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(54) **ORGANIC ELECTROLUMINESCENT DIODE DEVICE, DISPLAY PANEL, AND MANUFACTURING METHOD THEREOF**

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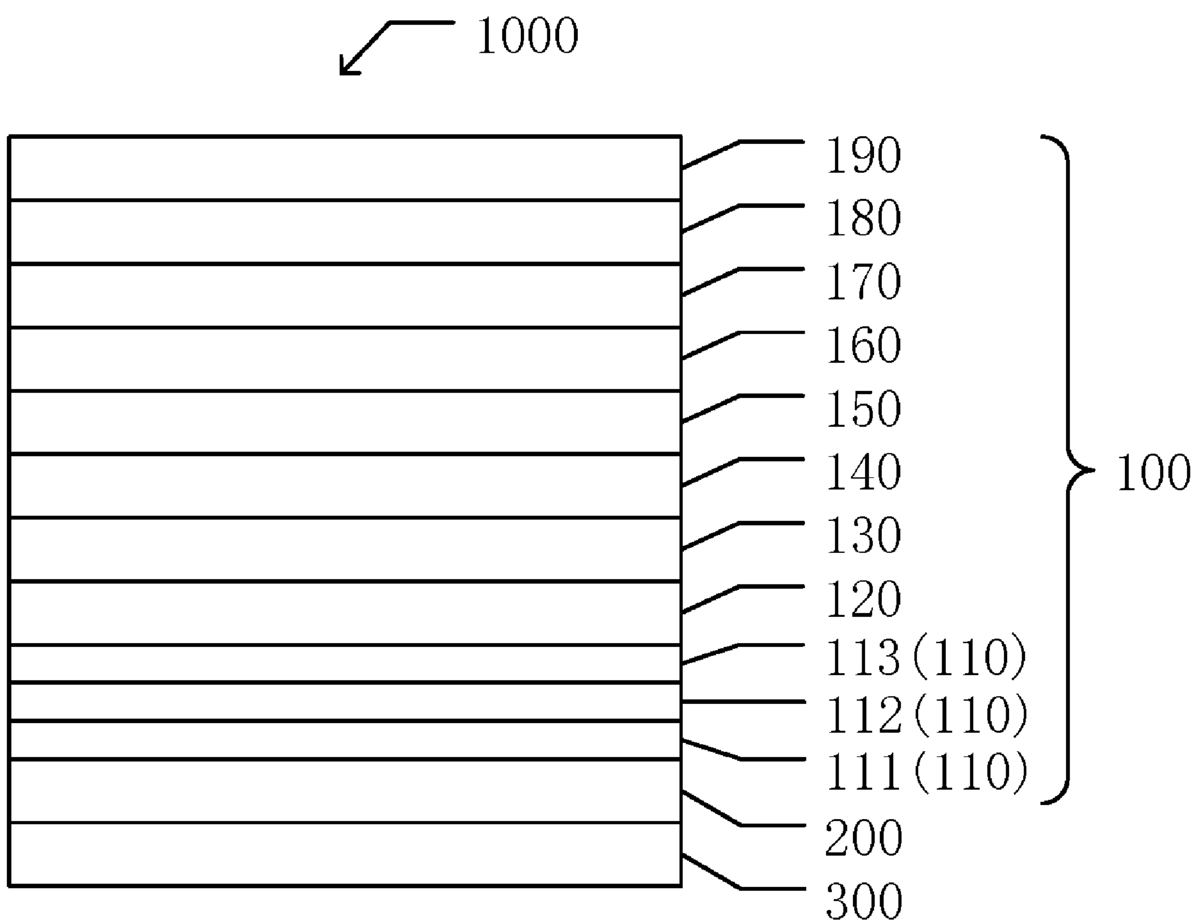
(57) **ABSTRACT**

The present invention provides an organic electroluminescent diode device, a display panel, and a manufacturing method thereof. The organic electroluminescent diode device includes a first electrode layer, a conductive layer, an electron injection layer, a light-emitting layer, a hole injection layer, and a second electrode layer, and the conductive layer is provided between the first electrode layer and the electron injection layer.



