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(54) **VAPOR DEPOSITION SOURCE AND METHOD FOR MAKING ORGANIC LIGHT-EMITTING DIODE DISPLAY PANEL**

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

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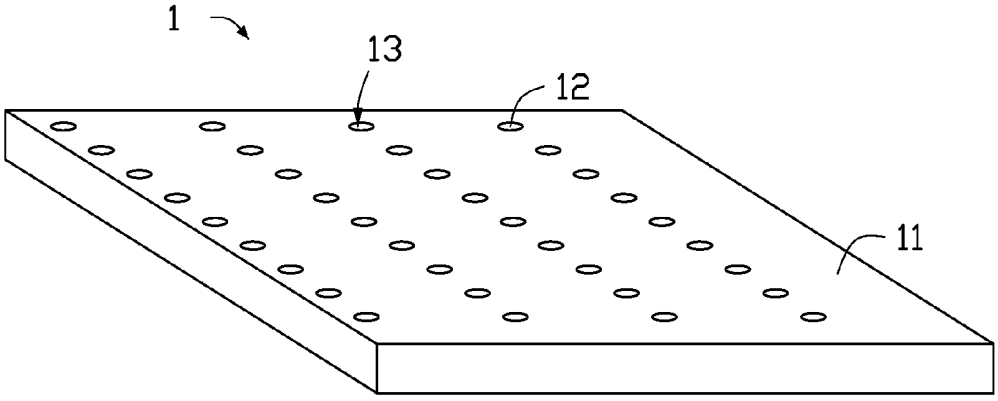
(57) **ABSTRACT**

A source to facilitate precise vapor deposition in processes to obtain organic light emitting diodes (OLEDs) in a display panel, includes forming a plurality of grooves on a first substrate; in filling organic light emitting materials into the grooves and providing a second substrate to receive the vaporized organic light emitting materials. The first substrate is aligned with the second substrate and the first substrate is heated to vaporize the organic light emitting materials in the grooves. The vapor deposition regions of the second substrate form an organic light emitting material layer after the deposition, the layer can then be used in an OLED display panel. The shadow effect is greatly reduced, a method for the procedure is also disclosed.



