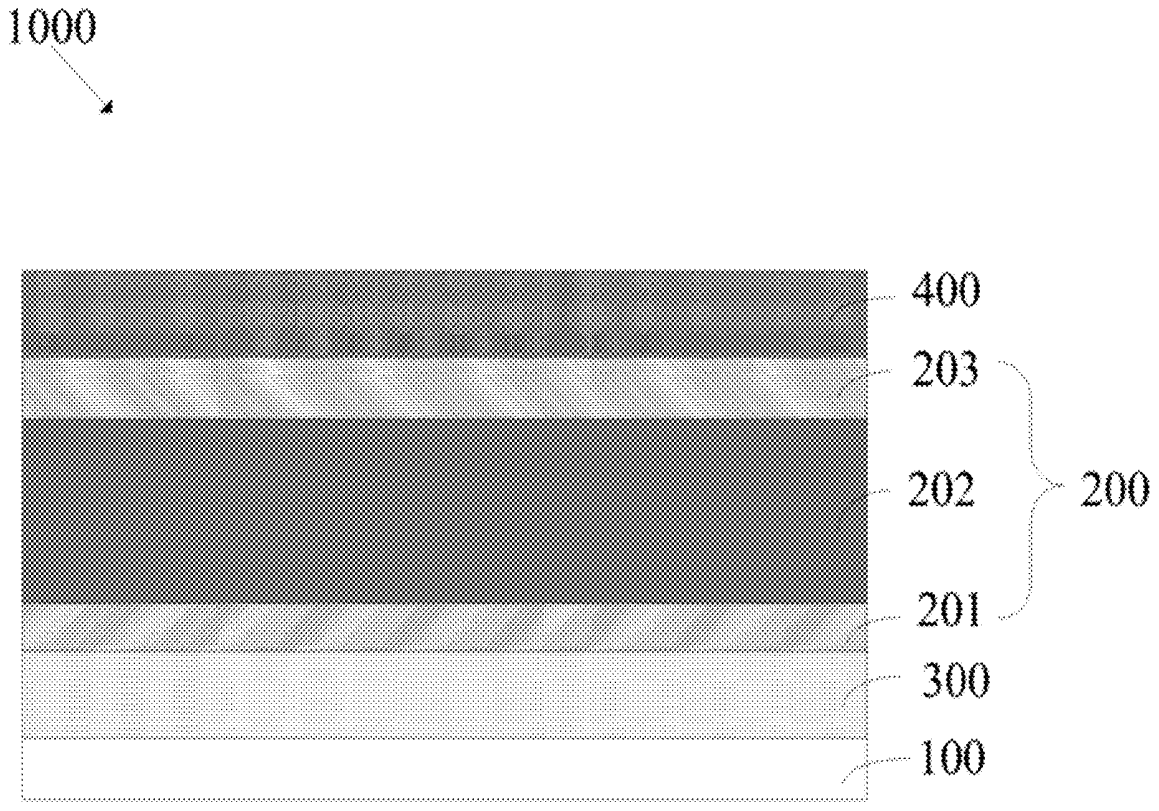
(57) **ABSTRACT**

The present invention provides an encapsulation thin-film, including a first inorganic layer composed of a first oxide; a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond. The encapsulation thin-film and the display device according to the present invention, the first inorganic layer, the polymer layer and the second inorganic layer are bonded by a chemical bond, thus can prevent external water and oxygen corrosion and improve bending resistance of the display device.