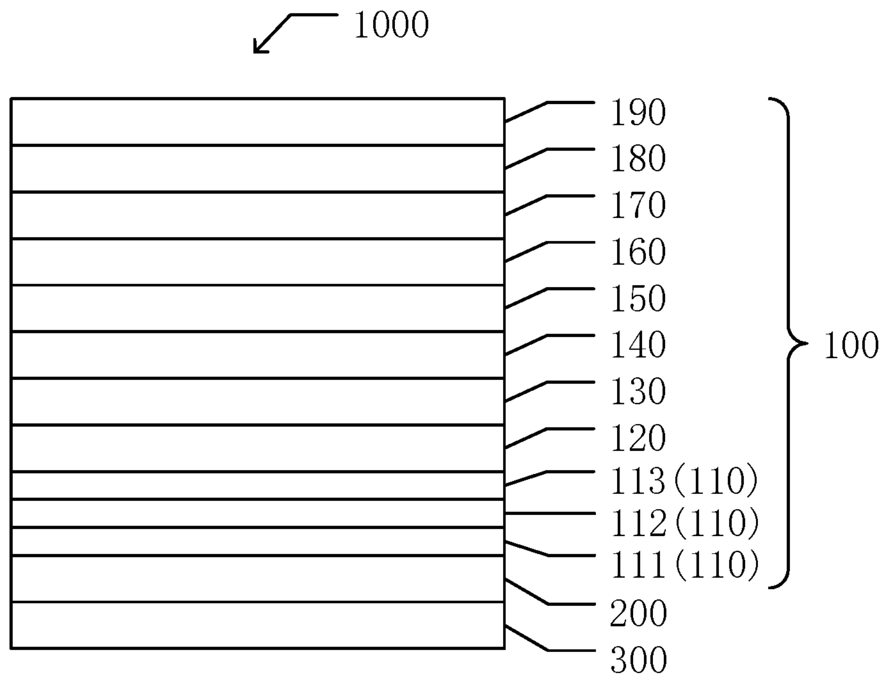

1000
190
180
170
160
150
140
130
120
113(110)
112(110)
111(110)
200
300
100

FIG. 1

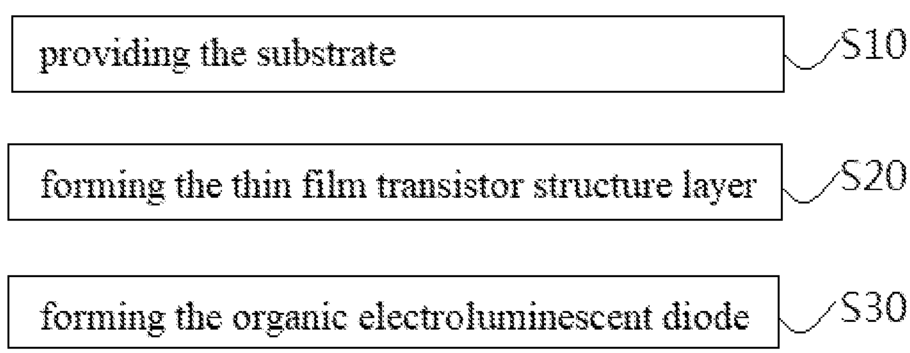

providing the substrate
S10
forming the thin film transistor structure layer
S20
forming the organic electroluminescent diode
S30

FIG. 2

ORGANIC ELECTROLUMINESCENT DIODE DEVICE, DISPLAY PANEL, AND MANUFACTURING METHOD THEREOF

BACKGROUND OF INVENTION

Field of Invention

[0001] The invention relates to a field of display devices, in particular to an organic electroluminescent diode device, a display panel, and a manufacturing method thereof.