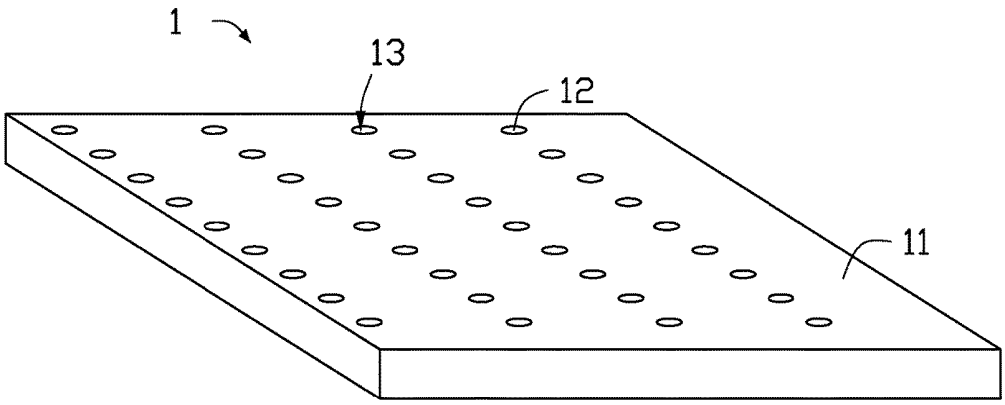


FIG. 1

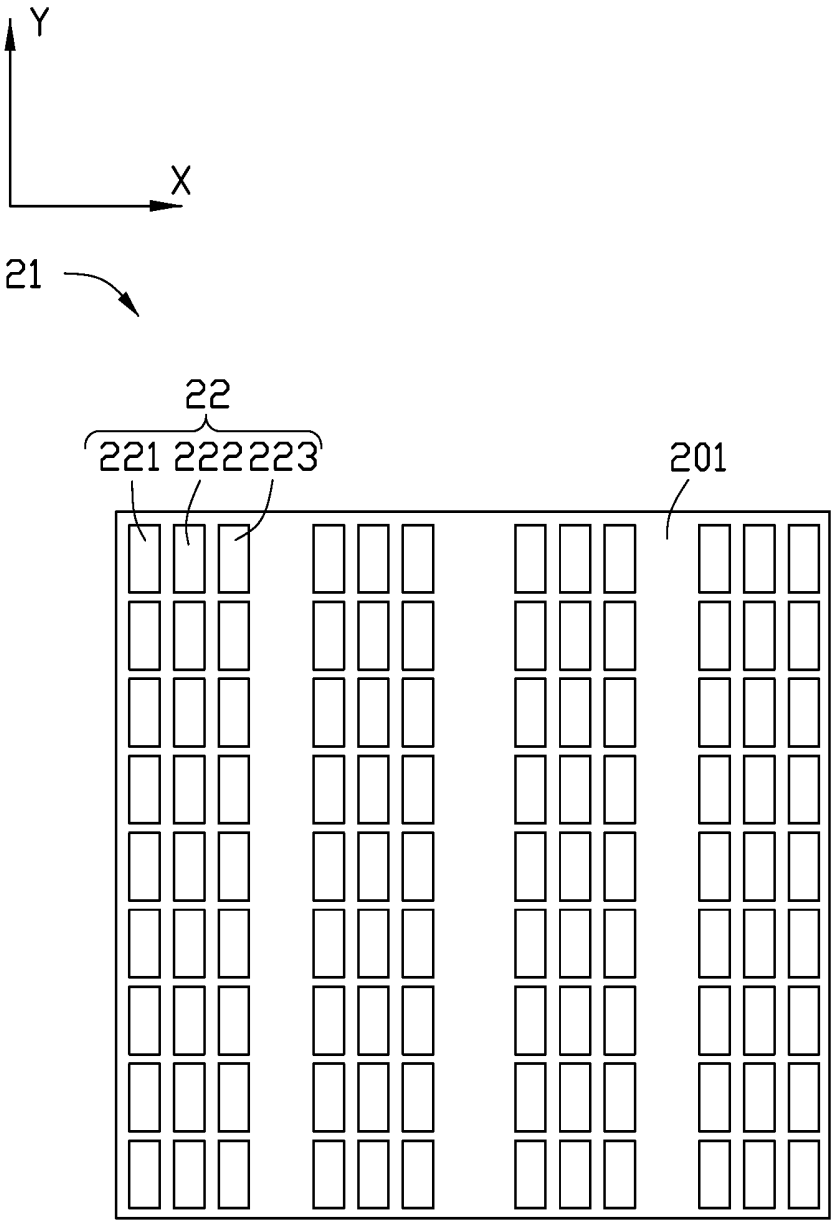


FIG. 2

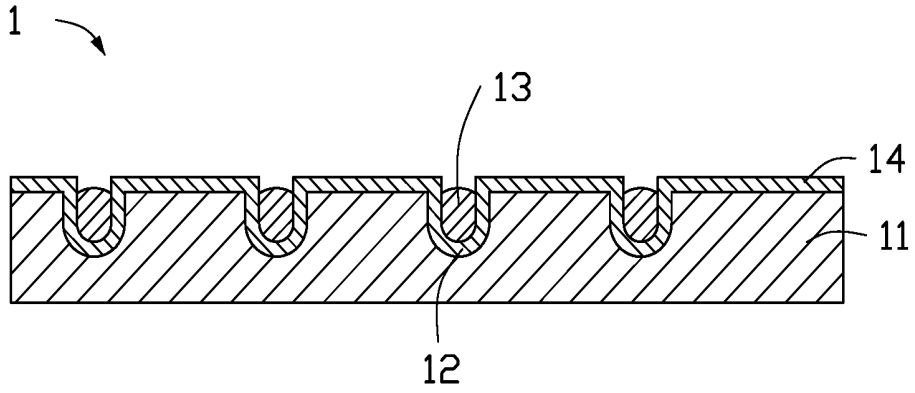


FIG. 3

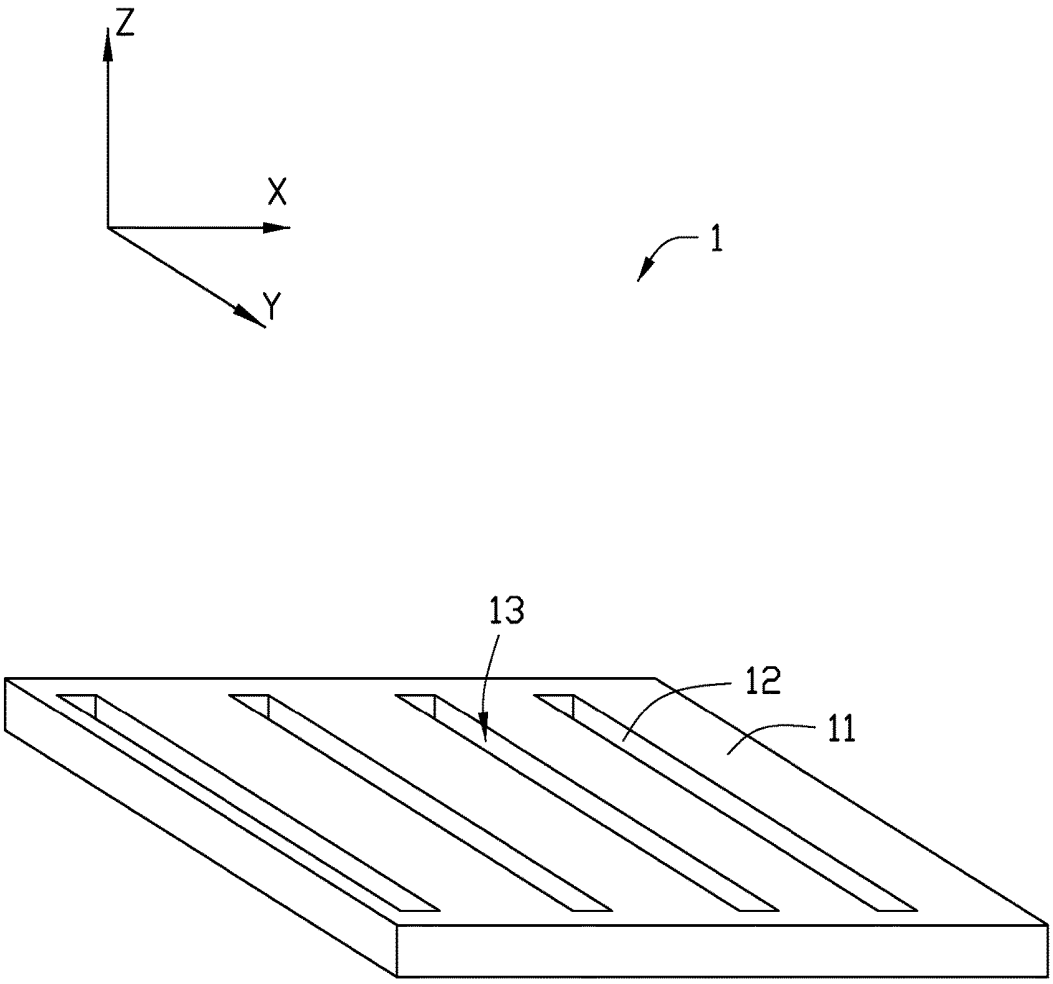


FIG. 4

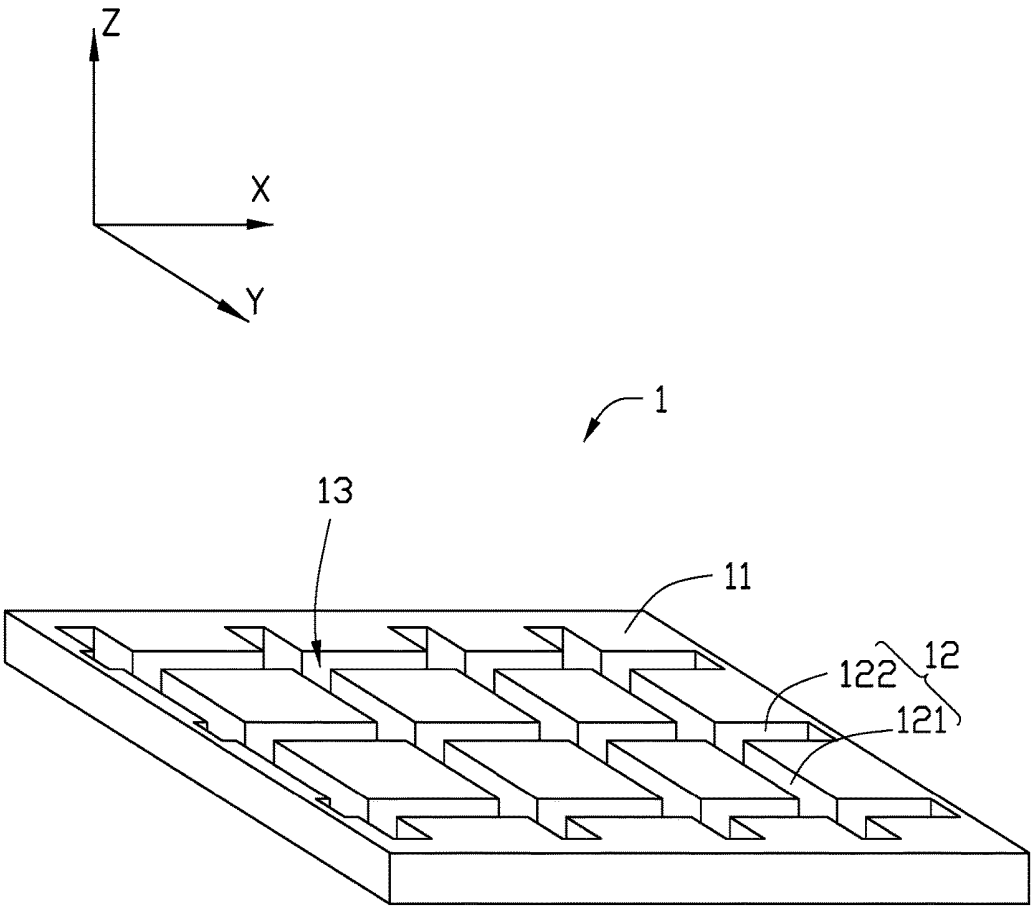


FIG. 5

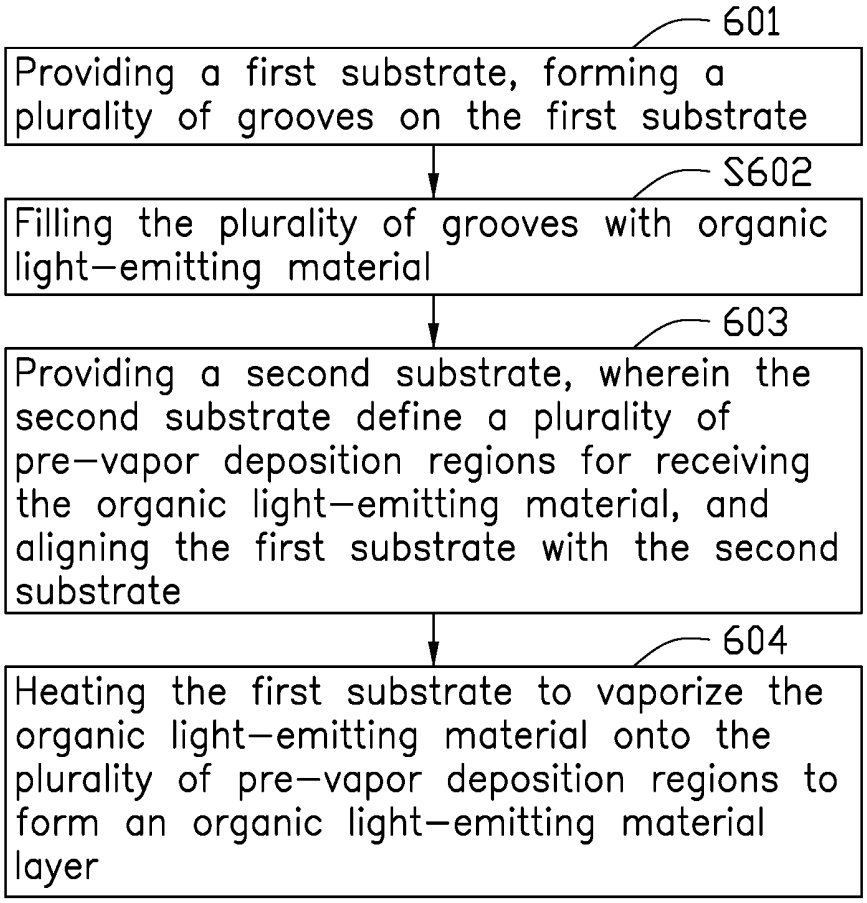

601
Providing a first substrate, forming a plurality of grooves on the first substrate
S602
Filling the plurality of grooves with organic light-emitting material
603
Providing a second substrate, wherein the second substrate define a plurality of pre-vapor deposition regions for receiving the organic light-emitting material, and aligning the first substrate with the second substrate
604
Heating the first substrate to vaporize the organic light-emitting material onto the plurality of pre-vapor deposition regions to form an organic light-emitting material layer

