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Chi et al.

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(54) **TRANSPARENT OLED DISPLAY PANEL AND MANUFACTURING METHOD THEREOF**

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H01L 51/56 (2006.01)

(52) **U.S. Cl.**

CPC **H01L 51/5234** (2013.01); **H01L 51/5209** (2013.01); **H01L 51/5218** (2013.01); **H01L 51/56** (2013.01); **H01L 2251/308** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0029539 A1 2/2007 Yashima et al.
2017/0110661 A1* 4/2017 Lee H01L 51/56
2018/0097195 A1* 4/2018 Inoue H05B 33/06

FOREIGN PATENT DOCUMENTS

CN 102163615 A 8/2011
CN 103872072 A 6/2014

(Continued)

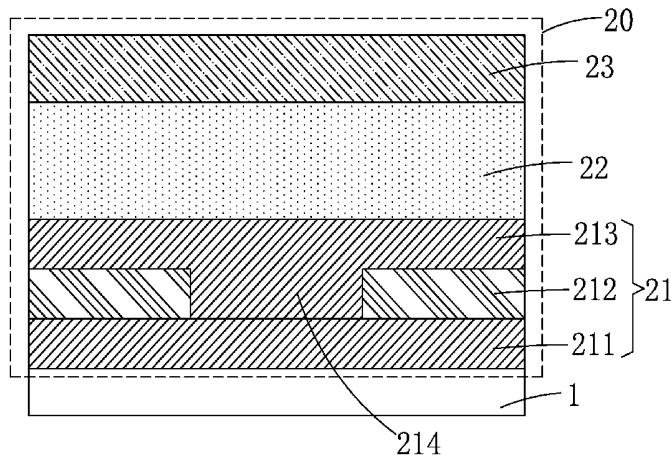
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(57) **ABSTRACT**

The invention provides a transparent OLED display panel and manufacturing method thereof, the OLED display panel comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array; each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer; the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area at the center; through forming hollow area on the reflective electrode of the anode, the light can be emitted simultaneously for the cathode and the hollow area to achieve transparent display with a simple and stable structure, high yield rate and low production cost.