Description of Prior Art

[0002] Ink-jet printing an organic light-emitting diode (IJP OLED) is a novel type of display technology, which has physical advantages unmatched by liquid crystal display (LCD) technology, and possesses characteristics such as active light emission, high color reality, infinite contrast, zero delay, transparent display, flexible display, free display form, and so on, and thus is the display technology of next generation that can replace the liquid crystal display technology. The IJP OLED display technology has a structure simpler than LCD since it does not require support by backlight, such that the display product can be made lighter and thinner. Moreover, its working conditions have a series of advantages such as low driving voltage, low energy consumption, and matching with solar cells and integrated circuits. Because the IJP OLED devices are fully solid-state, non-vacuum devices, and have the characteristics of anti-vibration and low temperature resistance (−40° C.), they have a wide range of applications.

[0003] In a direction of a large-size panel, in order to meet the needs of a high-resolution 8K display, the IJP OLED structure has changed from a bottom-emitting structure to a top-emitting structure. However, there are still many problems with the currently developed top-emitting IJP OLED structure. One of the most critical issues of the top-emitting IJP OLED structure is that a top electrode is implemented with a thinner cathode material, which usually has a larger resistance, so when conducting current, the panel has a severe voltage drop (IR drop), wherein the larger a size of a panel, the more obvious the IR drop, and since a terminal input voltage is a fixed value, an in-plane voltage will be uneven, resulting in uneven brightness of the panel. A main solution is to increase a number of driver chips and employ a complicated external compensation algorithm to compensate for the uneven brightness of the panel caused by the IR drop. However, how to improve the structure of the OLED device more effectively to eliminate impact of IR drop is a major problem for an OLED panel manufacturer at present.

[0004] Meanwhile, due to degradation of the device itself, the IJP OLED structure has a high operating current density when the panel is lit, resulting in a short operating life of the panel. In addition, because the device is degraded, under the same brightness, the operating current must be increased with the time of use, which causes a source voltage of a thin film transistor to increase significantly, resulting in image sticking of the panel. Therefore, how to solve the problem of image sticking is another difficult problem for various OLED device manufacturers.

SUMMARY OF INVENTION

[0005] An object of the present invention is to provide an organic electroluminescence diode device, a display panel, and a manufacturing method thereof, in order to solve the problems such as difficulty of electron injection, uneven brightness of a display screen caused by a panel IR drop, image sticking, and so on in the organic electroluminescence diode device of the prior art.

[0006] In order to achieve the above object, the present invention provides an organic electroluminescent diode device, which includes a first electrode layer, a conductive layer, an electron injection layer, a light-emitting layer, a hole injection layer, and a second electrode layer.

[0007] The conductive layer disposed on the first electrode layer. The electron injection layer disposed on the conductive layer. The light-emitting layer disposed on the electron injection layer. The hole injection layer disposed on the light-emitting layer. The second electrode layer disposed on the hole injection layer.

[0008] Further, the organic electroluminescent diode device further includes an electron transport layer and a hole transport layer, wherein the electron transport layer is disposed between the electron injection layer, and the light-emitting layer hole transport layer is disposed between the hole injection layer and the light-emitting layer.

[0009] Further, the organic electroluminescent diode device further includes a light-coupling layer disposed on a surface of the second electrode layer away from the hole injection layer.

[0010] Further, the first electrode layer includes a first conductive layer, a second conductive layer, and a reflective electrode layer, wherein the first conductive layer; the second conductive layer disposed on the first conductive layer; and the reflective electrode layer disposed between the first conductive layer and the second conductive layer.

[0011] Further, the first conductive layer and the second conductive layer are made of indium tin oxide; and the reflective electrode layer is made of metal.

[0012] Further, the conductive layer is made of a material including a metal, an alloy, and a metal nanowire.

[0013] The present invention also provides a display panel including a substrate, a thin film transistor structure layer, and the organic electroluminescence diode device, wherein the thin film transistor structure layer is disposed on the substrate, and the organic electroluminescent diode device is disposed on a surface of the thin film transistor structure layer away from the substrate.

[0014] The invention further provides a method of manufacturing a display panel, including the following steps: providing the substrate; forming the thin film transistor structure layer on the substrate; and forming the organic electroluminescent diode on the thin film transistor structure layer.

