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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 **438/99**; 257/40

(58) **Field of Classification Search**

USPC 438/99; 257/40

See application file for complete search history.

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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 by using the method. 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 plurality of patterning slits having different lengths arranged in the first direction; 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 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.

32 Claims, 13 Drawing Sheets

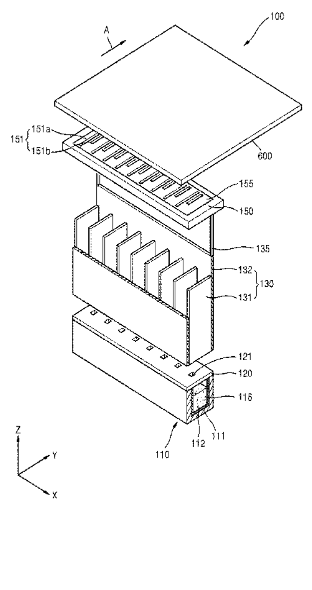

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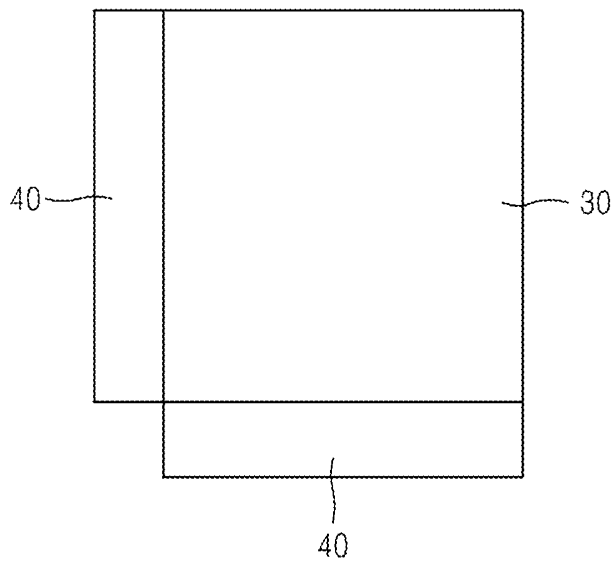
FIG. 1



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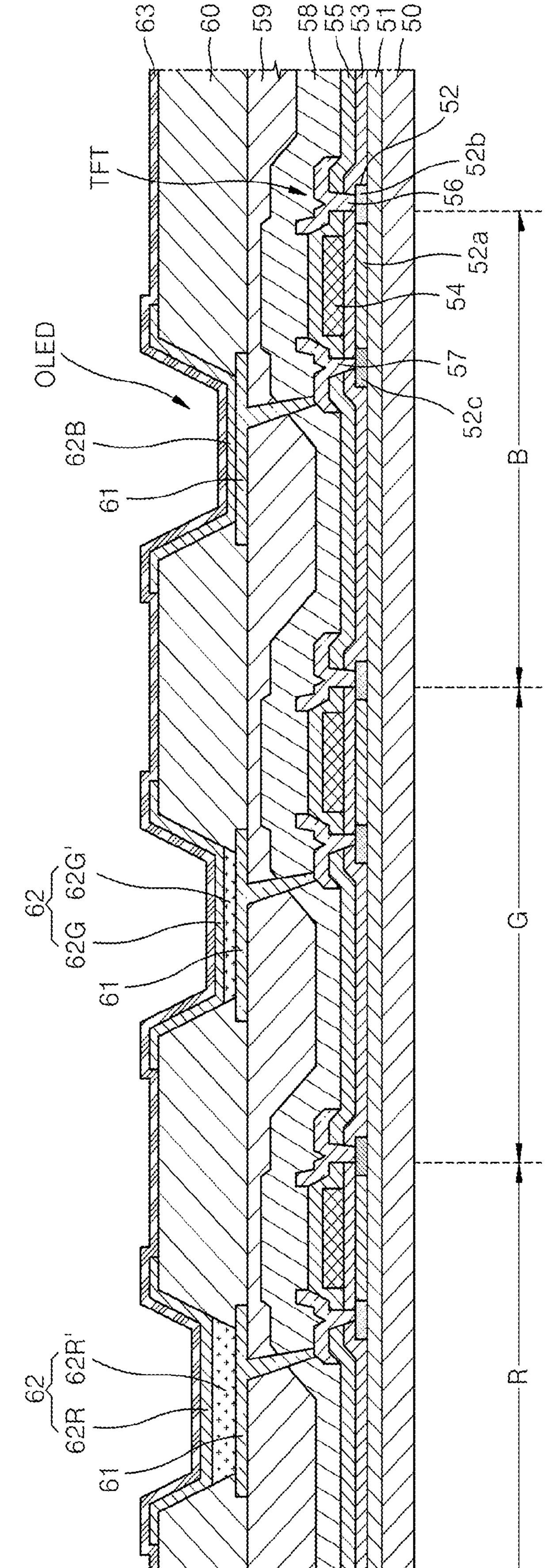
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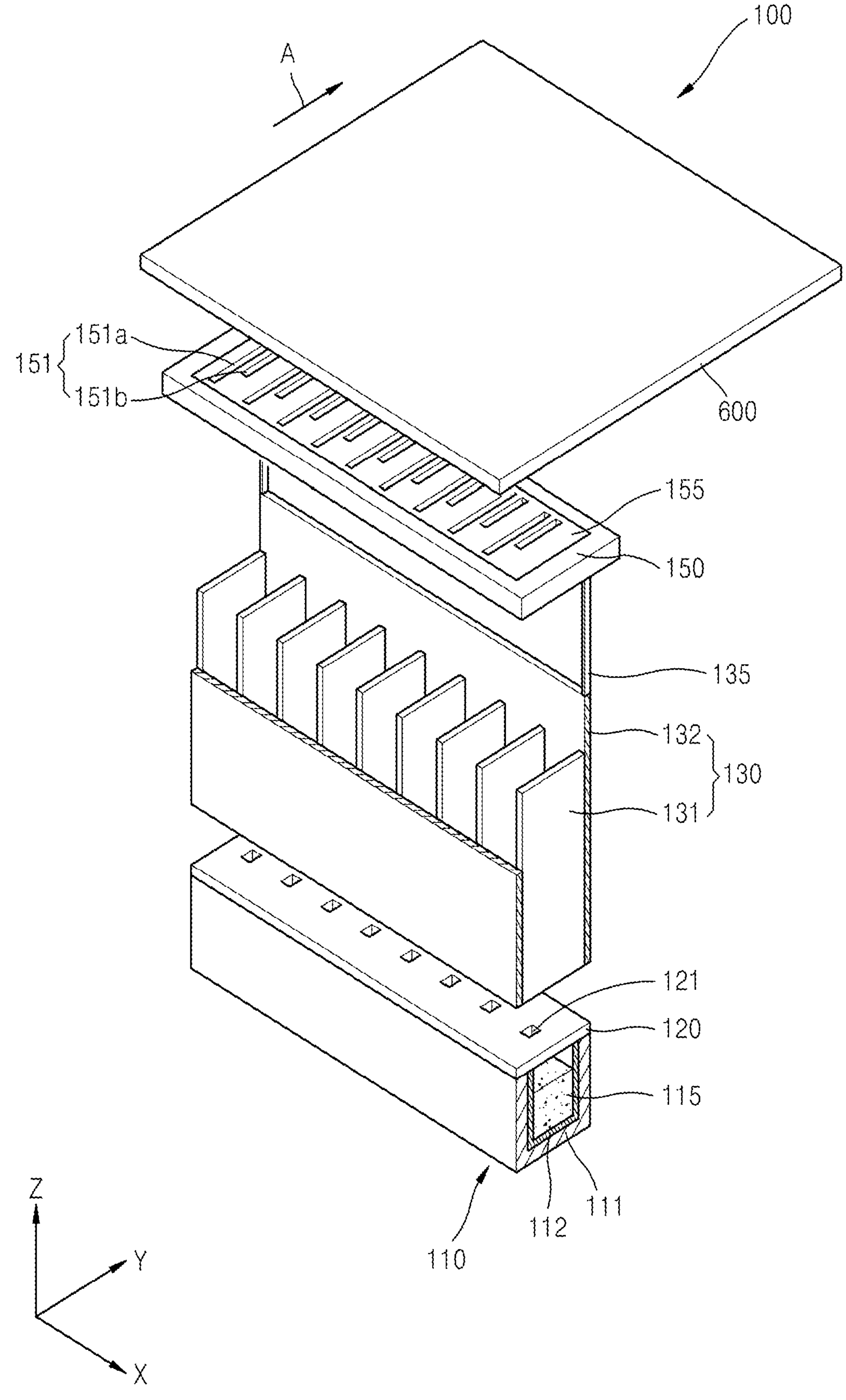
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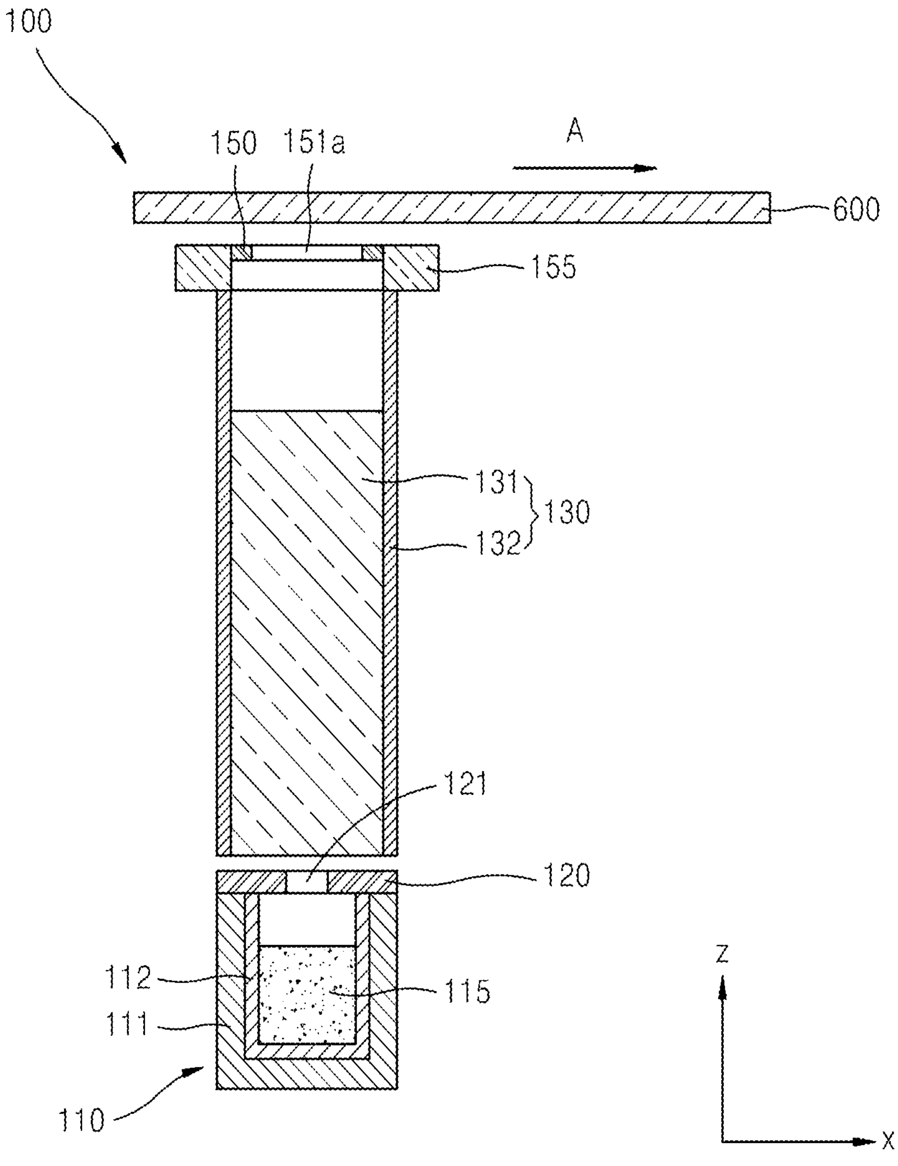

