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(54) **THIN FILM DEPOSITION APPARATUS,
METHOD OF MANUFACTURING ORGANIC
LIGHT-EMITTING DISPLAY DEVICE BY
USING THE APPARATUS, AND ORGANIC
LIGHT-EMITTING DISPLAY DEVICE
MANUFACTURED BY USING THE METHOD**

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USPC **445/23**; 438/30

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See application file for complete search history.

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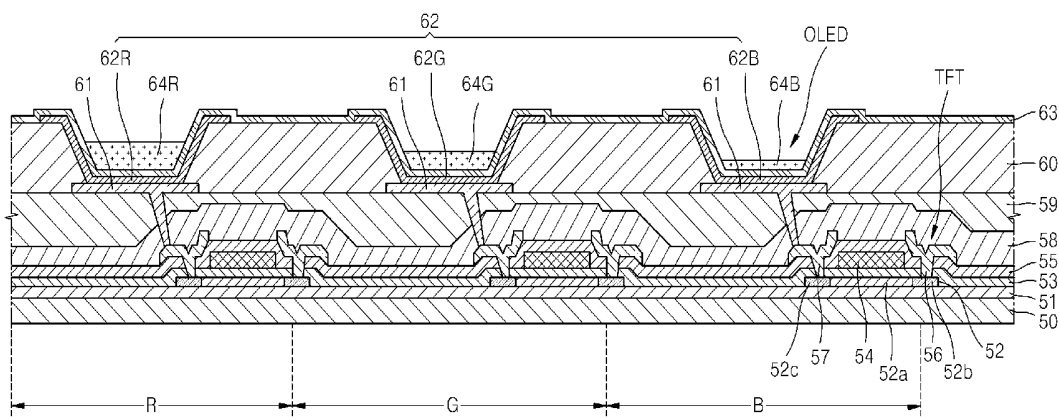
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(57) **ABSTRACT**

A thin film deposition apparatus, a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus, and an organic light-emitting display device manufactured using the method. In the thin film deposition apparatus for forming a thin film on a substrate, the apparatus includes a deposition source that discharges a deposition material; a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length; and a barrier plate assembly disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and including a plurality of barrier plates that partition a deposition space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces. The thin film deposition apparatus is separated from the substrate by a predetermined distance. The thin film deposition apparatus and the substrate are movable relative to each other.