11 Claims, 5 Drawing Sheets



(56) **References Cited**

FOREIGN PATENT DOCUMENTS

CN	104485346 A	4/2015
CN	104795434 A	7/2015
CN	104885250 A	9/2015
CN	105789260 A	7/2016

* cited by examiner

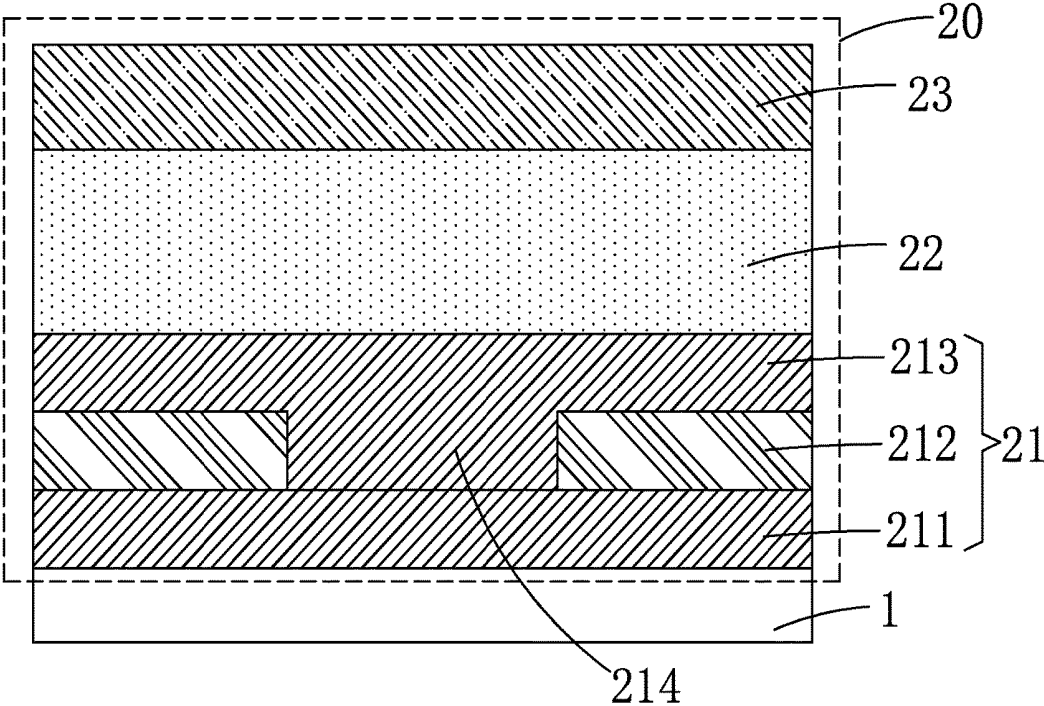