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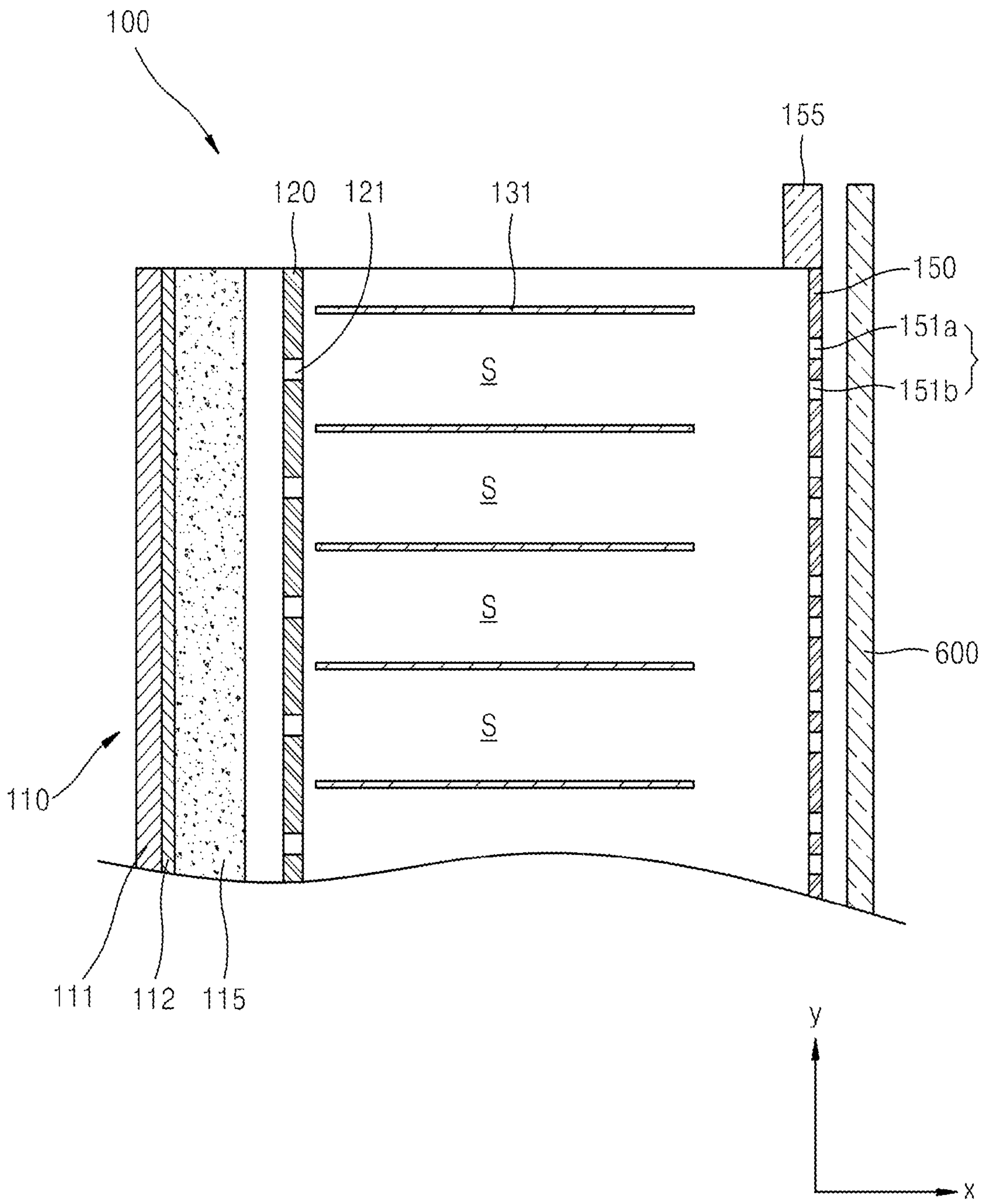
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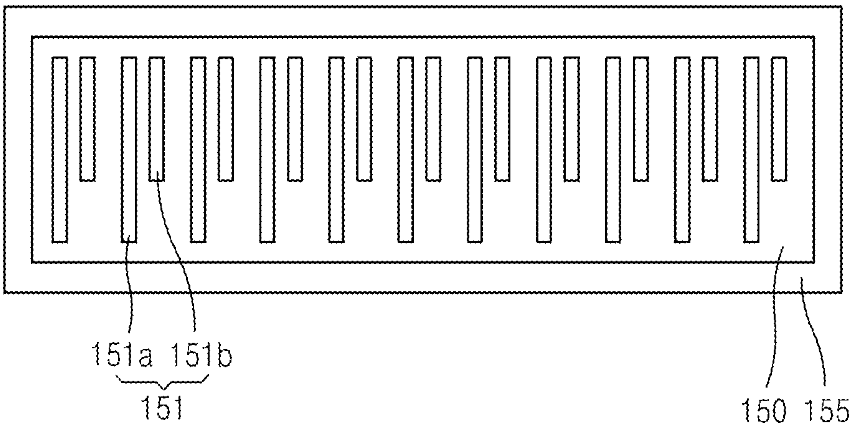
FIG. 6A



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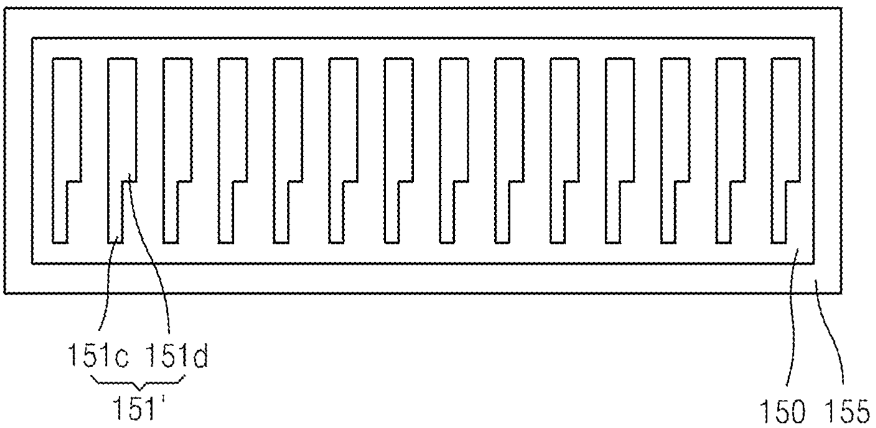