34 Claims, 10 Drawing Sheets



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FIG. 1

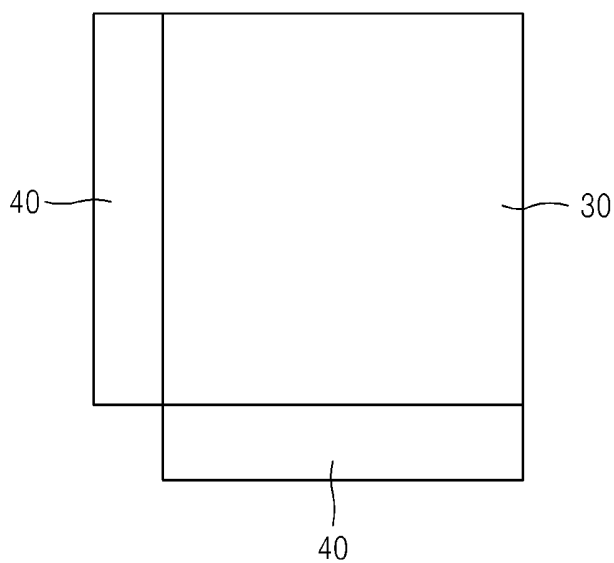


FIG. 2

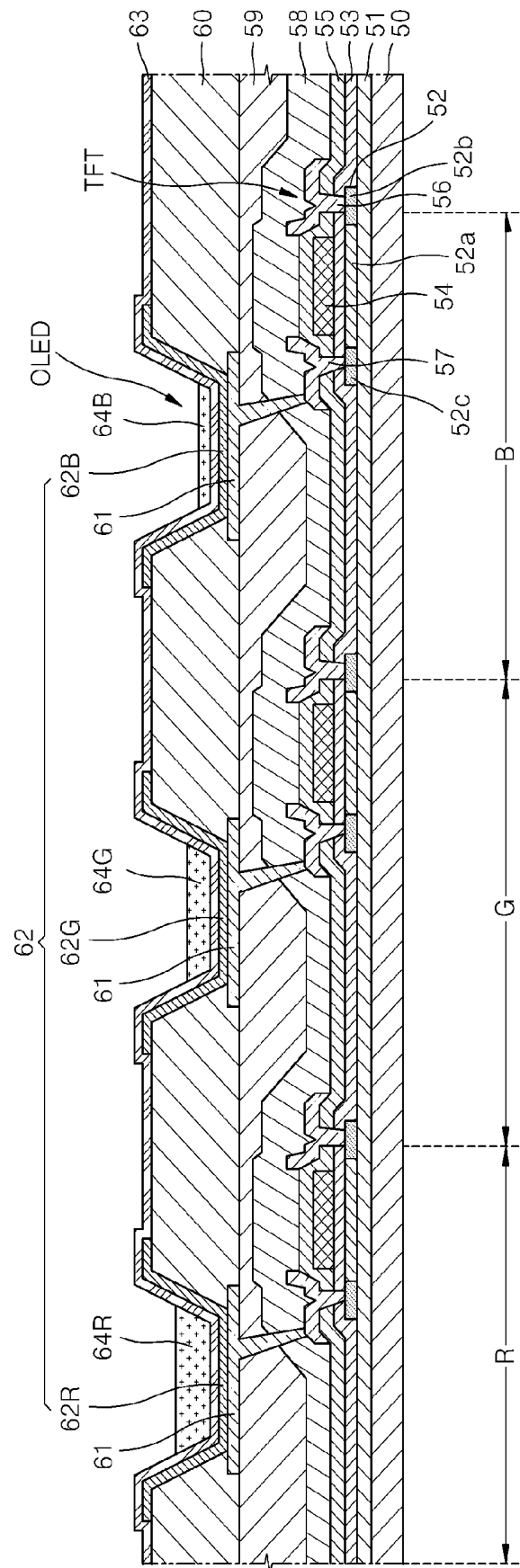


FIG. 3

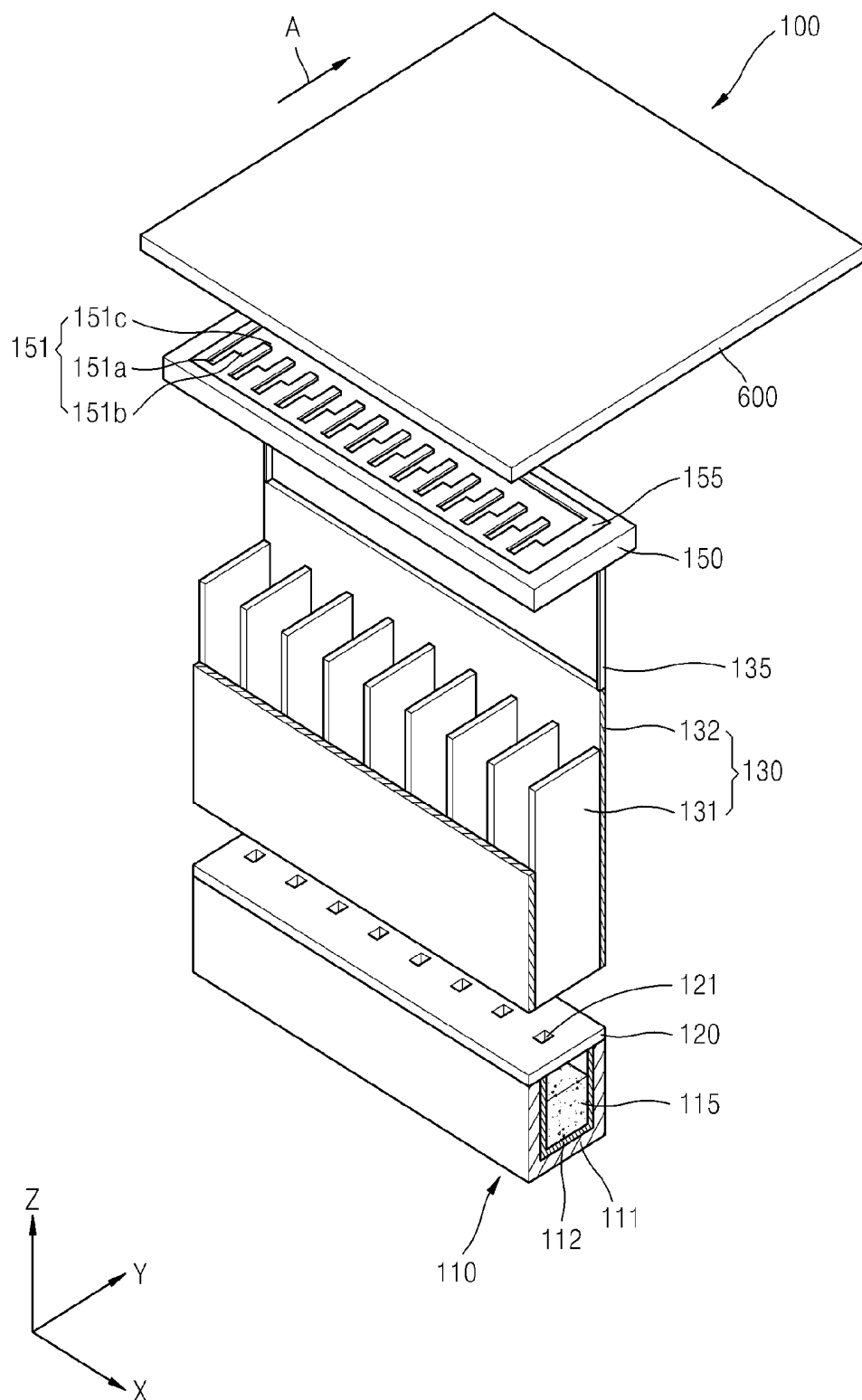


FIG. 4

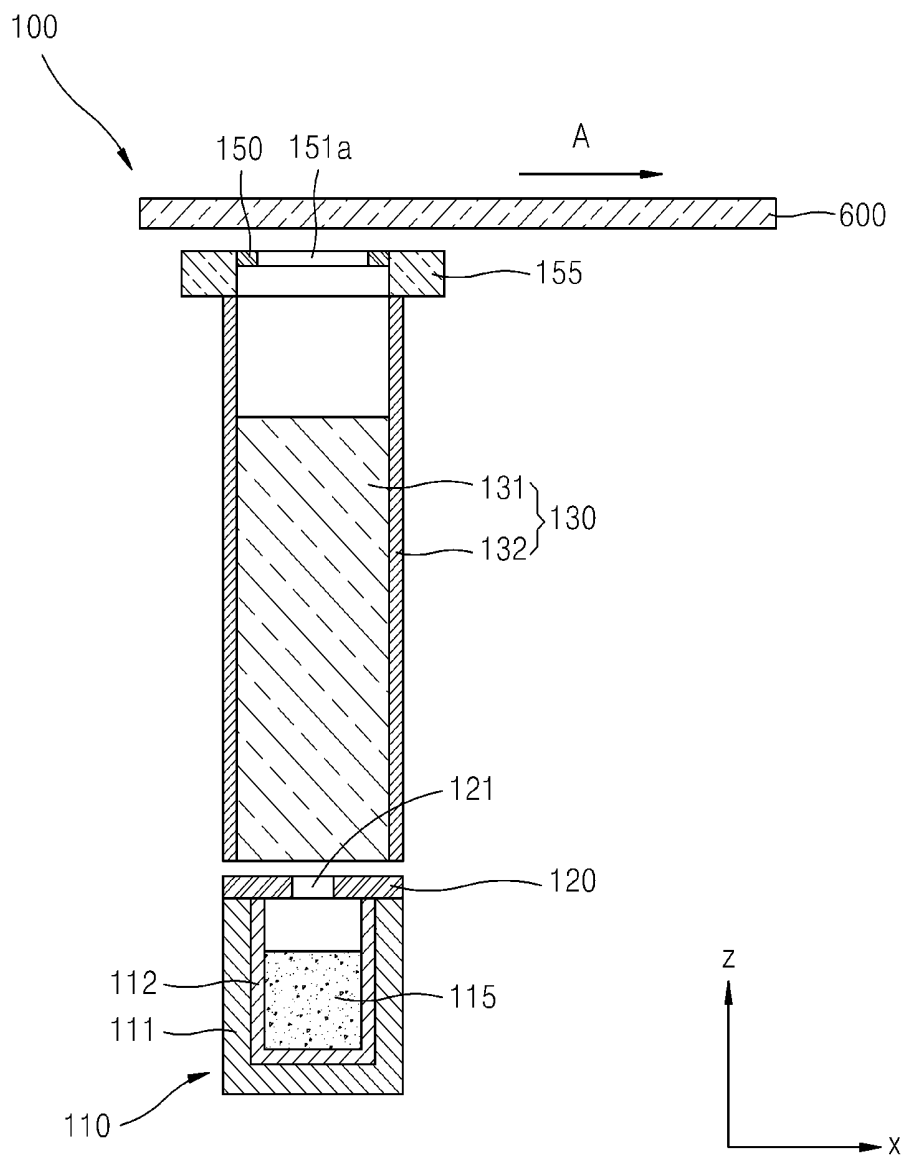


FIG. 5

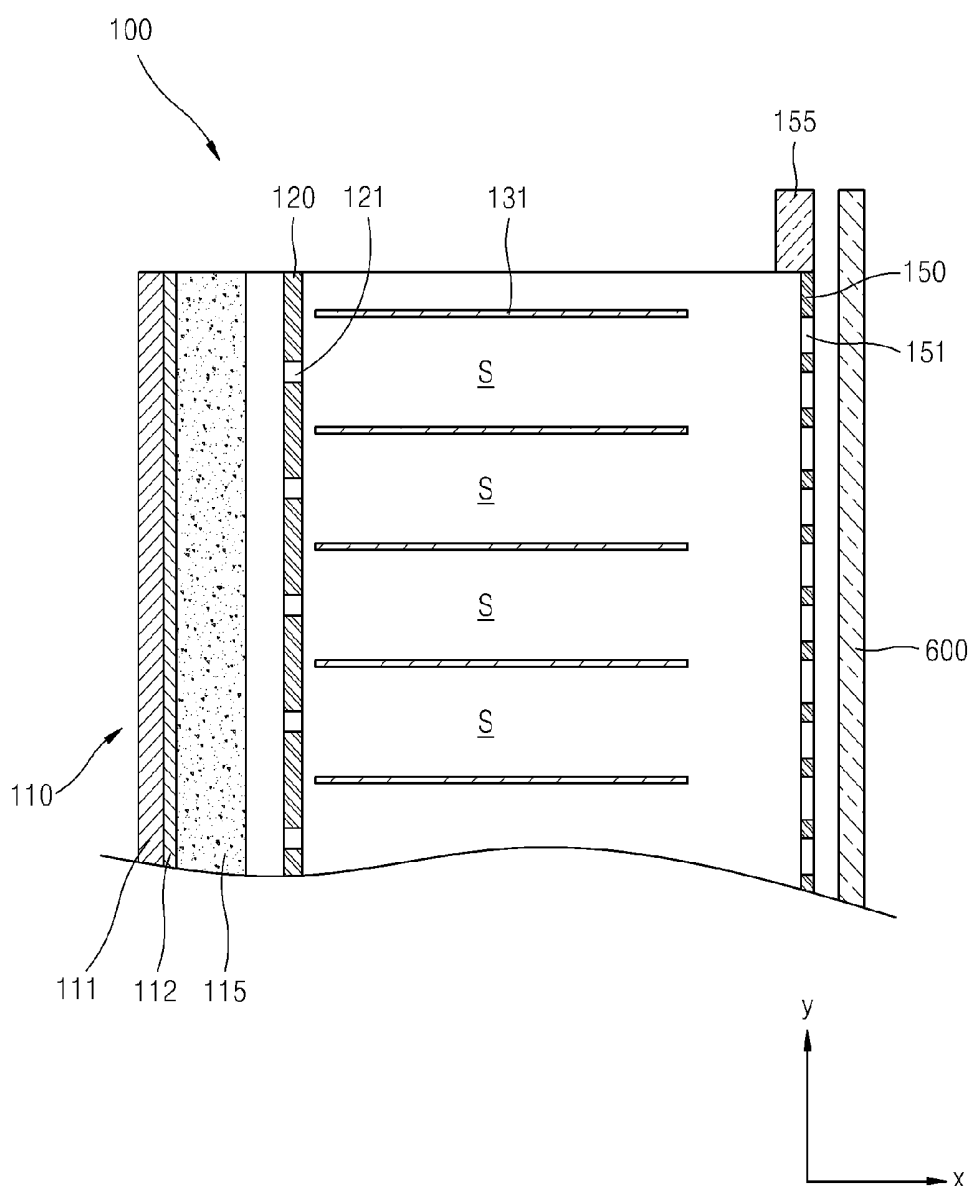


FIG. 6

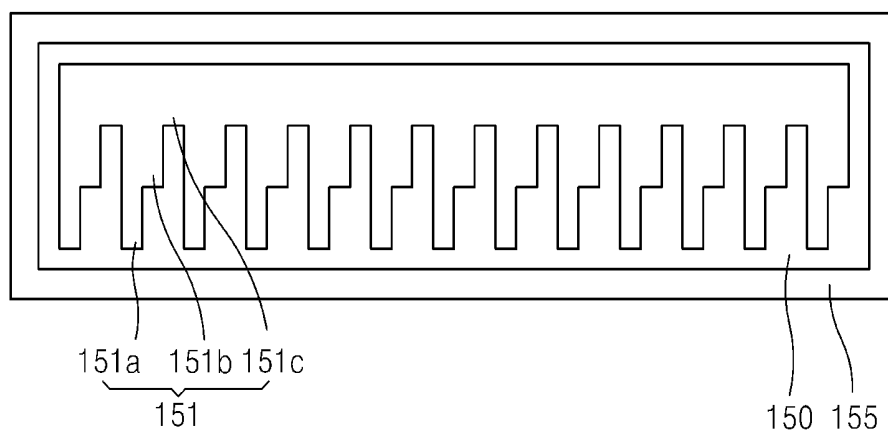


FIG. 7

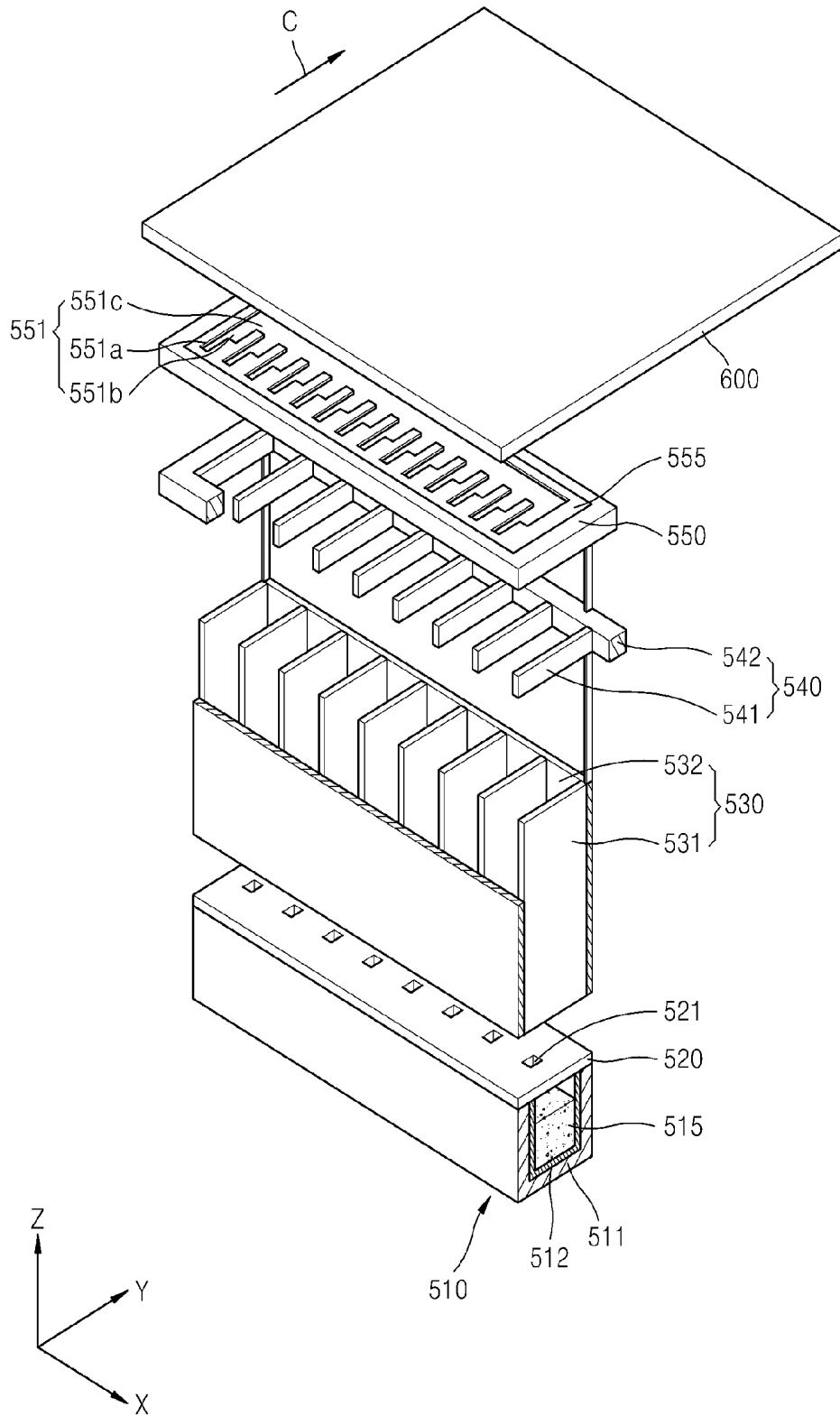


FIG. 8

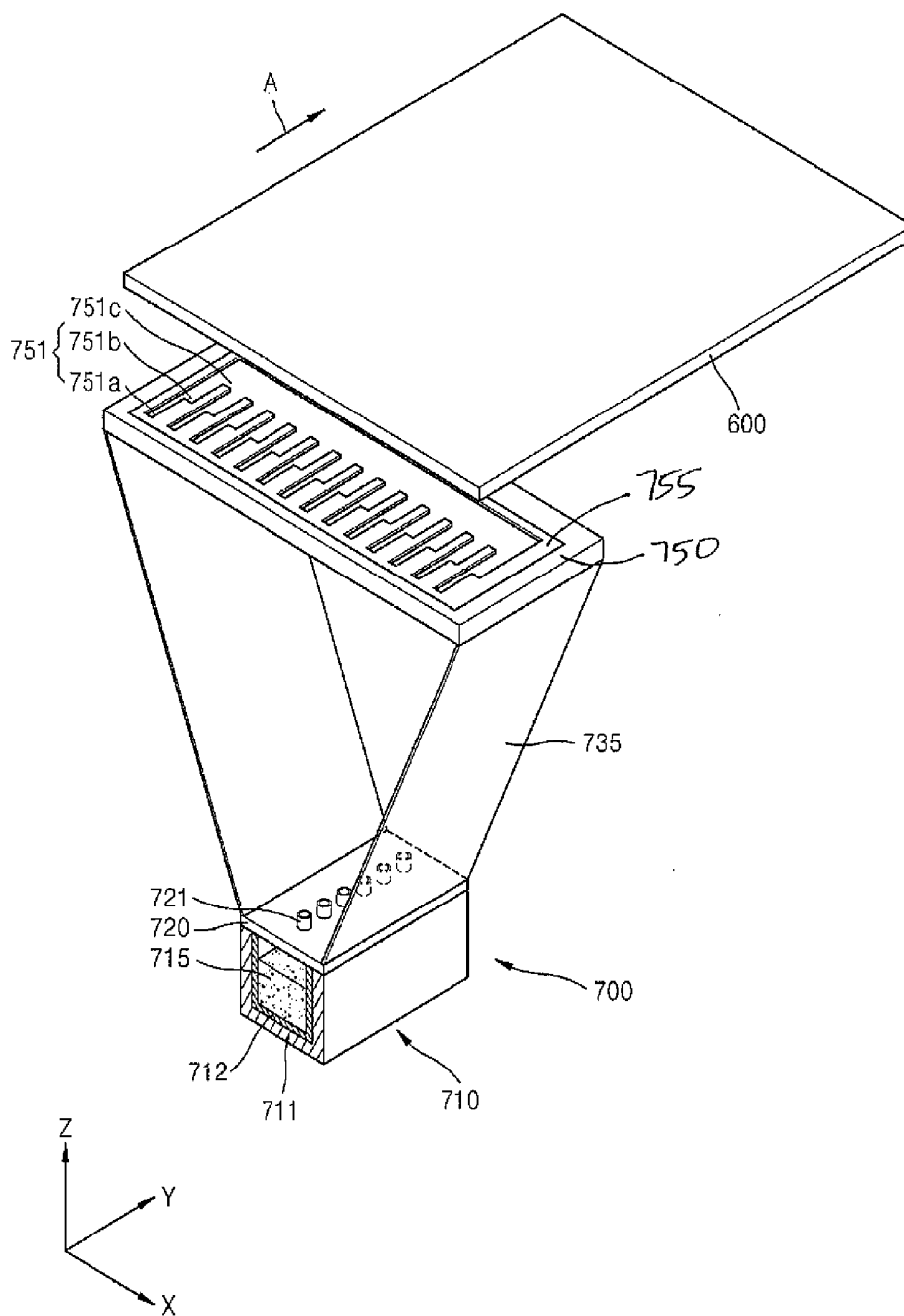


FIG. 9

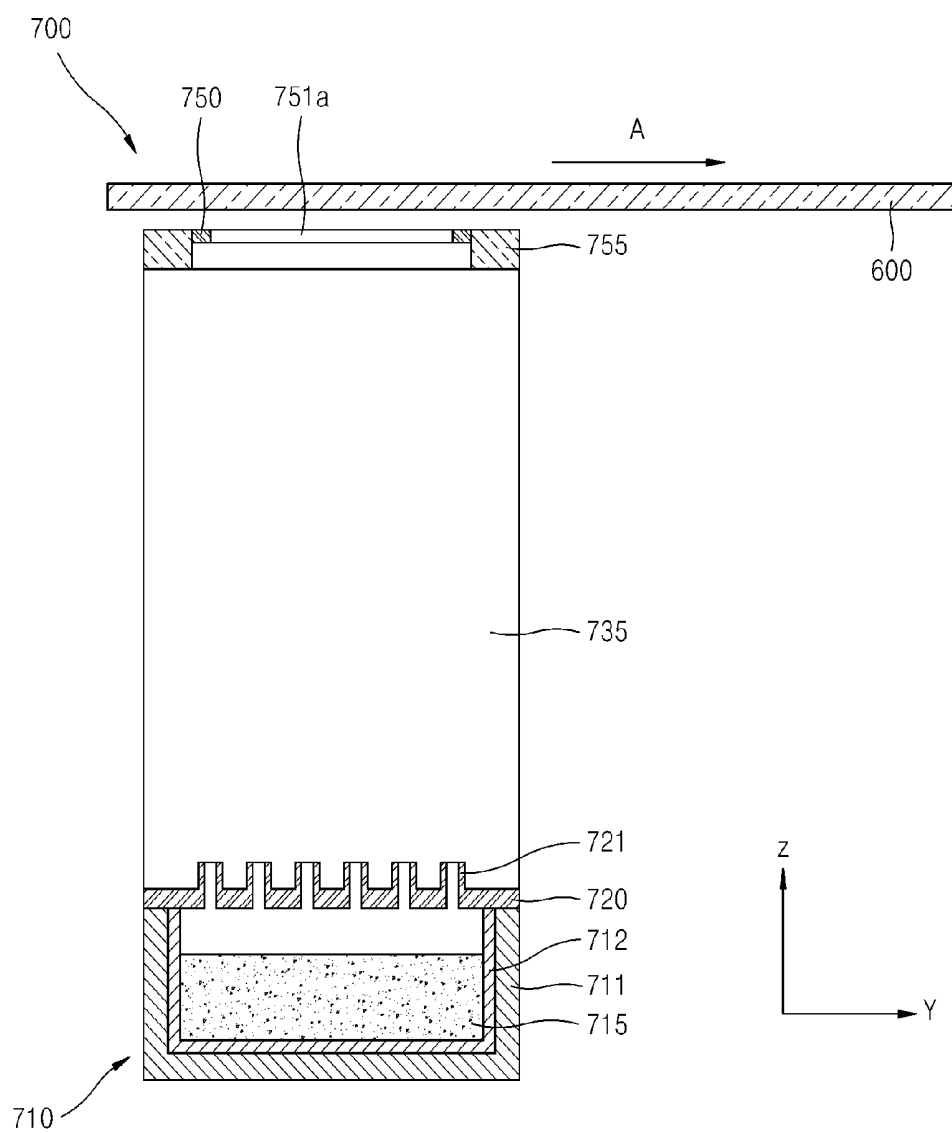
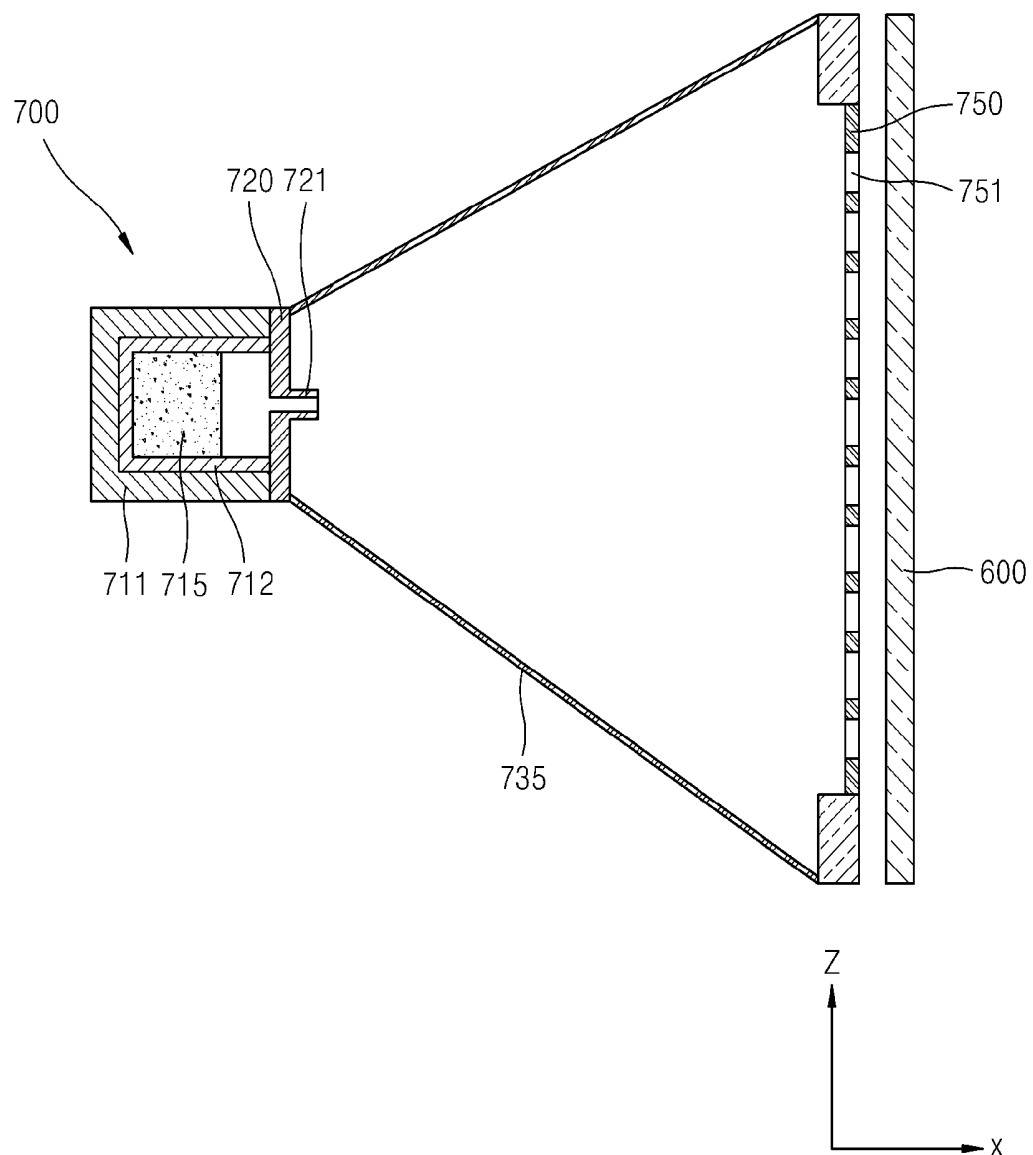


FIG. 10



**THIN FILM DEPOSITION APPARATUS,
METHOD OF MANUFACTURING ORGANIC
LIGHT-EMITTING DISPLAY DEVICE BY
USING THE APPARATUS, AND ORGANIC
LIGHT-EMITTING DISPLAY DEVICE
MANUFACTURED BY USING THE METHOD**

**CROSS-REFERENCE TO RELATED
APPLICATION**

This application claims the benefit of Korean Patent Application No. 10-2010-0009160, filed on Feb. 1, 2010, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

An aspect of the present invention relates to a thin film deposition apparatus, a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus, and an organic light-emitting display device manufactured by using the method. More particularly, an aspect of the present invention relates to a thin film deposition apparatus suitable for manufacturing large-sized display devices on a mass scale and that can improve manufacturing yield, a method of manufacturing an organic light-emitting display device using the thin film deposition apparatus, and an organic light-emitting display device manufactured by the method.

