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Kim et al.

(10) **Patent No.: US 8,921,831 B2**
(45) **Date of Patent: Dec. 30, 2014**

(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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(73) Assignee: **Samsung Display Co., Ltd.**, Yongin-si (KR)

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(22) Filed: **Jul. 15, 2010**

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Aug. 24, 2009 (KR) 10-2009-0078171

(51) **Int. Cl.**

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C23C 14/04	(2006.01)
C23C 14/12	(2006.01)
C23C 14/24	(2006.01)
H01L 51/56	(2006.01)
H01L 51/00	(2006.01)

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

CPC ***C23C 14/042*** (2013.01); ***C23C 14/12*** (2013.01); *H01L 51/0011* (2013.01); ***C23C 14/243*** (2013.01); ***H01L 51/56*** (2013.01)

USPC **257/40**; 438/34; 438/82; 438/89; 438/99; 438/780

(58) **Field of Classification Search**

CPC C23C 14/042; C23C 14/12; C23C 14/243; H01L 51/56; H01L 51/0011

USPC 438/22, 24, 99, E51.008, E51.022, 758; 118/720; 257/40, E51.018, E51.026, 257/79, 257

See application file for complete search history.

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(57) **ABSTRACT**

A thin film deposition apparatus that includes a thin film deposition assembly incorporating: a deposition source that discharges a deposition material; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a barrier plate assembly including a plurality of barrier plates that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and partition a space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, wherein each of the barrier plates is separate from the patterning slit sheet.

11 Claims, 13 Drawing Sheets

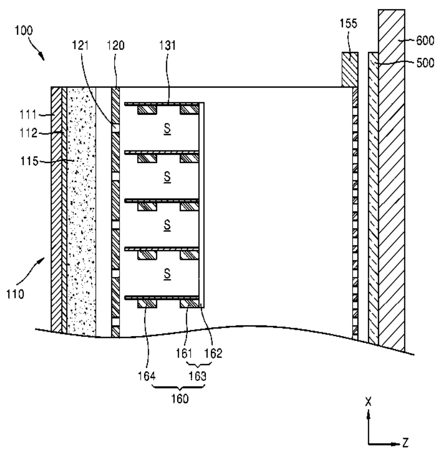

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FIG. 1

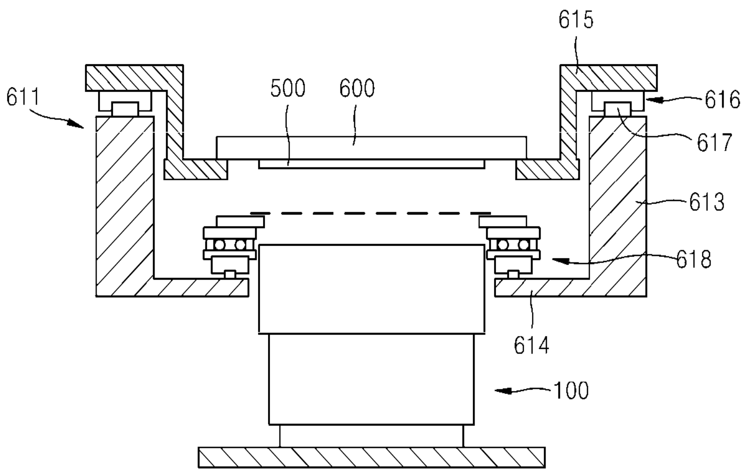

FIG. 2

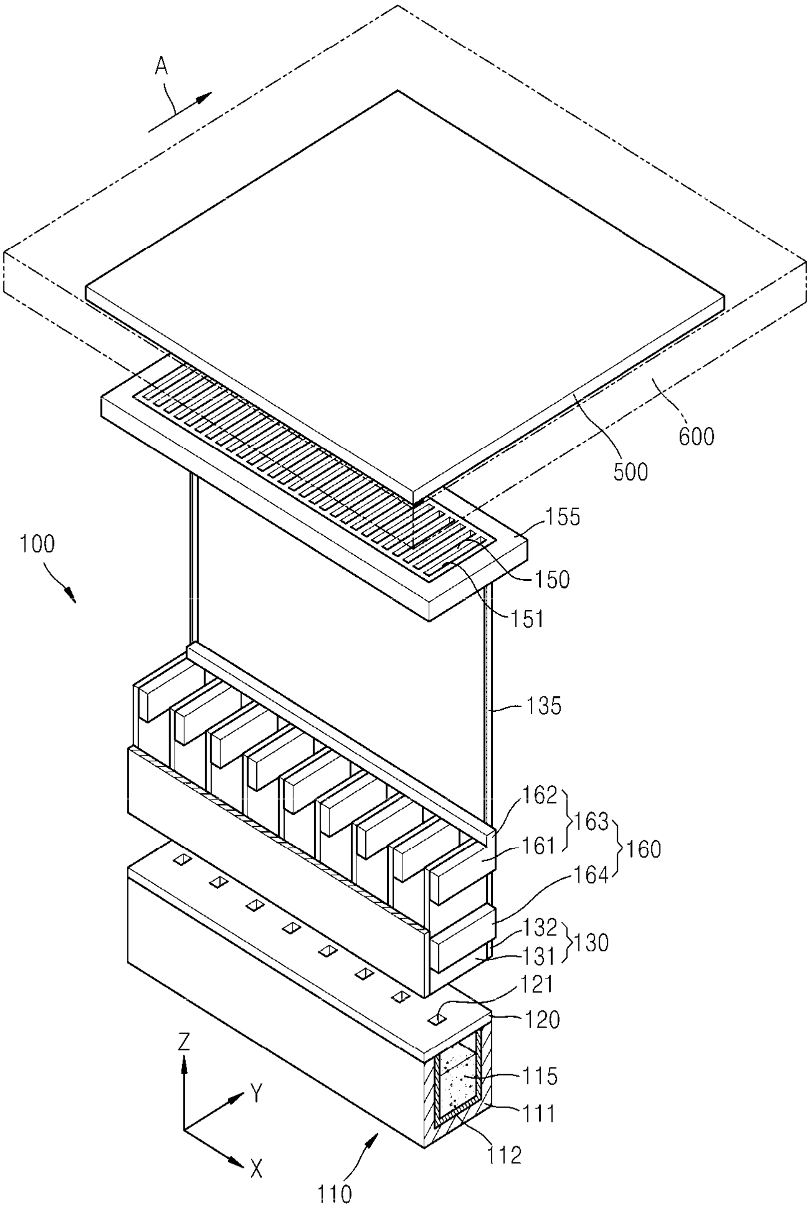
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FIG. 3

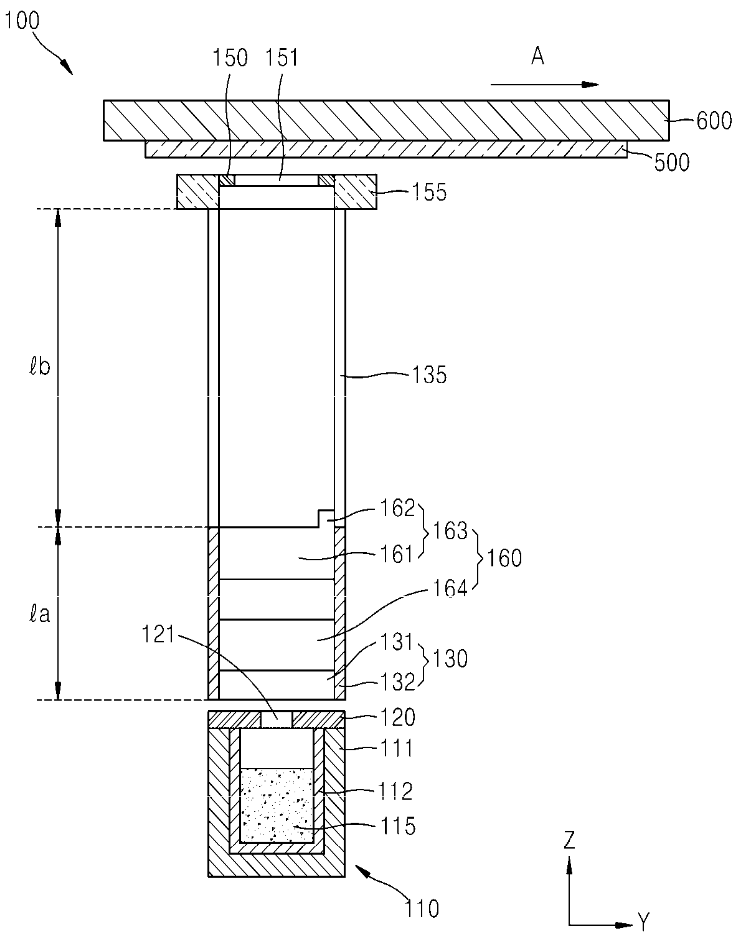

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FIG. 4

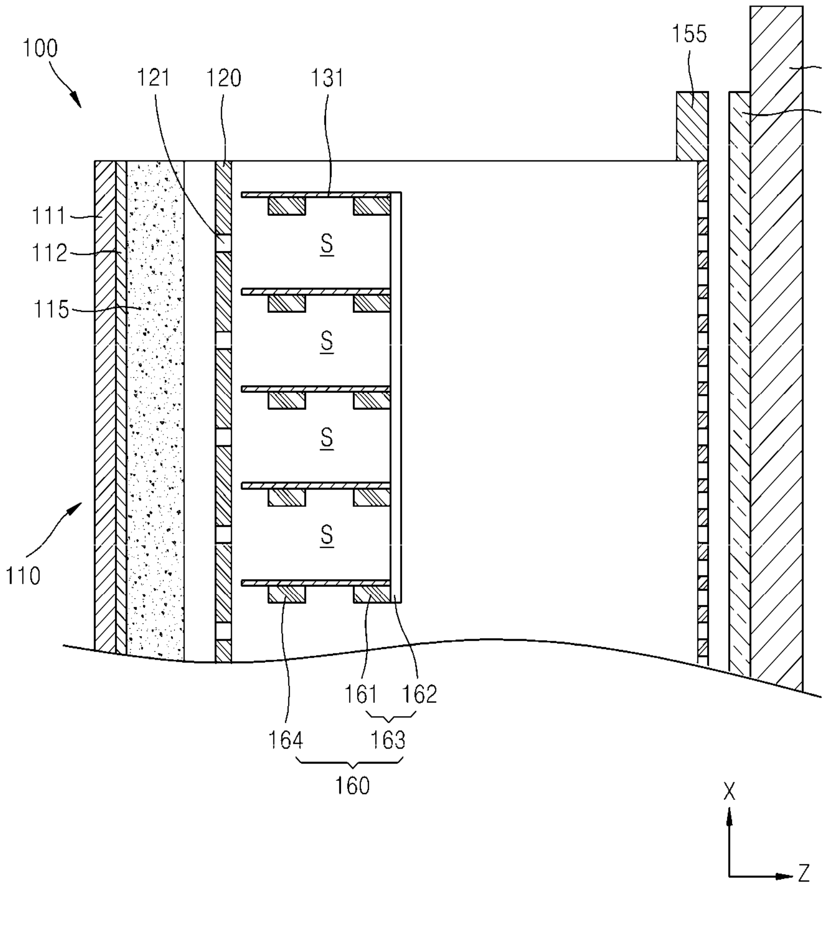
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FIG. 5A