FIG. 6C

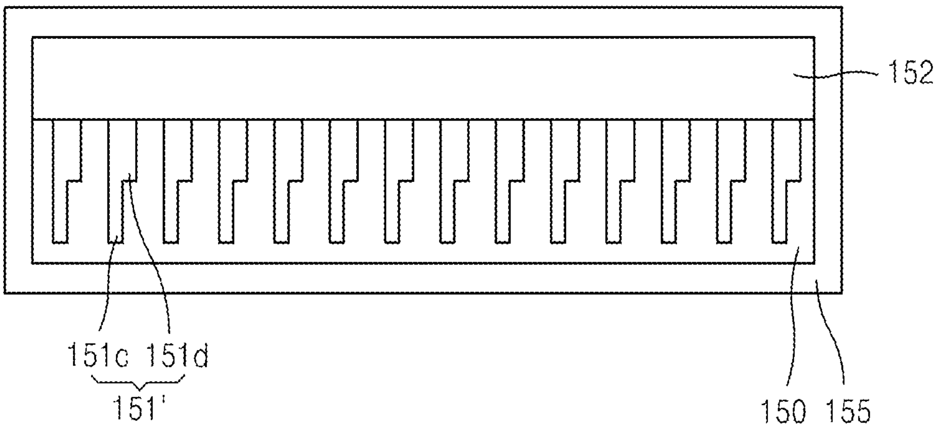


FIG. 6D

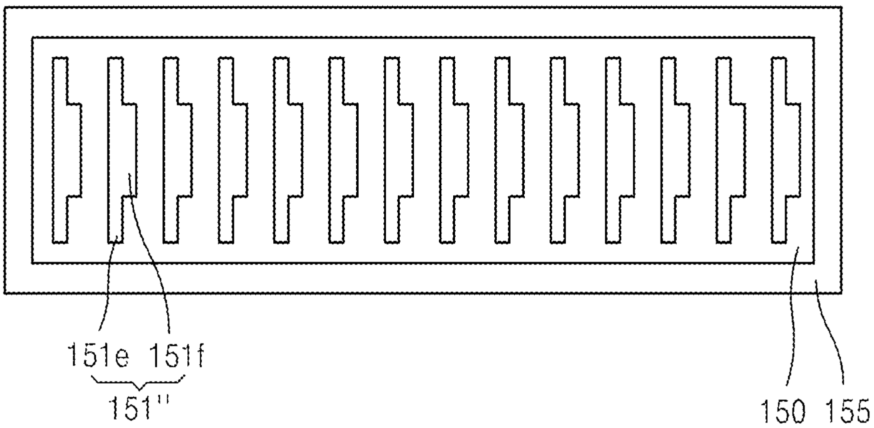


FIG. 6E

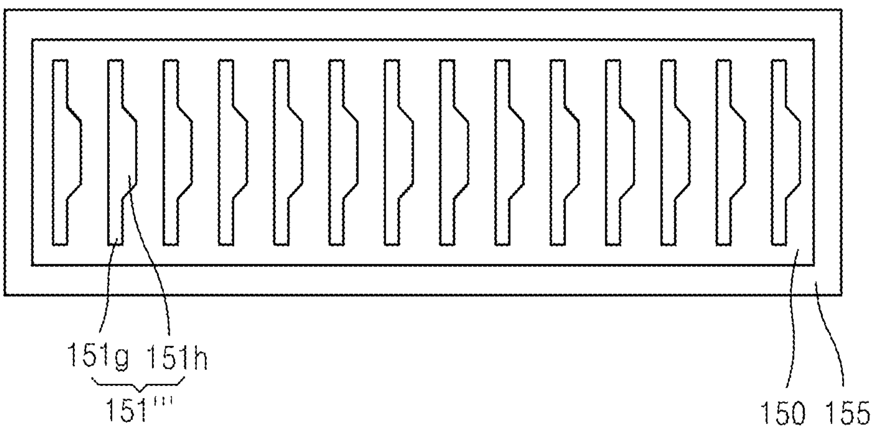


FIG. 7

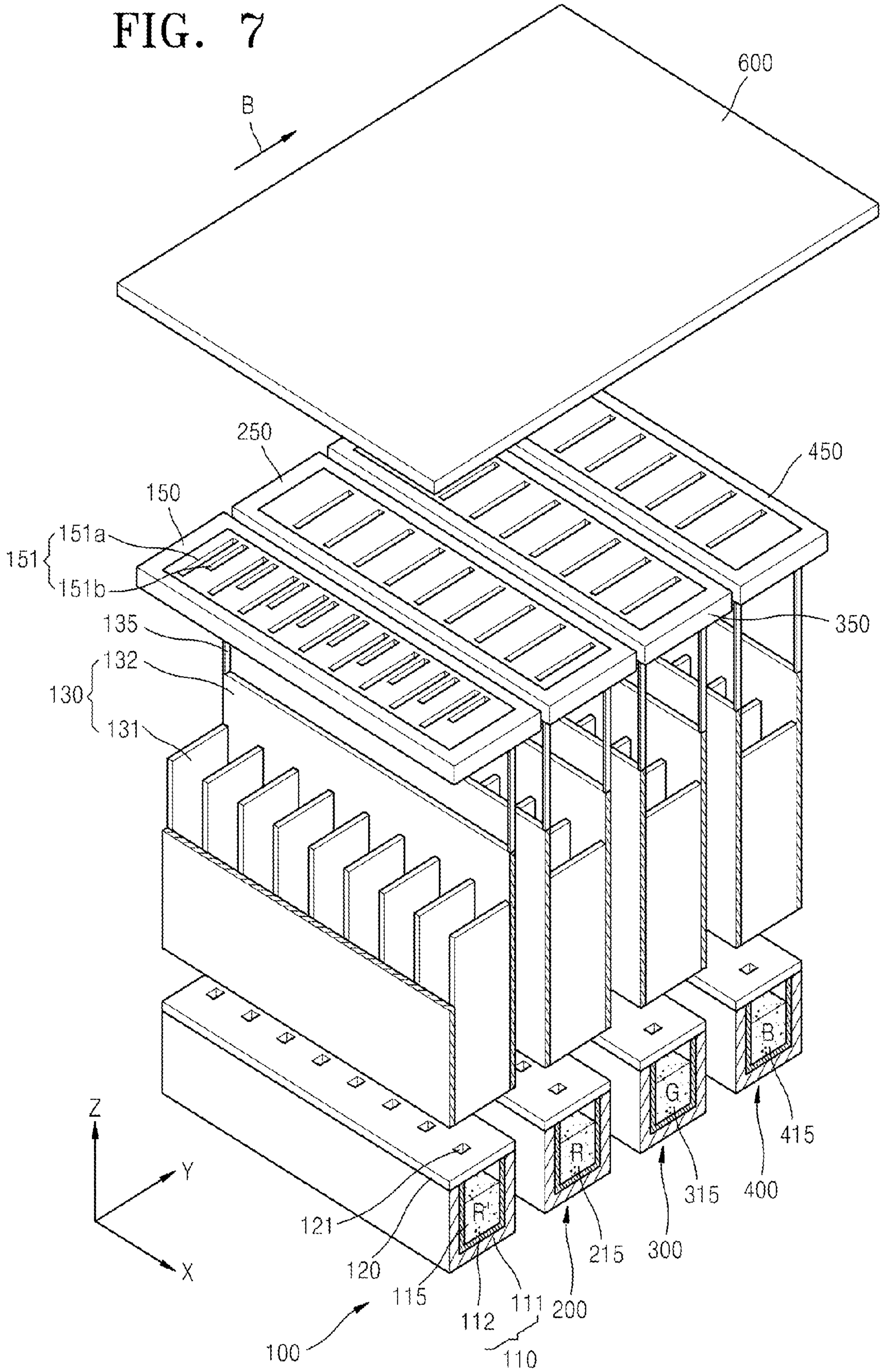

B
600
250
450
150
151
151a
151b
135
350
130
132
131
Z
Y
X
121
120
115
112
111
110
100
R
R
G
B
200
215
300
315
400
415

FIG. 8

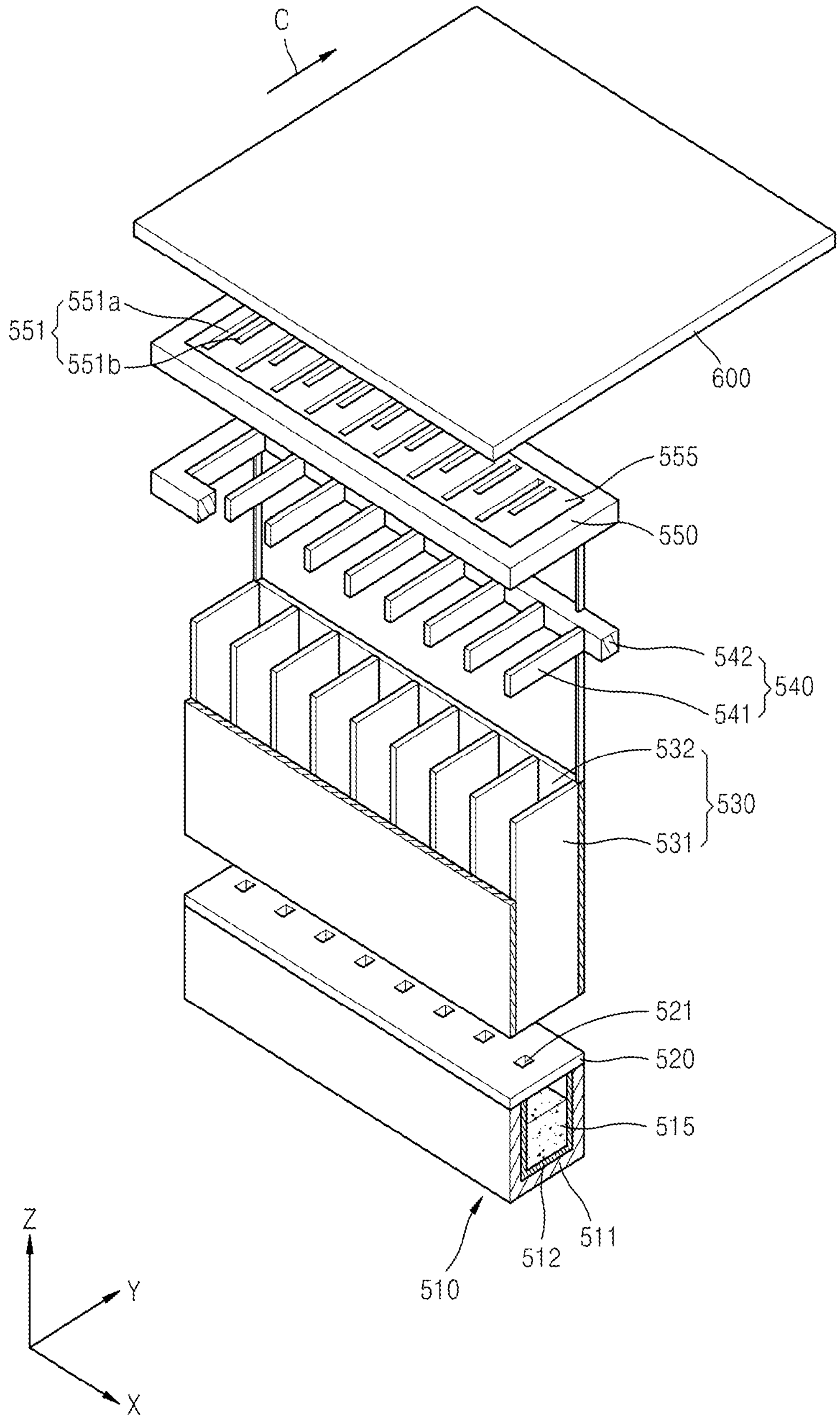

C
551
551a
551b
600
555
550
542
540
541
532
530
531
521
520
515
511
512
510
Z
Y
X

