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

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(57) **ABSTRACT**

A thin film deposition apparatus that is suitable for production of large-sized substrates with fine patterns includes: an electrostatic chuck including a body that contacts a substrate that constitutes a deposition target and including a supporting surface supporting the substrate, an electrode installed in the body to generate an electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body; a plurality of chambers that are maintained in vacuum states; at least one thin film deposition assembly disposed in one of the plurality of chambers, separated by a predetermined distance from the substrate, and forming a thin film on the substrate supported by the electrostatic chuck; and a carrier moving the electrostatic chuck through the chambers.

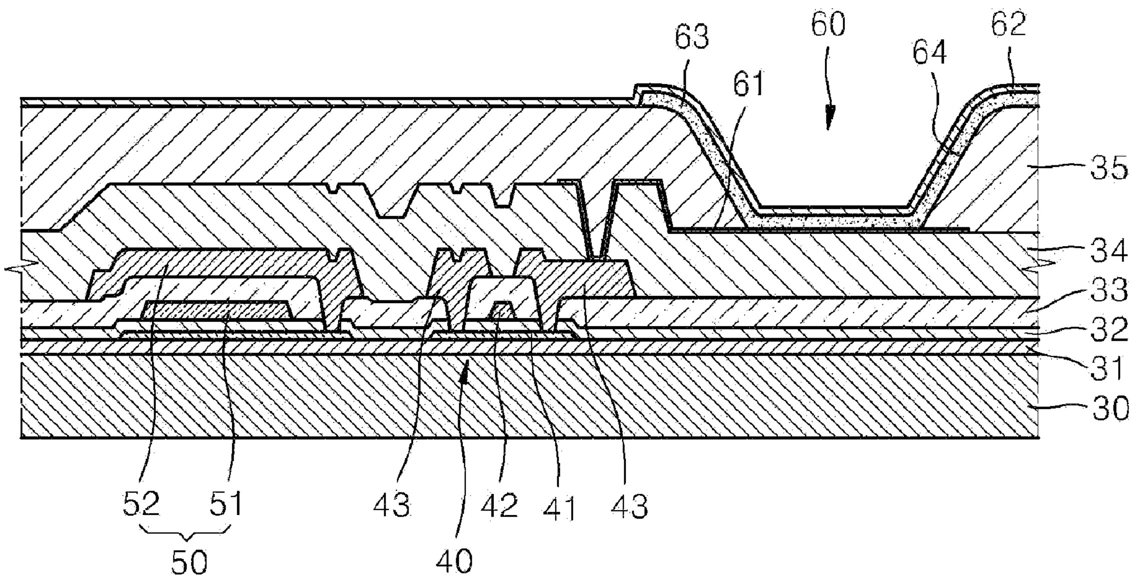


FIG. 1

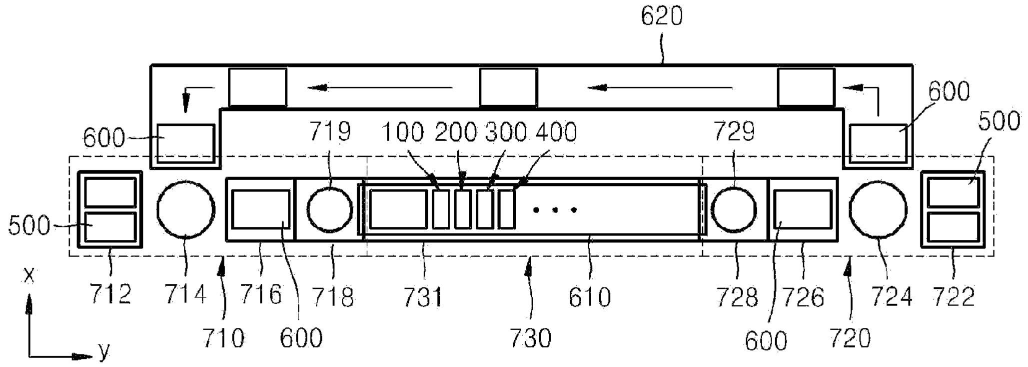

620
600
500
600
719
100 200 300 400
729
500
712
714
716
718
731
610
728
726
724
722
x
y
710
600
730
600
720