FIG. 6

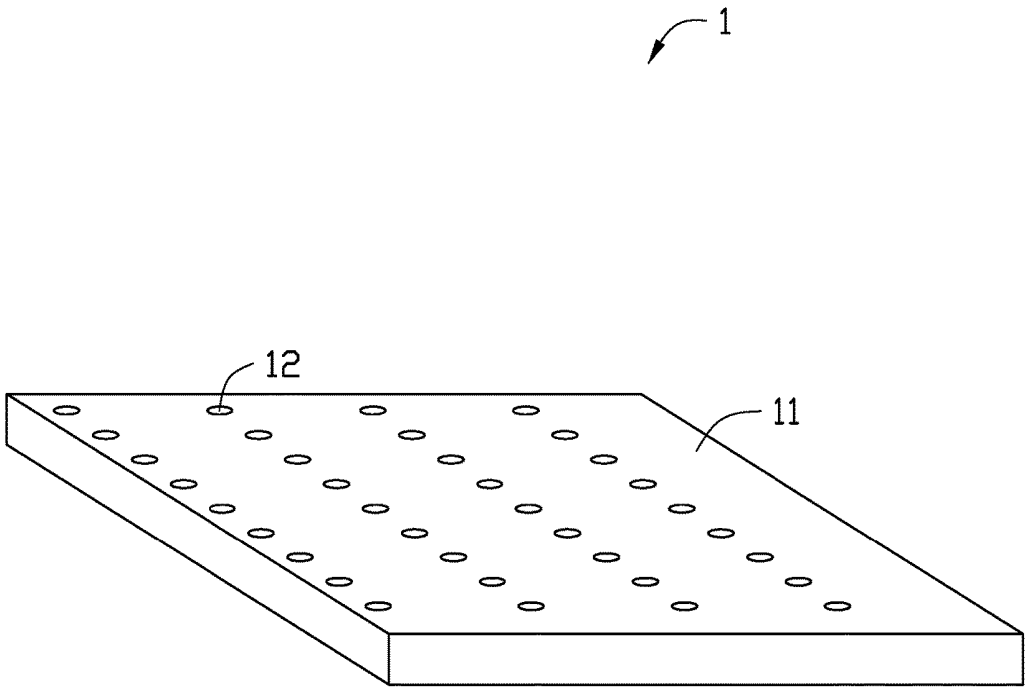


FIG. 7

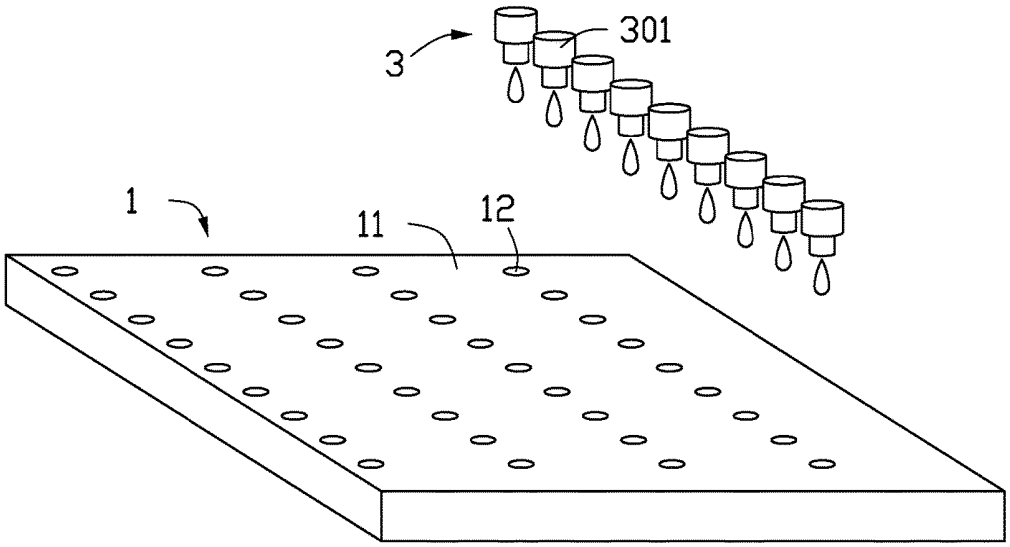


FIG. 8

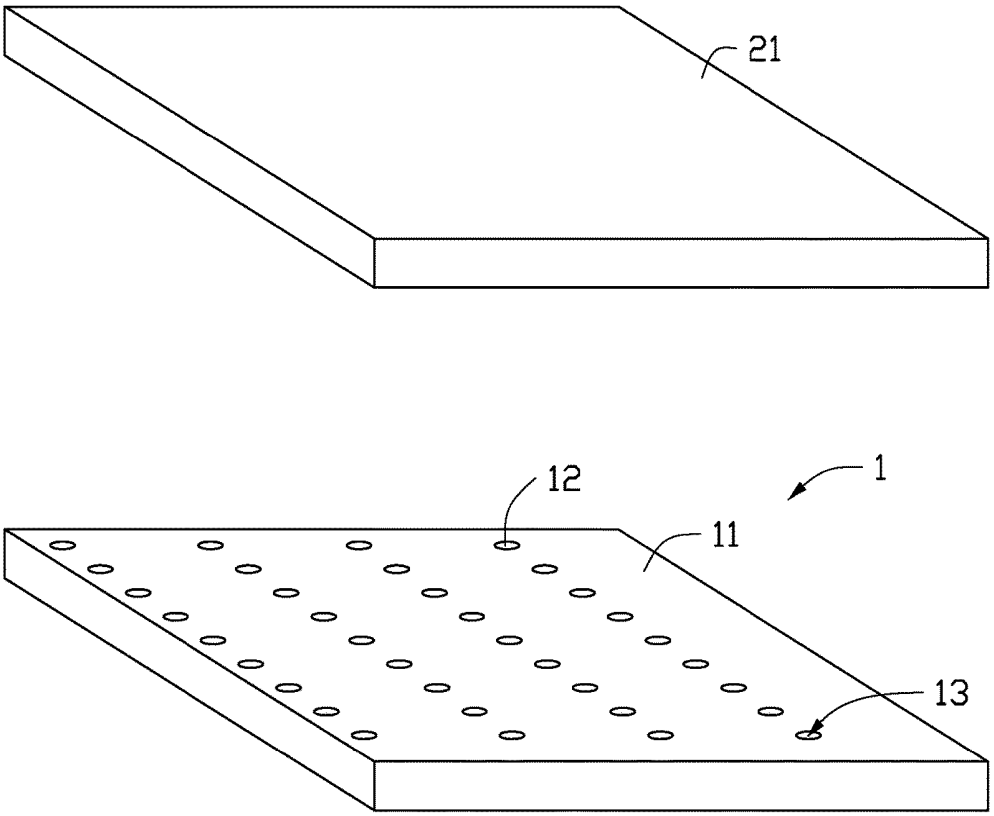


FIG. 9

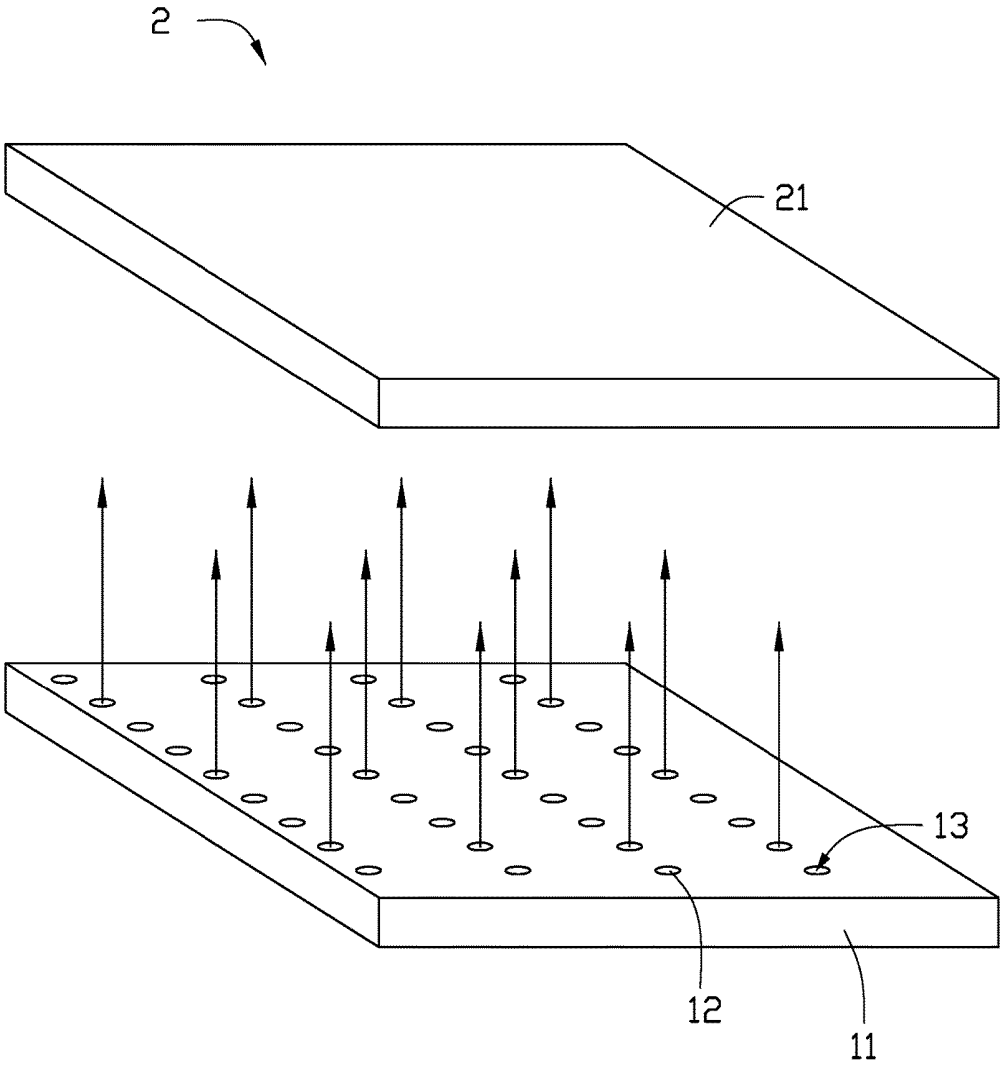


FIG. 10

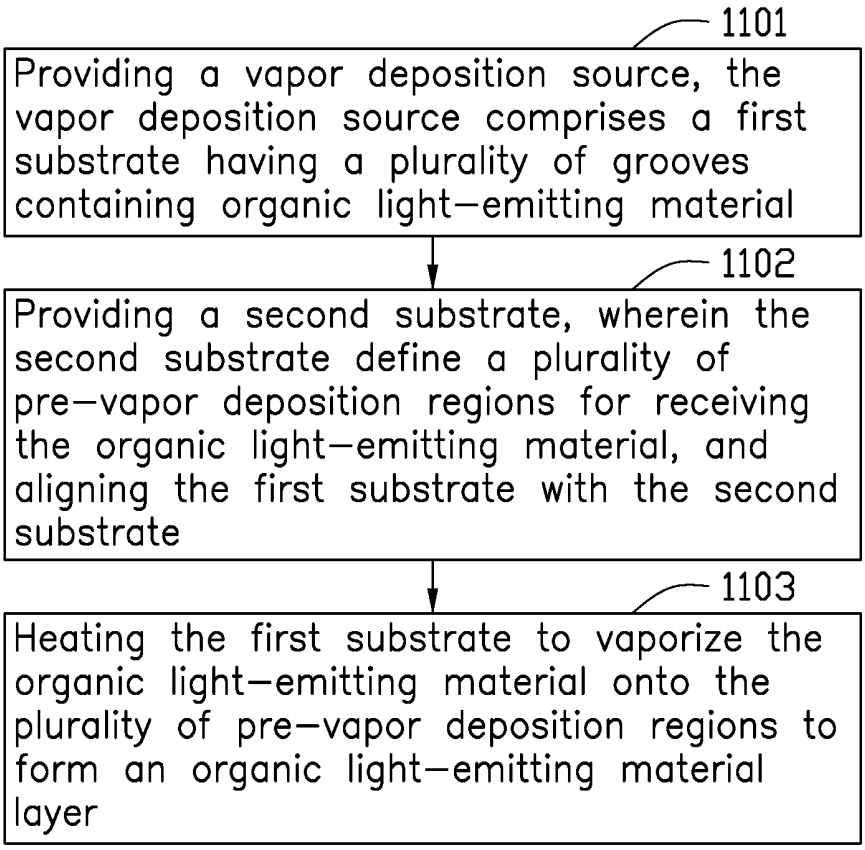

1101
Providing a vapor deposition source, the vapor deposition source comprises a first substrate having a plurality of grooves containing organic light-emitting material
1102
Providing a second substrate, wherein the second substrate define a plurality of pre-vapor deposition regions for receiving the organic light-emitting material, and aligning the first substrate with the second substrate
1103
Heating the first substrate to vaporize the organic light-emitting material onto the plurality of pre-vapor deposition regions to form an organic light-emitting material layer

FIG. 11

VAPOR DEPOSITION SOURCE AND METHOD FOR MAKING ORGANIC LIGHT-EMITTING DIODE DISPLAY PANEL

FIELD

[0001] The subject matter herein generally relates to organic light emitting diode (OLED) manufacture.

BACKGROUND

[0002] Organic Light-Emitting Diode (OLED) displays permit wide color gamut. OLEDs are light weight, and consumer little power. An OLED display does not use a backlight as a light source but an organic light-emitting material located on a glass substrate of the OLED display. Generally, the light-emitting material layer is formed by vapor deposition. However, a vapor deposition angle of a vapor deposition source may be too small or too large, resulting in shadow effects or uneven film thickness.

[0003] Therefore, there is room for improvement in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Implementations of the present technology will now be described, by way of embodiment, with reference to the attached figures.

[0005] FIG. **1** is a perspective view of a vapor deposition source according to a first embodiment of the present disclosure.

[0006] FIG. **2** is a planar view of a second substrate for carrying a vapor deposition material according to the first embodiment of the present disclosure.

[0007] FIG. **3** is a cross-sectional view of a vapor deposition source according to another embodiment of the present disclosure.

[0008] FIG. **4** is a perspective view of a vapor deposition source according to a second embodiment of the present disclosure.

[0009] FIG. **5** is a perspective view of a vapor deposition source according to a third embodiment of the present disclosure.

[0010] FIG. **6** is a flowchart of a method for manufacturing an OLED display panel according to the first embodiment of the present disclosure.

[0011] FIG. **7** through FIG. **10** are perspective views showing a method for manufacturing the OLED display panel according to the first embodiment of the present disclosure.