FIG. 9

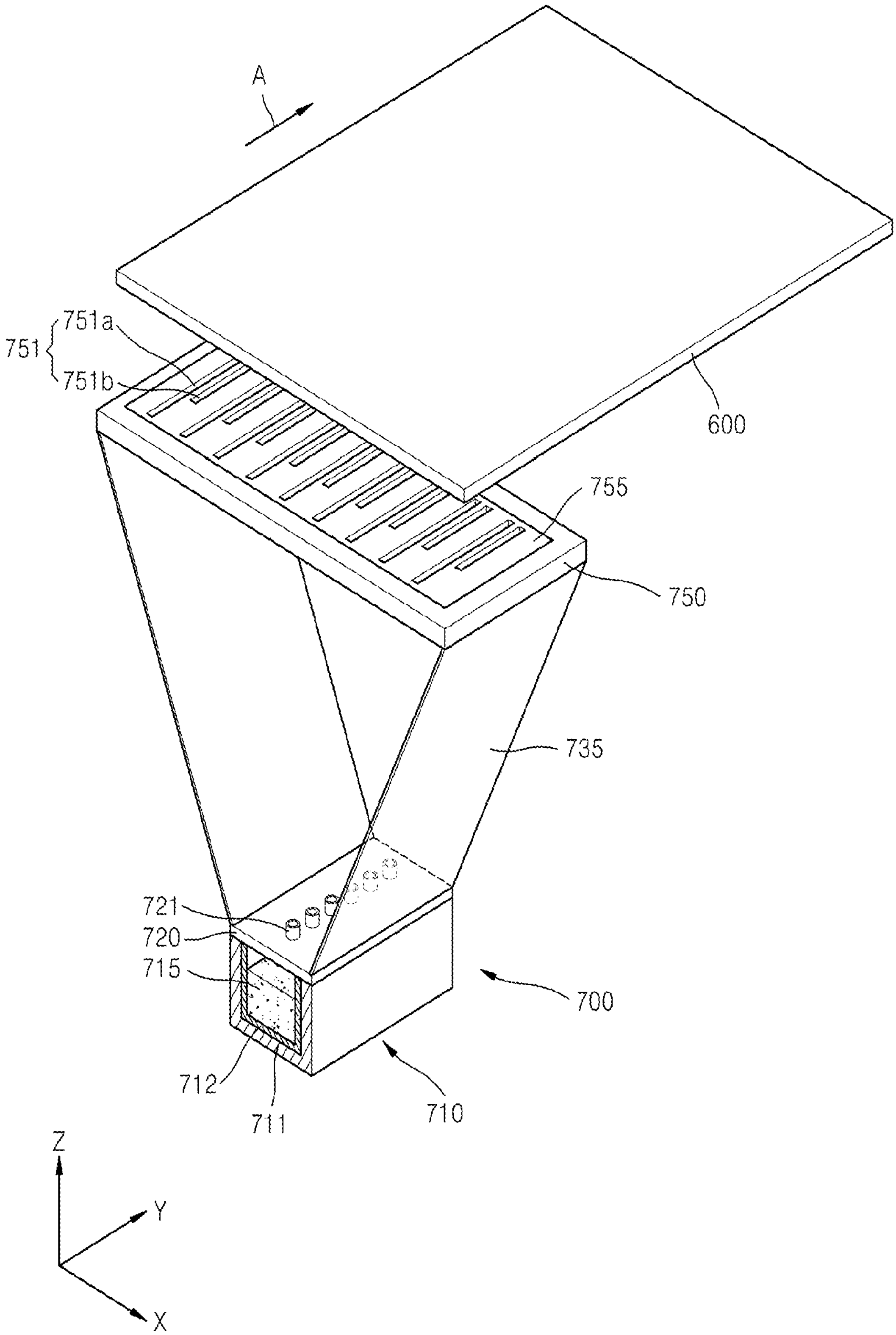


FIG. 10

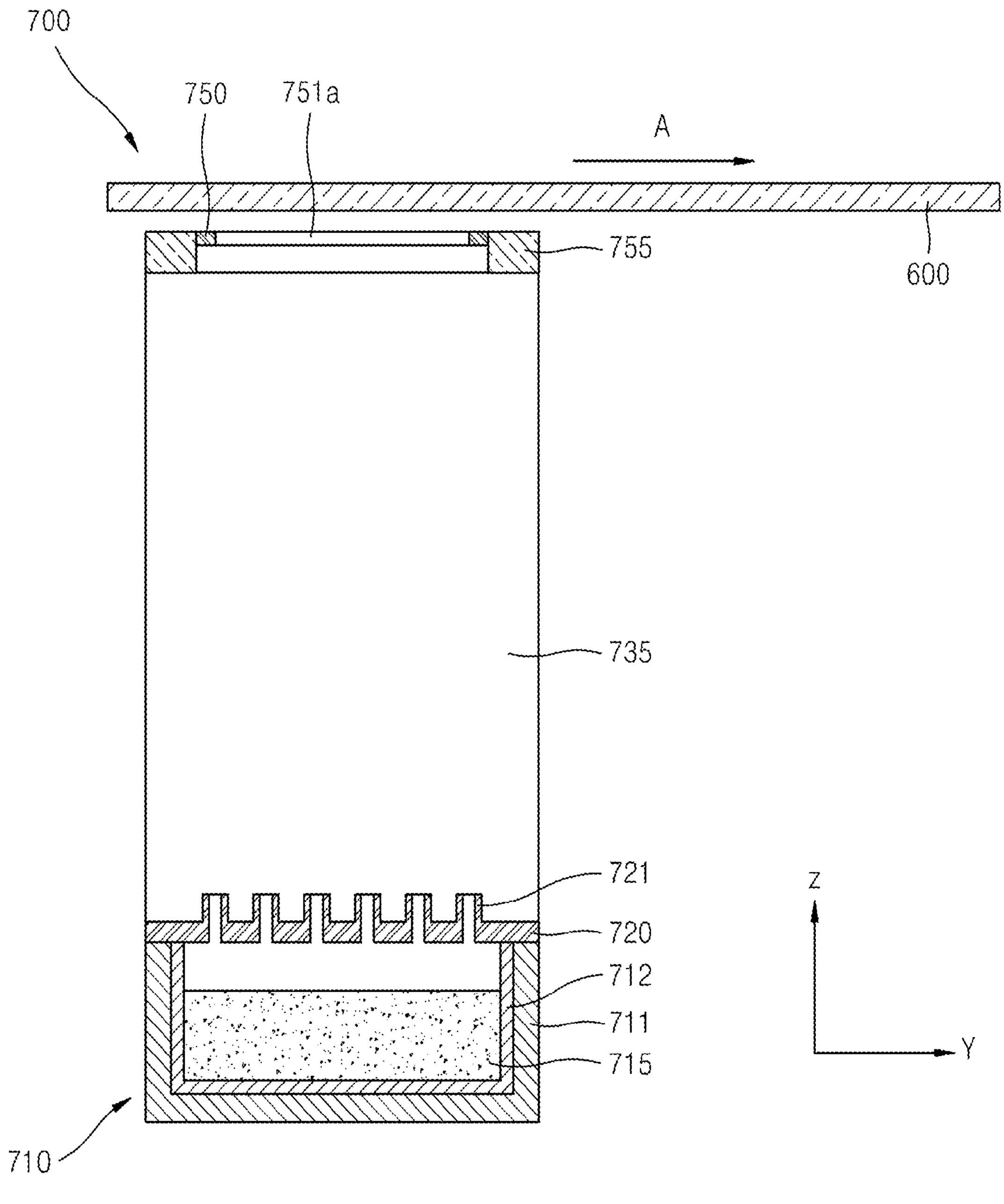


FIG. 11

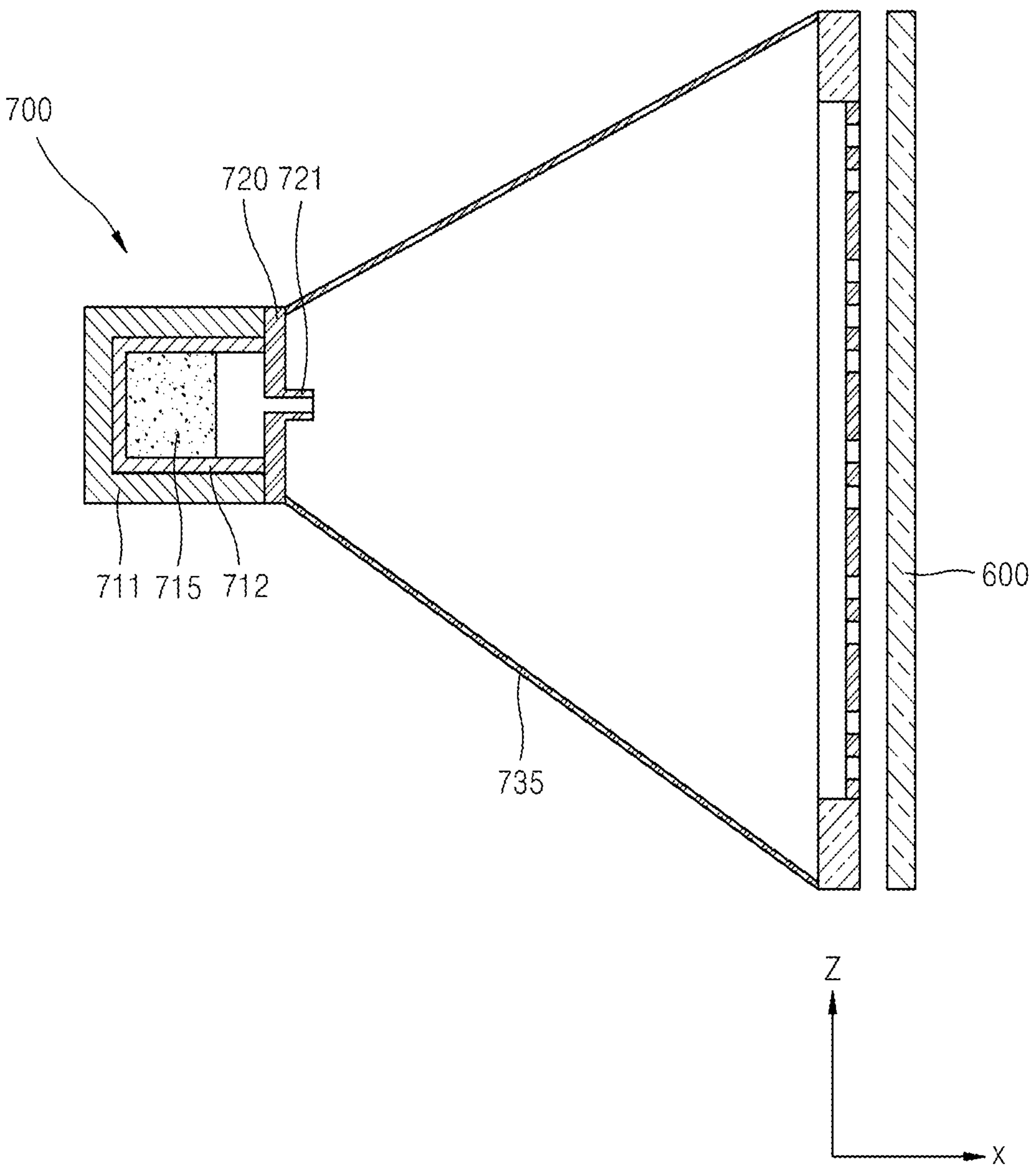
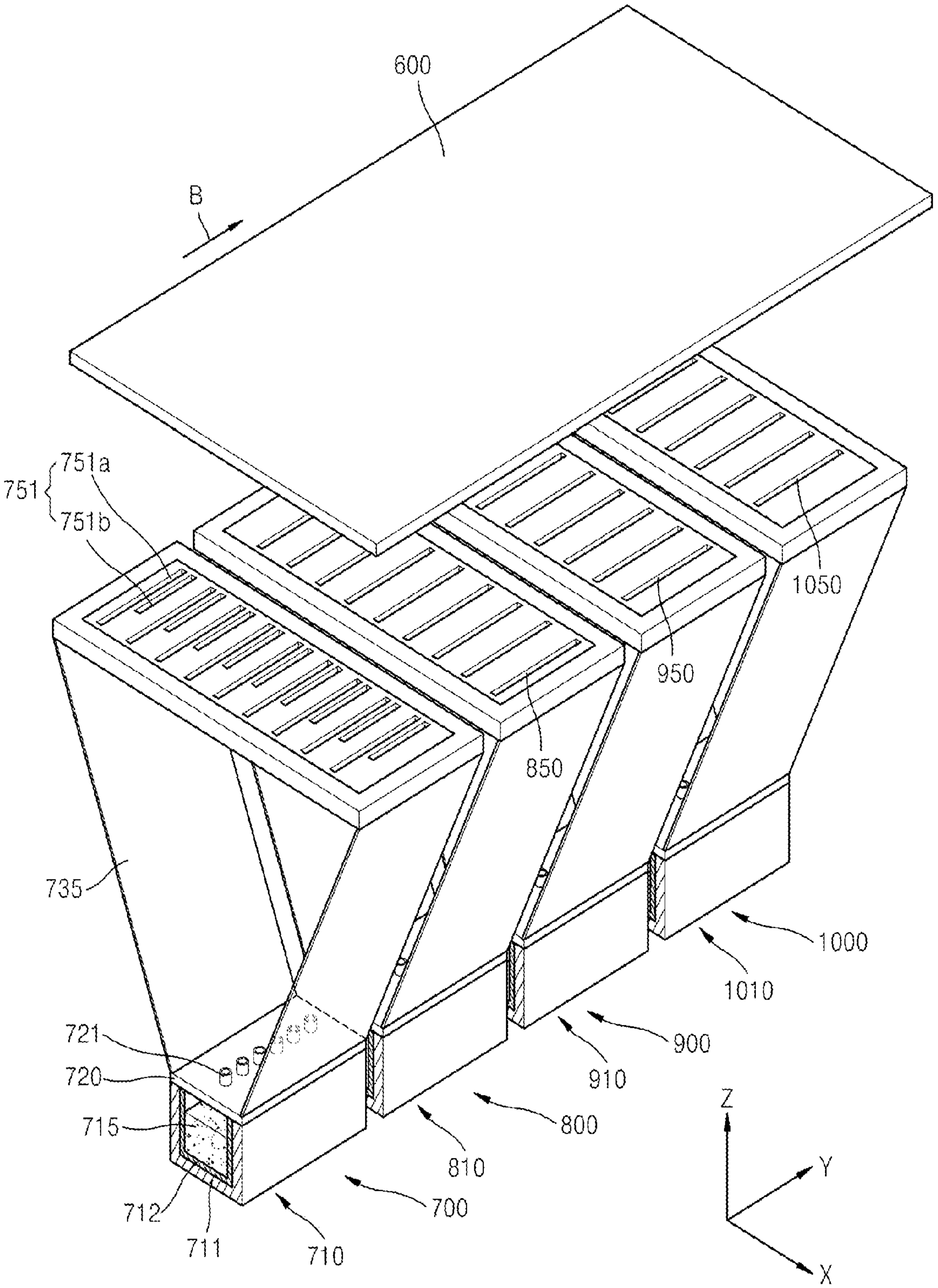