[0015] Further, the step of forming the organic electroluminescent diode on the thin film transistor structure layer includes the following steps: forming the first electrode layer in the thin film transistor structure layer; forming the conductive layer on the first electrode layer by evaporation coating or inkjet printing; forming the electron injection layer, an electron transport layer, the light-emitting layer, a hole transport layer, and the hole injection layer on the conductive layer sequentially by inkjet printing; and forming the second electrode layer and the light-coupling layer on the hole injection layer and the thin film transistor structure layer by sputtering or evaporation coating.

[0016] The present invention also provides a display device including the display panel as described above.

[0017] An advantage of the present invention is that an organic electroluminescent diode device and a display panel of the present invention can effectively reduce a potential gap between the first electrode layer and the electron injection layer by adding a conductive layer between a first electrode layer and an electron injection layer of the organic electroluminescent diode device, thereby increasing an effect of electron injection. In addition, the organic light-emitting diode device in the present invention is an inverted OLED device, which is not impacted by the degraded characteristics of the OLED, so that the display panel does not have the problem of image sticking, and can thereby solve the problem of uneven brightness caused by the IR drop of the panel.

BRIEF DESCRIPTION OF DRAWINGS

[0018] In order to more clearly illustrate the embodiments or the technical solutions of the existing art, the drawings illustrating the embodiments or the existing art will be briefly described below. Obviously, the drawings in the following description merely illustrate some embodiments of the present invention. Other drawings may also be obtained by those skilled in the art according to these figures without paying creative work.

[0019] FIG. **1** is a schematic diagram of a layered structure of a display panel according to an embodiment of the present invention.

[0020] FIG. **2** is a schematic flowchart of a manufacturing method according to an embodiment of the present invention.

[0021] Elements in the drawings are designated by reference numerals listed below.

[0022] organic electroluminescent diode device **100**;

[0023] first electrode layer **110**; first conductive layer **111**;

[0024] reflective electrode layer **112**; second conductive layer **113**;

[0025] conductive layer **120**; electron injection layer **130**;

[0026] electron transport layer **140**; light-emitting layer **150**;

[0027] hole transport layer **160**; hole injection layer **170**;

[0028] second electrode layer **180**; light-coupling layer **190**;

[0029] display panel **1000**; thin film transistor structure layer **200**;

[0030] substrate **300**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0031] The preferred embodiments of the present invention are described below with reference to the accompanying drawings, which are configured to exemplify the embodiments of the present invention, which can fully describe the technical contents of the present invention to make the technical content of the present invention clearer and easy to understand. However, the present invention may be embodied in many different forms of embodiments, and the scope of the present invention is not limited to the embodiments set forth herein.

[0032] In the drawings, the spatially relative terms are intended to encompass different orientations in addition to the orientation as depicted in the figures. Moreover, the size and thickness of each component shown in the drawings are arbitrarily shown for ease of understanding and description, and the invention does not limit the size and thickness of each component. In order to make the illustration clearer, the thickness of components is exaggerated in some positions of the drawings.

[0033] The following description of the various embodiments is provided to illustrate the specific embodiments of the invention. Directional terminology mentioned in the present invention, such as "vertical", "horizontal", "upper", "bottom", "pre", "post", "left", "right", "inside", "outside", "side", etc., only refer to the direction of the additional drawing. Therefore, the directional terminology is configured to better and more clearly explain and understand the present invention, rather than to indicate or imply that the device or element referred to must have a specific orientation, or must be constructed and operated in a specific orientation, and thus the directional terminology cannot be construed as limiting the present invention. In addition, the terms "first", "second", "third", etc. are used for descriptive purposes only and should not be construed to indicate or imply relative importance.

[0034] When a component is described as "on" another component, the components are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. When a component is described as "installed to" or "connected to" another component, it can be understood that a component is "directly installed" or "directly connected" to another component, or a component is "installed to" or "connected with" another component through an intermediate component.