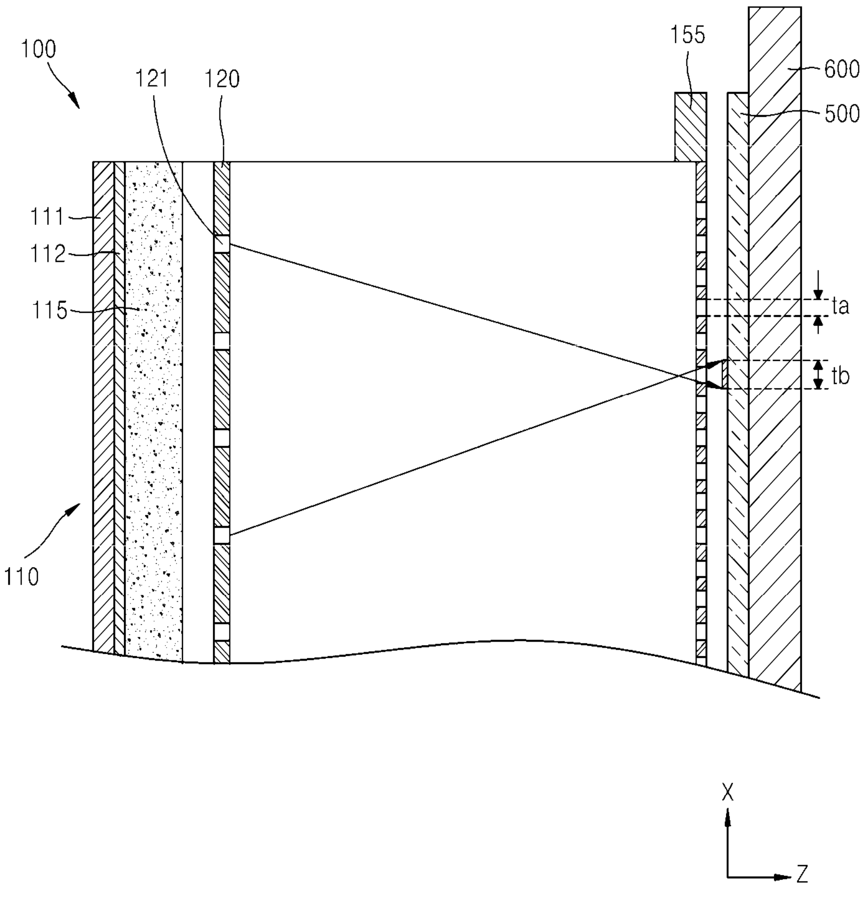

FIG. 5B

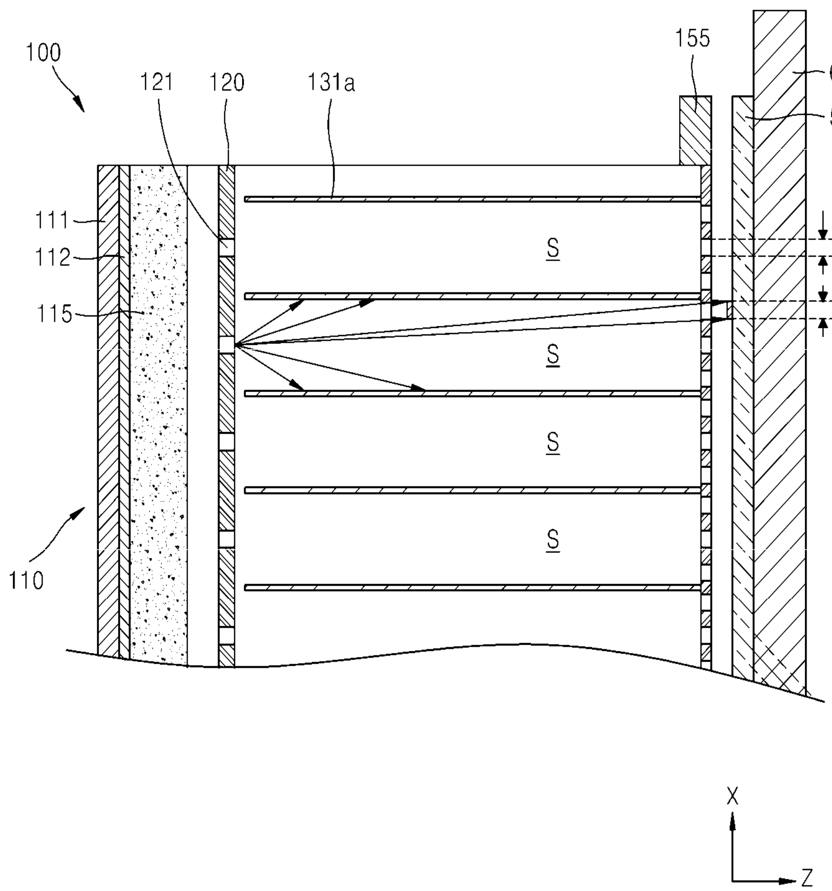

FIG. 5C

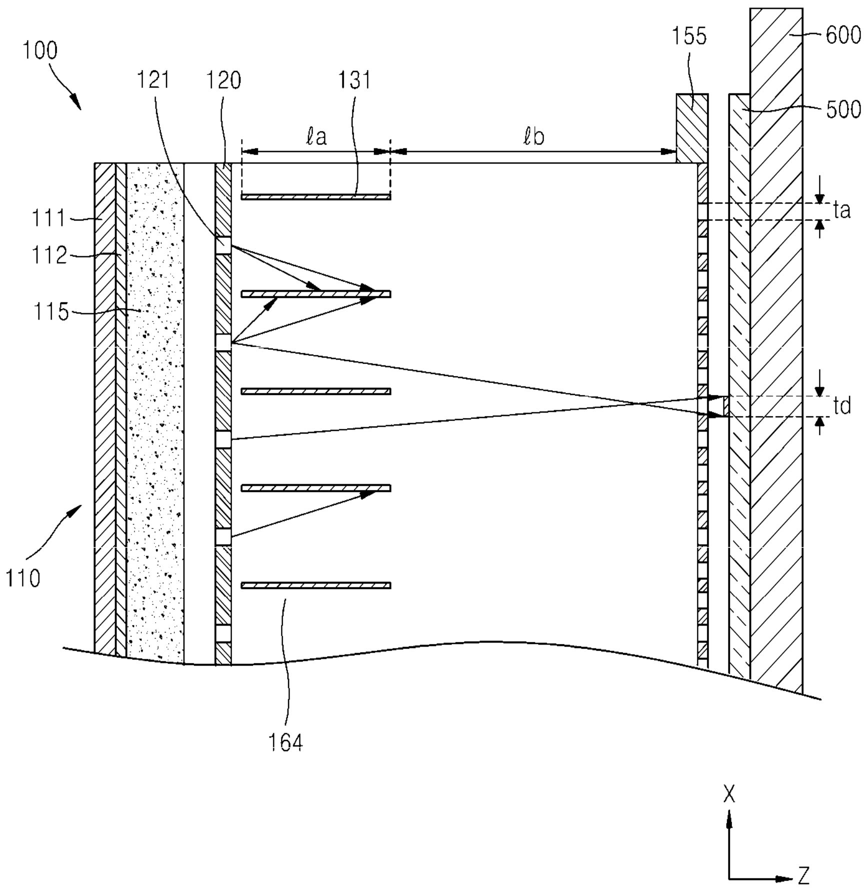

FIG. 6

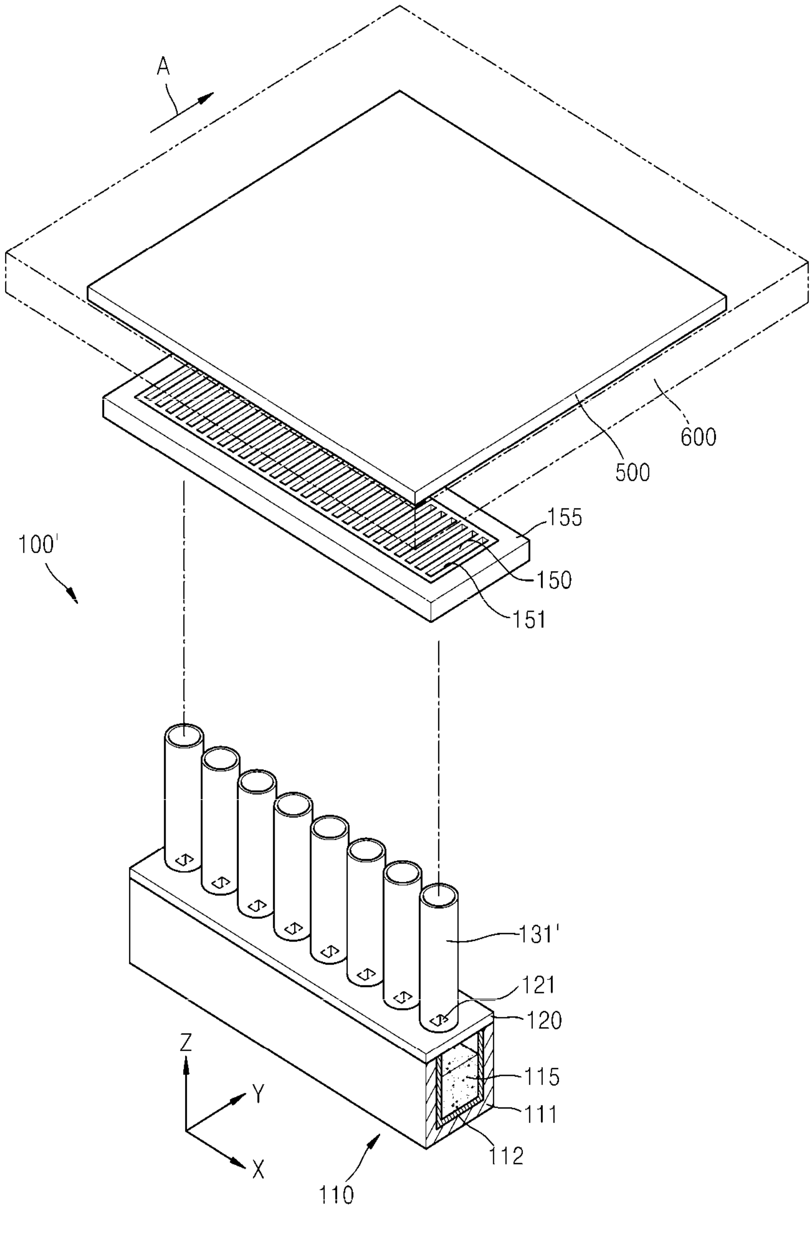

FIG. 7