FIG. 12



600
B
751
751a
751b
850
950
1050
735
721
720
715
712
711
710
700
810
800
910
900
1010
1000
Z
Y
X

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. 10-2010-0003545, filed on Jan. 14, 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 that is suitable for manufacturing large-sized display devices on a mass scale with a high yield, 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.

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 5G 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. 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 interlayer 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 easily used to manufacture large-sized display devices on a mass scale, 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 by 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 plurality of patterning slits having different lengths arranged in the first direction; 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 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.

The patterning slits may include first patterning slits having a first length and second patterning slits having a second length that is different from the first length.

The first patterning slits and the second patterning slits may be alternately disposed.

The first patterning slits may be formed so as to correspond to a red sub-pixel region, and the second patterning slits are formed so as to correspond to a green sub-pixel region, wherein the first patterning slits are longer than the second patterning slits.

The pattering slits may not be formed in a region of the patterning slit sheet corresponding to a blue sub-pixel region.

The amounts of the deposition materials deposited on the substrate may be controlled according to the lengths of the patterning slits.

The deposition materials discharged from the deposition source may simultaneously be deposited on the red sub-pixel region and the green sub-pixel region.

The thickness of the deposition material deposited on the red sub-pixel region may be greater than that of the deposition material deposited on the green sub-pixel region.

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

The plurality of barrier plates may be arranged at equal intervals.

Each of the barrier plate assemblies 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 each of the second barrier plates may extend in a second direction that is substantially perpendicular to the first direction, in order to partition the 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 thin film deposition apparatus may include a plurality of thin film deposition assemblies, wherein each of the thin film deposition assemblies includes the deposition source, the deposition source nozzle unit, the patterning slit sheet, and the barrier plate assembly.

The deposition sources of the plurality of thin film deposition assemblies may respectively contain different deposition materials.

The deposition materials respectively contained in the deposition sources of the plurality of thin film deposition assemblies may be simultaneously deposited on the substrate.

The number of thin film deposition assemblies may be at least four, and deposition materials respectively contained in the deposition sources of the at least four thin film deposition assemblies may include materials for forming auxiliary layers and red, green and blue emission layers.

Deposition temperatures of the deposition sources of the plurality of thin film deposition assemblies may be separately controllable.

The deposition material discharged from the thin film deposition apparatus may continuously be 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 movable relative to each other along a plane parallel to a surface of the substrate on which the deposition materials are deposited.

The patterning slit sheets of the plurality of thin film deposition assemblies may be smaller than the substrate.

The barrier plate assemblies may guide the deposition materials discharged from the deposition sources.

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 plurality of patterning slits having different lengths arranged in a second direction perpendicular to the first direction, wherein a deposition is performed while the substrate moves 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 each other.

The patterning slits may include first patterning slits having a first length and second patterning slits having a second length that is different from the first length.

The first patterning slits and the second patterning slits may alternatingly be disposed.

The first patterning slits may be formed so as to correspond to a red sub-pixel region, and the second patterning slits may be formed so as to correspond to a green sub-pixel region, wherein the first patterning slits are longer than the second patterning slits.

Pattering slits may not be formed in a region of the patterning slit sheet corresponding to a blue sub-pixel region.

The amounts of the deposition materials deposited on the substrate may be controlled according to the lengths of the patterning slits.

The deposition materials discharged from the deposition source may simultaneously be deposited on the red sub-pixel region and the green sub-pixel region.

The thickness of the deposition material deposited on the red sub-pixel region may be greater than that of the deposition material deposited on the green sub-pixel region.

The deposition source and the deposition source nozzle unit, and the patterning slit sheet may be connected to each other by a connection member.

The connection member may guide movement of the discharged deposition material.

The connection member may seal a space between the deposition source and 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 continuously be deposited on the substrate while the substrate is moved relative to the thin film deposition apparatus in the first direction.

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

The thin film deposition apparatus may include a plurality of thin film deposition assemblies, wherein each of the thin film deposition apparatus includes the deposition source, the deposition source nozzle unit, the patterning slit sheet, and the barrier plate assembly.

The deposition sources of the plurality of thin film deposition assemblies may respectively contain different deposition materials.

The deposition materials respectively contained in the deposition sources of the plurality of thin film deposition assemblies may simultaneously be deposited on the substrate.

The number of thin film deposition assemblies may be at least four, and deposition materials respectively contained in the deposition sources of the at least four thin film deposition assemblies may include materials for forming auxiliary layers and red, green and blue emission layers.

Deposition temperatures of the deposition sources of the plurality of thin film deposition assemblies may be separately controllable.

According to another aspect of the present invention, there is provided a method of manufacturing an organic light-emitting display device, the method including: separating a thin film deposition assembly from a substrate that is fixedly supported by a chuck and performing deposition on the substrate while the thin film deposition assembly or the substrate fixedly supported by the chuck is moved relative to each other, wherein 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 plurality of patterning slits having different lengths arranged in the first direction, 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 space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces.

According to another aspect of the present invention, there is provided a method of manufacturing an organic light-emitting display device, the method including: separating a thin film deposition assembly from a substrate that is fixedly supported by a chuck and performing deposition on the substrate while the thin film deposition assembly or the substrate fixedly supported by the chuck is moved relative to each other, wherein 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 plurality of patterning slits having different lengths arranged in a second direction perpendicular to the first direction.

The deposition materials may include organic materials, and auxiliary layers having different thicknesses formed in the red, green, and blue sub-pixels which respectively emit red, green, and blue light by the thin film deposition apparatus.

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 sectional view of a pixel of the organic light-emitting display device illustrated in FIG. **1**;

FIG. **3** is a schematic perspective view of a thin film deposition assembly according to an embodiment of the present invention;

FIG. **4** is a schematic sectional view of the thin film deposition assembly illustrated in FIG. **3**;

FIG. **5** is a schematic plan view of the thin film deposition assembly illustrated in FIG. **3**;

FIG. **6**A is a plan view of a patterning slit sheet in the thin film deposition assembly illustrated in FIG. **3**;

FIGS. **6**B-**6**E are plan views of other patterning slit sheets for use in the thin film deposition assembly illustrated in FIG. **3**;

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 assembly according to another embodiment of the present invention;

FIG. **9** is a schematic perspective view of a thin film deposition assembly according to another embodiment of the present invention;

FIG. **10** is a schematic sectional view of the thin film deposition assembly illustrated in FIG. **9**;

FIG. **11** is a schematic plan view of the thin film deposition assembly illustrated in FIG. **9**;

FIG. **12** is a schematic perspective view of a thin film deposition apparatus according to another 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. Moreover, it is to be understood that where is stated herein that one film or layer is "formed on" or "disposed on" a second layer or film, the first layer or film may be formed or disposed directly on the second layer or film or there may be intervening layers or films between the first layer or film and the second layer or film. Further, as used herein, the term "formed on" is used with the same meaning as "located on" or "disposed on" and is not meant to be limiting regarding any particular fabrication process.

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.

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 may include a monochromatic flat display device. However, it is understood that the organic light-emitting display device may include other flat display devices.

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, 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 the circuit region **40** may include a circuit TFT constituted to implement a predetermined circuit.

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

FIG. **2** is a sectional view of a pixel of the organic light-emitting display device illustrated in FIG. **1**.

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 **52***b* and **52***c*, respectively, of the active layer **52** through contact holes. A passivation layer **58** is formed of SiO_2, 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 first electrode **61**, which functions as an anode of the OLED, is formed on the planarization layer **59**, and a pixel defining layer **60** formed of an organic material is formed to cover the first electrode **61**. An opening is formed in the pixel defining layer **60**, and an organic layer **62** is formed on a surface of the pixel defining layer **60** and on a surface of the first electrode **61** exposed through the opening. The organic layer **62** includes an emission layer. 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 first electrode **61**, which is connected to the drain electrode **56** of the TFT and to which a positive power voltage is applied, a second electrode **63**, which is formed so as to cover the entire pixel and to which a negative power voltage is applied, and the organic layer **62**, which is disposed between the first electrode **61** and the second electrode **63** to emit light.

The first electrode **61** and the second electrode **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 be formed of a low-molecular weight organic material or a high-molecular weight organic material. When a low-molecular weight organic material is used, 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). Examples of available organic materials may include copper phthalocyanine (CuPc), N,N'-di(naphthalene-1-yl)-N,N'-diphenyl-benzidine (NPB), tris-8-hydroxyquinoline aluminum (Alq3), and the like. 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 polyphenylenevinylenes (PPVs) or polyfluorenes. 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** may function as an anode, and the second electrode **63** may function 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 indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium oxide (In_2O_3). Such a reflective electrode may be formed by forming a reflective layer from 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 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**.

In the organic light-emitting display device described above, the organic layer **62** including the emission layer may be formed by using a thin film deposition assembly **100** (see FIG. **3**), which will be described later.

Specifically, the organic layer **62** may include emission layers **62**R, **62**G, and **62**B and auxiliary layers **62**R' and **62**G'. The emission layers **62**R, **62**G, **62**B may emit red, green, or blue lights based on the material. Meanwhile, the auxiliary layers **62**R' and **62**G' may be formed of the same material as the HTL.

Meanwhile, one of the first electrode **61** and the second electrode **63** is a reflective electrode and the other is a semi-transparent electrode or a transparent electrode. Thus, resonance may occur between the first electrode **61** and the second electrode **63** while the organic light-emitting display device is driving. Accordingly, while the organic light-emitting display device is driving, light that is generated in emission layers **62**R, **62**G, and **62**B formed between the first electrode **61** and the second electrode **63** resonates between the first electrode **61** and the second electrode **63** to be emitted out of the organic light-emitting display device, so that emitting brightness and emitting efficiency may be improved.