[0012] FIG. **11** is a flowchart of a method for manufacturing an OLED display panel according to another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0013] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

[0014] The term "coupled" is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The connection can be such that the objects are permanently connected or releasably connected. The term "comprising" when utilized, means "including, but not necessarily limited to"; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

[0015] As shown in FIG. **1**, a vapor deposition source **1** according to a first embodiment of present disclosure comprises a first substrate **11**. The first substrate **11** is a flat plate, the first substrate **11** is made of a heatable material which can conduct heat. In an embodiment, the first substrate **11** may be one of a glass substrate, a quartz substrate, a silicon substrate, or a plastic substrate.

[0016] As shown in FIG. **1**, a plurality of grooves **12** are provided on a surface of the first substrate **11** and spaced apart from each other. In this embodiment, each of the grooves **12** is a circular dot-shaped groove. In other embodiments, each of the grooves **12** may be a square, rhombic, triangular, or other shape. The number and positions of the grooves **12** can be set according to the required structure of organic light-emitting layers of pixels of the OLED display. In the embodiment, the grooves **12** are evenly distributed on the first substrate **11**.

[0017] Each groove contains vapor deposition material **13**. Each groove **12** may contain same weight of vapor deposition material. It can be understood that the weight of the vapor deposition material **13** in each groove **12** may vary depending on the design of the structure and number of grooves **12**. For example, when the area of blue organic light-emitting layer is to be larger than the area of red/green organic light-emitting material layer, the vapor deposition source **1** may comprise a plurality of grooves **12** containing blue-light vapor deposition material and a plurality of grooves **12** containing vapor deposition material of other colors, and a weight of the vapor deposition material **13** in the groove **12** containing blue-light vapor deposition material is heavier than a weight of the vapor deposition material **13** in the groove **12** containing vapor deposition material of other colors.

[0018] It can be understood that, when designing the vapor deposition source **1**, in addition to adjust the weight of the vapor deposition material **13** in the grooves **12**, the depth, area, and other feature of the grooves **12** can also be adjusted.

[0019] FIG. **2** shows a second substrate **21** for carrying a vapor deposition material according to the first embodiment of the present disclosure. The second substrate **21** comprises a first surface **201**, and the first surface **201** defines a plurality of pre-vapor deposition regions **22**. The pre-vapor deposition regions **22** receives the vapor deposition material **13** in vaporized form, and then cooling the vapor deposition material **13** in vaporized form. That is, the vapor deposition material **13** may be formed on the pre-vapor deposition region **22** of the first surface **201** of the second substrate **21** after vapor deposition.

[0020] In this embodiment, each pre-vapor deposition region **22** comprises at least one first pre-vapor deposition sub-region **221**, at least one second pre-vapor deposition sub-region **222**, and at least one third pre-vapor deposition sub-region **223**. That is, the second substrate **21** includes a plurality of first pre-vapor deposition sub-regions **221**, a plurality of second pre-vapor deposition sub-regions **222**, and a plurality of third pre-vapor deposition sub-regions **223**.

[0021] After different vapor deposition processes, different vapor deposition materials **13** may be formed on each first pre-vapor deposition sub-region **221**, each second pre-vapor deposition sub-region **222**, and each pre-vapor deposition sub-region **223** respectively.

[0022] As shown in FIG. **2**, the plurality of pre-vapor deposition regions **22** are arranged in rows and columns in a matrix on the second substrate **21**. The first pre-vapor deposition sub-region **221**, the second pre-vapor deposition sub-region **222**, and the third pre-vapor deposition sub-region **223** of each pre-vapor deposition region **22** are arranged sequentially in rows (an X direction as shown in FIG. **2**).

[0023] The plurality of first pre-vapor deposition sub-regions **221** are arranged in a columnar direction (a Y direction as shown in FIG. **2**) to form a plurality of columns of the first pre-vapor deposition sub-regions **221**. The plurality of second pre-vapor deposition sub-regions **222** are also arranged in the columnar direction (the Y direction shown in FIG. **2**) to form a plurality of columns of the second pre-vapor deposition sub-regions **222**. The plurality of third pre-vapor deposition sub-regions **223** are also arranged in the columnar direction (the Y direction shown in FIG. **2**) to form a plurality of columns of the third pre-vapor deposition sub-regions **223**.

[0024] Each pre-vapor deposition sub-region **22** is to be a pixel region of the OLED display, and each pre-vapor deposition sub-region **22** will receive organic light-emitting material of a predetermined light-color. The first pre-vapor deposition sub-region **221**, the second pre-vapor deposition sub-region **222**, and the second pre-vapor deposition sub-region **223** respectively correspond to pixel regions of different light-colors. The pre-vapor deposition sub-regions **22** located in the same column correspond to pixel regions of the same light-color.

[0025] In this embodiment, the vapor deposition material **13** is organic light-emitting material. After the first substrate **11** is aligned with the second substrate **21**, the plurality of grooves **12** on the first substrate **11** correspond to the plurality of first pre-vapor deposition regions **221** on the second substrate **21**. The projections of the grooves **12** on the first substrate **11** overlap with the first pre-vapor-deposition regions **221**. The organic light-emitting material of a first light-color in the grooves **12** can be vapor deposited on the plurality of first pre-vapor deposition regions **221** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the first color.

[0026] It can be understood that after forming the organic light emitting material layer of the first color, a first substrate **11** including a plurality of grooves **12** containing organic light-emitting material of a second light-color may be provided. In an embodiment, after the first substrate **11** is aligned with the second substrate **21**, the plurality of grooves **12** on the first substrate **11** correspond to the plurality of second pre-vapor deposition regions **222**. The projections of the grooves **12** on the first substrate **11** overlap with the second pre-vapor-deposition regions **222** on the second substrate **21**. The organic light-emitting material of the second color in the grooves **12** can be vapor deposited on the plurality of second pre-vapor deposition regions **222** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the second color. Furthermore, after forming the organic light-emitting material layer of the second color, another first substrate **11** including a plurality of grooves **12** containing organic light emitting material of a third light-color may be provided. In an embodiment, after the first substrate **11** is aligned with the second substrate **21**, the plurality of grooves **12** on the first substrate **11** correspond to the plurality of third pre-vapor deposition regions **223** on the second substrate **21**. The projections of the grooves **12** on the first substrate **11** overlap with the third pre-vapor-deposition regions **223** on the second substrate **21**. The organic light-emitting material of the third color in the grooves **12** can be vapor deposited on the plurality of third pre-vapor deposition regions **223** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the third color.