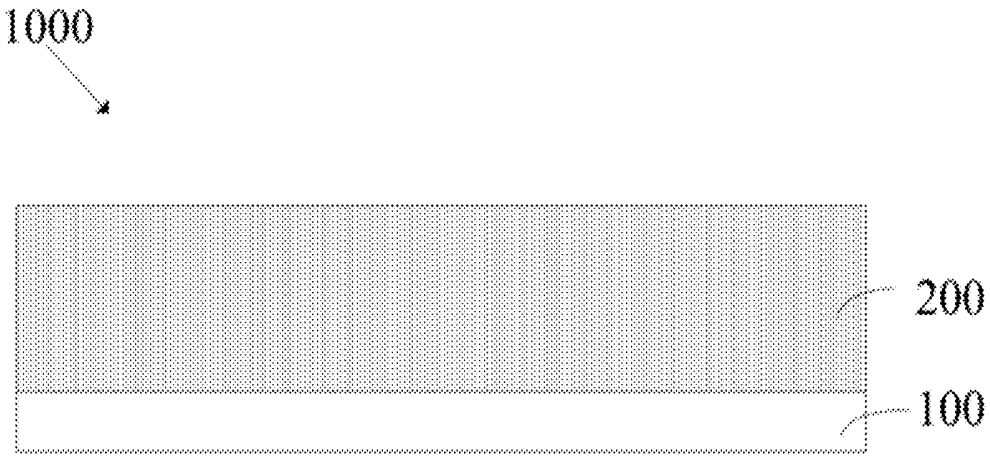



FIG. 1

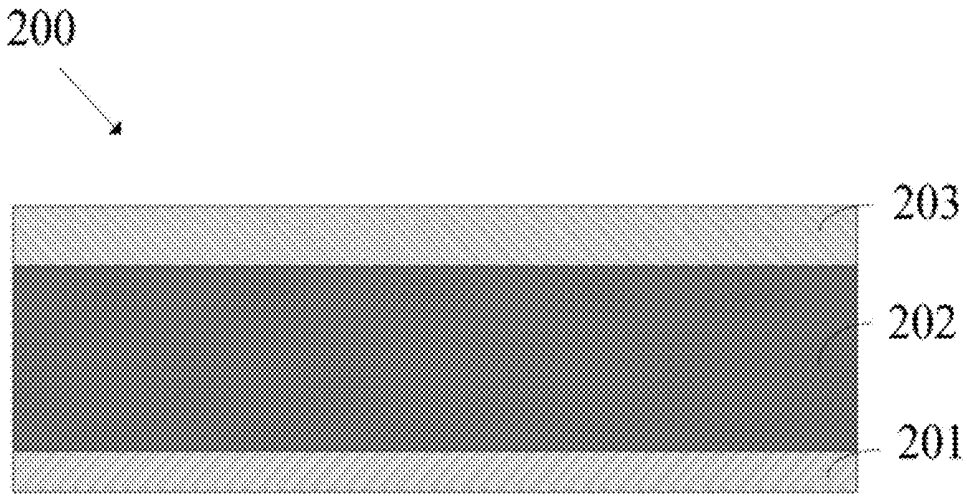



FIG. 2

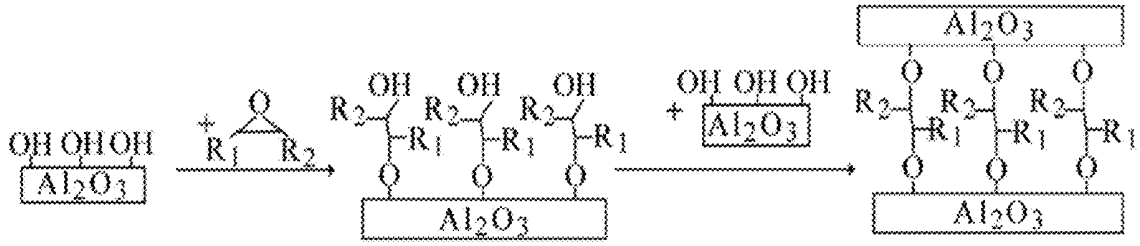

OH OH OH
Al2O3
R1
R2
OH OH OH
R2
R1
Al2O3
OH OH OH
Al2O3
Al2O3
Al2O3

FIG. 3

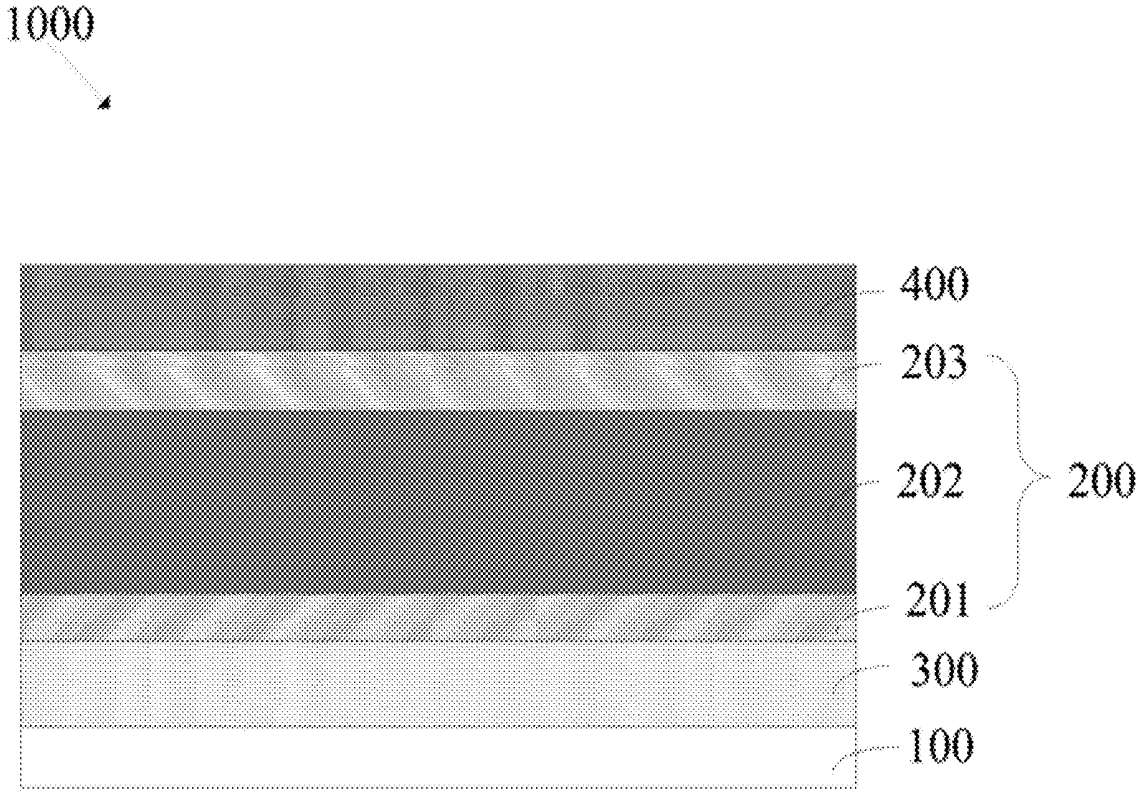

1000
400
203
202
201
200
300
100

FIG. 4

# MANUFACTURING METHOD OF OLED DISPLAY PANEL

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a U.S. National Phase application submitted under 35 U.S.C. § 371 of Patent Cooperation Treaty Application serial No. PCT/CN2017/117354, filed on Dec. 20, 2017, which claims the priority of China Patent Application serial No. 201711135645.6, filed on Nov. 16, 2017, the disclosures of which are incorporated herein by reference in their entirety.

## FIELD OF INVENTION

**[0002]** The present invention relates to the field of display technologies, and in particular to an encapsulation thin-film and a display device.

## BACKGROUND OF INVENTION

**[0003]** Organic light-emitting diode (OLED) display technologies are widely used in the fields of mobile devices, wearable devices and large-size curved televisions because OLED display technologies can have flexible display properties.

**[0004]** However, flexible OLED display technologies also face two major challenges. First, water and oxygen from external environment cause erosion of OLED materials so as to cause property loss. Second, the panel will cause breakage between two thin-film layers during bending.

## SUMMARY OF INVENTION

**[0005]** An object of the present invention provides an encapsulation thin-film and a display device that can prevent external water and oxygen corrosion and improve bending resistance of the display device.

**[0006]** An embodiment according the present invention provides an encapsulation thin-film, comprising:

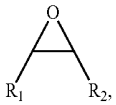
**[0007]** a first inorganic layer composed of a first oxide;

**[0008]** a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

**[0009]** a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond;

**[0010]** wherein the polymer is formed by polymerization of an epoxy compound monomer and wherein the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**[0011]** In some embodiments, the epoxy compound monomer includes




R1 and R2 separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the R1 and R2 are physically adsorbed on the first inorganic layer.

**[0012]** In some embodiments, the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**[0013]** In some embodiments, a portion of the polymer is bonded to the first oxide by an oxygen ion.