2. Description of the Related Art

Organic light-emitting display devices have a larger viewing angle, better contrast characteristics, and a faster response rate than other display devices, and thus have drawn attention as a next-generation display device.

Organic light-emitting display devices generally have a stacked structure including an anode, a cathode, and an emission layer interposed between the anode and the cathode. The devices display images in color when holes and electrons, injected respectively from the anode and the cathode, recombine in the emission layer and thus emit light. However, it is difficult to achieve high light-emission efficiency with such a structure, and thus intermediate layers, including an electron injection layer, an electron transport layer, a hole transport layer, a hole injection layer, or the like, are optionally additionally interposed between the emission layer and each of the electrodes.

Also, it is practically very difficult to form fine patterns in organic thin films such as the emission layer and the intermediate layers, and red, green, and blue light-emission efficiency varies according to the organic thin films. For these reasons, it is not easy to form an organic thin film pattern on a large substrate, such as a mother glass having a size of 5 G or more, by using a conventional thin film deposition apparatus, and thus it is difficult to manufacture large organic light-emitting display devices having satisfactory driving voltage, current density, brightness, color purity, light-emission efficiency, life-span characteristics, and so on. Thus, there is a demand for improvement in this regard.

An organic light-emitting display device includes intermediate layers, including an emission layer disposed between a first electrode and a second electrode that are arranged opposite to each other. The intermediate layers and the first and second electrodes may be formed using a variety of methods one of which is a deposition method. When an organic light-emitting display device is manufactured by using the deposition method, a fine metal mask (FMM) having the same

pattern as a thin film to be formed is disposed to closely contact a substrate, and a thin film material is deposited over the FMM in order to form the thin film having the desired pattern.

SUMMARY

Aspects of the present invention provide a thin film deposition apparatus that may be easily manufactured, that may be simply applied to manufacture large-sized display devices on a mass scale, and that improves manufacturing yield and deposition efficiency; a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus, and an organic light-emitting display device manufactured using the method.

According to an aspect of the present invention, there is provided a thin film deposition apparatus for forming a thin film on a substrate, the apparatus including a deposition source that discharges a deposition material; a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length; and a barrier plate assembly disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and including a plurality of barrier plates that partition a deposition space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, wherein the thin film deposition apparatus is separated from the substrate by a predetermined distance, and the thin film deposition apparatus and the substrate are movable relative to each other.

Each of the plurality of patterning slits may include a first patterning sub slit having a first length, a second patterning sub slit having a second length that is different from the first length, and a third patterning sub slit having a third length that is different from the first and second lengths.

According to another aspect of the present invention, the first to third patterning sub slits may be alternately and repeatedly formed in the patterning slit sheet.

The first to third patterning slits may correspond to a red sub pixel region, a green sub pixel region, and a blue sub pixel region of the substrate, respectively. The first length may be longer than the second length and the second length is longer than the third length.

According to another aspect of the present invention, amounts of the deposition material deposited on regions of the substrate may be controlled according to the lengths of the first to third patterning sub slits.

The deposition material discharged from the deposition source may be subsequently deposited on the red, green, and blue sub pixel regions on the substrate.

The deposition material deposited on the red sub pixel region may be thicker than the deposition material deposited on the green pixel region, and the deposition material deposited on the green sub pixel region may be thicker than the deposition material deposited on the blue sub pixel region.

According to another aspect of the present invention, each of the barrier walls may extend in a second direction that is substantially perpendicular to the first direction, in order to

partition the deposition space between the deposition source nozzle unit and the patterning slit sheet into the plurality of sub-deposition spaces.

According to another aspect of the present invention, the plurality of barrier plates may be arranged at equal intervals.

The barrier plate assembly may include a first barrier plate assembly including a plurality of first barrier plates and a second barrier plate assembly including a plurality of second barrier plates.

Each of the first barrier plates and the second barrier plates may extend in a second direction that is substantially perpendicular to the first direction, in order to partition the deposition space between the deposition source nozzle unit and the patterning slit sheet into the plurality of sub-deposition spaces.

The first barrier plates may be arranged to respectively correspond to the second barrier plates.

Each pair of the corresponding first and second barrier plates may be arranged on substantially the same plane.

The deposition material discharged from the thin film deposition apparatus may be continuously deposited on the substrate while the substrate is moved relative to the thin film deposition apparatus.

The thin film deposition apparatus or the substrate may be moved relative to each other along a plane parallel to a surface of the substrate on which the deposition material is deposited.

According to another aspect of the present invention, the barrier plate assembly may guide the deposition material discharged from the deposition source.

The patterning slit sheet of the thin film deposition apparatus may be smaller than the substrate.

According to another aspect of the present invention, there is provided a thin film deposition apparatus for forming a thin film on a substrate, the apparatus including a deposition source that discharges a deposition material; a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; and a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length, wherein deposition is performed while the substrate is moved relative to the thin film deposition apparatus in the first direction, and the deposition source, the deposition source nozzle unit, and the patterning slit sheet are formed integrally with one another.

Each of the plurality of patterning slits may include a first patterning sub slit having a first length, a second patterning sub slit having a second length that is different from the first length, and a third patterning sub slit having a third length that is different from the first and second lengths.

According to another aspect of the present invention, the first to third patterning sub slits may be alternately and repeatedly formed in the patterning slit sheet.

The first to third patterning slits may correspond to a red sub pixel region, a green sub pixel region, and a blue sub pixel region of the substrate, respectively, and the first length may be longer than the second length and the second length is longer than the third length.

Amounts of the deposition material deposited on regions of the substrate may be controlled according to the lengths of the first to third patterning sub slits.

The deposition material discharged from the deposition source may be subsequently deposited on the red, green, and blue sub pixel regions on the substrate.

The deposition material deposited on the red sub pixel region may be thicker than the deposition material deposited on the green sub pixel region, and the deposition material deposited on the green sub pixel region may be thicker than the deposition material deposited on the blue sub pixel region.

The patterning slit sheet of the thin film deposition apparatus may be smaller than the substrate.

The deposition source, the deposition source nozzle unit, and the patterning slit sheet may be formed integrally with one another by a connection unit.

According to another aspects of the present invention, the connection unit may guide movement of the discharged deposition material.

The connection unit may seal a space between the deposition source, the deposition source nozzle unit, and the patterning slit sheet.

The thin film deposition apparatus may be separated from the substrate by a predetermined distance.

The deposition material discharged from the thin film deposition apparatus may be continuously deposited on the substrate while the substrate is moved relative to the thin film deposition apparatus in the first direction.

According to another aspect of the present invention, there is provided a method of manufacturing an organic light-emitting display device, the method including performing deposition on a substrate that is a deposition target while a thin film deposition apparatus and the substrate are moved relative to each other. The substrate is fixedly supported by a chuck and the thin film deposition apparatus is disposed apart from the substrate. The thin film deposition apparatus includes a deposition source that discharges a deposition material; a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length; and a barrier plate assembly disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and including a plurality of barrier plates that partition a deposition space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces.

The deposition material may include an organic material. The thin film deposition apparatus may further include a plurality of capping layers corresponding to a sub pixel emitting red light, a sub pixel emitting green light, and a sub pixel emitting blue light, respectively, where the plurality of capping layers have different thicknesses from one another.

According to another aspect of the present invention, there is provided an organic light-emitting display device manufactured using the method.

According to another aspect of the present invention, there is provided a method of manufacturing an organic light-emitting display device, the method including performing deposition on a substrate that is a deposition target while a thin film deposition apparatus and the substrate are moved relative to each other, wherein the substrate is fixedly supported by a chuck and the thin film deposition apparatus is disposed apart from the substrate. The thin film deposition apparatus includes a deposition source that discharges a deposition

material; a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; and a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length.

The deposition material may include an organic material. The thin film deposition apparatus may further include a plurality of capping layers corresponding to a sub pixel emitting red light, a sub pixel emitting green light, and a sub pixel emitting blue light, respectively, where the plurality of capping layers have different thicknesses from one another.

According to another aspect of the present invention, there is provided an organic light-emitting display device manufactured using the method.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a plan view of an organic light-emitting display device manufactured by using a thin film deposition apparatus, according to an embodiment of the present invention;

FIG. 2 is a cross-sectional view of one of the pixels of the organic light-emitting display device illustrated in FIG. 1, according to an embodiment of the present invention;

FIG. 3 is a schematic perspective view of a thin film deposition apparatus according to another embodiment of the present invention;

FIG. 4 is a schematic side view of the thin film deposition apparatus illustrated in FIG. 3, according to an embodiment of the present invention;

FIG. 5 is a schematic plan view of the thin film deposition apparatus illustrated in FIG. 3, according to an embodiment of the present invention;

FIG. 6 is a plan view of a patterning slit sheet included in the thin film deposition apparatus of FIG. 3, according to an embodiment of the present invention;

FIG. 7 is a schematic perspective view of a thin film deposition apparatus according to another embodiment of the present invention;

FIG. 8 is a schematic perspective view of a thin film deposition apparatus according to another embodiment of the present invention;

FIG. 9 is a schematic side view of the thin film deposition apparatus illustrated in FIG. 8, according to an embodiment of the present invention; and

FIG. 10 is a schematic plan view of the thin film deposition apparatus of FIG. 8, according to an embodiment of the present invention.

DETAILED DESCRIPTION

Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The

embodiments are described below in order to explain the present invention by referring to the figures.

FIG. 1 is a plan view of an organic light-emitting display device manufactured by using a thin film thin film deposition apparatus, according to an embodiment of the present invention. Referring to FIG. 1, the organic light-emitting display device includes a pixel region 30 and circuit regions 40 disposed at edges of the pixel region 30. The pixel region 30 includes a plurality of pixels, and each of the pixels includes an emission unit that emits light to display an image.

In an embodiment of the present invention, the emission unit may include a plurality of sub-pixels, each of which includes an organic light-emitting diode (OLED). In a full-color organic light-emitting display device, red (R), green (G) and blue (B) sub-pixels are arranged in various patterns, for example, in a line, mosaic, or lattice pattern, to constitute a pixel. The organic light-emitting display device according to an aspect of the present invention may include a monochromatic flat display device.