[0027] In this embodiment, when forming the organic light-emitting material layers of different light-colors, different vapor deposition sources **1** containing the organic light-emitting material of different light-colors may be used. However, it can be understood that, in an embodiment, one vapor deposition source **1** can be used at a time during several processes to form organic light-emitting material layers of different light-colors. When the organic light-emitting material of the first light-color in the vapor deposition source **1** needs to be changed to the organic light-emitting material of the second light-color, the grooves **12** may be cleaned to remove the organic light-emitting material of the first light-color remaining.

[0028] As shown in FIG. **3**, in an embodiment, when one vapor deposition source **1** is used to form the organic light-emitting material layers of different light-colors, in order to prevent the light-emitting material remaining in the groove **12**, a peelable layer **14** covering inner surfaces of the grooves **12** may be provided. The peelable layer **14** may also cover a surface of the first substrate on which the grooves **12** are formed. The peelable layer **14** can be easily separated from the first substrate **11**. After the organic light-emitting material of the first light-color is vapor deposited, the peelable layer **14** may be peeled off, and another peelable layer **14** may be formed before depositing organic light-emitting material of the different light-color. The method of peeling off the peelable layer **14** may be physical or chemical. For example, the peelable layer **14** may be a photoresist material that can be removed by an ashing process, or may be an organic material layer that can be easily dissolved in a solvent.

[0029] In the following embodiments, elements having the same or similar functions as those of the first embodiment are described by the same reference numerals.

[0030] As shown in FIG. **4**, the vapor deposition source **1** of a second embodiment comprises a first substrate **11**. A plurality of grooves **12** are provided on a surface of the first substrate **11** and spaced from each other. The plurality of grooves contain the vapor deposition material **13**. In this embodiment, the plurality of grooves **12** are linear grooves in straight lines. In other embodiments, the grooves **12** may

also be linear grooves in curved lines or broken lines. In this embodiment, the grooves **12** may be parallel to each other.

[0031] In this embodiment, after the first substrate **11** is aligned with the second substrate **21**, each of the grooves **12** extending in a Y direction as in FIG. **4** corresponds to a column of the plurality of first pre-vapor deposition regions **221**. That is, a projection of each of the grooves **12** extending in the Y direction on the first substrate **11** overlaps with a column of first pre-vapor deposition regions **221**. The grooves **12** contain vapor deposition materials **13**. The vapor deposition materials **13** may be formed in the first pre-vapor deposition regions **221** after the vapor deposition process. In this embodiment, an organic light-emitting materials of the first color in the grooves **12** can be vapor deposited on the first pre-vapor deposition regions **221** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the first color.

[0032] It can be understood that after forming the organic light emitting material layer of the first light-color, a first substrate **11** including a plurality of grooves **12** containing organic light emitting materials of the second color may be provided. In an embodiment, after the first substrate **11** is aligned with the second substrate **21**, the plurality of grooves **12** on the first substrate **11** corresponds to the second pre-vapor deposition regions **222**. The projections of the grooves **12** on the first substrate **11** overlap with the second pre-vapor-deposition regions **222**. The organic light-emitting materials of the first color in the grooves **12** can be vapor deposited to the plurality of second pre-vapor deposition regions **222** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the second light-color. Furthermore, after forming the organic light emitting material layer of the second light-color, another first substrate **11** including grooves **12** containing organic light emitting materials of the third light-color may be provided. In an embodiment, after the first substrate **11** is aligned with the second substrate **21**, the plurality of grooves **12** on the first substrate **11** correspond to the plurality of third pre-vapor deposition regions **223** on the second substrate **21**. The projections of the grooves **12** on the first substrate **11** overlap with the third pre-vapor-deposition regions **223**. The organic light-emitting materials of the third first color in the grooves **12** can be vapor deposited to the plurality of third pre-vapor deposition regions **223** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer of the third light-color.

[0033] As shown in FIG. **5**, the vapor deposition source **1** of a third embodiment comprises a first substrate **11**. Grooves **12** are provided on a surface of the first substrate **11** and are spaced from each other. The grooves **12** contain vapor deposition material **13**. In this embodiment, the grooves **12** comprises a plurality of first grooves **121** extending in a Y direction in FIG. **5** and a plurality of second grooves **122** extending in a X direction in FIG. **5**. The first grooves **121** and the second grooves **122** intersect with each other to form a matrix. In this embodiment, a projection of the first grooves **121** and the second grooves **122** on the first substrate **11** forms a mesh pattern.

[0034] In this embodiment, after the first substrate **11** is aligned with the second substrate **21**, each of the grooves **12** extending in the Y direction in FIG. **5** corresponds to a column of a plurality of first pre-vapor deposition regions **221**. That is, a projection of each of the grooves **12** extending in the Y direction in FIG. **5** on the first substrate **11** overlaps with the plurality of first pre-vapor deposition regions **221**. The grooves **12** contain vapor deposition materials **13**. The vapor deposition materials **13** may be formed in the plurality of first pre-vapor deposition regions **221** after the vapor deposition.

[0035] The grooves **12** of the vapor deposition source **1** in above embodiments are located to correspond to the pre-vapor deposition regions **22** when in the vapor deposition, so that the vapor deposition materials **13** in the grooves **12** can be vapor deposited to the second substrate **21** at an incident angle of approximately 90° or equal to 90° to form an organic light-emitting material layer. This effectively reduces the shadow effect or uneven film thickness.

[0036] As shown in FIG. **6**, a method for manufacturing an OLED display panel according to the first embodiment comprises:

[0037] Step S**601**: as shown in FIG. **7**, a first substrate **11** is provided, a plurality of grooves **12** are formed on the first substrate **11**.

[0038] The first substrate **11** is made of a heatable and heat-conducting material. Each of the grooves **12** may be one of a circular, square, rhombic, triangular or other shapes. In this embodiment, the grooves **12** are circular dot-shaped grooves.

[0039] The grooves **12** may be etched by laser etching or by a suitable etching method such as by liquid etching.

[0040] Step S**602**, as shown in FIG. **8**, vapor deposition material **13** is put in the grooves **12** to form a vapor deposition source **1**.

[0041] In this embodiment, the vapor deposition material **13** is organic light-emitting material.

[0042] In this embodiment, a spraying tool **3** containing vapor deposition material **13** is provided. The spraying tool **3** includes a plurality of nozzles **31**, and each nozzle can be precisely aligned with one of the grooves **12**, and inject the vapor deposition material **13** into each of the grooves **12**.

[0043] In this embodiment, the spraying tool **3** can set up according to the required area and thickness of the organic light-emitting material layer, and precisely align the groove **12** through the nozzle **31**, and inject an appropriate amount of the vapor deposition material **13** into the groove **12**.