FIG. 2

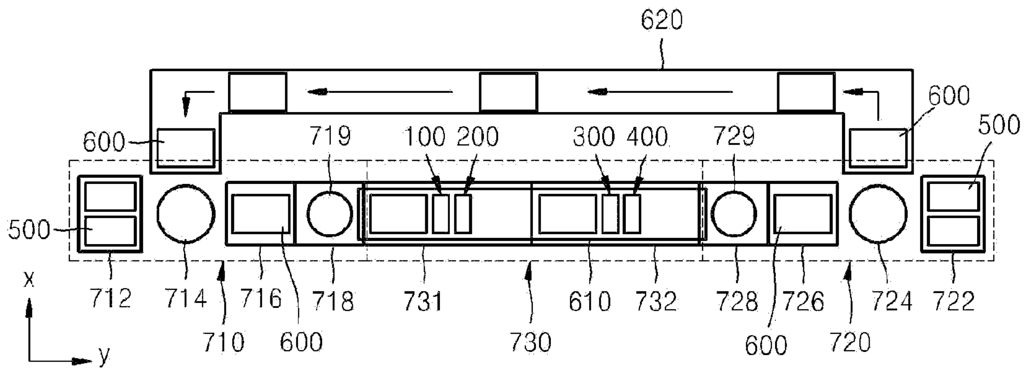

620
600
500
600
719
100 200
300 400
729
500
712
714
716
718
731
610
732
728
726
724
722
x
y
710
600
730
600
720