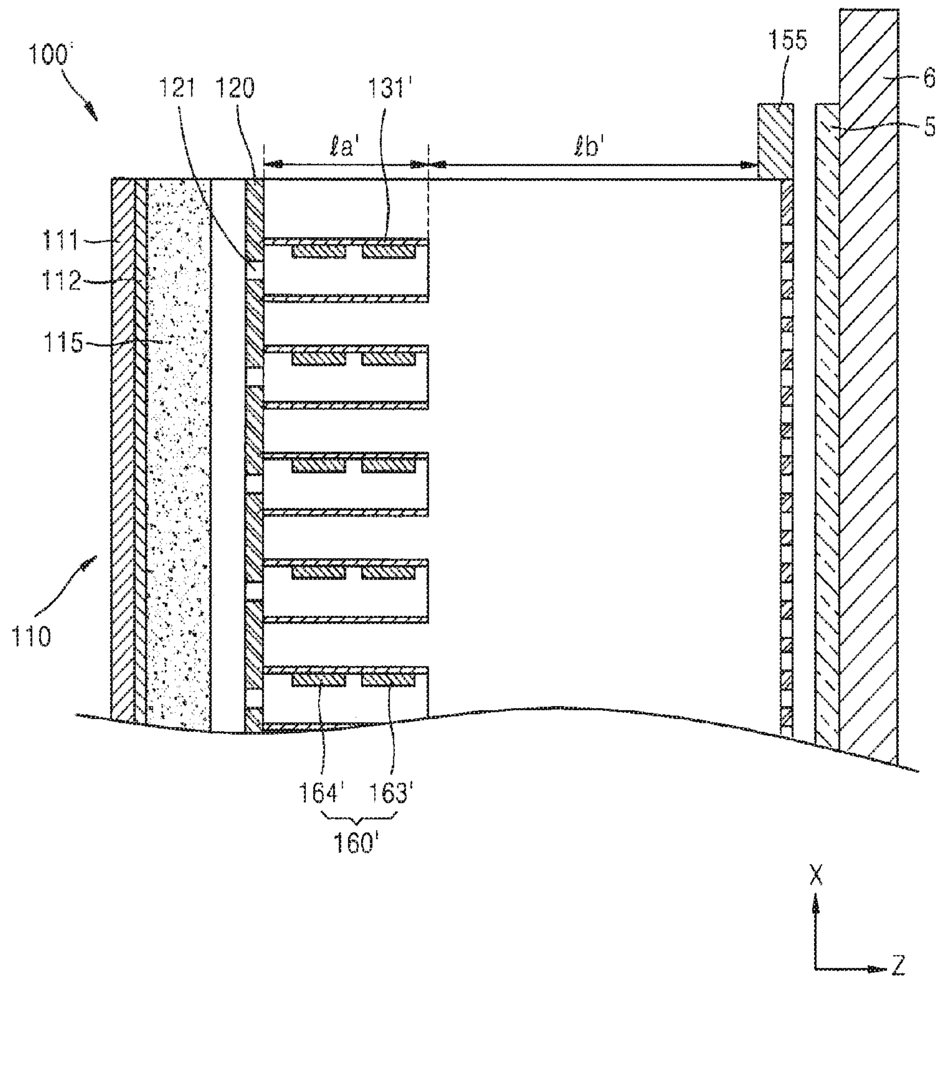

FIG. 8

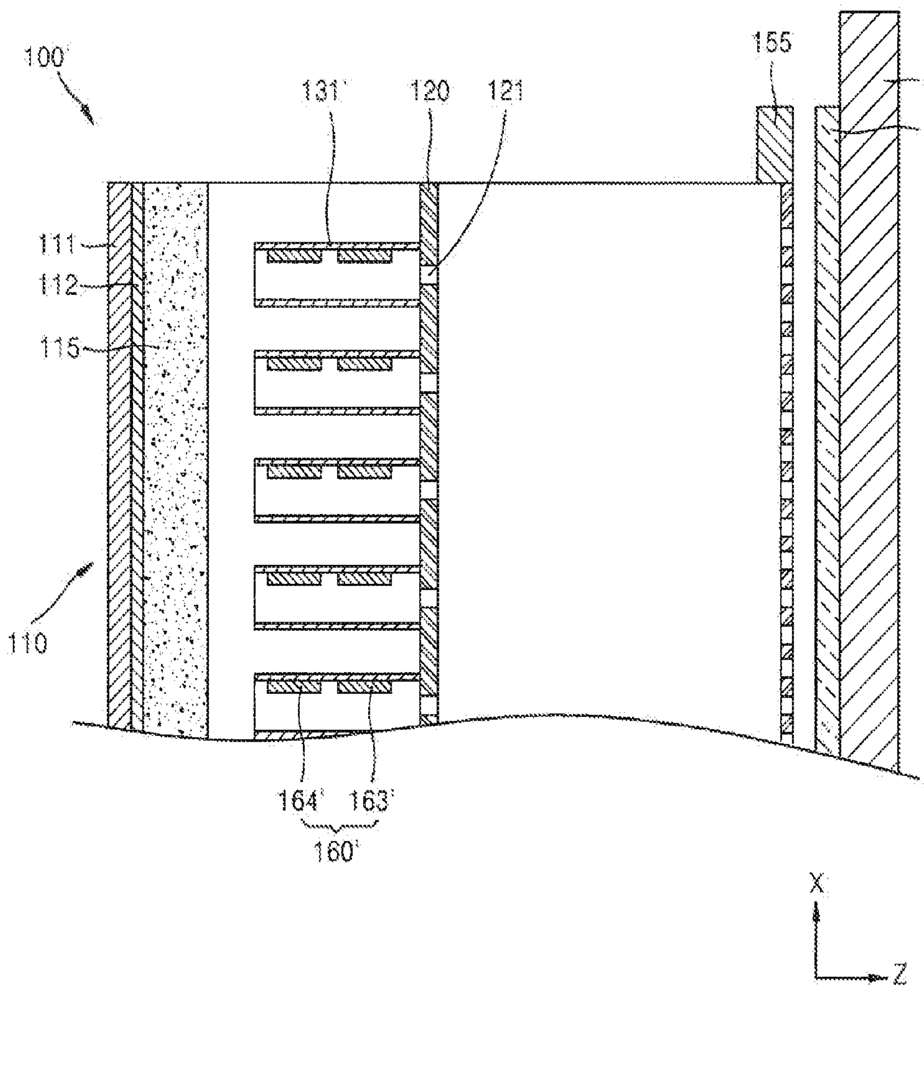

FIG. 9

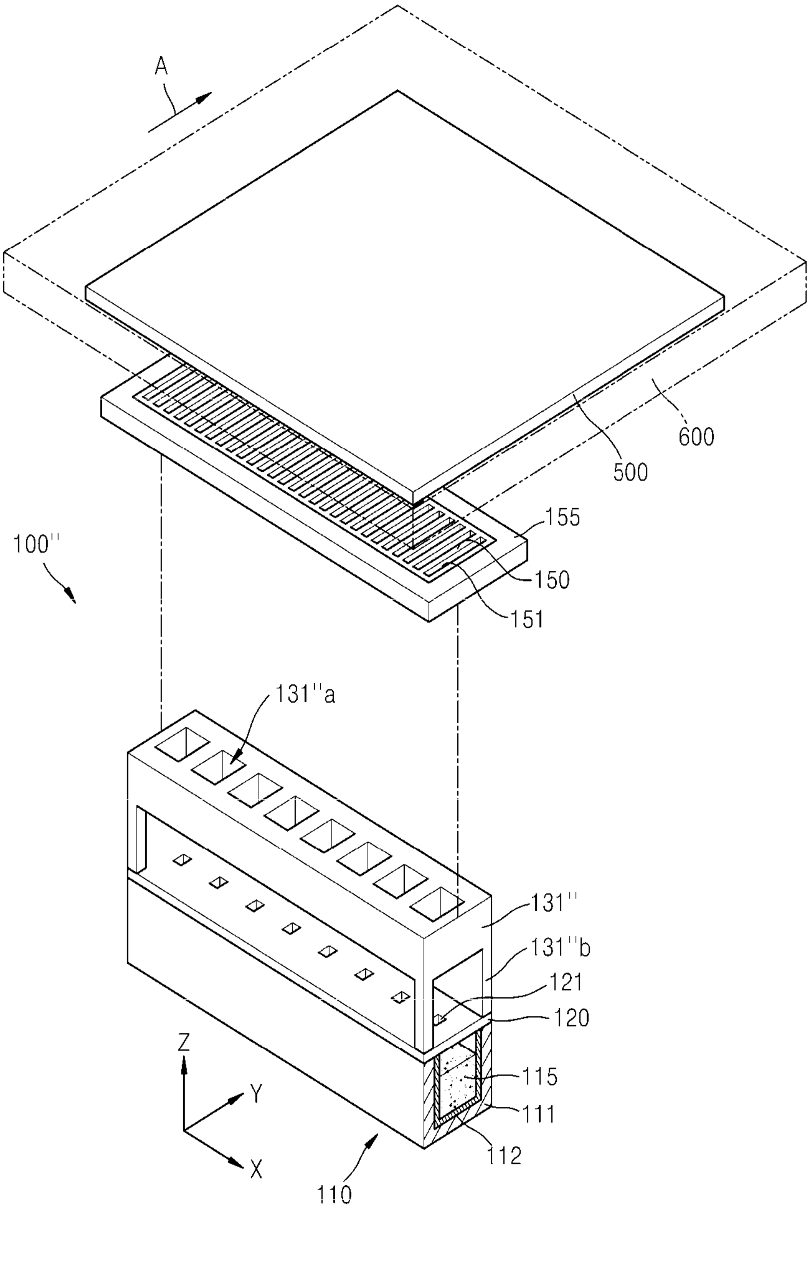
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FIG. 10