Fig. 1

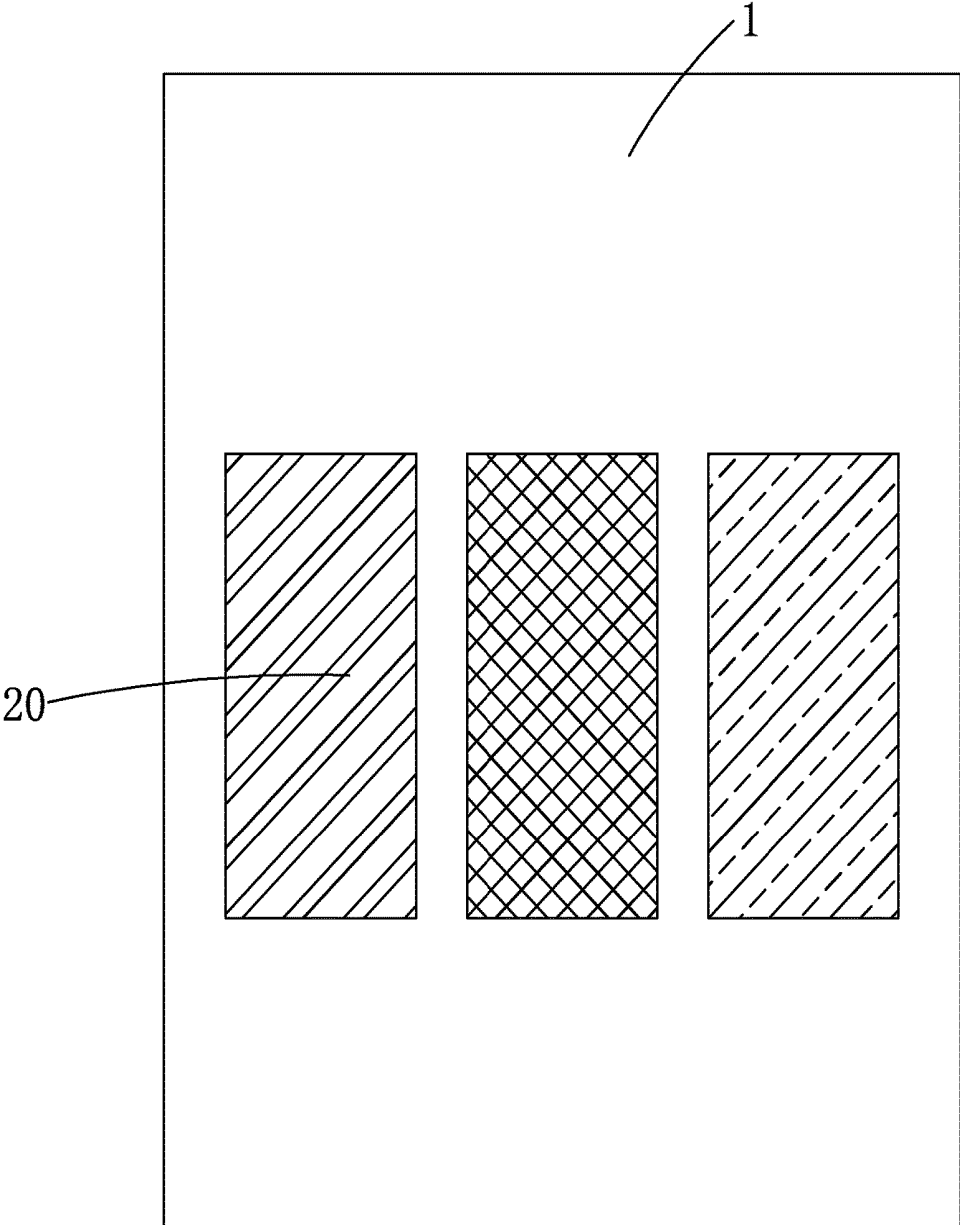


Fig. 2

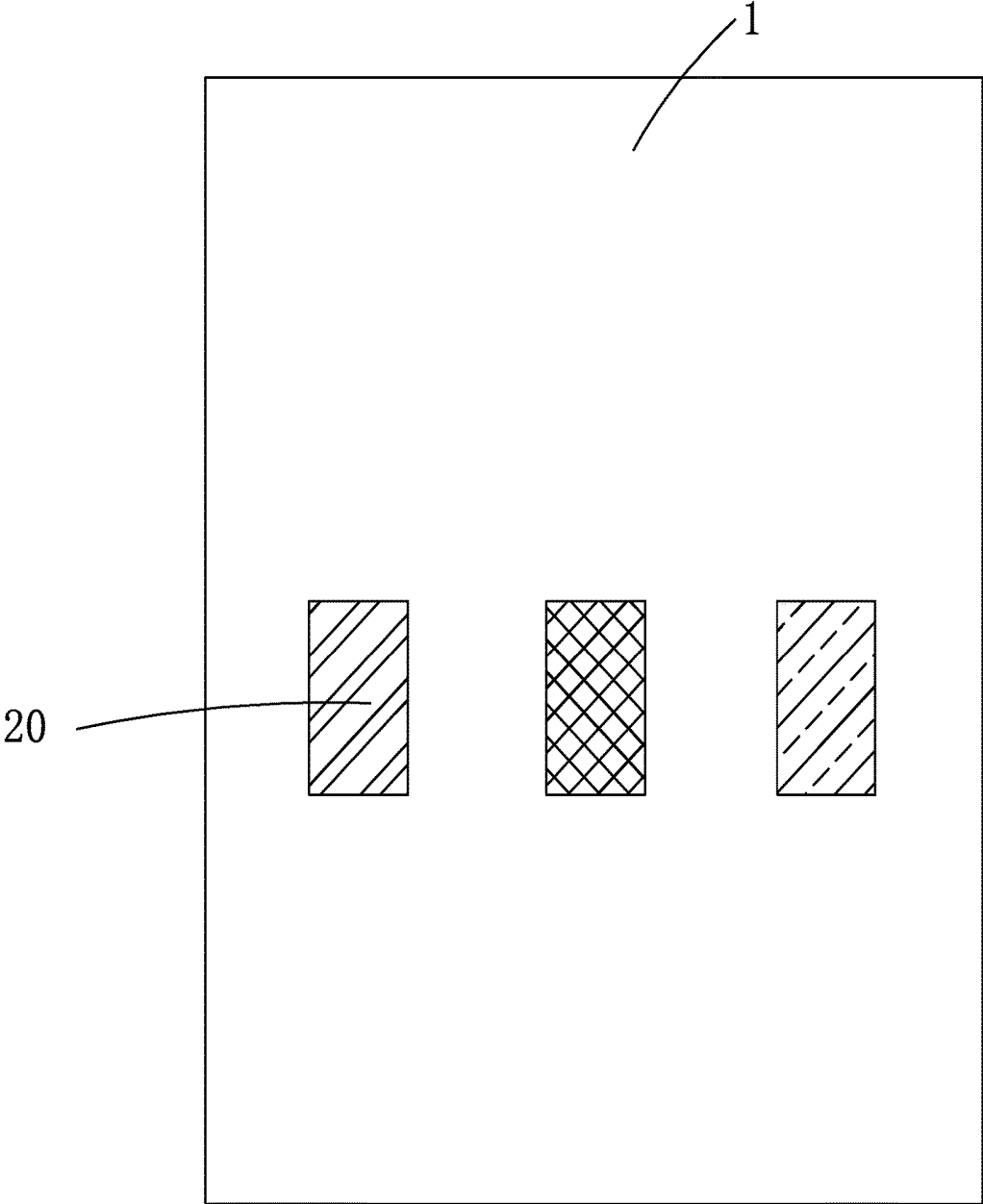


Fig. 3

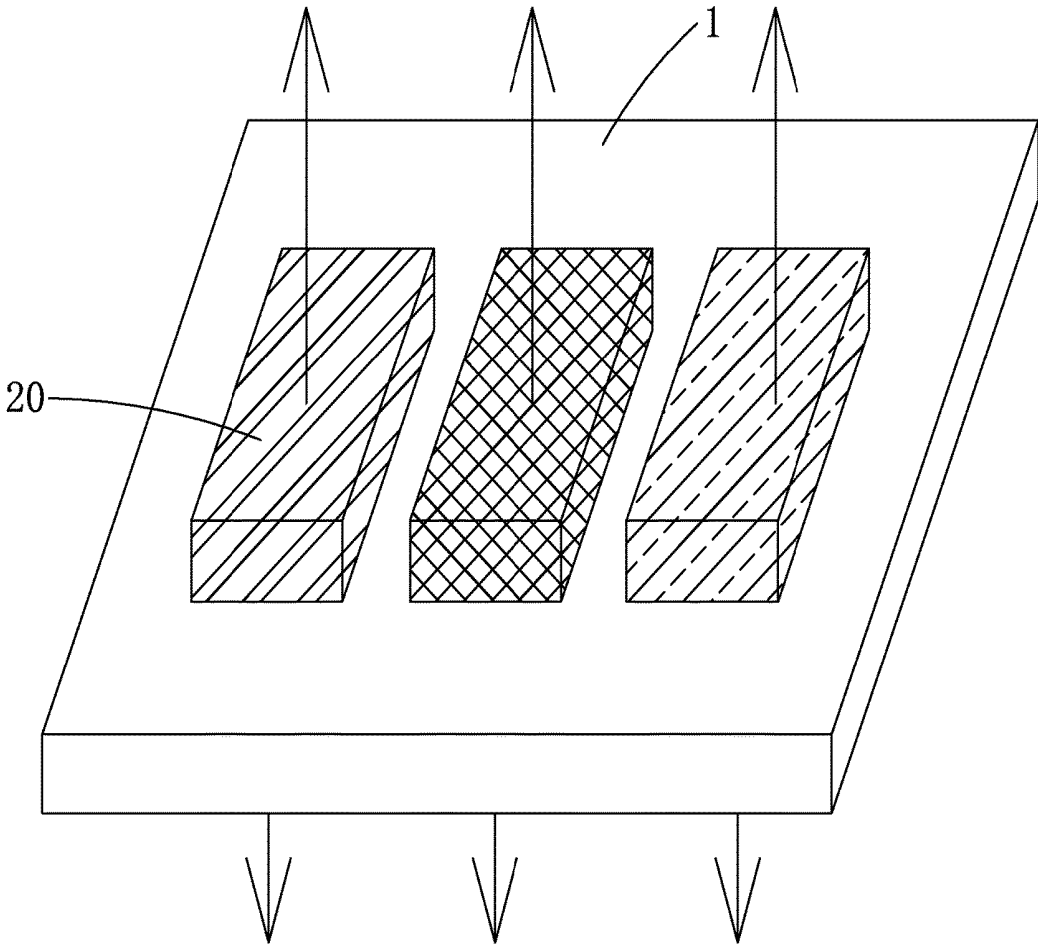


Fig. 4

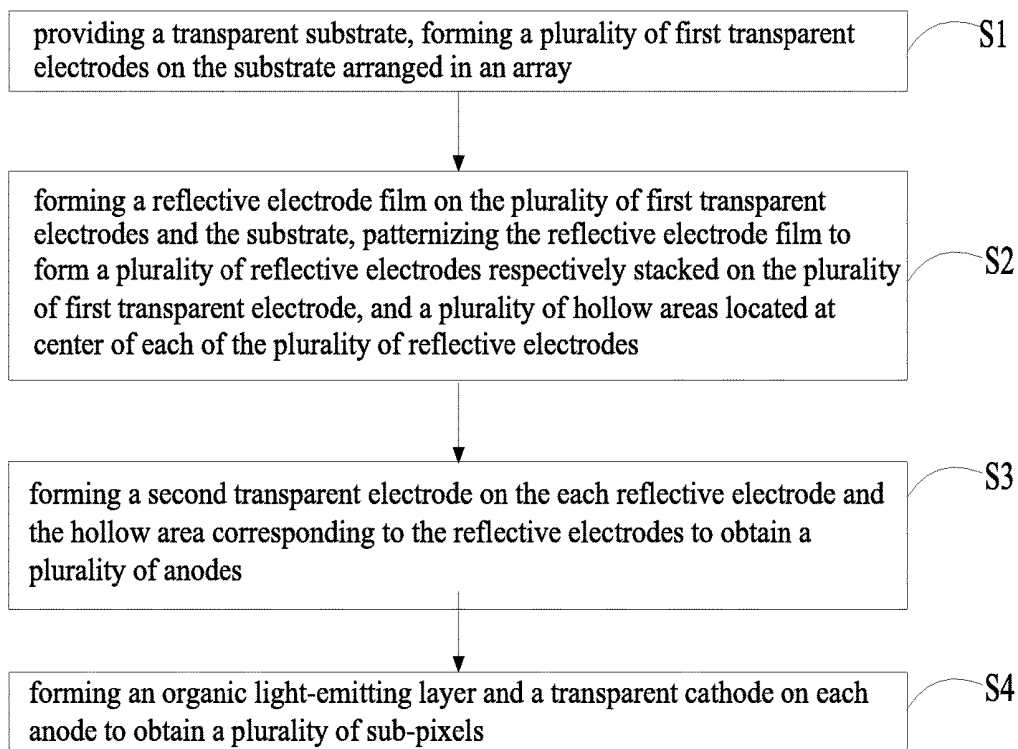


Fig. 5

**TRANSPARENT OLED DISPLAY PANEL AND
MANUFACTURING METHOD THEREOF**

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of display techniques, and in particular to a transparent OLED display panel and manufacturing method thereof.