The circuit regions 40 control, for example, an image signal that is input to the pixel region 30. In the organic light-emitting display device according to an aspect of the present invention, at least one thin film transistor (TFT) may be installed in each of the pixel region 30 and the circuit region 40.

The at least one TFT installed in the pixel region 30 may include a pixel TFT, such as a switching TFT that transmits a data signal to an OLED according to a gate line signal to control the operation of the OLED, and a driving TFT that drives the OLED by supplying current according to the data signal. The at least one TFT installed in each of the circuit regions 40 may include a circuit TFT formed to implement a predetermined circuit.

The number and arrangement of TFTs may vary according to the features of the display device and a driving method thereof.

FIG. 2 is a sectional view of one of the pixels of the organic light-emitting display device illustrated in FIG. 1, according to an embodiment of the present invention. Referring to FIG. 2, a buffer layer 51 is formed on a substrate 50 formed of glass or plastic. A TFT and an OLED are formed on the buffer layer 51.

An active layer 52 having a predetermined pattern is formed on the buffer layer 51. A gate insulating layer 53 is formed on the active layer 52, and a gate electrode 54 is formed in a predetermined region of the gate insulating layer 53. The gate electrode 54 is connected to a gate line (not shown) that applies a TFT ON/OFF signal. An interlayer insulating layer 55 is formed on the gate electrode 54. Source/drain electrodes 56 and 57 are formed such as to contact source/drain regions 52b and 52c of the active layer 52 through contact holes, respectively. A gate region 52a is disposed between the source/drain regions 52b and 52c. A passivation layer 58 is formed of SiO₂, SiN_x, or the like, on the source/drain electrodes 56 and 57. A planarization layer 59 is formed of an organic material, such as acryl, polyimide, benzocyclobutene (BCB), or the like, on the passivation layer 58. A pixel electrode 61, which functions as an anode of the OLED, is formed on the planarization layer 59, and a pixel defining layer 60 is formed of an organic material to cover the pixel electrode 61. An opening is formed in the pixel defining layer 60, and then an organic layer 62 is formed on the pixel defining layer 60 and the pixel electrode 61 that is exposed through the opening. The organic layer 62 includes a plurality of emission layers 62R, 62G, and 62B. However, the aspects of the present invention are not limited to the structure of the organic light-emitting display device described above, and

various structures of organic light-emitting display devices may be applied to the aspects of the present invention.

The OLED displays predetermined image information by emitting red, green and blue light as current flows. The OLED includes the pixel electrode **61**, which is connected to a drain electrode **57** of the TFT and to which a positive power voltage is applied, a second electrode **63**, which is formed to cover all the pixels and to which a negative power voltage is applied, the organic layer **62**, which is disposed between the pixel electrode **61** and the second electrode **63** to emit light, and a plurality of capping layers (CPL) **64R**, **64G**, and **64B** formed on the second electrode **63** to correspond to a plurality of sub pixels, respectively.

The first and second electrode **61** and **63** are insulated from each other by the organic layer **62**, and respectively apply voltages of opposite polarities to the organic layer **62** to induce light emission in the organic layer **62**.

The organic layer **62** may include a low-molecular weight organic layer or a high-molecular weight organic layer. When a low-molecular weight organic layer is used as the organic layer **62**, the organic layer **62** may have a single or multi-layer structure including at least one selected from the group consisting of a hole injection layer (HIL), a hole transport layer (HTL), an emission layer (EML), an electron transport layer (ETL), and an electron injection layer (EIL). The low-molecular weight organic layer may be formed by vacuum deposition.

When a high-molecular weight organic layer is used as the organic layer **62**, the organic layer **62** may mostly have a structure including a HTL and an EML. In this case, the HTL may be formed of poly(ethylenedioxythiophene) (PEDOT), and the EML may be formed of, for example, a polyphenylenevinylenes (PPVs) or polyfluorenes-based high-molecular weight organic material. The HTL and the EML may be formed by screen printing, inkjet printing, or the like.

The organic layer **62** is not limited to the organic layers described above and may be embodied in various ways.

The first electrode **61** functions as an anode, and the second electrode **63** functions as a cathode. Alternatively, the first electrode **61** may function as a cathode, and the second electrode **63** may function as an anode.

The first electrode **61** may be formed as a transparent electrode or a reflective electrode. Such a transparent electrode may be formed of an indium tin oxide (ITO), an indium zinc oxide (IZO), a zinc oxide (ZnO), or an indium oxide (In_2O_3). Such a reflective electrode may be formed by forming a reflective layer of silver (Ag), magnesium (Mg), aluminum (Al), platinum (Pt), palladium (Pd), gold (Au), nickel (Ni), neodymium (Nd), iridium (Ir), chromium (Cr) or a compound thereof and forming a layer of ITO, IZO, ZnO, or In_2O_3 on the reflective layer.

The second electrode **63** may also be formed as a transparent electrode or a reflective electrode. When the second electrode **63** is formed as a transparent electrode, the second electrode **63** functions as a cathode. To this end, such a transparent electrode may be formed by depositing a metal having a low work function, such as lithium (Li), calcium (Ca), lithium fluoride/calcium (LiF/Ca), lithium fluoride/aluminum (LiF/Al), aluminum (Al), silver (Ag), magnesium (Mg), or a compound thereof on a surface of the organic layer **62** and forming an auxiliary electrode layer or a bus electrode line thereon from a transparent electrode forming material, such as ITO, IZO, ZnO, In_2O_3 , or the like. When the second electrode **63** is formed as a reflective electrode, the reflective layer may be formed by depositing Li, Ca, LiF/Ca, LiF/Al, Al, Ag, Mg, or a compound thereof on the entire surface of the organic layer **62**.

The capping layers (CPL) **64R**, **64G**, and **64B** increase the brightness of the OLED and have thicknesses suitable for emitting red, green, and blue lights, respectively. A low or high molecular weight organic layer may be used for each of the capping layers (CPL) **64R**, **64G**, and **64B**, and the same material used to form the organic layer **62** may also be used to form the capping layers (CPL) **64R**, **64G**, and **64B**.

In the organic light-emitting display apparatus described above, the organic layer **62** including the emission layers **62R**, **62G**, and **62B** and the capping layers (CPL) **64R**, **64G**, and **64B** may be formed by using a thin film deposition apparatus **100** (see FIG. 3), which will be described later.

In the organic light-emitting display device manufactured with the thin film deposition apparatus according to an aspect of the present invention, the capping layers (CPL) **64R**, **64G**, and **64B** corresponding to R, G, and B sub-pixels that emit red, green and blue light, respectively, have different thicknesses.

In detail, the first or second electrode **61** or **63** is a reflective electrode and the other electrode is a semi-transparent or transparent electrode. Thus, oscillation may occur between the first and second electrodes **61** and **63** when the organic light-emitting display device is driven. Since the first or second electrode **61** or **63** is a reflective electrode and the other is a semi-transparent or transparent electrode, when the organic light-emitting display device is driven, lights generated by the respective emission layers **62R**, **62G**, and **62B** between the first and second electrodes **61** and **63** are emitted outside the organic light-emitting display device while oscillating between the first and second electrodes **61** and **63**, thereby increasing the luminance and efficiency of light emission. In this case, the thicknesses of the emission layers **62R**, **62G**, and **62B** for respective red, green, and blue lights may be different from one another in order to maximize oscillation efficiency. Accordingly, the capping layers (CPL) **64R**, **64G**, and **64B** corresponding to the sub-pixels that emit red, green, and blue lights, respectively, may be formed to different thicknesses.

TABLE 1

	R	G	B
CPL efficiency (cd/A) when the capping layers (CPL) 64R , 64G , and 64B have the same thickness	30.8	40.2	2.6
CPL efficiency (cd/A) when the thicknesses of the capping layers (CPL) 64R , 64G , and 64B are optimally determined	30.8	43.4	3.9
White Efficiency	16.9 -> 21.5		

Table 1 shows data representing white efficiency when the thicknesses of the capping layers (CPL) **64R**, **64G**, and **64B** are optimally determined. Referring to Table 1, white efficiency when the thicknesses of the capping layers (CPL) **64R**, **64G**, and **64B** corresponding to the sub-pixels that emit red, green, and blue lights, respectively, are optimally determined, is improved by 30% or higher than when the thicknesses of the capping layers (CPL) **64R**, **64G**, and **64B** are the same.

That is, oscillation may occur between the first and second electrodes **61** and **63** when the organic light-emitting display device is driven. However, since the capping layers (CPL) **64R**, **64G**, and **64B** disposed between the first and second electrodes **61** and **63** have thicknesses optimal for the respective colors of lights emitted by the emission layers **62R**, **62G**,

and 62B, the organic light-emitting display devices may have improved driving voltage, current density, brightness, color purity, light-emission efficiency, and lifetime.

The capping layers (CPL) 64R, 64G, and 64B may be formed by performing only a process using a thin film deposition apparatus according to an embodiment of the present invention. This will be described in detail later.

A thin film deposition apparatus and a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus according to an embodiment of the present invention will now be described in detail.

FIG. 3 is a schematic perspective view of a thin film deposition apparatus 100 according to an embodiment of the present invention. FIG. 4 is a schematic side view of the thin film deposition apparatus 100 of FIG. 3. FIG. 5 is a schematic plan view of the thin film deposition apparatus 100 of FIG. 3.

Referring to FIGS. 3, 4 and 5, the thin film deposition apparatus 100 includes a deposition source 110, a deposition source nozzle unit 120, a barrier plate assembly 130, and a patterning slit sheet 150.

Although a chamber is not illustrated in FIGS. 3, 4 and 5 for convenience of explanation, all the components of the thin film deposition apparatus 100 may be disposed within a chamber that is maintained at an appropriate degree of vacuum. The chamber is maintained at an appropriate vacuum in order to allow a deposition material to move in a substantially straight line through the thin film deposition apparatus 100.

A substrate 600 that is a deposition target on which a deposition material 115 is to be deposited, is disposed in the chamber. The substrate 600 may be a substrate for flat panel displays. A large substrate, such as a mother glass, for manufacturing a plurality of flat panel displays, may be used as the substrate 600. Other substrates may also be employed.

According to an aspect of the present invention, deposition may be performed while the substrate 600 is moved relative to the thin film deposition apparatus 100, but the invention is not limited thereto. Therefore, deposition may also be performed while the thin film deposition apparatus 100 is moved relative to the substrate 600.

In particular, in a conventional FMM deposition method, the size of an FMM has to be equal to the size of a substrate. Thus, the size of the FMM has to be increased as the substrate becomes larger. However, it is neither straightforward to manufacture a large FMM nor to extend an FMM to be accurately aligned with a pattern.

In order to overcome this problem, in the thin film deposition apparatus 100 according to an aspect of the present invention, deposition may be performed while the thin film deposition apparatus 100 or the substrate 600 is moved relative to each other. In other words, deposition may be continuously performed while the substrate 600 is disposed to face the thin film deposition apparatus 100 is moved in a Y-axis direction. That is, deposition is performed in a scanning manner while the substrate 600 is moved in a direction of arrow A in FIG. 3. Although the substrate 600 is illustrated as being moved in the Y-axis direction in FIG. 3 when deposition is performed, the aspects of the present invention are not limited thereto and as noted above deposition may be performed while the thin film deposition apparatus 100 is moved in the Y-axis direction, whereas the substrate 600 is fixed.