**[0014]** An embodiment according the present invention provides an encapsulation thin-film, comprising:

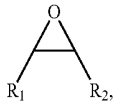
**[0015]** a first inorganic layer composed of a first oxide;

**[0016]** a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

**[0017]** a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond.

**[0018]** In some embodiments, the polymer is formed by polymerization of an epoxy compound monomer.

**[0019]** In some embodiments, the epoxy compound monomer includes




R1 and R2 separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the R1 and R2 are physically adsorbed on the first inorganic layer.

**[0020]** In some embodiments, the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**[0021]** In some embodiments, the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**[0022]** In some embodiments, a portion of the polymer is bonded to the first oxide by an oxygen ion.

**[0023]** In some embodiments, a thickness of the first inorganic layer ranges from 10 to 1000 nm, a thickness of the polymer layer ranges from 1 to 20 μm, and a thickness of the second inorganic layer ranges from 10 to 1,000 nm.

**[0024]** An embodiment according the present invention provides a display device, comprising a plurality of organic light-emitting devices and an encapsulation thin-film disposed on the organic light-emitting devices,

**[0025]** the encapsulation thin-film, comprising:

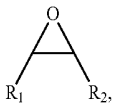
**[0026]** a first inorganic layer composed of a first oxide;

**[0027]** a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

**[0028]** a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond.

**[0029]** In some embodiments, the polymer is formed by polymerization of an epoxy compound monomer.

**[0030]** In some embodiments, the epoxy compound monomer includes



R1 and R2 separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the R1 and R2 are physically adsorbed on the first inorganic layer.

**[0031]** In some embodiments, the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**[0032]** In some embodiments, the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**[0033]** In some embodiments, a portion of the polymer is bonded to the first oxide by an oxygen ion.

**[0034]** In some embodiments, a thickness of the first inorganic layer ranges from 10 to 1000 nm, a thickness of the polymer layer ranges from 1 to 20 μm, and a thickness of the second inorganic layer ranges from 10 to 1,000 nm.

**[0035]** In some embodiments, the display device further comprises:

**[0036]** a third inorganic layer disposed between the organic light emitting device and the first inorganic layer, wherein the third inorganic layer covers the organic light emitting devices; and

**[0037]** a fourth inorganic layer disposed on the second inorganic layer.

**[0038]** In some embodiments, the third inorganic layer and the fourth inorganic layer are made of at least one of materials selected from the group consisting of zirconium aluminate, graphene, aluminum oxide, zirconium dioxide, silicon nitride compound, silicon carbonitride, silicon oxide compound, titanium dioxide and diamond-like carbon.

**[0039]** Compare with the prior art, the encapsulation thin-film and the display device according to the present invention, the first inorganic layer, the polymer layer and the second inorganic layer are bonded by a chemical bond, thus can prevent external water and oxygen corrosion and improve bending resistance of the display device.

**[0040]** In order to more dearly understand the foregoing content of the present invention, the preferred embodiments are described below with reference the accompanying drawings, which detailed description is as follows:

## DESCRIPTION OF DRAWINGS

**[0041]** FIG. **1** is a schematic view of a display device structure according to an embodiment of the present invention.

**[0042]** FIG. **2** is a schematic view of an encapsulation thin-film structure according to an embodiment of the present invention.

**[0043]** FIG. **3** is a schematic view of a chemical reaction which is a forming process of the encapsulation thin-film according to an embodiment of the present invention.

**[0044]** FIG. **4** is schematic view of another display device according to an embodiment of the present invention.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

**[0045]** The structure and the technical means adopted by the present invention to achieve the above and other objects may be best understood by referring to the following detailed description of the preferred embodiments and the accompanying drawings. Furthermore, directional terms described by the present invention, such as upper, lower, front, back, left, right, inner, outer, side, longitudinal/vertical, transverse/horizontal, etc., are only directions by referring to the accompanying drawings, and thus the used directional terms are used to describe and understand the present invention, but the present invention is not limited thereto.

**[0046]** In the drawings, structurally similar elements are given the same reference numerals.

**[0047]** Term "embodiment" herein refer to specific features, structures, or characteristics described in connection with the embodiments may be included in at least one embodiment of the present invention. The term appeared in various position of the specification may not necessarily refer to the same embodiment, nor is an independent or alternative embodiment which is mutually exclusive other embodiments. A person of ordinary skill in the art explicitly and implicitly understand, the embodiments described herein may be combined with other embodiments.