2. The Related Arts

The organic light-emitting diode (OLED) display technology is a highly promising panel display technology, as the OLED has a very excellent display performance, such as, active-luminous, simple structure, ultra-thin, fast response, wide viewing angle, low power consumption and ability to achieve flexible display, and so on, and is known as the "dream display". Thus, the OLED has attracted the major display manufacturers and has become the main technology in the field of the third generation display device.

The OLED display is an active light-emitting display device, usually comprises a pixel electrode (used as anode), a common electrode (used as cathode), and an organic light-emitting layer disposed between the element electrode and the common electrode, so that the organic light emitting layer emits light when an appropriate voltage is applied to the anode and cathode. The organic light-emitting layer comprises a hole injection layer disposed on the anode, a hole transport layer disposed on the hole injection layer, a light-emitting layer disposed on the hole transport layer, an electron transport layer disposed on the light-emitting layer, an electron injection layer disposed on the electron transport layer. The light-emission principle behind the OLED display device is as follows: under certain voltage driving, electrons and holes are injected from the cathode and the anode into the electron injection layer and the hole injection layer respectively. The electrons and the holes migrate through the electron transport layer and the hole transport layer to the light emitting layer respectively, and meet in the light emitting layer to form excitons to cause the light emitting molecules to excite, and the latter emits visible light by radiation relaxation.

A transparent display generally refers to a display that can form a transparent display state so that the viewer can see the image displayed in the display and the scene behind the display. The transparent displays provide many possible applications, such as, windows for buildings or cars and shopping windows for shopping malls. In addition to the use of these large devices, small devices such as handheld computers can also benefit from transparent displays, such as, enabling users to view the map and be able to view the front view through the screen.

The OLED display device is currently one of the most suitable for the production of transparent display, but the conventional top-emitting OLED display panel, usually using the micro-cavity resonance principle in the anode to manufacture a layer of metal reflective layer (usually silver), that is, using a sandwich structure with two layers of transparent material (usually indium tin oxide, ITO) and a layer of metal material in-between to improve the reflectivity of the anode. However, to ensure the high reflectivity usually requires a thicker metal reflective layer, and the light

from the organic light-emitting layer is unable to penetrate, and unable to achieve transparency display.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a transparent OLED display panel, with a simple and stable structure, high yield rate and low production cost.

Another object of the present invention is to provide a manufacturing method of transparent OLED display panel, able to simplify the production process of transparent OLED display device, improve yield rate of the transparent OLED display device, and reduce the production cost of transparent OLED display device.

To achieve the above object, the present invention provides a transparent OLED display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array;

each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer;

the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area at the center.

According to a preferred embodiment of the present invention, the first transparent electrode and the second transparent electrode are made of ITO, and the reflective electrode is made of silver.

According to a preferred embodiment of the present invention, the hollow area has a round, rectangular, or centrally-symmetric polygon shape.

According to a preferred embodiment of the present invention, the hollow area has a size smaller than or equal to $\frac{1}{3}$ of the area of the sub-pixel.

According to a preferred embodiment of the present invention, the plurality of sub-pixels comprises: at least two different colors of sub-pixels, area ration between the hollow areas of the at least two different colors of sub-pixels is equal to the area ratio between the areas of the at least two different colors of sub-pixels.

The present invention also provides a manufacturing method of transparent OLED display panel, comprising the steps of: providing a transparent substrate, forming a plurality of first transparent electrodes on the substrate arranged in an array; forming a reflective electrode film on the plurality of first transparent electrodes and the substrate, patterning the reflective electrode film to form a plurality of reflective electrodes respectively stacked on the plurality of first transparent electrode, and a plurality of hollow areas located at center of each of the plurality of reflective electrodes; forming a second transparent electrode on the each reflective electrode and the hollow area corresponding to the reflective electrodes to obtain a plurality of anodes; forming an organic light-emitting layer and a transparent cathode on each anode to obtain a plurality of sub-pixels.

According to a preferred embodiment of the present invention, the first transparent electrode and the second transparent electrode are made of ITO, and the reflective electrode is made of silver.

According to a preferred embodiment of the present invention, the hollow area has a round, rectangular, or centrally-symmetric polygon shape.

According to a preferred embodiment of the present invention, the hollow area has a size smaller than or equal to $\frac{1}{3}$ of the area of the sub-pixel.