[0035] An embodiment of the present invention provides an organic electroluminescent diode device **100**. As shown in FIG. **1**, the organic electroluminescent diode device **100** includes a first electrode layer **110**, a conductive layer **120**, an electron injection layer **130**, and an electron transport layer **140**, a light-emitting layer **150**, a hole transport layer **160**, a hole injection layer **170**, a second electrode layer **180**, and a light-coupling layer **190**.

[0036] The first electrode layer **110** is disposed on the substrate **300**. The first electrode layer **110** is a total reflection electrode and includes a first conductive layer **111**, a reflective electrode layer **112**, and a second conductive layer **113**. The first conductive layer **111** is provided on the substrate **300**, the reflective electrode layer **112** is provided on a surface of the first conductive layer **111** away from the substrate **300**, and the second conductive layer **113** is provided on the substrate **300**. The reflective electrode layer **112** is located on a surface away from the first conductive layer **111**. The first conductive layer **111** and the second conductive layer **113** are made of indium tin oxide (ITO), and have thicknesses of 50-700 Å. The reflective electrode layer is made of a highly stable and reflective conductive metal, such as silver, aluminum, gold, platinum, copper, molybdenum, titanium, and the like. The first conductive layer **111** and the second conductive layer **113** are configured to transmit current, and the reflective electrode layer **112** has the function of reflecting light while transmitting the current.

[0037] The conductive layer **120** is disposed on a surface of the first electrode layer **110** away from the substrate **300**. The conductive layer **120** is made of a metal, an alloy, or a metal nanowire with excellent conductivity, such as conductive metals or alloys of silver, aluminum, gold, platinum, copper, molybdenum, titanium, and the like. The conductive layer **120** has a thickness ranging from 5 to 500 Å, which can be prepared by inkjet printing or evaporation coating. The conductive layer **120** can effectively reduce the potential gap between the first electrode layer **110** and the organic electron injection material, and improve the effect of electron injection.

[0038] The electron injection layer **130** is disposed on a surface of the conductive layer **120** away from the first electrode layer **110**. The electron injection layer **130** is made of an inorganic material with a lower vacuum energy level or an organic material with a lower lowest unoccupied molecular orbital (LUMO), such as alkali metal oxides, alkaline earth metal oxides, alkali metal carbonates, alkaline earth metal carbonates, alkali metal fluorides, alkaline earth metal fluorides, Alkaline earth metal hydroxide, and alkali metal hydroxide. Specific examples include zinc oxide, lithium fluoride, (8-hydroxyquinoline)-lithium, calcium fluoride, magnesium fluoride, sodium fluoride, potassium fluoride, fluorine barium chloride, cesium fluoride, cesium hydroxide, cesium carbonate, zinc magnesium oxide, and so on. The electron injection layer **130** is configured to inject electrons into the light-emitting layer **150**.

[0039] The electron transport layer **140** is disposed on a surface of the electron injection layer **130** away from the conductive layer **120**, and is made of an organic material. The electron transport layer **140** has an electron carrier transport function, and is configured to transport electrons in the electron injection layer **130** into the light-emitting layer **150**.

[0040] The light-emitting layer **150** is disposed on a surface of the electron-transport layer **140** away from the electron-injecting layer **130**. The light-emitting layer **150** is made of a material including a fluorescent material. The light-emitting layer **150** may emit one of red light, green light, and blue light. The organic electroluminescent diode device **100** realizes self-emission through the light-emitting layer **150**.

[0041] The hole transport layer **160** is disposed on a surface of the light-emitting layer **150** away from the electron transport layer **140** and is made of an organic material. The hole transport layer **160** has a hole carrier transport function, and is configured to transport holes in the hole injection layer **170** into the light-emitting layer **150**.

[0042] The hole injection layer **170** is disposed on a surface of the hole transport layer **160** away from the light-emitting layer **150** and is made of an organic material. The hole injection layer **170** is configured to inject holes into the light-emitting layer **150**.

[0043] The second electrode layer **180** is disposed on a surface of the hole injection layer **170** away from the hole transport layer **160**, and is made of a material including one or more of a metal with excellent conductivity and a transparent conductive oxide (TCO), such as indium zinc oxide (IZO), indium tin oxide (ITO), etc.