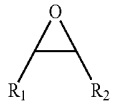
**[0048]** Please refer to FIG. **1**. FIG. **1** is a schematic view of a display device structure according to an embodiment of the present invention. A display device **1000** includes an organic light-emitting device **100** and an encapsulation thin-film **200** disposed on the organic light-emitting device **100**. The organic light-emitting device **100** is configured for emitting light, the encapsulation thin-film **200** is configured for preventing the organic light-emitting device **100** from external water and oxygen corrosion, and improving bending resistance of the display device **1000**.

**[0049]** Please refer to FIG. **2**. FIG. **2** is a schematic view of an encapsulation thin-film structure according to an embodiment of the present invention. An encapsulation thin-film **200** includes a first inorganic layer **201**, a polymer layer **202**, and a second inorganic layer **203**.

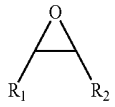
**[0050]** The first inorganic layer **201** is composed of a first oxide. The first oxide includes a metal oxide and/or a non-metal oxide such as at least one of materials is selected from the group consisting of $Al_2O_3$, $ZrO_2$, or $SiO_2$. Meanwhile, surfaces of these oxides are rich in a hydroxyl group. Specifically, an oxide may be deposited on the organic light emitting device by using an atomic force deposition, a pulsed laser deposition, a sputtering deposition, a plasma enhanced chemical vapor deposition etc., thereby forms the first inorganic layer **201**. So that the first inorganic layer **201** blocks the erosion by water and oxygen from the external environment. A thickness of the first inorganic layer **201** ranges from 10 to 1000 nm.

**[0051]** The polymer layer **202** is disposed on the first inorganic layer **201**. The polymer layer **202** is composed of a polymer, the polymer contains a hydroxyl or carboxyl group. The polymer is bonded to the first oxide by a chemical bond. The chemical bond improves the adhesion between the first inorganic layer **201** and the polymer layer **202**. Specifically, the polymer layer **202** is bonded to the first oxide **201** by an oxygen ion.

**[0052]** In some embodiments, a layer of epoxy compound monomer



may be coated on the first inorganic layer **201** by inkjet printing, PECVD, slit spin coating, spin coating, injection, and the like. $R_1$ and $R_2$ separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and $R_1$ and $R_2$ may be bonded to the first oxide in the first inorganic layer **201** by a chemical bond. $R_1$ and $R_2$ are physically adsorbed on the first inorganic layer. Alternatively, $R_1$ and $R_2$ may be physically adsorbed on the first inorganic layer **201**. Therefore the adhesion between the first inorganic layer **201** and the polymer layer **202** increases. After that, these epoxy compound monomers

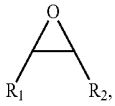


are polymerized under an ultraviolet ray or low-temperature heating to form the polymer, and thus the polymer layer **202** is formed so that the stress can be buffered and particle contaminants can be blocked. Thereby bending resistance of the display device **1000** is improved. In some embodiments, a thickness of the polymer layer **202** ranges from 1 to 20 μm.

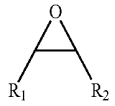
**[0053]** A second inorganic layer **203** is disposed on the polymer layer **202**, the second inorganic layer **203** is composed of a second oxide. The second oxide includes a metal oxide and/or a non-metal oxide such as at least one of materials is selected from the group consisting of $Al_2O_3$, $ZrO_2$, or $SiO_2$. Meanwhile, surfaces of these oxides are rich in a hydroxyl group. The second oxide is bonded to a portion of the polymer by a chemical bond. The chemical bond improves the adhesion between the second inorganic layer **203** and the polymer layer **202**. Specifically, since the polymer contains a hydroxyl or carboxyl group, a precursor of the second oxide reacts with the hydroxyl or carboxyl group and then is bonded by an ionic bond. It should be noted that the first oxide and the second oxide may be same or different.

**[0054]** In some embodiments, an oxide may be deposited on the organic light emitting device by using an atomic force deposition, a pulsed laser deposition, a sputtering deposition, a plasma enhanced chemical vapor deposition etc., thereby forms the second inorganic layer **203**. So that the second inorganic layer **203** blocks the erosion by water and oxygen from the external environment. A thickness of the second inorganic layer **203** ranges from 10 to 1000 nm. Since the polymer is rich in the hydroxyl or carboxyl group, the adsorption of the precursor of the second oxide may be speed up, so that the second inorganic layer **203** may be quickly deposited on the polymer layer **202**.