[0044] Step S**603**, as shown in FIG. **9**, a second substrate **21** is provided as a substrate for carrying a vapor deposition material, and the second substrate **21** is aligned with the first substrate.

[0045] As shown in FIG. **2**, the second substrate **21** comprises a first surface **201**, the first surface **201** defines a plurality of pre-vapor deposition regions **22**. Each pre-vapor deposition region **22** comprises a plurality of first pre-vapor deposition sub-regions **221**, a plurality of second pre-vapor deposition sub-regions **222**, and a plurality of third pre-vapor deposition sub-regions **223**. Each of the pre-vapor deposition region **22** comprises one first pre-vapor deposition region **221**, one second pre-vapor deposition region **222**, and one third pre-vapor deposition region **223** arranged in sequence. In this embodiment, the plurality of grooves **12** corresponds to the plurality of first pre-vapor deposition regions **221**, the projections of the grooves **12** on the first substrate **11** overlap with the first pre-vapor deposition regions **221**.

[0046] Step S**604**: as shown in FIG. **10**, the first substrate **11** is heated to vaporize the vapor deposition material **13** (organic light-emitting material) on the pre-vapor deposition

regions **22**, thereby forming an organic light-emitting material layer of an OLED display panel **2**.

[0047] In this embodiment, the vapor deposition material **13** in the grooves **12** is vaporized on the first pre-vapor deposition region **221** of the second substrate **21** to form an organic light-emitting layer.

[0048] It can be understood that the method of forming the organic light-emitting material layers in the second pre-vapor deposition region **222** and the third pre-vapor deposition region **223** is similar to the method of forming the organic light-emitting material layer in the first pre-vapor deposition region **221** described above.

[0049] As shown in FIG. **11**, a method for manufacturing an OLED display panel according to another embodiment comprises:

[0050] Step S**1101**: a first substrate **11** with a plurality of grooves **12** is provided, the grooves **12** contain vapor deposition material **13**.

[0051] In this embodiment, the vapor deposition material **13** is an organic light-emitting material.

[0052] Step S**1102**: a second substrate **21** is provided as a substrate for carrying a vapor deposition material, and the second substrate **21** is aligned with the first substrate.

[0053] Step S**1103**: the first substrate **11** is heated to vaporize the vapor deposition material **13** on the pre-vapor deposition regions **22**, thereby forming an organic light-emitting material layer of a OLED display panel **2**.

[0054] It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A method for making organic light emitting diode display panel, comprising:

providing a first substrate, forming a plurality of grooves on the first substrate;

filling the plurality of grooves with organic light-emitting material;

providing a second substrate, wherein the second substrate defines a plurality of pre-vapor deposition regions for carrying the organic light-emitting material;

aligning the first substrate with the second substrate; and

heating the first substrate to vaporize the organic light-emitting material onto the plurality of pre-vapor deposition regions to form an organic light-emitting material layer of the organic light emitting diode display panel.

2. The method of claim **1**, wherein the organic light-emitting material is injected into each of the plurality of grooves.

3. The method of claim **2** further comprises:

providing a spraying tool comprising a plurality of nozzles;

aligning each of the plurality of nozzles with one of the plurality of grooves and inject the organic light-emitting material into the plurality of grooves which are aligned with the plurality of nozzles.

4. The method of claim **1**, wherein the method further comprises forming a peelable layer on inner surfaces of the plurality of grooves before filling the plurality of grooves with an organic light-emitting material.

5. The method of claim **4**, wherein the peelable layer further cover a surface of the first substrate on which the plurality of grooves is formed.

6. The method of claim **1** further comprises:

sequentially arranging one first pre-vapor deposition sub-region, one second pre-vapor deposition sub-region, and one third pre-vapor deposition sub-region in each of the plurality of pre-vapor deposition regions; and

forming the organic light-emitting material layers of a different material on the first pre-vapor deposition sub-regions, the second pre-vapor deposition sub-regions, and the third pre-vapor deposition sub-regions.

7. The method of claim **6**, wherein each of the plurality of grooves is corresponding aligned to one of the plurality of pre-vapor deposition regions.

8. The method of claim **7**, wherein the first substrate is aligned with the second substrate so that a projection of each of the plurality of grooves on the first substrate overlaps with one of the plurality of pre-vapor deposition regions.

9. The method of claim **1**, wherein the plurality of grooves are formed to be spaced apart from each other on the first substrate.

10. A method for making organic light emitting diode display panel, comprising:

providing a vapor deposition source, wherein the vapor deposition source comprises a first substrate comprising a plurality of grooves containing organic light-emitting material;

providing a second substrate, wherein the second substrate defines a plurality of pre-vapor deposition regions for carrying the organic light-emitting material;

aligning the first substrate with the second substrate;

heating the first substrate to vaporize the organic light-emitting material onto the plurality of pre-vapor deposition regions to form an organic light-emitting material layer of the organic light emitting diode display panel.

11. The method of claim **10**, wherein the first substrate is aligned with the second substrate so that each of the plurality of grooves is correspondingly aligned to one of the plurality of pre-vapor deposition regions.

12. The method of claim **11**, wherein a projection of each of the plurality of grooves on the first substrate overlaps with the corresponding one of the plurality of pre-vapor deposition regions.

13. The method of claim **10**, wherein the plurality of grooves are formed to be spaced apart from each other on the first substrate.

14. A vapor deposition source, comprising:

A first substrate that is heat conducting;

a plurality of grooves defined on the first substrate, the plurality of grooves are configured to contain organic light-emitting material.

15. The vapor deposition source of claim **14**, wherein the plurality of grooves are spaced apart from each other.

16. The vapor deposition source of claim **14**, wherein the plurality of grooves are dot-shaped grooves.

17. The vapor deposition source of claim **14**, wherein the plurality of grooves are linear grooves.

18. The vapor deposition source of claim **17**, wherein the plurality of grooves are parallel to each other.

19. The vapor deposition source of claim **14**, wherein the plurality of grooves are intersected to each other to form a matrix.

20. The vapor deposition source of the claim **14**, wherein the plurality of grooves are evenly distributed on the first substrate.

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摘要(译)

在显示面板中获得有机发光二极管（OLED）的过程中促进精确气相沉积的源包括在第一基板上形成多个凹槽;将有机发光材料填充到凹槽中并提供第二基板以接收蒸发的有机发光材料。第一基板与第二基板对准，并且加热第一基板以蒸发凹槽中的有机发光材料。在沉积之后，第二基板的气相沉积区域形成有机发光材料层，然后该层可以用在OLED显示面板中。阴影效果大大降低，还公开了该方法的方法。