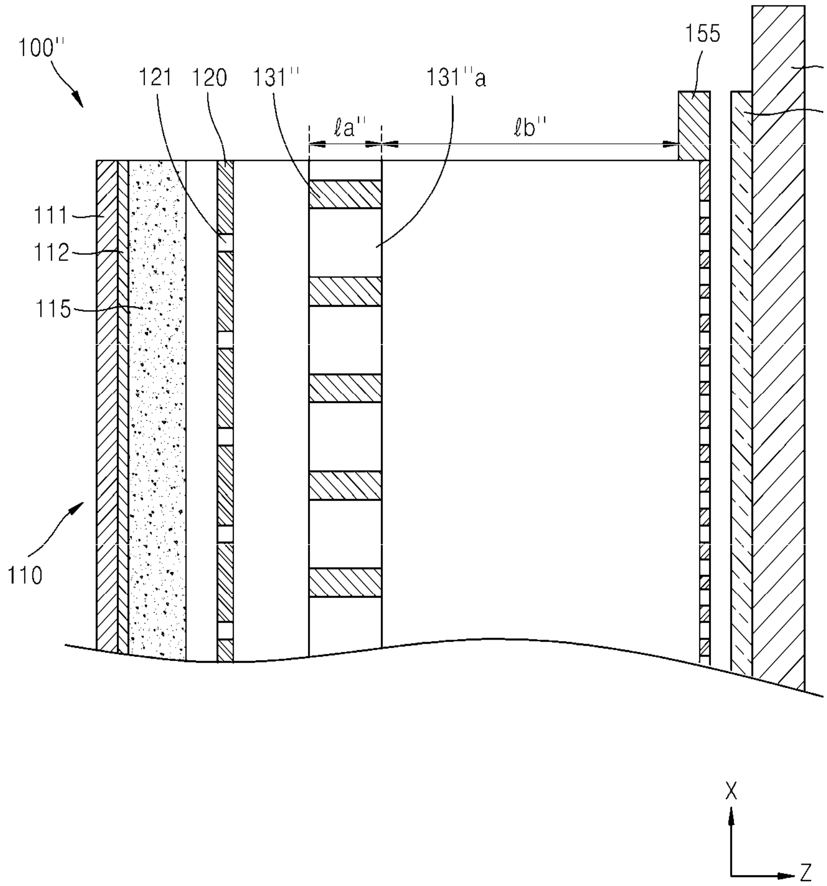
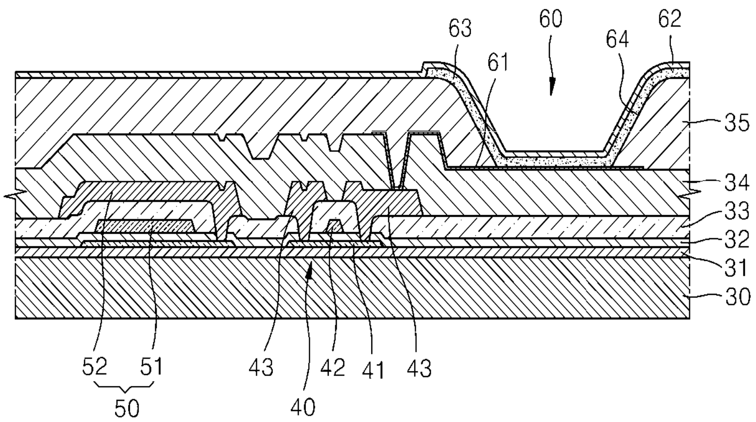


FIG. 11



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 Application No. 10-2009-0078171, filed Aug. 24, 2009 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Aspects of the present invention relate 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, aspects of the present invention relate to a thin film deposition apparatus that is suitable for manufacturing large-sized display devices on a mass scale and that can be used for high-definition patterning, 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 next-generation display devices. Such organic light-emitting display devices include intermediate layers, including an emission layer disposed between a first electrode and a second electrode that are arranged opposite to each other. The first and second electrodes and the intermediate layers may be formed by using various 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 the 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.

However, the deposition method using such an FMM is not suitable for manufacturing larger devices using a mother glass having a size of 5G or greater. In other words, the larger the mother glass, the larger the FMM. Thus, when such a large FMM is used, the FMM may bend due to gravity, thereby distorting the pattern. This is not conducive with the recent trend toward high-definition patterns.

SUMMARY OF THE INVENTION

Aspects of the present invention provide a thin film deposition apparatus that is suitable for manufacturing large-sized display devices on a mass scale and that can be used for high-definition patterning, 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.

An aspect of the present invention provides a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that discharges a deposition material; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a barrier plate assembly including a plurality of barrier plates that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and partition the space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, wherein each of the barrier plates is separate from the patterning slit sheet.

The thin film deposition apparatus may further include a chuck that fixedly supports a substrate to be subjected to deposition, wherein the thin film deposition assembly may deposit a thin film on the substrate fixedly supported by the chuck.

The thin film deposition assembly may be separate from the substrate fixedly supported by the chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck may be movable relative to the other.

The thin film deposition apparatus may further include a barrier plates temperature control unit that controls the temperature of the barrier plates.

The barrier plates temperature control unit may maintain the barrier plates at a low temperature while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and at a high temperature while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The barrier plates temperature control unit may control the temperature of the barrier plates to be higher while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck than while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck.

The barrier plates temperature control unit may maintain the temperature of the barrier plates to be lower than the vaporization temperature of the deposition material while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and to be higher than the vaporization temperature of the deposition material while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The distance from the patterning slit sheet to the end of the barrier plates close to the patterning slit sheet may be greater than the length of the barrier plates.

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

The deposition source and the barrier plate assembly may be separate from each other.

Another aspect of the present invention provides a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that includes an opening and discharges a deposition material contained therein; a deposition source nozzle unit that is disposed at a side of the deposition source to cover the opening of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction, the deposition source nozzle unit having a planar shape; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a plurality of barrier pipes that are disposed on a surface of the deposition source nozzle unit facing the patterning slit sheet or on a surface of the deposition source nozzle unit opposite to the patterning slit sheet of the deposition source, the plurality of barrier pipes respectively corresponding to the plurality of deposition source nozzles, wherein each of the barrier plates is separate from the patterning slit sheet.

The thin film deposition apparatus may further include a chuck that fixedly supports a substrate to be subjected to deposition, wherein the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck.

The thin film deposition assembly may be separate from the substrate fixedly supported by the chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck may be movable relative to the other.

The thin film deposition apparatus may further include a barrier pipes temperature control unit that controls the temperature of the barrier pipes.

The barrier pipes temperature control unit may maintain the barrier pipes at a low temperature while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and at a high temperature while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The barrier pipes temperature control unit may control the temperature of the barrier pipes to be higher while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck than while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck.

The barrier pipes temperature control unit may maintain the temperature of the barrier pipes to be lower than the vaporization temperature of the deposition material while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and to be higher than the vaporization temperature of the deposition material while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The barrier pipes may be arranged on the surface of the deposition source nozzle unit facing the patterning slit sheet, and the distance from the patterning slit sheet to an end of the barrier pipes close to the patterning slit sheet may be greater than a length of the barrier pipes.

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

The deposition source nozzle unit may include a cooling plate, and the barrier pipes may include a hot wire.

Another aspect of the present invention provides a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that discharges a deposition material; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a barrier nozzle unit including a plurality of barrier nozzles that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and partition a space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, wherein the barrier nozzle unit is separate from the patterning slit sheet.

The thin film deposition apparatus may further include a chuck that fixedly supports a substrate to be subjected to deposition, wherein the thin film deposition assembly may deposit a thin film on the substrate fixedly supported by the chuck.

The thin film deposition assembly may be separate from the substrate fixedly supported by the chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck may be movable relative to the other.

The thin film deposition apparatus may further include a barrier nozzle temperature control unit that controls the temperature of the barrier nozzle unit.

The barrier nozzle temperature control unit may maintain the barrier nozzle unit at a low temperature while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and at a high temperature while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The barrier nozzle temperature control unit may control the temperature of the barrier nozzle unit to be higher while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck than while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck.

The barrier nozzle temperature control unit may maintain the temperature of the barrier nozzle unit to be lower than a vaporization temperature of the deposition material while the thin film deposition assembly deposits a thin film on the substrate fixedly supported by the chuck, and to be higher than the vaporization temperature of the deposition material while the thin film deposition assembly does not deposit a thin film on the substrate fixedly supported by the chuck.

The distance from the patterning slit sheet to the end of the barrier nozzle unit close to the patterning slit sheet may be greater than a length of the barrier nozzle unit.

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

The deposition source and the barrier nozzle unit may be separate from each other.

Another aspect of the present invention provides a method of manufacturing an organic light-emitting display device by using a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that discharges a deposition material; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a barrier plate assembly including a plurality of barrier plates that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and partition a space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, and wherein the thin film deposition assembly is separate from a substrate fixedly supported by a chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck is movable relative to the other while deposition is performed on the substrate.

Another aspect of the present invention provides a method of manufacturing an organic light-emitting display device by using a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that includes an opening and discharges a deposition material contained therein; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a plurality of barrier pipes that are disposed on a surface of the deposition source nozzle unit facing the patterning slit sheet or on a surface of the deposition source nozzle unit opposite to the patterning slit sheet of the deposition source, the plurality of barrier pipes respectively corresponding to the plurality of deposition source nozzles, and wherein the thin film deposition assembly is separate from a substrate fixedly supported by a chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck is movable relative to the other while deposition is performed on the substrate.

Another aspect of the present invention provides a method of manufacturing an organic light-emitting display device by using a thin film deposition apparatus including a thin film deposition assembly, wherein the thin film deposition assembly includes: a deposition source that discharges a deposition material; a deposition source nozzle unit that is disposed at a side of the deposition source and includes a plurality of deposition source nozzles arranged in a first direction; a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and includes a plurality of patterning slits arranged in the first direction; and a barrier nozzle unit including a plurality of barrier nozzles that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and partition a space between the deposition source nozzle unit and the patterning slit sheet into a plurality of sub-deposition spaces, and wherein the thin film deposition assembly is separate from a substrate fixedly supported by a chuck, and the thin film deposition assembly or the substrate fixedly supported by the chuck is movable relative to the other while deposition is performed on the substrate.

Other aspects of the present invention provide an organic light-emitting display device manufactured using any one of the methods described above.