FIG. 3

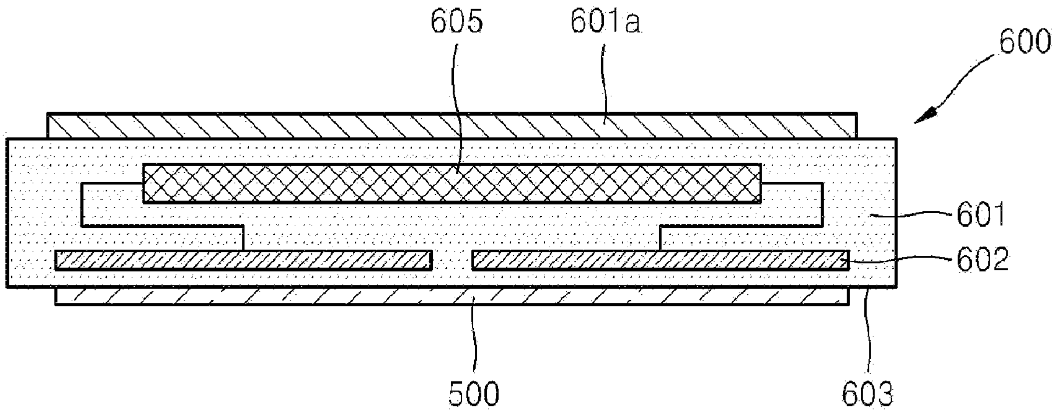


FIG. 4

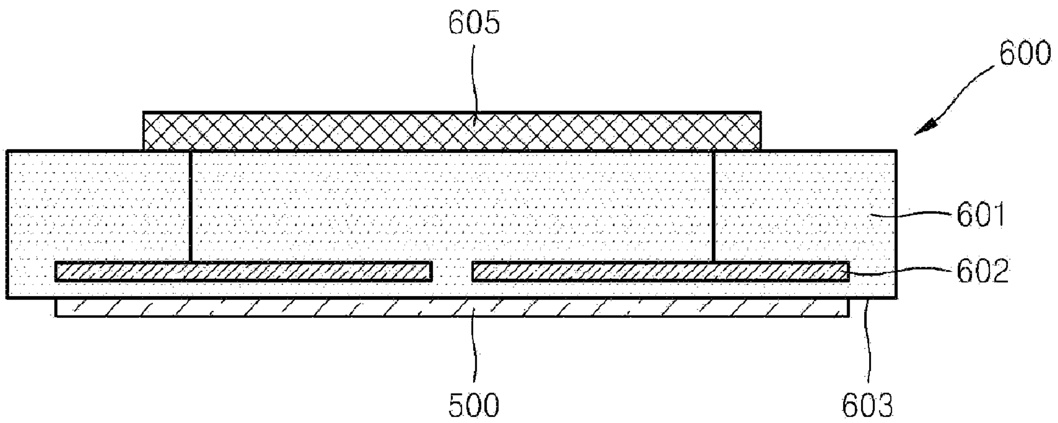


FIG. 5

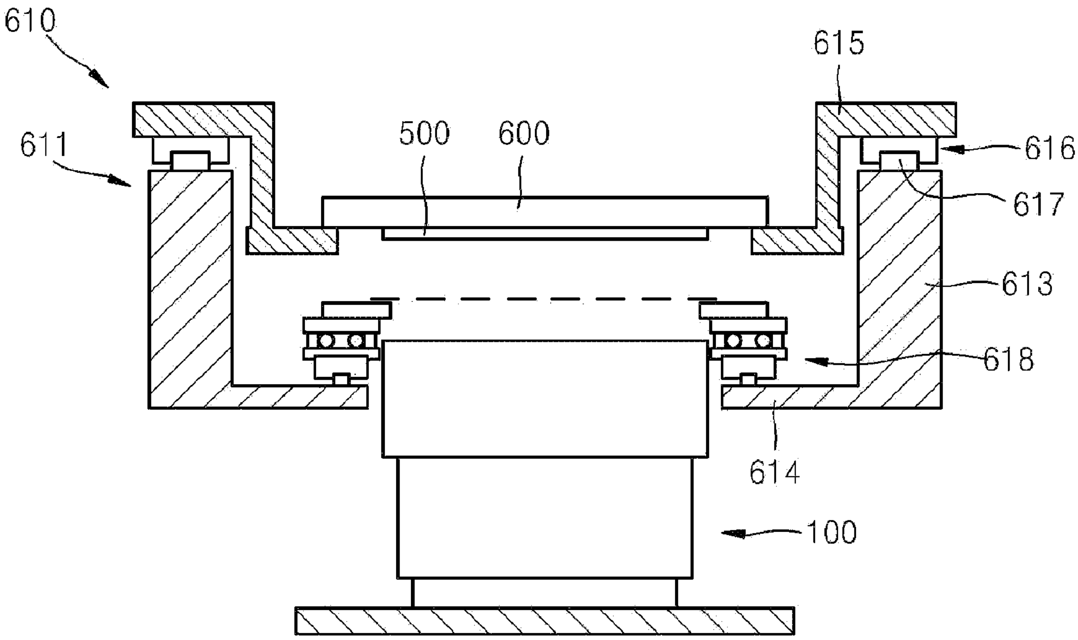

610
611
500
600