[0044] The light-coupling layer **190** is disposed on a surface of the second electrode layer **180** away from the hole injection layer **170**. The light-coupling layer **190** includes the light-coupling output material, which is configured to subject the light emitted from the light-emitting layer **150** to a light-coupling process.

[0045] The electrons in the first electrode layer **110** and the holes in the second electrode layer **180** pass through the electron injection layer **130**, the electron transport layer **140**, the hole injection layer **170**, and the hole transport layer **160** respectively under the effect of current and voltage, to converge in the light-emitting layer **150** for combination, so as to excite the fluorescent material in the light-emitting layer **150** to emit light, thereby achieving screen display.

[0046] An embodiment of the present invention provides a display panel **1000**. As shown in FIG. **1**, the display panel **1000** includes a substrate **300**, a thin film transistor structure layer **200**, and the organic electroluminescent diode device **100** as described above.

[0047] The substrate **300** may be a glass substrate **300** or a flexible polyimide substrate **300**, and the substrate **300** is configured to protect the overall structure of the display panel **1000**. The thin film transistor structure layer **200** is disposed on the substrate **300**. The thin film transistor structure layer **200** may be one or more of thin film transistor structures of low temperature polysilicon, metal oxides, amorphous silicon, and so on. The thin film transistor structure layer **200** is configured to control the light emission of the organic electroluminescent diode device **100** and provide power to the organic electroluminescent diode device **100**. The organic electroluminescent diode device **100** is provided on a surface of the thin film transistor structure layer **200** away from the substrate **300**, and the first electrode layer **110** in the organic electroluminescent diode device **100** is electrically connected to the thin film transistor structure layer **200**.

[0048] An embodiment of the present invention also provides a method of manufacturing the display panel **1000**, as shown in FIG. **2**, which includes the following steps:

[0049] Step S**10**) providing the substrate **300**, wherein the substrate **300** may be one of insulating substrates such as a glass substrate **300** or a flexible polyimide substrate **300**.

[0050] Step S**20**) forming a thin film transistor structure layer **200**: sequentially preparing devices in the thin film transistor structure layer **200** to form the thin film transistor structure layer **200** on the substrate **300**.

[0051] Step S**30**) forming the organic electroluminescence diode device **100**: forming the first electrode layer **110** in the thin film transistor structure by processes such as sputtering, photoresist coating, exposure, development, photoresist stripping, etc. A conductive material **120** with a thickness of 2 nm is prepared on the first electrode layer **110** by evaporation coating or inkjet printing to form the conductive layer **120**. An electron injection layer **130** having a thickness of 10 nm, an electron-transport layer **140** having a thickness of 20 nm, a light-emitting layer **150** having a thickness of 40 nm, a hole-transport layer **160** having a thickness of 20 nm, and a hole injection layer **170** having a thickness of 15 nm are sequentially formed on the conductive layer **120** by inkjet printing, wherein the material of the electron injection layer **130** is zinc oxide, the material of the electron transport layer **140** is TAZ, the material of the light-emitting layer **150** is 3,7-di-tert-butylcarbazole doped with PtOEP (by a mass ratio of 20%), the material of the hole transport layer **160** is TFB, and the material of the hole injection layer **170** is HATCN. A magnesium-silver alloy (mass ratio of 1:9) having a thickness of 15 nm is prepared on the hole injection layer **170** by sputtering or evaporation coating to form the second electrode layer **180**. A TcTa material layer having a thickness of 60 nm is prepared on the second electrode layer **180** by sputtering or evaporation coating to form the light-coupling layer **190**. As a result, the organic electroluminescent diode device **100** is formed.

[0052] An embodiment of the present invention provides a display device including the display panel **1000**. The display device may be any product or component having a display function, such as a liquid crystal display, a mobile phone, a tablet computer, a notebook computer, a digital camera, a navigator, and the like.