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 schematic cross-sectional view of a thin film deposition apparatus including a thin film deposition assembly, according to an embodiment of the present invention;

FIG. **2** is a schematic perspective view of the thin film deposition assembly of FIG. **1**;

FIG. **3** is a schematic side cross-sectional view of the thin film deposition assembly of FIG. **2**;

FIG. **4** is a schematic plan cross-sectional view of the thin film deposition assembly of FIG. **2**;

FIG. **5**A is a view illustrating the width of a thin film deposited on a substrate when no barrier plate is used;

FIG. **5**B is a view illustrating the width of a thin film deposited on a substrate when barrier plates are formed extending to a patterning slit sheet;

FIG. **5**C is a view illustrating the width of a thin film deposited on a substrate using the thin film deposition assembly of FIG. **2**;

FIG. **6** is a schematic perspective view of a thin film deposition assembly of a thin film deposition apparatus according to another embodiment of the present invention;

FIG. **7** is a schematic plan cross-sectional view of the thin film deposition assembly of FIG. **6**;

FIG. **8** is a schematic plan cross-sectional view of a thin film deposition assembly of a thin film deposition apparatus according to another embodiment of the present invention;

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

FIG. **10** is a schematic plan cross-sectional view of the thin film deposition assembly of FIG. **9**; and

FIG. **11** is a schematic cross-sectional view of an organic light-emitting display device manufactured by using a thin film deposition apparatus according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

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 structure is "formed on" or "disposed on" a second structure, the first structure may be formed or disposed directly on the second structure or there may be an intervening structure between the first structure and the second structure. 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 schematic cross-sectional view of a thin film deposition apparatus including a thin film deposition assembly **100**, according to an embodiment of the present invention, FIG. **2** is a schematic perspective view of the thin film deposition assembly **100** of FIG. **1**, FIG. **3** is a schematic side cross-sectional view of the thin film deposition assembly **100** of FIG. **2**, and FIG. **4** is a schematic plan cross-sectional view of the thin film deposition assembly **100** of FIG. **2**.

The thin film deposition apparatus according to the current embodiment of the present invention includes the thin film deposition assembly **100**. Although a chamber is not illustrated in FIGS. **1-4** for convenience of explanation, 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 straight direction.

The thin film deposition assembly **100** according to the current embodiment of the present invention includes a deposition source **110**, a deposition source nozzle unit **120**, a barrier plate assembly **130**, and a patterning slit sheet **150**.

The deposition source **110** may discharge a deposition material **115**. In particular, the deposition source **110** includes a crucible **112** that is filled with the deposition material **115**, and a cooling block **111** surrounding the crucible **112**. The cooling block **111** prevents radiation of heat from the crucible outside, i.e., into the chamber. The cooling block **111** may include a heater (not shown) that heats the crucible **111**.

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 a substrate **500** on which the deposition material **115** discharged from the deposition source **110** is to be deposited. The deposition source nozzle unit **120** includes a plurality of deposition source nozzles **121** arranged in a first, X-axis direction, as illustrated in FIG. **2**. The plurality of deposition source nozzles **121** may be arranged at equal intervals. The deposition material **115** that is vaporized in the deposition source **110** passes through the deposition source nozzles **121** of the deposition source nozzle unit **120** toward the substrate **500**, which constitutes a target on which the deposition material **115** is to be deposited. The substrate **500** 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 **500**.

The patterning slit sheet **150** is disposed opposite to the deposition source nozzle unit **120** and comprises a plurality of patterning slits **151** arranged in a first direction, i.e. the X-axis direction. The thin film deposition assembly **100** may further include a frame **155** supporting the patterning slit sheet **150**, as illustrated in FIG. **2**. 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**. Each of the patterning slits **151** extends in a second direction, i.e., the Y-axis direction in FIG. **2**, intersecting the first direction. The deposition material **115** that has been vaporized in the deposition source **110** and has passed through the deposition source nozzle **121** passes through the patterning slits **151** toward the substrate **500**.

The patterning slit sheet **150** may be formed of a metal thin film. The patterning slit sheet **150** is fixed to the frame **150** such that a tensile force is exerted thereon. The patterning slits **151** may be formed by etching the patterning slit sheet **150** to a stripe pattern. The total number of patterning slits **151** may be greater than the total number of deposition source nozzles **121**. This will be described later.

The barrier plate assembly **130** is disposed between the deposition source nozzle unit **120** and the patterning slit sheet **150** in a third, Z direction, and comprises a plurality of barrier plates **131** that partition the space between the deposition source nozzle unit **120** and the patterning slit sheet **150** into a plurality of sub-deposition spaces S. In the thin film deposition assembly **100** according to the current 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, as illustrated in FIG. **4**. The barrier plate assembly **130** may further include a barrier plate frame **132** that covers sides of the barrier plates **131**, if needed, as illustrated in FIG. **2**.

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 the YZ plane in FIG. **2**, and may have a rectangular shape.

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**. In particular, the deposition source nozzles **121** may be respectively located at the midpoint between two adjacent barrier plates **131**, as illustrated in FIGS. **2** and **4**. 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 the patterning slits **151** so as to be deposited on the substrate **500**. 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, i.e., in the Z-axis direction, not to flow in the X-axis direction.

As described above, the deposition material **115** is forced to move straighter in the Z direction by installing the barrier plates **131**, so that a smaller shadow zone may be formed on the substrate **500** compared to the case where no barrier plates are installed. Thus, the thin film deposition assembly **100** and the substrate **500** can be separate from each other by a predetermined distance. This will be described later in detail.

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

The deposition source nozzle unit **120** and the barrier plate assembly **130** may be separate from each other by a predetermined distance. This may prevent the heat radiated from the deposition source unit **110** from being conducted to the barrier plate assembly **130**. However, the present invention is not limited to this. In particular, an appropriate heat insulator (not shown) may be further disposed between the deposition source nozzle unit **120** and the barrier plate assembly **130**. In this case, the deposition source nozzle unit **120** and the barrier plate assembly **130** may be bound together with the heat insulator therebetween. Alternatively, the deposition source nozzle unit **120** and the barrier plate assembly **130** may be disposed to contact each other without a heat insulator therebetween.

In addition, the barrier plate assembly **130** may be constructed to be detachable from the thin film deposition assembly **100**. In the thin film deposition assembly **100** according to the current embodiment of the present invention, the deposition space is enclosed by using the barrier plate assembly **130**, so that the deposition material **115** that remains undeposited is deposited mostly 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 assembly **100** according to the present embodiment, the reuse rate of the deposition material **115** is increased, so that the deposition efficiency is improved, and thus the manufacturing costs are reduced.

As described above, 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**. The number of patterning slits **151** may be equal to the number of deposition patterns to be formed on the substrate **500**. Thus, a layer pattern corresponding to the patterning slits **151** may be deposited on the substrate **500** without using an additional mask.

In addition, the barrier plate assembly **130** and the patterning slit sheet **150** may be disposed to be separate 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**. In particular, 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** may be separate from each other by a predetermined distance. The barrier plate assembly **130** and the patterning slit sheet **150** may be separate from each other by a predetermined distance for reasons to be described later with reference to FIGS. **5**A through **5**C, in addition to the reason described above. This will be described later.

The thin film deposition apparatus including the thin film deposition assembly **100** may include a chuck **600** that fixedly supports the substrate **500**. The thin film deposition assembly **100** is disposed to be separate from the substrate **500** on which the chuck **600** is fixed. The thin film deposition assembly **100** and the substrate **500** fixed on the chuck **600** are moved relative to each other while a thin film is deposited on the substrate **500**. The chuck **600** may comprise an electrostatic chuck. Electrostatic chucks may comprise an electrode embedded in its main body formed of ceramic, wherein the electrode is supplied with power. Such an electrostatic chuck may fix the substrate **500** on a surface of the main body as a high voltage is applied to the electrode.

The thin film deposition apparatus will now be described in detail. As illustrated in FIG. **1**, the chuck **600** fixedly supporting the substrate **500** is moved by a scanner **611**. The scanner **611** includes a first support **613**, a second support **614**, a movement bar **615**, and a first driving unit **616**.

The first support **613** and the second support **614** are disposed to pass through a chamber (not shown). The first support **613** is vertically disposed in the upper portion of the chamber, and the second support **614** is horizontally disposed below the first support **613** in the chamber. As illustrated in FIG. **1**, the first support **613** and the second support **614** may be disposed perpendicular to each other forming a bent structure. However, the present invention is not limited to this structure, and the first support **613** and the second support **614** may have any structure, provided that the first support **613** is disposed above the second support **614**.

The movement bar **615** is movable along the first support **613**. One end of the movement bar **615** is supported by the first support **613**, and the other end of the movement bar **615** is supported by an edge of the chuck **600**. The chuck **600** is supported by the movement bar **615** to be movable along the first support **613**. A portion of the movement bar **615** supporting the chuck **600** is bent toward the thin film deposition assembly **100**, and thus can move the substrate **500** closer to the thin film deposition assembly **100**.

The first driving unit **616** is disposed between the movement bar **615** and the first support **613**. The first driving unit **616** may include a roller **617** rolling along the first support **613**. The first driving unit **616** moves the movement bar **615** along the first support **613**. The first driving unit **616** may generate a driving force by itself or may transfer a driving force generated by a separate driving source to the movement bar **615**. The first driving unit **616** may comprise any driving element, in addition to the roller **617**, provided it can move the movement bar **615**.

The thin film deposition assembly **100** may be mounted on the second support **614**, as illustrated in FIG. **1**. A second driving unit **618** is disposed on the second support **614**, and is connected to the frame **155** of the patterning slit sheet **150** of the thin film deposition assembly **100** in order to precisely control alignment between the substrate **500** and the thin film deposition assembly **100**. Such a precise alignment control may be performed in real time during deposition.

In the thin film deposition apparatus, in order to deposit the deposition material **115** that has been discharged from the deposition source **110** and passed through the deposition source nozzle unit **120** and the patterning slit sheet **151**, onto the substrate **500** in a desired pattern, it is required to maintain the chamber in a high-vacuum state. In the structure of the thin film deposition apparatus, the deposition material **115** moves in a random direction immediately after being discharged from the deposition source **110**, but is then guided by the barrier plates **131**, which extend in the Z-axis direction, to move in the Z-axis direction. The deposition material **115** discharged in undesired directions may adhere to surfaces of the barrier plate assembly **130**, i.e., the barrier plates **131**, and may be more unlikely to collide with the deposition material **115** discharged straight, and thus, the deposition material **115** is forced to move in a straight direction.