In this regard, in an organic light-emitting display device manufactured using the thin film deposition apparatus, organic layers, including auxiliary layers **62**R' and **62**G', in R, G, and B sub-pixels, which respectively emit red, green and blue light, may have different thicknesses.

In particular, the auxiliary layer **62**R' in the R sub-pixel may have a thickness of about 1600 Å to about 2200 Å. If the thickness of the auxiliary layer **62**R' is not within the range defined above, the auxiliary layer **62**R' may not have sufficient hole injecting capability and hole transporting capability to induce a resonance effect in the red emission layer **62**R. Thus, color purity may deteriorate, and emission efficiency may be reduced. In addition, if the thicknesses of the auxiliary layer **62**R' is greater than the upper limit defined above, the driving voltage may be increased.

The auxiliary layer **62**G' in the G sub-pixel may have a thickness of about 1000 Å to about 1200 Å. If the thickness of the auxiliary layer **62**G' is not within the range defined above, the auxiliary layer **62**G' may not have sufficient hole injecting capability and hole transporting capability to induce a resonance effect in the green emission layer **62**G. Thus, color purity may be deteriorated, and emission efficiency may be reduced. In addition, if the thickness of the auxiliary layer **62**G' is greater than the upper limit defined above, the driving voltage may be increased.

In the organic light-emitting display device, a resonance phenomenon may occur between the first electrode **61** and the second electrode **63** while driving the organic light-emitting display device. In this regard, since the auxiliary layers **62**R' and **62**G' among the organic layers that are interposed between the first electrode **61** and the second electrode **63** have different thicknesses according to the color of lights emitted in the emission layers **62**R, **62**G, and **62**B as described above, the organic light-emitting display device may have excellent characteristics such as driving voltage, high current density, high brightness, color purity, light-emission efficiency, and life-span characteristics.

Here, the auxiliary layer **62**R' of the R sub-pixel that emits red light and the auxiliary layer **62**G' of the G sub-pixel that emits green light may be prepared using a single process by using the thin film deposition apparatus, which will be described in detail later.

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

FIG. **3** is a schematic perspective view of a thin film deposition assembly **100** according to an embodiment of the present invention, FIG. **4** is a schematic sectional view of the thin film deposition assembly **100** illustrated in FIG. **3**, and FIG. **5** is a schematic plan view of the thin film deposition assembly **100** illustrated in FIG. **3**.

Referring to FIGS. **3**, **4** and **5**, the thin film deposition assembly **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 assembly **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.

In particular, in order to deposit a deposition material **115** that is emitted from the deposition source **110** and is discharged through the deposition source nozzle unit **120** and the patterning slit sheet **150**, onto a substrate **600** in a desired pattern, it is required to maintain the chamber in a high-vacuum state as in a deposition method using a fine metal mask (FMM). In addition, the temperatures of barrier plates **131** and the patterning slit sheet **150** have to be sufficiently lower than the temperature of the deposition source **110**. In this regard, the temperatures of the barrier plates **131** and the patterning slit sheet **150** may be about 100° C. or less. This is so the deposition material **115** that has collided against the barrier plates **131** is not re-vaporized. In addition, thermal expansion of the patterning slit sheet **150** may be minimized when the temperature of the patterning slit sheet **150** is sufficiently low. The barrier plate assembly **130** faces the deposition source **110** which is at a high temperature. In addition, the temperature of a portion of the barrier plate assembly **130** close to the deposition source **110** rises by a maximum of about 167° C., and thus a partial-cooling apparatus may be further included if needed. To this end, the barrier plate assembly **130** may include a cooling member.

The substrate **600**, which constitutes a target on which a deposition material 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 **160**. Other substrates may also be employed.

In an embodiment of the present invention, deposition may be performed while the substrate **600** is moved relative to the thin film deposition assembly **100**.

In particular, in the conventional FMM deposition method, the size of the 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 assembly **100** according to an embodiment of the present invention, deposition may be performed while the thin film deposition assembly **100** or the substrate **600** is moved relative to each other. In other words, deposition may be continuously performed while the substrate **600**, which is disposed such as to face the thin film deposition assembly **100**, is moved in a Y-axis direction. In other words, deposition is performed in a scanning manner while the substrate **600** is moved in a direction of an 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 present invention is not limited thereto. Deposition may also be performed while the thin film deposition assembly **100** is moved in the Y-axis direction, whereas the substrate **600** is fixed.

Thus, in the thin film deposition assembly **100**, the patterning slit sheet **150** may be significantly smaller than an FMM used in a conventional deposition method. In other words, in the thin film deposition assembly **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 patterning slit sheet **150** in the X-axis and Y-axis directions 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 an FMM used in a conventional deposition method, it is relatively easy to manufacture the patterning slit sheet **150**. In other words, using the patterning slit sheet **150**, which is smaller than an FMM used in a 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 assembly **100** or the substrate **600** is moved relative to each other as described above, the thin film deposition assembly **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 at equal intervals 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 the 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 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 assembly **100** according to an embodiment of the present invention, 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 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 assembly **100** and the substrate **600** can be separated from each other by a predetermined distance. This will be described later in detail.

The barrier plate frame **132**, which forms 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.

Although the deposition source nozzle unit **120** and the barrier plate assembly **130** are illustrated as being separated from each other by a predetermined distance, the present invention is not limited thereto. In order to prevent the heat emitted from the deposition source **110** from being conducted to the barrier plate assembly **130**, the deposition source nozzle unit **120** and the barrier plate assembly **130** may be separated from each other by a predetermined distance. Alternatively, if a heat insulator is disposed between the deposition source nozzle unit **120** and the barrier plate assembly **130**, the deposition source nozzle unit **120** and the barrier plate assembly **130** may be bound together with the heat insulator therebetween.

In addition, the barrier plate assembly **130** may be constructed to be detachable from the thin film deposition assembly **100**. A conventional FMM deposition method has low deposition efficiency. Deposition efficiency refers to the ratio of a deposition material deposited on a substrate to the deposition material vaporized from a deposition source. The conventional FMM deposition method has a deposition efficiency of about 32%. Furthermore, in the conventional FMM deposition method, about 68% of organic deposition material that is not deposited on the substrate remains adhered to a deposition apparatus, and thus reusing the deposition material is not straightforward.

In order to overcome these problems, in the thin film deposition assembly **100** according to an embodiment of the present invention, the deposition space is enclosed by using the barrier plate assembly **130**, so that the deposition material **115** that is not deposited on the substrate **600** 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 assembly **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 assembly **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, a reuse rate of the deposition material **115** is increased, so that the deposition efficiency is improved, whereas the manufacturing costs are reduced.

The patterning slit sheet **150** and a frame **155** in which the patterning slit sheet **150** is bound 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** is bound inside 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 a conventional method of manufacturing an FMM, and in particular, a striped FMM.

In the thin film deposition assembly **100**, the patterning slits **151** may have different lengths. This will be described in detail with reference to FIG. **6**A.

In the thin film deposition assembly **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, at least 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 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 correspond 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**.

In addition, 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 member **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 a predetermined distance.

As described above, the thin film deposition assembly **100** performs deposition while being moved relative to the substrate **600**. In order to move the thin film deposition assembly

100 relative to the substrate **600**, the patterning slit sheet **150** is separated from the substrate **600** by a predetermined distance. In addition, 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 **600** 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 **600** is sharply reduced.

In particular, in a conventional deposition method using an 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. However, it is not easy to manufacture such a large mask.

In order to overcome this problem, in the thin film deposition assembly **100**, the patterning slit sheet **150** is disposed to be separated from the substrate **600** by a 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 embodiment 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, 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** of the thin film deposition assembly **100** according to an embodiment of the present invention will be described in detail.

FIG. **6**A is a plan view of a patterning slit sheet **150** in the thin film deposition assembly illustrated in FIG. **3**; Referring to FIG. **6**A, in the thin film deposition assembly, the patterning slits **151** may have different lengths.

As described above, in an organic light-emitting display device manufactured using the thin film deposition apparatus according to an embodiment of the present invention, organic layers, including auxiliary layers **62**R' and **62**G' (see FIG. **2**), in R, G, and B sub-pixels, which respectively emit red, green and blue light, may have different thicknesses. In this regard, the thickness of each of the sub-pixels may be adjusted by controlling the thicknesses of the auxiliary layers **62**R' and **62**G' (see FIG. **2**). In other words, the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel may be the thickest, the auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel may be thinner than the auxiliary layer **62**R', and an auxiliary layer in the B sub-pixel may be thinner than the auxiliary layer **62**G' or may not be formed at all.

Meanwhile, in the conventional FMM deposition method, only a single layer can be stacked by a single process, and thus the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel and auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel need to be deposited using separate processes.

However, the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel and the auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel are formed of the same material and only the thicknesses and deposition positions of the auxiliary layer **62**R' and the auxiliary layer **62**G' are different from each other. Thus, in the thin film deposition assembly **100**, the auxiliary layer **62**R' and the auxiliary layer **62**G' may be simultaneously formed by installing the patterning slits **151** of the R, G, and B sub-pixel regions to have different lengths.

In other words, the patterning slits **151** includes first patterning slits **151***a* and second patterning slits **151***b*. In this regard, the first patterning slits **151***a* are formed so as to correspond to the R sub-pixel region, and the second patterning slits **151***b* are formed so as to correspond to the G sub-pixel region. In other words, since a deposition material that has passed through the patterning slit **151** can only be deposited on the substrate **600**, the thickness of an organic layer that is deposited on the substrate **600** increases as the size of the patterning slit **151** increases. Accordingly, the first patterning slits **151***a* for forming the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel that is the thickest have to be the longest, the second patterning slits **151***b* for forming the auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel that is thinner than the auxiliary layer **62**R' have to be shorter than the first patterning slits **151***a*, and the patterning slits are not formed in a region corresponding to the B sub-pixel. Although the patterning slits are not formed in a region corresponding to the B sub-pixel in FIG. **6**A, the present invention is not limited thereto. If an auxiliary layer is required to be formed in the B sub-pixel region, a patterning slit may be formed such as to correspond thereto.

By using patterning slits having different lengths, a relatively large amount of the deposition material may be passed through a relatively long patterning slit for a region on which a relatively large amount of the deposition material is required to be deposited, and a relatively small amount of the deposition material may be passed through a relatively short patterning slit for a region on which a relatively small amount of the deposition material is required to be deposited to simultaneously form two layers. Thus, the number of the thin film deposition assemblies may be reduced, the time it takes to manufacture the organic light-emitting display device is sharply reduced, and equipment used to manufacture the organic light=emitting display device may be simplified.

FIG. **6**B is a plan view of a modification of the patterning slit sheet of FIG. **6**A. As shown in FIG. **6**B, first patterning slits **151***c* and second patterning slits **151***d* having different lengths may be integrally formed. In this case, a patterning slit sheet **151'** may be efficiently manufactured.