According to a preferred embodiment of the present invention, the plurality of sub-pixels comprises: at least two different colors of sub-pixels, area ration between the hollow areas of the at least two different colors of sub-pixels is equal to the area ratio between the areas of the at least two different colors of sub-pixels.

The present invention also provides a transparent OLED display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array; each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer; the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area at the center;

wherein the first transparent electrode and the second transparent electrode being made of ITO, and the reflective electrode being made of silver;

wherein the hollow area having a round, rectangular, or centrally-symmetric polygon shape;

wherein the hollow area having a size smaller than or equal to $\frac{1}{3}$ of the area of the sub-pixel;

wherein, the plurality of sub-pixels comprising: at least two different colors of sub-pixels, area ration between the hollow areas of the at least two different colors of sub-pixels being equal to the area ratio between the areas of the at least two different colors of sub-pixels.

Compared to the known techniques, the present invention provides the following advantages. The present invention provides a transparent OLED display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array; each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer; the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area at the center; through forming hollow area on the reflective electrode of the anode, the light can be emitted simultaneously for the cathode and the hollow area to achieve transparent display with a simple and stable structure, high yield rate and low production cost. The present invention also provides a manufacturing method of transparent OLED display panel, able to simplify the production process of transparent OLED display device, improve yield rate of the transparent OLED display device, and reduce the production cost of transparent OLED display device.

BRIEF DESCRIPTION OF THE DRAWINGS

To make the technical solution of the embodiments according to the present invention, a brief description of the drawings that are necessary for the illustration of the embodiments will be given as follows. Apparently, the drawings described below show only example embodiments of the present invention and for those having ordinary skills in the art, other drawings may be easily obtained from these drawings without paying any creative effort. In the drawings:

FIG. 1 is a cross-sectional view showing a transparent OLED display panel provided by an embodiment of the present invention;

FIG. 2 is a top view showing a transparent OLED display panel provided by an embodiment of the present invention;

FIG. 3 is a bottom view showing a transparent OLED display panel provided by an embodiment of the present invention;

FIG. 4 is a 3D schematic view showing a transparent OLED display panel provided by an embodiment of the present invention;

FIG. 5 is a schematic view showing a flowchart of the manufacturing method of transparent OLED display panel provided by an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

To further explain the technique means and effect of the present invention, the following uses preferred embodiments and drawings for detailed description.

Referring to FIG. 2 to FIG. 4, the present invention provides a transparent OLED display panel, comprising: a transparent substrate **1** and a plurality of sub-pixels **20** disposed on the substrate **1** arranged in an array;

Referring to FIG. 1, each sub-pixel **20** comprising: an anode **21** disposed on the substrate **1**, an organic light-emitting layer **22** disposed on the anode **21**, and a transparent cathode **23** disposed on the organic light-emitting layer **22**;

the anode **21** comprising: a first transparent electrode **211**, a reflective electrode **212** stacked on the first transparent electrode **211**, a second transparent electrode **213** stacked on the reflective electrode **212**, the reflective electrode **212** forming a hollow area **214** at the center.

Preferably, the first transparent electrode **211** and the second transparent electrode **212** are made of indium tin oxide (ITO), and the reflective electrode is made of silver (Ag).

Specifically, the shape of the hollow area **214** depends on the application requirements; preferably, the hollow area **214** has a round, rectangular, or centrally-symmetric polygon shape.

Moreover, to consider both the reflection effect of the reflective electrode **212** and the display effect of transparent display, the hollow area **214** preferably has a size smaller than or equal to $\frac{1}{3}$ of the area of the sub-pixel **20**.

Specifically, the plurality of sub-pixels **20** comprises: at least two different colors of sub-pixels **20**, area ration between the hollow areas **214** of the at least two different colors of sub-pixels **20** is equal to the area ratio between the areas of the at least two different colors of sub-pixels **20**.

For example, the plurality of sub-pixels **20** of the transparent OLED display panel comprises a plurality of red sub-pixels, a plurality of green sub-pixels, and a plurality of blue sub-pixels; and if the area ratio among the red sub-pixels, the green sub-pixels and the blue sub-pixels is 1:1:2, the ratio of the hollow areas **214** area of the red sub-pixels, the green sub-pixels, and the blue sub-pixels is also 1:1:2.

It should be noted that, as shown in FIG. 4, the present invention, by adding the hollow area **214** to the reflective electrode **212** so that the light emitted to the hollow are **214** through the second transparent electrode **213** is no longer reflected but continues through the first transparent electrode **211** to be emitted from the bottom of the substrate **1**. The light emitted to the reflective electrode **212** is still reflected and emitted from the cathode **23** so as to realize transparent

display. As such, the structure is simple and stable, and the yield is high and the production cost is low.