The substrate **500** supported by the chuck **600** or the thin film deposition assembly **100** are movable relative to each other. For example, as illustrated in FIG. **2**, the substrate **500** may be moved in the direction of the arrow A relative to the thin film deposition assembly **100**.

In a conventional deposition method using a fine metal mask (FMM), the size of the FMM has to be greater or 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 and/or other problems, in the thin film deposition apparatus according to the current embodiment of the present invention, deposition may be performed while the thin film deposition assembly **100** or the substrate **500** is moved relative to the other. In other words, deposition may be continuously performed while the substrate **500**, which is disposed to face the thin film deposition assembly **100**, is moved in the Y-axis direction. In other words, deposition is performed in a scanning manner while the substrate **500** is moved in the direction of the arrow A in FIG. **2**. Although the substrate **500** is illustrated as being moved in the Y-axis direction in FIG. **3** when deposition is performed, the present invention is not limited thereto. That is, deposition may be performed while the thin film deposition assembly **100** is moved in the Y-axis direction and the substrate **500** is fixed. Alternatively, both the deposition assembly **100** and the substrate may move relative to the other.

Thus, in the thin film deposition assembly **100** according to the current embodiment of the present invention, 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** according to the current embodiment of the present invention, deposition is continuously performed, i.e., in a scanning manner while the substrate **500** is moved in the Y-axis direction. Thus, the length of the patterning slit sheet **150** in the Y-axis direction may be significantly less than the length of the substrate **500** provided the width of the patterning slit sheet **150** in the X-axis direction and the width of the substrate **500** in the X-axis direction are substantially equal to each other. However, even when the width of the patterning slit sheet **150** in the X-axis direction is less than the width of the substrate **500** in the X-axis direction, deposition may be performed on the entire substrate **500** in a scanning manner while the substrate **500** or the thin film deposition assembly **100** is moved relative to the other.

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** used in the present invention. 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 or a relatively large mother glass.

In order to perform deposition while the thin film deposition assembly **100** or the substrate **500** is moved relative to the other as described above, the thin film deposition assembly **100** and the substrate **500** may be separate from each other by a predetermined distance. In other words, the patterning slit sheet **150** and the substrate **500** may be separate from each other by a predetermined distance. This will be described later in detail. In addition, in order to prevent the formation of a relatively large shadow zone on the substrate **500** when the patterning slit sheet **150** and the substrate **500** are separate 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 **500** 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, such as scratches on patterns formed on the substrate. 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 or mother glasses become larger. However, it is not easy to manufacture such a large mask.

In order to overcome this and/or other problems, in the thin film deposition assembly **100** according to the current embodiment of the present invention, the patterning slit sheet **150** is disposed to be separate from the substrate **500**, which constitutes a target on which the deposition material **115** is to be deposited, 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 **500**.

As described above, when the patterning slit sheet **150** is manufactured to be smaller than the substrate **500**, the pattern slit sheet **150** may be moved relative to the substrate **500** during deposition. Thus, it is no longer necessary to manufacture a large FMM like one used in the conventional deposition method. In addition, since the substrate **500** and the patterning slit sheet **150** are separate from each other, defects caused due to contact therebetween may be prevented. In addition, since it is unnecessary to contact the substrate **500** with the patterning slit sheet **150** during a deposition process, the manufacturing speed may be improved.

In addition, as described above, the barrier plates **131** are also separate from the patterning slit sheet **150**. This will be described with reference to FIGS. **5**A through **5**C. FIG. **5**A is a view illustrating the width of a thin film deposited on the substrate **500** when no barrier plate is used, FIG. **5**B is a view illustrating the width of a thin film deposited on the substrate when barrier plates **131***a* are formed to extend to the patterning slit sheet **150**, and FIG. **5**C is a view illustrating the width of a thin film deposited on the substrate **500** using the thin film deposition assembly **100** of FIG. **2** in which the barrier plates **131** do not extend to the patterning slit sheet **150**.

When no barrier plate is formed, as illustrated in FIG. **5**A, the deposition material **115** that has just passed through the deposition source nozzles **121** may move toward the patterning slit sheet **150** in a random direction, i.e., not in a straight (Z) direction. Thus, a thin film having a width tb that is greater than a width ta of the patterning slits **151** is deposited on the substrate **500**, as illustrated in FIG. **5**A.

In order to prevent this, as illustrated in FIG. **5**B, the barrier plates **131***a* may be formed to extend to the patterning slit sheet **150**. In this case, the deposition material **115** that has passed through the deposition source nozzles **121** may adhere to the barrier plates **131***a* before reaching the patterning slit sheet **150**. Thus, as illustrated in FIG. **5**B, the deposition material **115** moving between the barrier plates **131***a* toward the patterning slit sheet **150** is forced to move straighter in the Z direction relative to the case of FIG. **5**A, so that a thin film having a similar width tc to the width ta of the patterning slits **151** may be deposited on the substrate **500**. However, a large amount of the deposition material **121** adheres to the barrier plates **131***a* after passing through the deposition source nozzles **121** and before reaching the patterning slit sheet **150** and therefore wasted until a thin film having a desired thickness is deposited on the substrate **500**.

Thus, in order to prevent this and/or other problems, in the thin film deposition assembly **100** according to the current embodiment of the present invention, the barrier plates **131** are disposed to be separate from the patterning slit sheet **150**, as illustrated in FIG. **5**C. In particular, the distance lb from the patterning slit sheet **150** to the ends of the barrier plates **131** closest to the patterning slit sheet **150** may be greater than the lengths la of the barrier plates **131**.

Thus, as illustrated in FIG. **5**C, the deposition material **115** is guided by the barrier plates **131** to reach the patterning slit sheet **150** at a restricted angle, so that a thin film having a width td substantially equal to the width ta of the patterning slits **151** may be deposited on the substrate **500**. Furthermore, since the lengths la of the barrier plates **131** are less than the lengths of the barrier plates **131***a* illustrated in FIG. **5**B, the amount of the deposition material **115** adhering to the barrier plates **131** may be markedly less compared to the case of FIG. **5**B. Thus, the deposition material **115** passing through the deposition source nozzle unit **120** may be forced to move in a straighter direction, and the amount of the deposition material **115** adhering to the barrier plates **131** may be reduced, thereby markedly increasing utilization efficiency of the deposition material **115**.

In addition, the thin film deposition assembly **100** may further include a barrier plates temperature control unit **160**, as illustrated in FIGS. **2** through **4**, if required. The barrier plates temperature control unit **160** maintains the barrier plates **131** at a low temperature while the thin film deposition assembly **100** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, and at a high temperature while the thin film deposition assembly **100** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier plates **131** are maintained at a low temperature, the deposition material **115** adheres to the barrier plates **131** and less vaporized deposition material **115** may move toward the patterning slit sheet **150**. Thus, the vaporized deposition material **115** moving between the barrier plates **131** is forced to move straighter in the Z direction toward the patterning slit sheet **150**. For this reason, the barrier plates **131** are maintained at a low temperature while the thin film deposition assembly **100** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier plates **131** are maintained at a high temperature, the deposition material **115** may pass through between the barrier plates **131** without being adhered thereto. Furthermore, the deposition material **115** adhering to the barrier plates **131** at a low temperature may separate from the barrier plates **131** and be discharged from the thin film deposition assembly **100**. For these reasons, when the thin film deposition assembly **100** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**, i.e., during idling of the thin film deposition assembly **100**, the barrier plates **131** are maintained at a high temperature to discharge the deposition material **115** adhering to the barrier plates **131**, and thus to significantly reduce the barrier plates **131** exchange cycle, that is, to increase the time necessary before barrier plates **131** must be exchanged.

As described above, the barrier plates temperature control unit **160** may control the temperature of the barrier plates **131** to be higher while the thin film deposition assembly **100** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600** than while the thin film deposition assembly **100** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In other words, in order to separate the deposition material **115** adhering to the barrier plates **131**, the temperature of the barrier plates **131** may be maintained to be higher than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**. The barrier plates temperature control unit **160** may maintain the temperature of the barrier plates **131** to be lower than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, in order to force the deposition material **115** to move in a straight direction.

To this end, the barrier plates temperature control unit **160** may include a cooling unit **163** and a heating unit **164**, as illustrated in FIGS. **2** through **4**. The cooling unit **163** may include cooling plates **161** and a cooling passage **162** in order to circulate a coolant. The heating unit **164** may include a hot wire. The cooling unit **163** may be constructed in various ways. For example, unlike as illustrated in FIGS. **2** through **4**, the cooling unit **163** may be disposed in spaces inside the barrier plates **131** to circulate a coolant within the inner spaces of the barrier plates **131**. In addition, the heating unit **164** may be disposed inside the barrier plates **131**.

FIG. **6** is a schematic perspective view of a thin film deposition assembly **100'** of a thin film deposition apparatus according to another embodiment of the present invention, and FIG. **7** is a schematic plan cross-sectional view of the thin film deposition assembly **100'** of FIG. **6**. Hereinafter, for convenience of explanation, a detailed description of elements similar to the elements of the thin film deposition apparatus described in the previous embodiment, and functions or operations thereof, will not be provided here.

Referring to FIGS. **6** and **7**, the thin film deposition assembly **100'** according to the current embodiment of the present invention includes a deposition source **110** having an opening, wherein the deposition source **110** is filled with a deposition material **115** and discharges the deposition material **115**. The deposition source nozzle unit **120**, which has a planar shape, is disposed at a side of the deposition source **110** to cover the opening of the deposition source **110**. The deposition source nozzle unit **120** includes a plurality of deposition source nozzles **121** arranged in a first direction, i.e., the X-axis direction in FIGS. **6** and **7**.

The thin film deposition assembly **100'** of the thin film deposition apparatus according to the current embodiment of the present invention includes a plurality of barrier pipes **131'**, instead of the plurality of barrier plates **131** (see FIG. **2**) of the previous embodiment. The barrier pipes **131'** are arranged on a surface of the deposition source nozzle unit **120** facing the patterning slit sheet **150**, and respectively correspond to the deposition source nozzles **121**. The plurality of barrier pipes **131'** may be arranged at equal intervals.

The barrier pipes **131'** are separate from the patterning slit sheet **150**, like the barrier plates **131** described in the previous embodiment. The barrier pipes **131'** may force the deposition material **115** discharged from the deposition source **110** through the deposition source nozzles **121** to move in a straight direction toward the patterning slit sheet **150**. In addition, the amount of the deposition material **115** adhering to the barrier pipes **131'** may be significantly less compared to when such barrier pipes are formed to extend to the patterning slit sheet **150**, so that utilization efficiency of the deposition material **115** is markedly increased. In the current embodiment, the distance lb' from the patterning slit sheet **150** to the end of the barrier pipes **131'** close to the patterning slit sheet **150** may be greater than the length la' of the barrier pipes **131'**, as illustrated in FIG. **7**.