Thus, in the thin film deposition apparatus 100, the patterning slit sheet 150 may be significantly smaller than the FMM used in the conventional deposition method. That is, in the thin film deposition apparatus 100, deposition is continuously performed, i.e., in a scanning manner while the substrate 600 is moved in the Y-axis direction. Thus, lengths of the pattern-

ing slit sheet 150 may be significantly less than the lengths of the substrate 600, in the X-axis and Y-axis directions. As described above, since the patterning slit sheet 150 may be formed to be significantly smaller than the FMM used in the conventional deposition method, it is relatively easy to manufacture the patterning slit sheet 150 according to an aspect of the present invention. In other words, using the patterning slit sheet 150, which is smaller than the FMM used in the conventional deposition method, is more convenient in all processes, including etching and subsequent other processes, such as precise extension, welding, moving, and cleaning processes, compared to the conventional deposition method using the larger FMM. This is more advantageous for a relatively large display device.

In order to perform deposition while the thin film deposition apparatus 100 or the substrate 600 is moved relative to each other as described above, the thin film deposition apparatus 100 and the substrate 600 may be separated from each other by a predetermined distance. This will be described later in detail.

The deposition source 110 that contains and heats the deposition material 115 is disposed in an opposite side of the chamber to that in which the substrate 600 is disposed. As the deposition material 115 contained in the deposition source 110 is vaporized, the deposition material 115 is deposited on the substrate 600.

In particular, the deposition source 110 includes a crucible 111 that is filled with the deposition material 115, and a heater 112 that heats the crucible 111 to vaporize the deposition material 115, which is contained in the crucible 111, towards a side of the crucible 111, and in particular, towards the deposition source nozzle unit 120.

The deposition source nozzle unit 120 is disposed at a side of the deposition source 110, and in particular, at the side of the deposition source 110 facing the substrate 600. The deposition source nozzle unit 120 includes a plurality of deposition source nozzles 121 arranged in the X-axis direction. The deposition material 115 that is vaporized in the deposition source 110, passes through the deposition source nozzle unit 120 towards the substrate 600.

The barrier plate assembly 130 is disposed at a side of the deposition source nozzle unit 120. The barrier plate assembly 130 includes a plurality of barrier plates 131, and a barrier plate frame 132 that covers sides of the barrier plates 131. The plurality of barrier plates 131 may be arranged parallel to each other at equal intervals in X-axis direction. In addition, each of the barrier plates 131 may be arranged parallel to an YZ plane in FIG. 3, i.e., perpendicular to the X-axis direction. The plurality of barrier plates 131 arranged as described above partition the deposition space between the deposition source nozzle unit 120 and the patterning slit sheet 150 into a plurality of sub-deposition spaces S (see FIG. 5). In the thin film deposition apparatus 100, the deposition space is divided by the barrier plates 131 into the sub-deposition spaces S that respectively correspond to the deposition source nozzles 121 through which the deposition material 115 is discharged.

The barrier plates 131 may be respectively disposed between adjacent deposition source nozzles 121. In other words, each of the deposition source nozzles 121 may be disposed between two adjacent barrier plates 131. The deposition source nozzles 121 may be respectively located at the midpoint between two adjacent barrier plates 131. As described above, since the barrier plates 131 partition the deposition space between the deposition source nozzle unit 120 and the patterning slit sheet 150 into the plurality of sub-deposition spaces S, the deposition material 115 discharged through each of the deposition source nozzles 121 is

not mixed with the deposition material **115** discharged through the other deposition source nozzles slits **121**, and passes through patterning slits **151** so as to be deposited on the substrate **600**. In other words, the barrier plates **131** guide the deposition material **115**, which is discharged through the deposition source nozzles slits **121**, to move straight, not to flow in the X-axis direction.

As described above, the deposition material **115** is forced to move straight by installing the barrier plates **131**, so that a smaller shadow zone may be formed on the substrate **600** compared to a case where no barrier plates are installed. Thus, the thin film deposition apparatus **100** and the substrate **600** may be separated from each other by a predetermined distance. This will be described later in detail.

The barrier plate frame **132**, which covers upper and lower sides of the barrier plates **131**, maintains the positions of the barrier plates **131**, and guides the deposition material **115**, which is discharged through the deposition source nozzles **121**, not to flow in the Y-axis direction.

The barrier plate assembly **130** may be constructed to be detachable from the thin film deposition apparatus **100**. A conventional FMM deposition method has low deposition efficiency. In order to overcome this problem, in the thin film deposition apparatus **100**, the deposition space is enclosed by using the barrier plate assembly **130**, so that the deposition material **115** that remains undeposited is mostly deposited within the barrier plate assembly **130**. Thus, since the barrier plate assembly **130** is constructed to be detachable from the thin film deposition apparatus **100**, when a large amount of the deposition material **115** lies in the barrier plate assembly **130** after a long deposition process, the barrier plate assembly **130** may be detached from the thin film deposition apparatus **100** and then placed in a separate deposition material recycling apparatus in order to recover the deposition material **115**. Due to the structure of the thin film deposition apparatus **100**, a reuse rate of the deposition material **115** is increased, improving the deposition efficiency, thus reducing manufacturing costs.

The patterning slit sheet **150** and a frame **155** are disposed between the deposition source **110** and the substrate **600**. The frame **155** may be formed in a lattice shape, similar to a window frame. The patterning slit sheet **150** bounds the frame **155**. The patterning slit sheet **150** includes a plurality of patterning slits **151** arranged in the X-axis direction. The deposition material **115** that is vaporized in the deposition source **110**, passes through the deposition source nozzle unit **120** and the patterning slit sheet **150** towards the substrate **600**. The patterning slit sheet **150** may be manufactured by etching, which is the same method as used in the conventional method of manufacturing the FMM, and in particular, a striped FMM.

Each of the patterning slits **151** includes a plurality of patterning sub slits **151a** to **151c** that are different in lengths. This will be described in detail with reference to FIG. 6 later.

In the thin film deposition apparatus **100**, the total number of patterning slits **151** may be greater than the total number of deposition source nozzles **121**. In addition, there may be a greater number of patterning slits **151** than deposition source nozzles **121** disposed between two adjacent barrier plates **131**.

In other words, one deposition source nozzle **121** may be disposed between each two adjacent barrier plates **131**. Meanwhile, a plurality of patterning slits **151** may be disposed between each two adjacent barrier plates **131**. The deposition space between the deposition source nozzle unit **120** and the patterning slit sheet **150** is partitioned by the barrier plates **131** into sub-deposition spaces S that corre-

spond to the deposition source nozzles **121**, respectively. Thus, the deposition material **115** discharged from each of the deposition source nozzles **121** passes through a plurality of patterning slits **151** disposed in the sub-deposition space S corresponding to the deposition source nozzle **121**, and is then deposited on the substrate **600**.

The barrier plate assembly **130** and the patterning slit sheet **150** may be formed to be separated from each other by a predetermined distance. Alternatively, the barrier plate assembly **130** and the patterning slit sheet **150** may be connected by a connection unit **135**. The temperature of the barrier plate assembly **130** may increase to 100° C. or higher due to the deposition source **110** whose temperature is high. Thus, in order to prevent the heat of the barrier plate assembly **130** from being conducted to the patterning slit sheet **150**, the barrier plate assembly **130** and the patterning slit sheet **150** are separated from each other by the predetermined distance.

As described above, the thin film deposition apparatus **100** performs deposition while being moved relative to the substrate **600**. In order to move the thin film deposition apparatus **100** relative to the substrate **600**, the patterning slit sheet **150** is separated from the substrate **600** by the predetermined distance. In order to prevent the formation of a relatively large shadow zone on the substrate **600** when the patterning slit sheet **150** and the substrate **400** are separated from each other, the barrier plates **131** are arranged between the deposition source nozzle unit **120** and the patterning slit sheet **150** to force the deposition material **115** to move in a straight direction. Thus, the size of the shadow zone formed on the substrate **400** is sharply reduced.

More specifically, in the conventional deposition method using the FMM, deposition is performed with the FMM in close contact with a substrate in order to prevent formation of a shadow zone on the substrate. However, when the FMM is used in close contact with the substrate, the contact may cause defects. In addition, in the conventional deposition method, the size of the mask has to be the same as the size of the substrate since the mask cannot be moved relative to the substrate. Thus, the size of the mask has to be increased as display devices become larger but it is not easy to manufacture such a large mask.

In order to overcome this problem, in the thin film deposition apparatus **100**, the patterning slit sheet **150** is disposed to be separated from the substrate **600** by the predetermined distance. This may be facilitated by installing the barrier plates **131** to reduce the size of the shadow zone formed on the substrate **600**.

As described above, according to an aspect of the present invention, a mask is formed to be smaller than a substrate, and deposition is performed while the mask is moved relative to the substrate. Thus, the mask can be easily manufactured. In addition, defects caused due to the contact between a substrate and a FMM, which occurs in the conventional deposition method, may be prevented. In addition, since it is unnecessary to use the FMM in close contact with the substrate during a deposition process, the manufacturing speed may be improved. As described above, the shadow zone formed on the substrate **600** may be reduced by installing the barrier plates **131**. Thus, the patterning slit sheet **150** can be separated from the substrate **600**.

Hereinafter, the patterning slit sheet **150** included in the thin film deposition apparatus **100** of FIG. 3 will be described in detail.

FIG. 6 is a plan view of the patterning slit sheet **150** included in the thin film deposition apparatus **100** of FIG. 3, according to an embodiment of the present invention. Referring to FIG. 6, in the patterning slit sheet **150**, each of the

patterning slits **151** includes the plurality of patterning sub slits **151a** to **151c** that are different in length.

As described above, in the organic light-emitting display device of FIG. 2, the capping layers **64R**, **64G**, and **64B** corresponding to sub pixels that emit red, green, and blue lights, respectively, have different thicknesses from one another. That is, the thickness of the capping layer **64R** corresponding to a red sub pixel that emits red light may be relative thick, the thickness of the capping layer **64G** corresponding to a green sub pixel that emits green light may be thinner than that of the capping layer **64R**, and the thickness of the capping layer **64B** corresponding to a blue sub pixel that emits blue light may be thinner than that of the capping layer **64G**.

In a conventional FMM deposition method, only one layer can be formed at a time, and in general, a capping layer corresponding to a red sub pixel that emits red light, a capping layer corresponding to a green sub pixel that emits green light, and a capping layer corresponding to a blue sub pixel that emits blue light are therefore formed separately.

However, in the organic light-emitting display device of FIG. 2, the capping layers **64R**, **64G**, and **64B** are formed of the same material and are different from one another only in terms of their location and thickness. Thus, in the thin film deposition apparatus **100** of FIG. 3, the capping layers **64R**, **64G**, and **64B** that correspond to the red, green, and blue sub pixels, respectively, are formed subsequently in such a manner that regions of each of the patterning slits **151**, which correspond to red, green, and blue sub pixel regions, respectively, are different from one another in length.