Meanwhile, the thickness of the organic layer **62** (FIG. **2**) may be changed in order to optimize the structure of the organic light-emitting diode. Accordingly, the thicknesses of the auxiliary layers **62**R' and **62**G' (FIG. **2**) may also be changed. In this regard, a deposition blade **152** may further be disposed as shown in FIG. **6**C so as not to manufacture the patterning slit sheet **151'** whenever the thicknesses of the auxiliary layers **62**R' and **62**G' (FIG. **2**) are changed. In other words, using the deposition blade **152** that screens a part of the patterning slit sheet **151'**, the thicknesses of the auxiliary layers **62**R' and **62**G' (FIG. **2**) may be adjusted by controlling the area of the deposition blade **152** without manufacturing a separate pattern slit sheet.

Meanwhile, if the patterning slit sheet **151'** is disposed as shown in FIG. **6**B, the upper and lower portions of the pattern slit sheet **151'** are asymmetrical. Thus, the pattern slit sheet **151'** may not be easily manufactured. In order to overcome this, a pattern slit sheet **151"** may be formed such that second patterning slits **151***f* are disposed at the centers of first patterning slits **151***e* as shown in FIG. **6**D.

Furthermore, in order to minimize deformation of the patterning slit sheet **151'** caused by extension, the patterning slit sheet **151"** may be formed such that second patterning slits **151***h* are disposed at the centers of first patterning slits **151***g* and both ends of the second patterning slits **151***h* are inclined as shown in FIG. **6**E.

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

Referring to FIG. **7**, the thin film deposition apparatus includes a plurality of thin film deposition assemblies, each of which has the structure of the thin film deposition assembly **100** illustrated in FIGS. **3** through **6**. In other words, the thin film deposition apparatus may include a multi-deposition source that simultaneously discharges deposition materials for forming auxiliary layers R' and G', an R emission layer, a G emission layer, and a B emission layer.

In particular, the thin film deposition apparatus includes a first thin film deposition assembly **100**, a second thin film deposition assembly **200**, a third thin film deposition assembly **300**, and a fourth thin film deposition assembly **400**. Each of the first thin film deposition assembly **100**, the second thin film deposition assembly **200**, the third thin film deposition assembly **300**, and the fourth thin film deposition assembly **400** has the same structure as the thin film deposition assembly described with reference to FIGS. **3** through **6**, and thus a detailed description thereof will not be provided here.

The deposition sources of the first thin film deposition assembly **100**, the second thin film deposition assembly **200**, the third thin film deposition assembly **300**, and fourth thin film deposition assembly **400** may contain different deposition materials, respectively. For example, the first thin film deposition assembly **100** may contain a deposition material for forming auxiliary layers R' and G', the second thin film deposition assembly **200** may contain a deposition material for forming an R emission layer, the third thin film deposition assembly **300** may contain a deposition material for forming a G emission layer, and the fourth thin film deposition assembly **400** may contain a deposition material for forming a B emission layer.

In other words, in a conventional method of manufacturing an organic light-emitting display device, a separate chamber and mask are used to form each color emission layer. However, when the thin film deposition apparatus is used, the auxiliary layers R' and G', the R emission layer, the G emission layer and the B emission layer may be formed at the same time with a single multi-deposition source. Thus, the time it takes to manufacture the organic light-emitting display device is sharply reduced. In addition, the organic light-emitting display device may be manufactured with less chambers, so that equipment costs are also markedly reduced.

In this regard, the patterning slit sheet **150** of the first thin film deposition assembly **100** may include the first patterning slits **151***a* and the second patterning slits **151***b* which have different lengths as described above. Here, the first patterning slits **151***a* are formed such as to correspond to the R sub-pixel region, and the second patterning slits **151***b* are formed such as to correspond to the G sub-pixel region.

In addition, a patterning slit sheet **250** of the second thin film deposition assembly **200**, a patterning slit sheet **350** of the third thin film deposition assembly **300**, and a patterning slit sheet **450** of the fourth thin film deposition assembly **400** may be arranged to be offset by a constant distance with respect to one another, in order for deposition regions corresponding to the patterning slit sheets **250**, **350** and **450** not to overlap on the substrate **600**. In other words, when the second thin film deposition assembly **200**, the third thin film deposition assembly **300**, and the fourth thin film deposition assembly **400** are used to deposit an R emission layer, a G emission layer and a B emission layer, respectively, patterning slits **251** of the second thin film deposition assembly **200**, patterning slits **351** of the third thin film deposition assembly **300**, and patterning slits **451** of the fourth thin film deposition assembly **400** are arranged not to be aligned with respect to one another, in order to form the R emission layer, the G emission layer and the B emission layer in different regions of the substrate **600**.

In addition, the deposition materials for forming the auxiliary layers R' and G', the R emission layer, the G emission layer, and the B emission layer may have different deposition temperatures. Therefore, the temperatures of the deposition sources **110**, **210**, **310**, and **410** of the respective first, second, third, and fourth thin film deposition assemblies **100**, **200**, **300**, and **400** may be set to be different.

Although the thin film deposition apparatus includes four thin film deposition assemblies, the present invention is not limited thereto. In other words, a thin film deposition apparatus may include a plurality of thin film deposition assemblies, each of which contains a different deposition material.

As described above, a plurality of thin films may be formed at the same time with a plurality of thin film deposition assemblies, and thus manufacturing yield and deposition efficiency are improved. In addition, the overall manufacturing process is simplified, and the manufacturing costs are reduced.

Organic layers (refer to the organic layer **62** in FIG. **2**), including the emission layer, of an organic light-emitting display device may be formed with a thin film deposition apparatus having the structure described above. A method of manufacturing an organic light-emitting display device according to an embodiment of the present invention may include: arranging the substrate **600** to be separated from the thin film deposition apparatus by a predetermined distance; and depositing a deposition material discharged from the thin film deposition apparatus on the substrate **600** while moving the thin film deposition apparatus or the substrate **600** relative to each other.

This will now be described in detail below.

Initially, the substrate **600** is arranged to be separated from the thin film deposition apparatus by a predetermined distance. As described above, the thin film deposition apparatus may include the patterning slit sheets **150**, **250**, **350**, and **450** each of which is smaller than the substrate **600**, and thus may be relatively easily manufactured. Thus, deposition may be performed while the thin film deposition apparatus or the substrate **600** is moved relative to each other. In other words, deposition may be continuously performed while the substrate **600**, which is arranged opposite to the thin film deposition apparatus, is moved in the Y-axis direction. In other words, deposition is performed in a scanning manner while the substrate **600** is moved in a direction of an arrow B in FIG. **7**. In addition, the thin film deposition apparatus and the substrate **600** have to be separated from each other by a predetermined distance in order to move the thin film deposition apparatus or the substrate **600** relative to each other. For this reason, the substrate **600** is arranged in a chamber (not shown) to be separated from the thin film deposition apparatus by a predetermined distance.

Next, a deposition material discharged from the thin film deposition apparatus is deposited on the substrate **600** while the thin film deposition apparatus or the substrate **600** is moved relative to each other. As described above, the thin film deposition apparatus may include the patterning slit sheets **150**, **250**, **350**, and **450**, each of which is smaller than the substrate **600**, and thus may be relatively easily manufactured. Thus, deposition is performed while the thin film deposition apparatus or the substrate **600** is moved relative to each other. Although FIG. **7** illustrates that the substrate **600** is moved in the Y-axis direction while the thin film deposition apparatus is fixed, the present invention is not limited thereto. For example, the substrate **600** may be fixed and the thin film deposition apparatus may be moved relative to the substrate **600**.

The thin film deposition apparatus for performing the method of manufacturing an organic light-emitting display device according to an embodiment of the present invention may include a multi-deposition source that simultaneously discharges deposition materials for forming auxiliary layers R' and G', an R emission layer, a G emission layer and a B emission layer. Thus, a plurality of organic layers may be simultaneously formed. In other words, the thin film deposition apparatus used to perform the method may include a plurality of thin film deposition assemblies, so that the auxiliary layers R' and G', the R emission layer, the G emission layer and the B emission layer may be formed at the same time with a single multi-deposition source. Thus, the time taken to manufacture the organic light-emitting display device is sharply reduced, and equipment costs are also markedly reduced since less chambers may be used.

FIG. **8** is a schematic perspective view of a thin film deposition assembly **500** according to another embodiment of the present invention.

Referring to FIG. **8**, the thin film deposition assembly **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. **8** for convenience of explanation, all the components of the thin film deposition assembly **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.

The substrate **600**, which constitutes a target on which a deposition material **515** is to be deposited, is disposed in the chamber. The deposition source **510** that contains and heats the 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 assembly **500** includes two separate barrier plate assemblies, i.e., the first barrier plate assembly **530** and the second barrier plate assembly **540**, unlike the thin film deposition assembly **100** illustrated in FIG. **3**, which includes one barrier plate assembly **130**.

The plurality of first barrier plates **531** may be arranged parallel to each other at equal intervals in the X-axis direction. In addition, each of the first barrier plates **531** may be formed to extend along an YZ plane in FIG. **8**, 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 along the YZ plane in FIG. **8**, 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 the space between the deposition source nozzle unit **520** and the patterning slit sheet **550**. In the thin film deposition assembly **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 respectively disposed to be parallel to and to be on the same plane as the first barrier plates **531**. 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 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 present invention is 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 assembly.

Although not illustrated, a thin film deposition apparatus according to an embodiment of the present invention may include a plurality of thin film deposition assemblies, each of which has the structure illustrated in FIG. **8**. In other words, the thin film deposition apparatus may include a multi-deposition source that simultaneously discharges deposition materials for forming auxiliary layers R' and G', a R emission layer, a G emission layer, and a B emission layer. Deposition is performed in a scanning manner while the substrate **600** is moved in a direction of an arrow C in FIG. **8**. Since the plurality of thin film deposition assemblies have been described in detail in the previous embodiment, a detailed description thereof will not be provided here.

FIG. **9** is a schematic perspective view of a thin film deposition assembly **700** according to another embodiment of the present invention, FIG. **10** is a schematic sectional view of the thin film deposition assembly **700** illustrated in FIG. **9**, and FIG. **11** is a schematic plan view of the thin film deposition assembly **700** illustrated in FIG. **9**.

Referring to FIGS. **9**, **10** and **11**, the thin film deposition assembly **700** includes a deposition source **710**, a deposition source nozzle unit **720**, and a patterning slit sheet **750**.

Although a chamber is not illustrated in FIGS. **9**, **10** and **11** for convenience of explanation, all the components of the thin film deposition assembly **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.

The substrate **600**, which constitutes a target on which a deposition material **715** is to be deposited, is disposed in the chamber. The deposition source **710** that contains and heats the 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 at equal intervals in the Y-axis direction, that is the scanning direction of the substrate **600**. 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, when 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**, a size of the pattern formed by the deposition material 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, and thus there is no shadow zone on the substrate. In addition, since the plurality of deposition source nozzles **721** are formed in the scanning direction of the substrate **600**, even if there is a difference between fluxes of the deposition source nozzles **721**, the difference may be compensated and deposition uniformity may be constantly maintained.