In addition, the thin film deposition apparatus according to the current embodiment of the present invention may include the chuck **600** that fixedly supports the substrate **500**, and the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In this case, the thin film deposition assembly **100'** is disposed to be separate from the substrate **500** fixedly supported by the chuck **600**, and the thin film deposition assembly **100'** or the substrate **500** fixedly supported by the chuck **600** move relative to each other.

The thin film deposition assembly **100'** may further include a barrier pipes temperature control unit **160'** that controls the temperature of the barrier pipes **131**. For example, the temperature of the barrier pipes **131'** may be lowered by circulating a coolant along the inner walls of some of the barrier pipes **131'**, and may be increased by installing hot-wires **164'** in some of the barrier pipes **131'**. In this case, a structure **163'** for circulating the coolant and the hot wires **164'** may constitute the barrier pipes temperature control unit **160'**. However, the barrier pipes temperature control unit is not limited to the structure described above, and may have various other structures. For example, the deposition source nozzle unit **120** may include a cooling plate in an inner space thereof to provide the effect of circulating a coolant, and the barrier pipes **131'** may include a hot wire.

Such a barrier pipes temperature control unit maintains the barrier pipes **131'** at a low temperature while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, and at a high temperature while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier pipes **131'** are maintained at a low temperature, the deposition material **115** adheres to the barrier pipes **131'** and less vaporized deposition material **115** may move toward the patterning slit sheet **150**. Thus, the vaporized deposition material **115** in the barrier pipes **131'** may be forced to move in straighter in the Z direction toward the patterning slit sheet **150**. For this reason, the barrier pipes **131'** are maintained at a low temperature while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier pipes **131'** are maintained at a high temperature, the deposition material **115** may pass through the barrier pipes **131'** without adhering thereto. Furthermore, the deposition material **115** adhering to the barrier pipes **131'** at a low temperature may separate from the barrier pipes **131'** and be discharged from the thin film deposition assembly **100'**. For these reasons, when the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**, i.e., during idling of the thin film deposition assembly **100'**, the barrier pipes **131'** are maintained at a high temperature to discharge the deposition material **115** adhering to the barrier pipes **131'**, and thus to significantly reduce the barrier pipes **131'** exchange cycle.

As described above, the barrier pipes temperature control unit may control the temperature of the barrier pipes' **131** to be higher while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600** than while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In other words, in order to separate the deposition material **115** adhering to the barrier pipes **131'**, the temperature of the barrier pipes **131'** may be maintained to be higher than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**. The barrier pipes temperature control unit may maintain the temperature of the barrier pipes **131'** to be lower than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, in order to force the deposition material **115** to move straighter in the Z direction.

FIG. **8** is a schematic plan cross-sectional view of a thin film deposition assembly **100'** according to another embodiment of the present invention. A difference between the thin film deposition assembly **100'** of the thin film deposition apparatus according to the present invention and the thin film deposition apparatus **100'** described in the previous embodiment with reference to FIGS. **6** and **7** is the location of the barrier pipes **131'**. In the thin film deposition assembly **100'** of the thin film deposition apparatus according to the current embodiment of the present invention, the barrier pipes **131'** are arranged on a surface of the deposition source nozzle unit **120** forming an inner wall of the deposition source **110**. Thus, the deposition material **115** that has entered the barrier pipes **131'** within the deposition source **110** may be forced to move straighter in the Z direction toward the patterning slit sheet **150**.

The thin film deposition assembly **100'** according to the current embodiment of the present invention may further include a barrier pipes temperature control unit **160'**. For example, the temperature of the barrier pipes **131'** may be lowered by circulating a coolant along the inner walls of some of the barrier pipes **131**, and may be increased by installing hot wires **164** in some of the barrier pipes **131'**. In this case, a structure **163'** for circulating the coolant and the hot wires **164'** may constitute the barrier pipes temperature control unit **160'**. However, the barrier pipes temperature control unit is not limited to the structure described above, and may have various other structures. For example, the deposition source nozzle unit **120** may include a cooling plate in an inner space thereof to provide an effect of circulating a coolant, and the barrier pipes **131'** may include a hot wire.

Such a barrier pipes temperature control unit maintains the barrier pipes **131'** at a low temperature while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, and at a high temperature while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier pipes **131'** are maintained at a low temperature, the deposition material **115** adheres to the barrier pipes **131'** and less vaporized deposition material **115** may move toward the patterning slit sheet **150**. Thus, the vaporized deposition material **115** in the barrier pipes **131'** may be forced to move straighter in the Z direction toward the patterning slit sheet **150**. For this reason, the barrier pipes **131'** are maintained at a low temperature while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier pipes **131'** are maintained at a high temperature, the vaporized deposition material **115** may pass through the barrier pipes **131'** without adhering thereto. Furthermore, the deposition material **115** adhered to the barrier pipes **131'** at a low temperature may separate from the barrier pipes **131'** and be discharged from the thin film deposition assembly **100'**. For these reasons, when the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**, i.e., during idling of the thin film deposition assembly **100'**, the barrier pipes **131'** are maintained at a high temperature to discharge the deposition material **115** adhered to the barrier pipes **131'**, and thus to significantly reduce a barrier pipes exchange cycle.

As described above, the barrier pipes temperature control unit may control the temperature of the barrier pipes' **131** to be higher while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600** than while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In other words, in order to separate the deposition material **115** adhering to the barrier pipes **131'**, the temperature of the barrier pipes **131'** may be maintained to be higher than a vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100'** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**. The barrier pipes temperature control unit may maintain the temperature of the barrier pipes **131'** to be lower than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100'** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, in order to force the deposition material **115** to move in a straight direction.

FIG. **9** is a schematic perspective view of a thin film deposition assembly **100"** of a thin film deposition apparatus according to another embodiment of the present invention, and FIG. **10** is a schematic plan cross-sectional view of the thin film deposition assembly **100"** of FIG. **9**. Hereinafter, for convenience of explanation, a detailed description of elements similar to the elements of the thin film deposition apparatuses described in the previous embodiments, and functions or operation thereof, will not be provided here.

Referring to FIGS. **9** and **10**, the thin film deposition assembly **100"** according to the current embodiment of the present invention includes a deposition source **110** having an opening, wherein the deposition source **110** is filled with a deposition material **115** and discharges the deposition material **115**. The deposition source nozzle unit **120**, which has a planar shape, is disposed at a side of the deposition source **110** to cover the opening of the deposition source **110**. The deposition source nozzle unit **120** includes a plurality of deposition source nozzles **121** arranged in a first direction, i.e., the X-axis direction in FIGS. **9** and **10**.

The thin film deposition assembly **100"** of the thin film deposition apparatus according to the current embodiment of the present invention includes a barrier nozzle unit **131"**, instead of the plurality of barrier plates **131** (see FIG. **2**) or the plurality of barrier pipes **131'** (see FIG. **6**) of the previous embodiments. The barrier nozzle unit **131"** is arranged on a surface of the deposition source nozzle unit **120** facing the patterning slit sheet **150**. The barrier nozzle unit **131"** may include a plurality of barrier nozzles 131"*a* arranged to respectively correspond to the deposition source nozzles **121**.

The barrier nozzle unit **131"** is separate from the patterning slit sheet **150**, like the barrier plates **131** or the barrier pipes **131'** described in the previous embodiments. The barrier nozzle unit **131"** may force the deposition material **115** discharged through the deposition source nozzle unit **120** from the deposition source to move straighter in the Z direction toward the patterning slit sheet **150**. In addition, since the barrier nozzle unit **131"** does not fully extend between the deposition source nozzle unit **120** and the patterning slit sheet **150**, the amount of the deposition material **115** adhering to inner walls of the barrier nozzle unit **131"** may be significantly less, thereby markedly increasing utilization efficiency of the deposition material **115**. In the current embodiment, the distance lb" from the patterning slit sheet **150** to an end of the barrier nozzle unit **131"** close to the patterning slit sheet **150** may be greater than the length la" of the barrier nozzle unit **131"**, as illustrated in FIG. **10**.

In addition, the thin film deposition apparatus according to the current embodiment of the present invention may include the chuck **600** that fixedly supports the substrate **500**, and the thin film deposition assembly **100"** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In this case, the thin film deposition assembly **100"** is disposed to be separate from the substrate **500** fixedly supported by the chuck **600**, and the thin film deposition assembly **100"** or the substrate **500** fixedly supported by the chuck **600** is moved relative to each other.

The thin film deposition assembly **100"** may further include a barrier nozzle temperature control unit (not shown) that controls the temperature of the barrier nozzle unit **131"**. For example, the temperature of the barrier nozzle unit **131"** may be lowered by circulating a coolant within the barrier nozzle unit **131"**, and may be increased by installing a hot wire in the barrier nozzle unit **131"**. In this case, a structure for circulating the coolant and the hot wire may constitute the barrier nozzle temperature control unit. However, the barrier nozzle temperature control unit is not limited to the structure described above, and may have various other structures. For example, the deposition source nozzle unit **120** may include a cooling plate in an inner space thereof to offer an effect of circulating a coolant, and the barrier nozzle unit **131"** may include a hot wire.

Such a barrier nozzle temperature control unit maintains the barrier nozzle unit **131"** at a low temperature while the thin film deposition assembly **100"** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, and at a high temperature while the thin film deposition assembly **100"** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier nozzle unit **131"** is maintained at a low temperature, deposition material **115** adheres to the barrier nozzle unit **131"** and less vaporized deposition material **115** may move toward the patterning slit sheet **150**. Thus, the vaporized deposition material **115** passing the barrier nozzle unit **131"** is forced to move straighter in the Z direction toward the patterning slit sheet **150**. For this reason, the barrier nozzle unit **131"** is maintained at a low temperature while the thin film deposition assembly **100"** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**.

When the barrier nozzle unit **131"** is maintained at a high temperature, the vaporized deposition material **115** may pass through the barrier nozzle unit **131"** without adhering thereto. Furthermore, the deposition material **115** already adhering to the barrier nozzle unit **131"** at a low temperature may separate from the barrier nozzle unit **131"** and be discharged from the thin film deposition assembly **100"**. For these reasons, when the thin film deposition assembly **100"** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**, i.e., during idling of the thin film deposition assembly **100"**, the barrier nozzle unit **131"** is maintained at a high temperature to discharge the deposition material **115** adhered to the barrier nozzle unit **131'1**, and thus to significantly reduce a barrier nozzle unit exchange cycle.