Moreover, refer to FIG. 5, in combination with FIGS. 1-4, the present invention also provides a manufacturing method of transparent OLED display panel, comprising the steps of:

Step S1: providing a transparent substrate **1**, forming a plurality of first transparent electrodes **211** on the substrate **1** arranged in an array.

Moreover, the step of forming a plurality of first transparent electrodes **211** specifically comprises: forming a transparent electrode film on the substrate **1**, patternizing the transparent electrode film to obtain a plurality of first transparent electrode **211**. Preferably, the substrate **1** is a glass substrate, and the first transparent electrode **211** is made of ITO.

Step S2: forming a reflective electrode film on the plurality of first transparent electrodes **211** and the substrate **1**, patternizing the reflective electrode film to form a plurality of reflective electrodes **212** respectively stacked on the plurality of first transparent electrode **211**, and a plurality of hollow areas **214** located at center of each of the plurality of reflective electrodes **212**.

Preferably, the reflective electrode **212** is made of silver.

Specifically, the shape of the hollow area **214** depends on the application requirements; preferably, the hollow area **214** has a round, rectangular, or centrally-symmetric polygon shape.

Moreover, to consider both the reflection effect of the reflective electrode **212** and the display effect of transparent display, the hollow area **214** preferably has a size smaller than or equal to $\frac{1}{3}$ of the area of the sub-pixel **20**.

Step S3: forming a second transparent electrode **213** on the each reflective electrode **212** and the hollow area **214** corresponding to the reflective electrodes **212** to obtain a plurality of anodes **21**.

Moreover, the step of forming a plurality of second transparent electrodes **213** specifically comprises: forming a transparent electrode film on the substrate **1**, patternizing the transparent electrode film to obtain a plurality of second transparent electrode **213**. Preferably, the second transparent electrode **213** is made of ITO.

Step S4: forming an organic light-emitting layer **22** and a transparent cathode **23** on each anode **21** to obtain a plurality of sub-pixels **20**.

Specifically, the plurality of sub-pixels **20** comprises: at least two different colors of sub-pixels **20**, area ration between the hollow areas **214** of the at least two different colors of sub-pixels **20** is equal to the area ratio between the areas of the at least two different colors of sub-pixels **20**.

For example, the plurality of sub-pixels **20** of the transparent OLED display panel comprises a plurality of red sub-pixels, a plurality of green sub-pixels, and a plurality of blue sub-pixels; and if the area ratio among the red sub-pixels, the green sub-pixels and the blue sub-pixels is 1:1:2, the ratio of the hollow areas **214** area of the red sub-pixels, the green sub-pixels, and the blue sub-pixels is also 1:1:2.

It should be noted that, as shown in FIG. 4, the present invention, by adding the hollow area **214** to the reflective electrode **212** so that the light emitted to the hollow are **214** through the second transparent electrode **213** is no longer reflected but continues through the first transparent electrode **211** to be emitted from the bottom of the substrate **1**. The light emitted to the reflective electrode **212** is still reflected and emitted from the cathode **23** so as to realize transparent display. As such, the structure is simple and stable, and the yield is high and the production cost is low.

In summary, the present invention provides a transparent OLED display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array; each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer; the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area at the center; through forming hollow area on the reflective electrode of the anode, the light can be emitted simultaneously for the cathode and the hollow area to achieve transparent display with a simple and stable structure, high yield rate and low production cost. The present invention also provides a manufacturing method of transparent OLED display panel, able to simplify the production process of transparent OLED display device, improve yield rate of the transparent OLED display device, and reduce the production cost of transparent OLED display device.

It should be noted that in the present disclosure the terms, such as, first, second are only for distinguishing an entity or operation from another entity or operation, and does not imply any specific relation or order between the entities or operations. Also, the terms "comprises", "include", and other similar variations, do not exclude the inclusion of other non-listed elements. Without further restrictions, the expression "comprises a . . ." does not exclude other identical elements from presence besides the listed elements.

Embodiments of the present invention have been described, but not intending to impose any unduly constraint to the appended claims. Any modification of equivalent structure or equivalent process made according to the disclosure and drawings of the present invention, or any application thereof, directly or indirectly, to other related fields of technique, is considered encompassed in the scope of protection defined by the claims of the present invention.

What is claimed is:

1. A transparent organic light-emitting diode (OLED) display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array;

each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer;

the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area in a center thereof.

2. The transparent OLED display panel as claimed in claim 1, wherein the first transparent electrode and the second transparent electrode are made of indium tin oxide (ITO), and the reflective electrode is made of silver (Ag).