Specifically, each of the patterning slits **151** includes a first patterning slit **151a**, a second patterning slit **151b**, and a third patterning slit **151c**. The first patterning slit **151a** corresponds to the red sub pixel region, the second patterning slit **151b** corresponds to the green sub pixel region, and the third patterning slit **151c** corresponds to the blue sub pixel region. That is, referring to FIG. 5, since the deposition material **115** that passes through the patterning slits **151** is deposited on the substrate **600**, the greater the patterning slit **151**, the thicker an organic layer to be formed on the substrate **600**. Thus, the first patterning slit **151a** for forming the capping layer **64R** corresponding to the red sub pixel, the thickness of which is relatively thick is the longest, the second patterning slit **151b** for forming the capping layer **64G** corresponding to the green sub pixel, the thickness of which is thinner than the capping layer **64R** is shorter than the first patterning slit **151a**, and the third patterning slit **151c** for forming the capping layer **64B** corresponding to the blue sub pixel, the thickness of which is thinner than the capping layer **64R** is shorter than the second patterning slit **151b**.

In other words, referring to FIG. 6, it would also be understood that the patterning slit sheet **150** is formed in such a manner that an upper portion of the patterning slit sheet **150** may be used as a common deposition region and a plurality of slits having different lengths, which correspond to the red, green, and blue sub pixels, respectively, are alternately and repeatedly formed in a lower portion of the patterning slit **151**.

As described above, according to an embodiment of the present invention, each of patterning slits has sub patterning slits that are different in length, in which long patterning sub slits correspond to portions of a substrate on which a large amount of a deposition material is to be deposited so that the large amount of the deposition material may pass through the long patterning slits, and short patterning sub slits correspond to portions of the substrate on which a small amount of the deposition material is to be deposited so that the small amount of the deposition material may pass through the short pattern-

ing slits. Accordingly, two layers may be formed at a time, thereby reducing the total number of thin film deposition apparatuses needed, reducing a time needed to manufacture the thin film deposition apparatuses, and simplifying equipment for manufacturing the thin film deposition apparatuses.

FIG. 7 is a schematic perspective view of a thin film deposition apparatus **500** according to another embodiment of the present invention. Referring to FIG. 7, the thin film deposition apparatus **500** includes a deposition source **510**, a deposition source nozzle unit **520**, a first barrier plate assembly **530**, a second barrier plate assembly **540**, a patterning slit sheet **550**, and a substrate **600**.

Although a chamber is not illustrated in FIG. 7 for convenience of explanation, all the components of the thin film deposition apparatus **500** may be disposed within a chamber that is maintained at an appropriate degree of vacuum. The chamber is maintained at an appropriate vacuum in order to allow a deposition material to move in a substantially straight line through the thin film deposition apparatus **500**.

The substrate **600** that is a deposition target is disposed in the chamber. The deposition source **510** that contains and heats a deposition material **515** is disposed in an opposite side of the chamber to that in which the substrate **600** is disposed. The deposition source **510** may include a crucible **511** and a heater **512**.

The deposition source nozzle unit **520** is disposed at a side of the deposition source **510**, and in particular, at the side of the deposition source **510** facing the substrate **600**. The deposition source nozzle unit **520** includes a plurality of deposition source nozzles **521** arranged in the X-axis direction.

The first barrier plate assembly **530** is disposed at a side of the deposition source nozzle unit **520**. The first barrier plate assembly **530** includes a plurality of first barrier plates **531**, and a first barrier plate frame **532** that covers sides of the first barrier plates **531**.

The second barrier plate assembly **540** is disposed at a side of the first barrier plate assembly **530**. The second barrier plate assembly **540** includes a plurality of second barrier plates **541**, and a second barrier plate frame **542** that covers sides of the second barrier plates **541**.

The patterning slit sheet **550** and a frame **555** in which the patterning slit sheet **550** is bound are disposed between the deposition source **510** and the substrate **600**. The frame **555** may be formed in a lattice shape, similar to a window frame. The patterning slit sheet **550** includes a plurality of patterning slits **551** arranged in the X-axis direction.

The thin film deposition apparatus **500** includes two separate barrier plate assemblies, i.e., the first barrier plate assembly **530** and the second barrier plate assembly **540**.

The plurality of first barrier plates **531** may be arranged parallel to each other at equal intervals in the X-axis direction. Each of the first barrier plates **531** may be formed to extend along an YZ plane in FIG. 7, i.e., perpendicular to the X-axis direction.

The plurality of second barrier plates **541** may be arranged parallel to each other at equal intervals in the X-axis direction. In addition, each of the second barrier plates **541** may be formed to extend in the YZ plane in FIG. 7, i.e., perpendicular to the X-axis direction.

The plurality of first barrier plates **531** and second barrier plates **541** arranged as described above partition a deposition space between the deposition source nozzle unit **520** and the patterning slit sheet **550**. In the thin film deposition apparatus **500**, the deposition space is divided by the first barrier plates **531** and the second barrier plates **541** into sub-deposition

spaces that respectively correspond to the deposition source nozzles **521** through which the deposition material **515** is discharged.

The second barrier plates **541** may be disposed to correspond respectively to the first barrier plates **531**. In other words, the second barrier plates **541** may be aligned with the first barrier plates **531**, respectively. Each pair of the corresponding first and second barrier plates **531** and **541** may be located on the same plane. As described above, since the deposition space between the deposition source nozzle unit **520** and the patterning slit sheet **550**, which will be described later, is partitioned by the first barrier plates **531** and the second barrier plates **541**, which are disposed parallel to each other, the deposition material **515** discharged through one of the deposition source nozzles **521** is not mixed with the deposition material **515** discharged through the other deposition source nozzles **521**, and is deposited on the substrate **600** through the patterning slits **551**. In other words, the first barrier plates **531** and the second barrier plates **541** guide the deposition material **515**, which is discharged through the deposition source nozzles **521**, not to flow in the X-axis direction.

Although the first barrier plates **531** and the second barrier plates **541** are respectively illustrated as having the same thickness in the X-axis direction, the aspects of the present invention are not limited thereto. In other words, the second barrier plates **541**, which need to be accurately aligned with the patterning slit sheet **550**, may be formed to be relatively thin, whereas the first barrier plates **531**, which do not need to be precisely aligned with the patterning slit sheet **550**, may be formed to be relatively thick. This makes it easier to manufacture the thin film deposition apparatus **500**.

FIG. **8** is a schematic perspective view of a thin film deposition apparatus **700** according to another embodiment of the present invention. FIG. **9** is a schematic side view of the thin film deposition apparatus **700** illustrated in FIG. **8**. FIG. **10** is a schematic plan view of the thin film deposition apparatus **700** illustrated in FIG. **8**.

Referring to FIGS. **8**, **9** and **10**, the thin film deposition apparatus **700** includes a deposition source **710**, a deposition source nozzle unit **720**, a patterning slit sheet **750** and a frame **755**.

Although a chamber is not illustrated in FIGS. **8**, **9** and **10** for convenience of explanation, all the components of the thin film deposition apparatus **700** may be disposed within a chamber that is maintained at an appropriate degree of vacuum. The chamber is maintained at an appropriate vacuum in order to allow a deposition material to move in a substantially straight line through the thin film deposition apparatus **700**.

A substrate **600** that is a deposition target is disposed in the chamber. The deposition source **710** that contains and heats a deposition material **715** is disposed in an opposite side of the chamber to that in which the substrate **600** is disposed. The deposition source **710** may include a crucible **711** and a heater **712**.

The deposition source nozzle unit **720** is disposed at a side of the deposition source **710**, and in particular, at the side of the deposition source **710** facing the substrate **600**. The deposition source nozzle unit **720** includes a plurality of deposition source nozzles **721** arranged in the Y-axis direction, i.e., a scanning direction of the substrate **600**. The plurality of deposition source nozzles **721** may be disposed at equal intervals. The deposition material **715** that is vaporized in the deposition source **710** passes through the deposition source nozzle unit **720** towards the substrate **600**. As described above, if the plurality of deposition source nozzles **721** are

formed on the deposition source nozzle unit **720** in the Y-axis direction, that is, the scanning direction of the substrate **600**, then a size of a pattern formed by the deposition material **715** that is discharged through each of patterning slits **751** in the patterning slit sheet **750** is only affected by the size of one deposition source nozzle **721**, that is, it may be considered that one deposition nozzle **721** exists in the X-axis direction. Thus, there is no shadow zone on the substrate **600**. Since the plurality of deposition source nozzles **721** are formed in the scanning direction of the substrate **600**, even there is a difference between fluxes of the deposition source nozzles **721**, the difference may be compensated for and deposition uniformity may be maintained constantly.

The patterning slit sheet **750** and a frame **755** are disposed between the deposition source **710** and the substrate **600**. The frame **755** may be formed in a lattice shape, similar to a window frame. The patterning slit sheet **750** is bound inside the frame **755**. The patterning slit sheet **750** includes a plurality of patterning slits **751** arranged in the X-axis direction. The deposition material **715** that is vaporized in the deposition source **710** passes through the deposition source nozzle unit **720** and the patterning slit sheet **750** towards the substrate **600**. The patterning slit sheet **750** may be manufactured by etching, which is the same method as used in a conventional method of manufacturing an FMM, and in particular, a striped FMM.

In the thin film deposition apparatus **700**, each of the patterning slits **751** includes sub slits that are different in length. Thus, a capping layer corresponding to a red sub pixel, a capping layer corresponding to a green sub pixel, and a capping layer corresponding to a blue sub pixel (see the capping layers **64R**, **64G**, and **64B** illustrated in FIG. **2**), may be sequentially formed. That is, each of the patterning slits **751** includes a first patterning sub slit **751a**, a second patterning sub slit **751b**, and a third patterning sub slit **751c**. The first patterning slit **751a** corresponds to a red sub pixel region, the second patterning slit **751b** corresponds to a green sub pixel region, and the third patterning slit **751c** corresponds to a blue sub pixel region.

The first patterning slit **751a** for forming the capping layer corresponding to the red sub pixel, the thickness of which is relative thick (see the capping layer **64R** of FIG. **2**) may be longest, the second patterning slit **751b** for forming the capping layer corresponding to the green sub pixel, the thickness of which is thinner than the capping layer corresponding to the red sub pixel (see the capping layer **64G** of FIG. **2**) may be shorter than the first patterning slit **751a**, and the capping layer corresponding to the blue sub pixel, the thickness of which is thinner than the capping layer corresponding to the green sub pixel (see the capping layer **64B** of FIG. **2**) may be shorter than the second patterning slit **751b**. The patterning slits **751** are as described above with reference to FIG. **3**.