[0053] The organic electroluminescent diode device **100** provided in the embodiment of the present invention is an inverted OLED device, which can increase the utilization rate of organic materials and effectively reduce the manufacturing cost of the panel. In addition, by adding a conductive layer **120** on a first electrode layer **110**, a potential gap between the first electrode layer **110** and the electron injection layer **130** can be effectively reduced, and the effect of electron injection can be effectively increased. In addition, the inverted organic electroluminescent diode device **100** is not impacted by the degraded characteristics when driving a gate-source voltage in the thin film transistor, and a drain current is only related to the gate voltage, which can effectively solve the problem of image sticking. Meanwhile, since the organic electroluminescent diode device **100** is an inverted type, its second electrode layer **180** is connected to the drain in the thin film transistor structure layer **200**, and when conducting current, the IR drop caused by the resistance of the second electrode layer **180** only affects the drain voltage, but the drain voltage is in an electrical saturation region in the thin film transistor structure layer **200**. The gate-source voltage is defined by the data input voltage minus the source voltage, so the change of the source voltage has little influence on the gate-source voltage, that is, the change of the drain voltage has little influence on the drain current, and in this way, the brightness of different positions in the panel can be displayed uniformly, which can effectively solve the problem of uneven brightness caused by the IR drop of panel.

[0054] Although the present invention is described herein with reference to specific embodiments, it should be understood that these embodiments are merely examples of the principles and applications of the present invention. It should therefore be understood that many modifications can be made to the exemplary embodiments and other arrangements can be devised without departing from the spirit and scope of the invention as defined by the appended claims. Further, it should be understood that different dependent claims and features described herein may be combined in a manner different from that described in the original claims. It can also be understood that combinations between features described in separate embodiments may be used in other described embodiments.

What is claimed is:

1. An organic electroluminescent diode device, comprising:
- a first electrode layer;
- a conductive layer disposed on the first electrode layer;
- an electron injection layer disposed on the conductive layer;
- a light-emitting layer disposed on the electron injection layer;
- a hole injection layer disposed on the light-emitting layer; and
- a second electrode layer disposed on the hole injection layer.

2. The organic electroluminescent diode device according to claim **1**, further comprising:
- an electron transport layer disposed between the electron injection layer and the light-emitting layer; and
- a hole transport layer disposed between the hole injection layer and the light-emitting layer.

3. The organic electroluminescent diode device according to claim **1**, further comprising:
- a light-coupling layer disposed on a surface of the second electrode layer away from the hole injection layer.

4. The organic electroluminescent diode device according to claim **1**, wherein the first electrode layer comprises:
- a first conductive layer;
- a second conductive layer disposed on the first conductive layer; and
- a reflective electrode layer disposed between the first conductive layer and the second conductive layer.

5. The organic electroluminescent diode device according to claim **4**, wherein the first conductive layer and the second conductive layer are made of indium tin oxide; and
- the reflective electrode layer is made of metal.

6. The organic electroluminescent diode device according to claim **1**, wherein the conductive layer is made of a material comprising a metal, an alloy, and a metal nanowire.

7. A display panel comprising:
- a substrate;
- a thin film transistor structure layer disposed on the substrate; and
- the organic electroluminescence diode device according to claim **1**, disposed on the thin film transistor structure layer.

8. A method of manufacturing the display panel according to claim **7**, comprising the following steps:
- providing the substrate;
- forming the thin film transistor structure layer on the substrate; and
- forming the organic electroluminescent diode on the thin film transistor structure layer.

9. The method according to claim **8**, wherein the step of forming the organic electroluminescent diode on the thin film transistor structure layer comprises the following steps:
- forming the first electrode layer in the thin film transistor structure layer;
- forming the conductive layer on the first electrode layer by evaporation coating or inkjet printing;
- forming the electron injection layer, an electron transport layer, the light-emitting layer, a hole transport layer, and the hole injection layer on the conductive layer sequentially by inkjet printing; and
- forming the second electrode layer and the light-coupling layer on the hole injection layer and the thin film transistor structure layer by sputtering or evaporation coating.

10. A display device, comprising the display panel according to claim **7**.

* * * * *