**[0055]** Please refer to FIG. **3**. FIG. **3** is a schematic view of a chemical reaction which is a forming process of the encapsulation thin-film according to an embodiment of the present invention. As shown in FIG. **2** and FIG. **3**, a first inorganic layer **201** is made of $Al_2O_3$ which is rich in a hydroxyl group. Firstly, the first inorganic layer **201** is coated with an epoxy compound monomer



wherein $R_1$ and $R_2$ are heterocyclic or hetero-chain groups, and further includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br. After the epoxy compound monomer



is polymerized, a polymer is obtained thus forms a polymer layer **202**. The polymer is rich in a hydroxyl group. A portion of the polymer which is on the polymer layer **202** is bonded to the first oxide by an oxygen ion. Aluminum oxide is then deposited on the polymer layer **202**, a precursor of the aluminum oxide reacts with the hydroxyl group which is on the polymer, via an ionic bond, and thereby the second inorganic layer **203** is obtained.

**[0056]** In some embodiments, as shown in FIG. **4**, the display device **1000** further includes a third inorganic layer **300**. The third inorganic layer **300** disposes between an organic light emitting device **100** and a first inorganic layer **201** and covers the organic light emitting device **100**, so as to block external water and oxygen corrosion. The third inorganic layer **300** is made of at least one of materials selected from the group consisting of zirconium aluminate ($ZrAl_xO_y$), graphene, aluminum oxide ($Al_2O_3$), zirconium dioxide ($ZrO_2$), silicon nitride compound ($SiN_x$), silicon carbonitride (SiCN), silicon oxide compound ($SiO_x$), titanium dioxide ($TiO_2$) and diamond-like carbon (DLC). A thickness of the third inorganic layer **300** ranges from 0.5 to 1 μm.

**[0057]** In some embodiments, as shown in FIG. **4**, the display device **1000** further includes a forth inorganic layer **400**. The forth inorganic layer **400** disposes on a second inorganic layer **203** of an encapsulation thin-film **200**, so as to block external water and oxygen corrosion. The forth inorganic layer **400** is made of at least one of materials selected from the group consisting of zirconium aluminate, graphene, aluminum oxide, zirconium dioxide, silicon nitride compound, silicon carbonitride, silicon oxide compound, titanium dioxide and diamond-like carbon. A thickness of the forth inorganic layer **400** ranges from 0.5 to 1 μm. Furthermore, since the fourth inorganic layer **400** has higher hardness, it is beneficial to the next process for manufacturing touch screen or module.

**[0058]** The embodiments according to the present invention provide an encapsulation thin-film and a display device. The first inorganic layer, the polymer layer and the second inorganic layer are bonded by a chemical bond, thus can prevent external water and oxygen corrosion and improve bending resistance of the display device.

**[0059]** In view of the above, although the present invention has been disclosed by way of preferred embodiments, the above preferred embodiments are not intended to limit the present invention, and one of ordinary skill in the art,

without departing from the spirit and scope of the invention, the scope of protection of the present invention is defined by the scope of the claims.

What is claimed is:

**1**. An encapsulation thin-film, comprising:

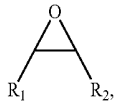
a first inorganic layer composed of a first oxide;

a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond;

wherein the polymer is formed by polymerization of an epoxy compound monomer and wherein the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**2**. The encapsulation thin-film according to claim **1**, wherein the epoxy compound monomer includes



$R_1$ and $R_2$ separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the $R_1$ and $R_2$ are physically adsorbed on the first inorganic layer.

**3**. The encapsulation thin-film according to claim **1**, wherein the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**4**. The encapsulation thin-film according to claim **1**, wherein a portion of the polymer is bonded to the first oxide by an oxygen ion.

**5**. An encapsulation thin-film, comprising:

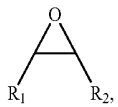
a first inorganic layer composed of a first oxide;

a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond.

**6**. The encapsulation thin-film according to claim **5**, wherein the polymer is formed by polymerization of an epoxy compound monomer.

**7**. The encapsulation thin-film according to claim **6**, wherein the epoxy compound monomer includes



$R_1$ and $R_2$ separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the $R_1$ and $R_2$ are physically adsorbed on the first inorganic layer.