The deposition source **710** (and the deposition source nozzle unit **720** coupled to the deposition source **710**) and the patterning slit sheet **750** may be formed to be separated from each other by a predetermined distance. Alternatively, the deposition source **710** (and the deposition source nozzle unit **720** coupled to the deposition source **710**) and the patterning slit sheet **750** may be connected by a connection unit **735**. That is, the deposition source **710**, the deposition source nozzle unit **720**, and the patterning slit sheet **750** may be formed integrally with one another by being connected to each other via the connection unit **735**. The connection unit **735** guides the deposition material **715**, which is discharged through the deposition source nozzles **721**, to move straight, not to flow in the X-axis direction. In FIGS. **8** through **10**, the connection units **735** are formed on left and right sides of the

deposition source **710**, the deposition source nozzle unit **720**, and the patterning slit sheet **750** to guide the deposition material **715** not to flow in the X-axis direction, however, the aspects of the present invention are not limited thereto. That is, the connection units **735** may be formed to seal the deposition source **710**, the deposition source nozzle unit **720**, and the patterning slit sheet **750** in the form of a box in order to guide the deposition material **715** in both the X-axis and Y-axis directions.

As described above, the thin film deposition apparatus **700** performs deposition while being moved relative to the substrate **600**. In order to move the thin film deposition apparatus **700** relative to the substrate **600**, the patterning slit sheet **750** is separated from the substrate **600** by a predetermined distance.

As described above, according to an aspect of the present invention, a mask is formed to be smaller than a substrate and deposition is performed while the mask is moved relative to the substrate. Thus, the mask can be easily manufactured. In addition, defects caused due to the contact between a substrate and an FMM, which occurs in the conventional deposition method, may be prevented. In addition, since it is unnecessary to use the FMM in close contact with the substrate during a deposition process, the manufacturing speed may be improved.

As described above, a thin film deposition apparatus, a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus, and an organic light-emitting display device manufactured using the method according to an aspect of the present invention may be simply applied to manufacture large-sized display devices on a mass scale. In addition, the thin film deposition apparatus and the organic-light-emitting display device may be easily manufactured and may improve manufacturing yield and deposition efficiency.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A thin film deposition apparatus for forming a thin film on a substrate, the apparatus comprising:

a deposition source that discharges a deposition material;

a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction;

a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length; and

a barrier plate assembly disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and including a plurality of barrier plates that partition a deposition space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces,

wherein the thin film deposition apparatus is separated from the substrate by a predetermined distance, and the thin film deposition apparatus and the substrate are movable relative to each other.

2. The thin film deposition apparatus of claim 1, wherein each of the plurality of patterning slits comprises a first pat-

terning sub slit having a first length, a second patterning sub slit having a second length that is different from the first length, and a third patterning sub slit having a third length that is different from the first and second lengths.

3. The thin film deposition apparatus of claim 2, wherein the first to third patterning sub slits are alternately and repeatedly formed in the patterning slit sheet.

4. The thin film deposition apparatus of claim 2, wherein the first to third patterning slits correspond to a red sub pixel region, a green sub pixel region, and a blue sub pixel region of the substrate, respectively, and the first length is longer than the second length and the second length is longer than the third length.

5. The thin film deposition apparatus of claim 2, wherein amounts of the deposition material deposited on regions of the substrate are controlled according to the lengths of the first to third patterning sub slits.

6. The thin film deposition apparatus of claim 2, wherein the deposition material discharged from the deposition source is subsequently deposited on the red, green, and blue sub pixel regions on the substrate.

7. The thin film deposition apparatus of claim 6, wherein a layer of the deposition material deposited on the red sub pixel region is thicker than a layer of the deposition material deposited on the green pixel region, and

a layer of the deposition material deposited on the green sub pixel region is thicker than a layer of the deposition material deposited on the blue sub pixel region.

8. The thin film deposition apparatus of claim 1, wherein each of the barrier walls extends in a second direction that is substantially perpendicular to the first direction, in order to partition the deposition space between the deposition source nozzle unit and the patterning slit sheet into the plurality of sub-deposition spaces.

9. The thin film deposition apparatus of claim 1, wherein the plurality of barrier plates are arranged at equal intervals.

10. The thin film deposition apparatus of claim 1, wherein the barrier plate assembly comprises a first barrier plate assembly including a plurality of first barrier plates and a second barrier plate assembly including a plurality of second barrier plates.

11. The thin film deposition apparatus of claim 10, wherein each of the first barrier plates and the second barrier plates extend in a second direction that is substantially perpendicular to the first direction, in order to partition the deposition space between the deposition source nozzle unit and the patterning slit sheet into the plurality of sub-deposition spaces.

12. The thin film deposition apparatus of claim 10, wherein the first barrier plates are arranged to respectively correspond to the second barrier plates.

13. The thin film deposition apparatus of claim 12, wherein each pair of the corresponding first and second barrier plates is arranged on substantially a same plane.

14. The thin film deposition apparatus of claim 1, wherein the deposition material discharged from the thin film deposition apparatus is continuously deposited on the substrate while the substrate is moved relative to the thin film deposition apparatus.

15. The thin film deposition apparatus of claim 1, wherein the thin film deposition apparatus or the substrate is moved relative to each other along a plane parallel to a surface of the substrate on which the deposition material is deposited.

16. The thin film deposition apparatus of claim 1, wherein the barrier plate assembly guides the deposition material discharged from the deposition source.

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17. The thin film deposition apparatus of claim 1, wherein the patterning slit sheet of the thin film deposition apparatus is smaller than the substrate.

18. A thin film deposition apparatus for forming a thin film on a substrate, the apparatus comprising:

a deposition source that discharges a deposition material;
a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; and

a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end and arranged in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length,

wherein deposition is performed while the substrate is moved relative to the thin film deposition apparatus in the first direction, and

the deposition source, the deposition source nozzle unit, and the patterning slit sheet are formed integrally with one another.

19. The thin film deposition apparatus of claim 18, wherein each of the plurality of patterning slits comprises a first patterning sub slit having a first length, a second patterning sub slit having a second length that is different from the first length, and a third patterning sub slit having a third length that is different from the first and second lengths.

20. The thin film deposition apparatus of claim 19, wherein the first to third patterning sub slits are alternately and repeatedly formed in the patterning slit sheet.

21. The thin film deposition apparatus of claim 19, wherein the first to third patterning slits correspond to a red sub pixel region, a green sub pixel region, and a blue sub pixel region of the substrate, respectively, and the first length is longer than the second length and the second length is longer than the third length.

22. The thin film deposition apparatus of claim 19, wherein amounts of the deposition material deposited on regions of the substrate are controlled according to the lengths of the first to third patterning sub slits.

23. The thin film deposition apparatus of claim 19, wherein the deposition material discharged from the deposition source is subsequently deposited on the red, green, and blue sub pixel regions on the substrate.

24. The thin film deposition apparatus of claim 23, wherein a layer of the deposition material deposited on the red sub pixel region is thicker than a layer of the deposition material deposited on the green pixel region, and

a layer of the deposition material deposited on the green sub pixel region is thicker than the deposition material deposited on the blue sub pixel region.

25. The thin film deposition apparatus of claim 18, wherein the patterning slit sheet of the thin film deposition apparatus is smaller than the substrate.

26. The thin film deposition apparatus of claim 18, wherein the deposition source, the deposition source nozzle unit, and the patterning slit sheet are formed integrally with one another by a connection unit.

27. The thin film deposition apparatus of claim 26, wherein the connection unit guides movement of the discharged deposition material.

28. The thin film deposition apparatus of claim 26, wherein the connection unit seals a space between the deposition source, the deposition source nozzle unit, and the patterning slit sheet.

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29. The thin film deposition apparatus of claim 18, wherein the thin film deposition apparatus is separated from the substrate by a predetermined distance.

30. The thin film deposition apparatus of claim 18, wherein the deposition material discharged from the thin film deposition apparatus is continuously deposited on the substrate while the substrate is moved relative to the thin film deposition apparatus in the first direction.

31. A method of manufacturing an organic light-emitting display device, the method comprising:

performing deposition on a substrate while a thin film deposition apparatus and the substrate are moved relative to each other, wherein the substrate is fixedly supported by a chuck and the thin film deposition apparatus is disposed apart from the substrate,

wherein the thin film deposition apparatus comprises:

a deposition source that discharges a deposition material;
a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction;

a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length; and

a barrier plate assembly disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and including a plurality of barrier plates that partition a deposition space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces.

32. The method of 31, wherein the deposition material comprises an organic material,

and the thin film deposition apparatus further comprises a plurality of capping layers corresponding to a sub pixel emitting red light, a sub pixel emitting green light, and a sub pixel emitting blue light, respectively, where the plurality of capping layers have different thicknesses from one another.

33. A method of manufacturing an organic light-emitting display device, the method comprising:

performing deposition on a substrate while a thin film deposition apparatus and the substrate are moved relative to each other, wherein the substrate is fixedly supported by a chuck and the thin film deposition apparatus is disposed apart from the substrate,

wherein the thin film deposition apparatus comprises:

a deposition source that discharges a deposition material;
a deposition source nozzle unit disposed at a side of the deposition source and including a plurality of deposition source nozzles arranged in a first direction; and

a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a common deposition region at an end of the patterning slit sheet and a plurality of patterning slits on the other end and arranged in a second direction perpendicular to the first direction, where each of the plurality of patterning slits includes a plurality of patterning sub slits that are different in length.

34. The method of 33, wherein the deposition material comprises an organic material, and

the thin film deposition apparatus further comprises a plurality of capping layers corresponding to a sub pixel emitting red light, a sub pixel emitting green light, and a sub pixel emitting blue light, respectively, where the plurality of capping layers have different thicknesses from one another.

* * * * *

专利名称(译)	薄膜沉积设备，通过使用该设备制造有机发光显示设备的方法，以及通过使用该方法制造的有机发光显示设备		
公开(公告)号	US8882556	公开(公告)日	2014-11-11
申请号	US12/984289	申请日	2011-01-04
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	KIM JUNG YEON SUNG UN CHEOL		
发明人	KIM, JUNG-YEON SUNG, UN-CHEOL		
IPC分类号	H01L51/56 C23C14/12 C23C14/04 C23C14/24 H01J9/00 C23C14/56		
CPC分类号	C23C14/12 H01L51/56 C23C14/044 C23C14/243 C23C14/562		
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外部链接	Espacenet USPTO		

摘要(译)

薄膜沉积设备，通过使用薄膜沉积设备制造有机发光显示设备的方法，以及使用该方法制造的有机发光显示设备。在用于在基板上形成薄膜的薄膜沉积设备中，该设备包括排出沉积材料的沉积源;沉积源喷嘴单元，设置在沉积源的一侧，并包括沿第一方向排列的多个沉积源喷嘴;图案化缝隙片，其与沉积源喷嘴单元相对设置，并且包括在图案化缝隙片的端部处的公共沉积区域和在垂直于第一方向的第二方向上的另一端上的多个图案化缝隙，其中每个图案化缝隙片多个图案化缝隙包括多个长度不同的图案化子缝隙;挡板组件，沿第一方向设置在沉积源喷嘴单元和图案化缝隙板之间，并包括多个挡板，挡板将沉积源喷嘴单元和图案化缝隙板之间的沉积空间分隔成多个子板 - 沉积空间。薄膜沉积设备与基板分开预定距离。薄膜沉积设备和基板可相对于彼此移动。