As described above, the barrier nozzle temperature control unit may control the temperature of the barrier nozzle unit **131"** to be higher while the thin film deposition assembly **100"** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600** than while the thin film deposition assembly **100"** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**. In other words, in order to separate the deposition material **115** adhering to the barrier nozzle unit **131"**, the temperature of the barrier nozzle unit **131"** may be maintained to be higher than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100"** does not deposit a thin film on the substrate **500** fixedly supported by the chuck **600**. The barrier nozzle temperature control unit may maintain the temperature of the barrier nozzle unit **131"** to be lower than the vaporization temperature, for example, about 200° C., of the deposition material **115** while the thin film deposition assembly **100"** deposits a thin film on the substrate **500** fixedly supported by the chuck **600**, in order to force the deposition material **115** to move straighter in the Z direction.

In addition, as illustrated in FIG. **9**, the barrier nozzle unit **131"** may include projections **131"***b* protruding toward the deposition source nozzle unit **120**. The projections **131"***b* separate the main body of the barrier nozzle unit **131"** from the deposition source **110**.

An active matrix organic light-emitting display device may be manufactured using such a thin film deposition apparatus described in the previous embodiments. FIG. **11** is a schematic cross-sectional view of an active matrix organic light-emitting display device manufactured by using such a thin film deposition apparatus described above, according to an embodiment of the present invention.

Referring to FIG. **11**, the active matrix organic light-emitting display device according to the current embodiment is disposed on a substrate **30**. The substrate **30** may be formed of a transparent material, for example, glass, plastic or metal. An insulating layer **31**, such as a buffer layer, is formed on an entire surface of the substrate **30**. A thin film transistor (TFT) **40**, a capacitor **50**, and an organic light-emitting diode **60** (OLED) are disposed on the insulating layer **31**, as illustrated in FIG. **11**.

A semiconductor active layer **41** is formed on an upper surface of the insulating layer **31** in a predetermined pattern. A gate insulating layer **32** is formed to cover the semiconductor active layer **41**. The semiconductor active layer **41** may include a p-type or n-type semiconductor material.

A gate electrode **42** of the TFT **40** is formed in a region of the gate insulating layer **32** corresponding to the semiconductor active layer **41**. An interlayer insulating layer **33** is formed to cover the gate electrode **42**. The interlayer insulating layer **33** and the gate insulating layer **32** are etched by, for example, dry etching, to form a contact hole exposing parts of the semiconductor active layer **41**.

A source/drain electrode **43** is formed on the interlayer insulating layer **33** to contact the semiconductor active layer **41** through the contact hole. A passivation or protective layer **34** is formed to cover the source/drain electrode **43**, and is etched to expose a part of the drain electrode **43**. An insulating layer (not shown) may be further formed on the protective layer **34** so as to planarize the protective layer **34**.

In addition, the OLED **60** displays predetermined image information by emitting red, green, or blue light as current flows. The OLED **60** includes a first electrode **61** formed on the protective layer **34**. The first electrode **61** is electrically connected to the drain electrode **43** of the TFT **40**.

A pixel defining layer **35** is formed to cover the first electrode **61**. An opening **64** is formed in the pixel defining layer **35**, and an intermediate layer **63**, including an emission layer, is formed in a region defined by the opening **64**. A second electrode **62** is formed on the intermediate layer **63**.

The pixel defining layer **35**, which defines individual pixels, is formed of an organic material. The pixel defining layer **35** also planarizes the surface of a region of the substrate **30** where the first electrode **61** is formed, and in particular, the surface of the protective layer **34**. The first electrode **61** and the second electrode **62** are insulated from each other, and respectively apply voltages of opposite polarities to the intermediate layer **63**, including the emission layer, to induce light emission.

The intermediate layer **63** 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 intermediate layer **63** 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 (α-NPB), tris-8-hydroxyquinoline aluminum (Alq3), and the like. Such a low-molecular weight organic material may be deposited by vacuum deposition using one of the thin film deposition apparatuses described above with reference to FIGS. **1** through **6**.

Once the opening **64** has been formed in the pixel defining layer **35**, the substrate **30** is transferred to a chamber (not shown). Then, the intermediate layer **63**, including the emission layer, is formed using one of the thin film deposition apparatuses according to the embodiments of the present invention described above. After the intermediate layer **63** is formed, the second electrode **62** may be formed by the same deposition method as used to form the intermediate layer **63**.

The first electrode **61** functions as an anode, and the second electrode **62** functions as a cathode. Alternatively, the first electrode **61** may function as a cathode, and the second electrode **62** may function as an anode. The first electrode **61** may be patterned to correspond to individual pixel regions, and the second electrode **62** may be formed to cover all the pixels.

The first electrode **61** may be formed as a transparent electrode or a reflective electrode. Such a transparent electrode may include a layer formed from indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium oxide (In_2O_3). Such a reflective electrode may include 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 a transparent electrode layer formed from ITO, IZO, ZnO, or In_2O_3. The first electrode **61** may be formed by forming a layer by, for example, sputtering, and then patterning the layer by, for example, photolithography.

The second electrode **62** may also be formed as a transparent electrode or a reflective electrode. When the second electrode **62** is formed as a transparent electrode, the second electrode **62** functions as a cathode. To this end, such a transparent electrode may be formed by depositing a metal or metal salt material 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 combination thereof on a surface of the intermediate layer **63** and forming an auxiliary electrode layer or a bus electrode line thereon from ITO, IZO, ZnO, In_2O_3, or the like. When the second electrode **62** 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 combination thereof on the entire surface of the intermediate layer **63**. The second electrode **62** may be formed by using the same deposition method as used to form the intermediate layer **63** described above. The thin film deposition apparatuses according to the embodiments of the present invention described above may be applied to form an organic layer or an inorganic layer of an organic TFT, and to form layers from various materials.

As described above, a thin film deposition apparatus according to the present invention is suitable for manufacturing large-sized display devices on a mass scale and can be used for high-definition patterning. The thin film deposition apparatus according to the present invention also may be used to manufacture an organic light-emitting display device.

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

What is claimed is:

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

a deposition source that comprises an opening and discharges a deposition material contained therein;

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

a patterning slit sheet that is disposed opposite to the deposition source nozzle unit and comprises a plurality of patterning slits arranged in the first direction;

a plurality of barrier pipes that are disposed on a surface of the deposition source nozzle unit facing the patterning slit sheet or on a surface of the deposition source nozzle unit opposite to the patterning slit sheet, the plurality of barrier pipes respectively corresponding to the plurality of deposition source nozzles, and

the method comprising:

fixedly supporting a substrate by a chuck;

spacing the substrate from the patterning slit sheet and adjacent to the patterning slit sheet so that no element is interposed between the substrate and the patterning slit sheet;

depositing the deposition material on the substrate to form a thin film; and

moving the thin film deposition assembly including the patterning slit sheet, or the substrate fixedly supported by the chuck relative to each other while depositing the deposition material on the substrate,

wherein, in depositing the deposition material on the substrate, the deposition material is discharged from the deposition source and passed through the deposition source nozzle unit, the barrier pipes, and the patterning slit sheet.

2. The method of claim 1, further comprising controlling a temperature of the barrier pipes using a barrier pipes temperature control unit of the thin film deposition apparatus.

3. The method of claim 2, further comprising maintaining the temperature of the barrier pipes using the barrier pipes temperature control unit at a first temperature while depositing the thin film on the substrate, and at a second temperature higher than the first temperature while not depositing the thin film on the substrate.

4. The method of claim 2, further comprising controlling the temperature of the barrier pipes using the barrier pipes temperature control unit to be higher while not depositing the thin film on the substrate than while depositing the thin film on the substrate.

5. The method of claim 2, further comprising maintaining the temperature of the barrier pipes using the barrier pipes temperature control unit to be lower than a vaporization temperature of the deposition material while depositing the thin film on the substrate, and to be higher than the vaporization temperature of the deposition material while not depositing the thin film on the substrate.

6. The method of claim 1, wherein the plurality of barrier pipes are disposed on the surface of the deposition source nozzle unit facing the patterning slit sheet, a distance from the patterning slit sheet to an end of the barrier pipes closest to the patterning slit sheet being greater than a length of the barrier pipes, and

wherein, in depositing the deposition material on the substrate, the deposition material is passed through the deposition source nozzle unit before being passed through the barrier pipes, and the deposition material is passed from the end of the barrier pipes to the patterning slit sheet through the distance that is greater than the length of the barrier pipes after being passed through the barrier pipes.

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

8. The method of claim 1, further comprising adjusting a temperature using at least one of a cooling plate of the deposition source nozzle unit or a hot wire of the barrier pipes.

9. The method of claim 1, wherein each of the barrier pipes is separate from the patterning slit sheet.

10. The method of claim 1, wherein the patterning slit sheet is smaller than the substrate in at least one of the first direction or a second direction perpendicular to the first direction.

11. The method of claim 1, wherein the deposition material discharged from the thin film deposition assembly is continuously deposited on the substrate while the substrate and the thin film deposition assembly are moved relative to each other in a second direction perpendicular to the first direction.

* * * * *

专利名称(译)	薄膜沉积设备，通过使用该设备制造有机发光显示设备的方法，以及通过使用该方法制造的有机发光显示设备		
公开(公告)号	[US8921831](US8921831)	公开(公告)日	2014-12-30
申请号	US12/836760	申请日	2010-07-15
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	KIM JONG HEON PARK HYUN SOOK RYU JAE KWANG KANG HEE CHEOL OH JI SOOK		
发明人	KIM, JONG-HEON PARK, HYUN-SOOK RYU, JAE-KWANG KANG, HEE-CHEOL OH, JI-SOOK		
IPC分类号	H01L51/05 H01L51/00 C23C14/12 C23C14/04 C23C14/24 H01L51/56		
CPC分类号	H01L51/56 C23C14/12 H01L51/0011 C23C14/042 C23C14/243		
优先权	1020090078171 2009-08-24 KR		
其他公开文献	US20110042659A1		
外部链接	Espacenet USPTO		

摘要(译)

一种薄膜沉积设备，包括薄膜沉积组件，所述薄膜沉积组件包括：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，其与沉积源喷嘴单元相对设置，并包括沿第一方向排列的多个图案化缝隙;挡板组件，包括多个挡板，挡板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，其中每个阻挡板与图案化缝隙片分离。