**8**. The encapsulation thin-film according to claim **5**, wherein the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**9**. The encapsulation thin-film according to claim **8**, wherein the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**10**. The encapsulation thin-film according to claim **5**, wherein a portion of the polymer is bonded to the first oxide by an oxygen ion.

**11**. The encapsulation thin-film according to claim **5**, wherein a thickness of the first inorganic layer ranges from 10 to 1000 nm, a thickness of the polymer layer ranges from 1 to 20 μm, and a thickness of the second inorganic layer ranges from 10 to 1,000 nm.

**12**. A display device, comprising a plurality of organic light-emitting devices and an encapsulation thin-film disposed on the organic light-emitting devices,

the encapsulation thin-film, comprising:

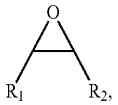
a first inorganic layer composed of a first oxide;

a polymer layer disposed on the first inorganic layer, and composed of a polymer bonded to the first oxide by a chemical bond; and

a second inorganic layer disposed on the polymer layer, and bonded to the polymer by a chemical bond.

**13**. The encapsulation thin-film according to claim **12**, wherein the polymer is formed by polymerization of an epoxy compound monomer.

**14**. The encapsulation thin-film according to claim **13**, wherein the epoxy compound monomer includes



$R_1$ and $R_2$ separately includes at least one of elements selected from the group consisting of B, O, S, Si, P, N, F, Cl and Br, and the $R_1$ and $R_2$ are physically adsorbed on the first inorganic layer.

**15**. The encapsulation thin-film according to claim **12**, wherein the polymer includes a hydroxyl or carboxyl group, the second inorganic layer is composed of a second oxide, and a precursor of the second oxide is bonded to the hydroxyl or carboxyl group by an ionic bond.

**16**. The encapsulation thin-film according to claim **15**, wherein the first oxide includes a metal oxide and/or a non-metal oxide, the second oxide includes a metal oxide and/or a non-metal oxide, and the first oxide and the second oxide are same or different.

**17**. The encapsulation thin-film according to claim **12**, wherein a portion of the polymer is bonded to the first oxide by an oxygen ion.

**18**. The encapsulation thin-film according to claim **12**, wherein a thickness of the first inorganic layer ranges from 10 to 1000 nm, a thickness of the polymer layer ranges from 1 to 20 μm, and a thickness of the second inorganic layer ranges from 10 to 1,000 nm.

**19**. The display device according to claim **12**, further comprising:

a third inorganic layer disposed between the organic light emitting device and the first inorganic layer, wherein the third inorganic layer covers the organic light emitting devices; and

a fourth inorganic layer disposed on the second inorganic layer.

**20**. The display device according to claim **19**, wherein the third inorganic layer and the fourth inorganic layer are made of at least one of materials selected from the group consisting of zirconium aluminate, graphene, aluminum oxide, zirconium dioxide, silicon nitride compound, silicon carbonitride, silicon oxide compound, titanium dioxide and diamond-like carbon.

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|---|---|---|---|
| 专利名称(译) | OLED显示面板的制造方法 | | |
| 公开(公告)号 | US20200044187A1 | 公开(公告)日 | 2020-02-06 |
| 申请号 | US15/738583 | 申请日 | 2017-12-20 |
| [标]发明人 | JIN JIANGJIANG | | |
| 发明人 | JIN, JIANGJIANG<br>HSIANG, LUN | | |
| IPC分类号 | H01L51/52 H01L51/00 | | |
| CPC分类号 | H01L51/5253 H01L2251/303 H01L2251/558 H01L51/0035 H01L27/32 H01L51/5237 H01L27/3241 H01L51/5256 | | |
| 优先权 | 201711135645.6 2017-11-16 CN | | |
| 外部链接 | Espacenet USPTO | | |


摘要(译)

本发明提供一种封装薄膜，其包括由第一氧化物组成的第一无机层；和聚合物层设置在第一无机层上，并且由通过化学键与第一氧化物键合的聚合物组成； 第二无机层设置在聚合物层上，并通过化学键与聚合物键合。 根据本发明的封装薄膜和显示装置，第一无机层，聚合物层和第二无机层通过化学键结合，因此可以防止外部水和氧腐蚀并提高显示器的抗弯曲性 设备。