The patterning slit sheet **750** and a frame **755** in which the patterning slit sheet **750** is bound 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 assembly **100**, the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel and the auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel may be simultaneously formed by installing the patterning slits **751** of the R, G, and B sub-pixel regions to have different lengths. In other words, the patterning slits **751** includes first patterning slits **751**_a_ and second patterning slits **751**_b_. In this regard, the first patterning slits **751**_a_ are formed so as to correspond to the R sub-pixel region, and the second patterning slits **751**_b_ are formed so as to correspond to the G sub-pixel region. In this regard, the first patterning slits **751**_a_ for forming the auxiliary layer **62**R' (see FIG. **2**) in the R sub-pixel that is the thickest have to be the longest, the second patterning slits **751**_b_ for forming the auxiliary layer **62**G' (see FIG. **2**) in the G sub-pixel that is thinner than the auxiliary layer **62**R' have to be shorter than the first patterning slits **751**_a_, and the patterning slits are not formed in a region corresponding to the B sub-pixel. Since the patterning slits **751** have been described in detail in the previous embodiment, a detailed description thereof will not be provided here.

In addition, 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 member **735**. That is, the deposition source **710**, the deposition source nozzle unit **720**, and the patterning slit sheet **750** may be formed integrally with each other by being connected to each other via the connection member **735**. The connection member **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. **9** through **11**, the connection members **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 present invention is not limited thereto. That is, the connection member **735** may be formed as a sealed type of a box shape to simultaneously guide flow of the deposition material **715** not to flow in the X-axis and Y-axis directions.

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

As described above, 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.

FIG. **12** is a schematic perspective view of a thin film deposition apparatus according to another embodiment of the present invention.

Referring to FIG. **12**, the thin film deposition apparatus includes a plurality of thin film deposition assemblies, each of which has the structure of the thin film deposition assembly **700** illustrated in FIGS. **9** through **11**. In other words, the thin film deposition apparatus may include a multi-deposition source that simultaneously discharges deposition materials for forming the auxiliary layers R' and G', the R emission layer, the G emission layer, and the B emission layer.

In particular, the thin film deposition apparatus includes a first thin film deposition assembly **700**, a second thin film deposition assembly **800**, a third thin film deposition assembly **900**, and a fourth thin film deposition assembly **1000**. Each of the first thin film deposition assembly **700**, the second thin film deposition assembly **800**, the third thin film deposition assembly **900**, and the fourth thin film deposition assembly **1000** has the same structure as the thin film deposition assembly described with reference to FIGS. **9** through **11**, and thus a detailed description thereof will not be provided here.

The deposition sources of the first thin film deposition assembly **700**, the second thin film deposition assembly **800**, the third thin film deposition assembly **900**, and fourth thin film deposition assembly **1000** may contain different deposition materials, respectively. For example, the first thin film deposition assembly **700** may contain a deposition material for forming auxiliary layers R' and G', the second thin film deposition assembly **800** may contain a deposition material for forming an R emission layer, the third thin film deposition assembly **900** may contain a deposition material for forming a G emission layer, and the fourth thin film deposition assembly **1000** may contain a deposition material for forming a B emission layer.

In other words, in a conventional method of manufacturing an organic light-emitting display device, a separate chamber and mask are used to form each color emission layer. However, when the thin film deposition apparatus according to an embodiment of the present invention is used, the auxiliary layers R' and G', the R emission layer, the G emission layer and the B emission layer may be formed at the same time with a single multi-deposition source. Thus, the time it takes to manufacture the organic light-emitting display device is sharply reduced. In addition, the organic light-emitting display device may be manufactured with less chambers, so that equipment costs are also markedly reduced.

In this regard, the patterning slit sheet **751** of the first thin film deposition assembly **700** may include the first patterning slits **751***a* and the second patterning slits **751***b* which have different lengths as described above. Here, the first patterning slits **751***a* are formed such as to correspond to the R sub-pixel region, and the second patterning slits **751***b* are formed such as to correspond to the G sub-pixel region.

In addition, a patterning slit sheet **850** of the second thin film deposition assembly **800**, a patterning slit sheet **950** of the third thin film deposition assembly **900**, a patterning slit sheet **1050** of the fourth thin film deposition assembly **1000** may be arranged to be offset by a constant distance with respect to each other, in order for deposition regions corresponding to the patterning slit sheets **850**, **950** and **1050** not to overlap on the substrate **600**. In other words, when the second thin film deposition assembly **800**, the third thin film deposition assembly **900**, and the fourth thin film deposition assembly **1000** are used to deposit an R emission layer, a G emission layer and a B emission layer, respectively, patterning slits **851** of the second thin film deposition assembly **800**, patterning slits **951** of the third thin film deposition assembly **900**, and patterning slits **1051** of the fourth thin film deposition assembly **1000** are arranged not to be aligned with respect to one another, in order to form the R emission layer, the G emission layer and the B emission layer in different regions of the substrate **600**.

In addition, the deposition materials for forming the R emission layer, the G emission layer, and the B emission layer may have different deposition temperatures. Therefore, the temperatures of the deposition sources **710**, **810**, **910**, and **1010** of the respective first, second, third, and fourth thin film deposition assemblies **700**, **800**, **900**, and **1000** may be set to be different.

Although the thin film deposition apparatus illustrated in FIG. **12** includes four thin film deposition assemblies, the present invention is not limited thereto. In other words, a thin film deposition apparatus according to the aspects of the present invention may include a plurality of thin film deposition assemblies, each of which contains a different deposition material.

As described above, a plurality of thin films may be formed at the same time with a plurality of thin film deposition assemblies, and thus manufacturing yield and deposition efficiency are improved. In addition, the overall manufacturing process is simplified, and the manufacturing costs are reduced.

As described above, according 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 according to aspects of the present invention, the thin film deposition apparatus may be easily used 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 have high manufacturing yield and deposition efficiency.

While the aspects of the present invention have been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

What is claimed is:

1. A method of manufacturing an organic light-emitting display device using a thin film deposition apparatus, the method comprising:

separating a thin film deposition assembly of the thin film deposition apparatus from a substrate that is fixedly supported by a chuck and performing deposition on the substrate while the thin film deposition assembly or the substrate fixedly supported by the chuck is moved relative to the other,

wherein the thin film deposition assembly 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 plurality of patterning slits having different lengths arranged in the first direction, 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 space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces.

2. The method of claim **1**, wherein the deposition material comprises an organic material, and auxiliary layers having different thicknesses are formed in red, green, and blue sub-pixels, which respectively emit red, green, and blue light, by the thin film deposition apparatus.

3. An organic light-emitting display device manufactured using the method of claim **1**.

4. The method of claim **1**, wherein the patterning slits comprise first patterning slits having a first length and second patterning slits having a second length that is different from the first length.

5. The method of claim **4**, wherein the first patterning slits and the second patterning slits are alternatingly disposed.

6. The method of claim 4, wherein the first patterning slits are formed to correspond to a red sub-pixel region of the thin film, and the second patterning slits are formed to correspond to a green sub-pixel region of the thin film, wherein the first patterning slits are longer than the second patterning slits.

7. The method of claim 6, wherein no pattering slits are formed in a region of the patterning slit sheet corresponding to a blue sub-pixel region.

8. The method of claim 1, wherein amounts of the deposition material deposited on the substrate are controlled according to the lengths of the patterning slits.

9. The method of claim 1, wherein the deposition material discharged from the deposition source is concurrently deposited on a red sub-pixel region and a green sub-pixel region of the substrate.

10. The method of claim 9, wherein a thickness of the deposition material deposited on the red sub-pixel region of the substrate is greater than a thickness of the deposition material deposited on the green sub-pixel region of the substrate.

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

12. The method of claim 1, wherein the plurality of barrier plates are arranged at equal intervals.

13. The method of claim 1, wherein the barrier plate assembly comprises a first barrier plate assembly comprising a plurality of first barrier plates, and a second barrier plate assembly comprising a plurality of second barrier plates.

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

16. The method of claim 1, wherein the patterning slit sheet of the thin film deposition assembly is smaller than the substrate.

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

separating a thin film deposition apparatus from a substrate that is fixedly supported by a chuck and performing deposition on the substrate while the thin film deposition apparatus or the substrate fixedly supported by the chuck is moved relative to the other in a first direction,

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 along the first direction, and a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a plurality of patterning slits having different lengths extending in the first direction and arranged along a second direction perpendicular to the first direction.

18. The method of claim 17, wherein the deposition material comprises an organic material, and auxiliary layers having different thicknesses are formed in red, green, and blue sub-pixels, which respectively emit red, green, and blue light, by the thin film deposition apparatus.

19. An organic light-emitting display device manufactured using the method of claim 17.

20. The method of claim 17, wherein the patterning slits comprise first patterning slits having a first length and second patterning slits having a second length that is different from the first length.

21. The method of claim 20, wherein the first patterning slits and the second patterning slits are alternately disposed.

22. The method of claim 20, wherein the first patterning slits are formed to correspond to a red sub-pixel region of the thin film, and the second patterning slits are formed to correspond to a green sub-pixel region of the thin film, wherein the first patterning slits are longer than the second patterning slits.

23. The method of claim 22, wherein no pattering slits are formed in a region of the patterning slit sheet corresponding to a blue sub-pixel region of the thin film.

24. The method of claim 17, wherein amounts of the deposition material deposited on the substrate are controlled according to the lengths of the patterning slits.

25. The method of claim 17, wherein the deposition material discharged from the deposition source is concurrently deposited on a red sub-pixel region of the substrate and a green sub-pixel region of the substrate.

26. The method of claim 25, wherein a thickness of the deposition material deposited on the red sub-pixel region of the substrate is greater than a thickness of the deposition material deposited on the green sub-pixel region of the substrate.

27. The method of claim 17, wherein the thin film deposition apparatus is separated from the substrate by a predetermined distance.

28. The method of claim 17, 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.

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

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

separating a thin film deposition apparatus from a substrate that is fixedly supported by a chuck and performing deposition on the substrate while the thin film deposition apparatus or the substrate fixedly supported by the chuck is moved relative to the other,

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 along a first direction, and a patterning slit sheet disposed opposite to the deposition source nozzle unit and including a plurality of patterning slits having different lengths arranged along a second direction perpendicular to the first direction,

wherein the deposition source and the deposition source nozzle unit, and the patterning slit sheet are connected to each other by a connection member.

31. The method of claim 30, wherein the connection member guides movement of the discharged deposition material.

32. The method of claim 30, wherein the connection member seals a space between the deposition source and the deposition source nozzle unit, and the patterning slit sheet.

* * * * *

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		
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[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.		
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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，以及通过使用该方法制造的有机发光显示设备。薄膜沉积设备包括：沉积源，其排出沉积材料;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，与沉积源喷嘴单元相对设置，并包括沿第一方向排列的具有不同长度的多个图案化缝隙;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空间分隔成多个子板沉积空间，其中薄膜沉积设备与基板分开预定距离，并且薄膜沉积设备和基板可相对于彼此移动。