3. The transparent OLED display panel as claimed in claim 1, wherein the hollow area has a round, rectangular, or centrally-symmetric polygon shape.

4. The transparent OLED display panel as claimed in claim 1, wherein the hollow area has a size smaller than or equal to $\frac{1}{3}$ of an area of the sub-pixel.

5. The transparent OLED display panel as claimed in claim 1, wherein the plurality of sub-pixels comprises: at least two different colors of sub-pixels, and an area ratio between the hollow areas of the at least two different colors

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of sub-pixels is equal to an area ratio between areas of the at least two different colors of sub-pixels.

6. A manufacturing method of transparent organic light-emitting diode (OLED) display panel, comprising the steps of:

providing a transparent substrate, forming a plurality of first transparent electrodes on the substrate arranged in an array;

forming a reflective electrode film on the plurality of first transparent electrodes and the substrate, patterning the reflective electrode film to form a plurality of reflective electrodes respectively stacked on the plurality of first transparent electrode, and a plurality of hollow areas located at center of each of the plurality of reflective electrodes;

forming a second transparent electrode on the each reflective electrode and the hollow area corresponding to the reflective electrodes to obtain a plurality of anodes;

forming an organic light-emitting layer and a transparent cathode on each anode to obtain a plurality of sub-pixels.

7. The manufacturing method of transparent OLED display panel as claimed in claim 6, wherein the first transparent electrode and the second transparent electrode are made of indium tin oxide (ITO), and the reflective electrode is made of silver (Ag).

8. The manufacturing method of transparent OLED display panel as claimed in claim 6, wherein the hollow area has a round, rectangular, or centrally-symmetric polygon shape.

9. The manufacturing method of transparent OLED display panel as claimed in claim 6, wherein the hollow area has a size smaller than or equal to $\frac{1}{3}$ of an area of the sub-pixel.

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10. The manufacturing method of transparent OLED display panel as claimed in claim 6, wherein the plurality of sub-pixels comprises: at least two different colors of sub-pixels, an area ratio between the hollow areas of the at least two different colors of sub-pixels is equal to an area ratio between areas of the at least two different colors of sub-pixels.

11. A transparent organic light-emitting diode (OLED) display panel, comprising: a transparent substrate and a plurality of sub-pixels disposed on the substrate arranged in an array;

each sub-pixel comprising: an anode disposed on the substrate, an organic light-emitting layer disposed on the anode, and a transparent cathode disposed on the organic light-emitting layer;

the anode comprising: a first transparent electrode, a reflective electrode stacked on the first transparent electrode, a second transparent electrode stacked on the reflective electrode, the reflective electrode forming a hollow area in a center thereof;

wherein the first transparent electrode and the second transparent electrode are made of indium tin oxide (ITO), and the reflective electrode is made of silver (Ag);

wherein the hollow area has a round, rectangular, or centrally-symmetric polygon shape;

wherein the hollow area has a size smaller than or equal to $\frac{1}{3}$ of an area of the sub-pixel;

wherein the plurality of sub-pixels comprises: at least two different colors of sub-pixels, an area ratio between hollow areas of the at least two different colors of sub-pixels is equal to an area ratio between the areas of the at least two different colors of sub-pixels.

* * * * *

专利名称(译)	透明OLED显示面板及其制造方法		
公开(公告)号	US10333098	公开(公告)日	2019-06-25
申请号	US15/557134	申请日	2017-08-18
[标]发明人	CHI MINGMING PEI LEI		
发明人	CHI, MINGMING PEI, LEI		
IPC分类号	H01L51/52 H01L51/56		
CPC分类号	H01L51/5234 H01L51/5209 H01L51/56 H01L51/5218 H01L2251/308 H01L27/3216 H01L51/5215 H01L2251/5323		
代理机构(译)	林雷, 鸿C.		
优先权	201710453650.5 2017-06-15 CN		
其他公开文献	US20180366678A1		
外部链接	Espacenet		

摘要(译)

本发明提供一种透明OLED显示面板及其制造方法，所述OLED显示面板包括：透明基板和设置在所述基板上的多个子像素，所述多个子像素排列成阵列；每个子像素包括：设置在基板上的阳极，设置在阳极上的有机发光层，和设置在有机发光层上的透明阴极；阳极包括：第一透明电极，堆叠在第一透明电极上的反射电极，堆叠在反射电极上的第二透明电极，反射电极在中心形成中空区域；通过在阳极反射电极上形成中空区域，可以同时为阴极和中空区域发光，实现透明显示，结构简单稳定，成品率高，生产成本低。