615
616
617
613
618
614
100

FIG. 6

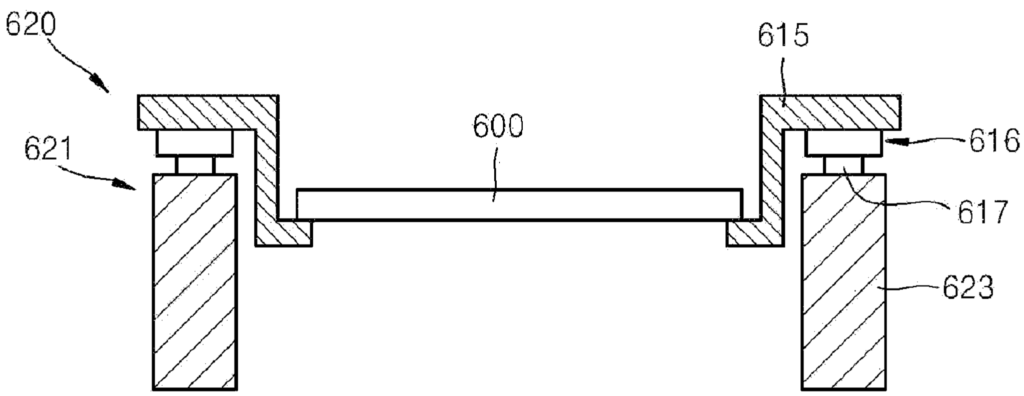

620
621
600
615
616
617
623

FIG. 7

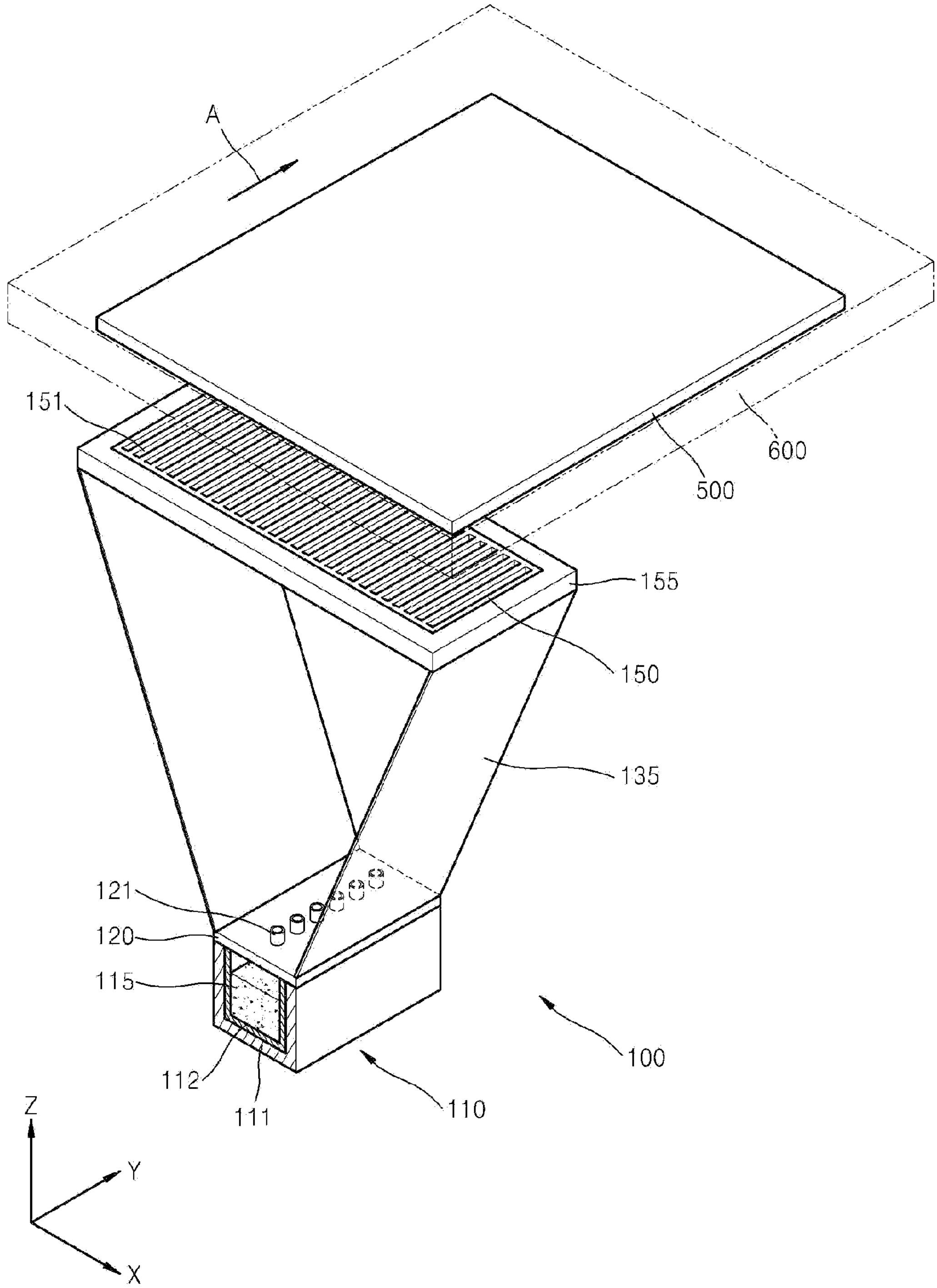


FIG. 8

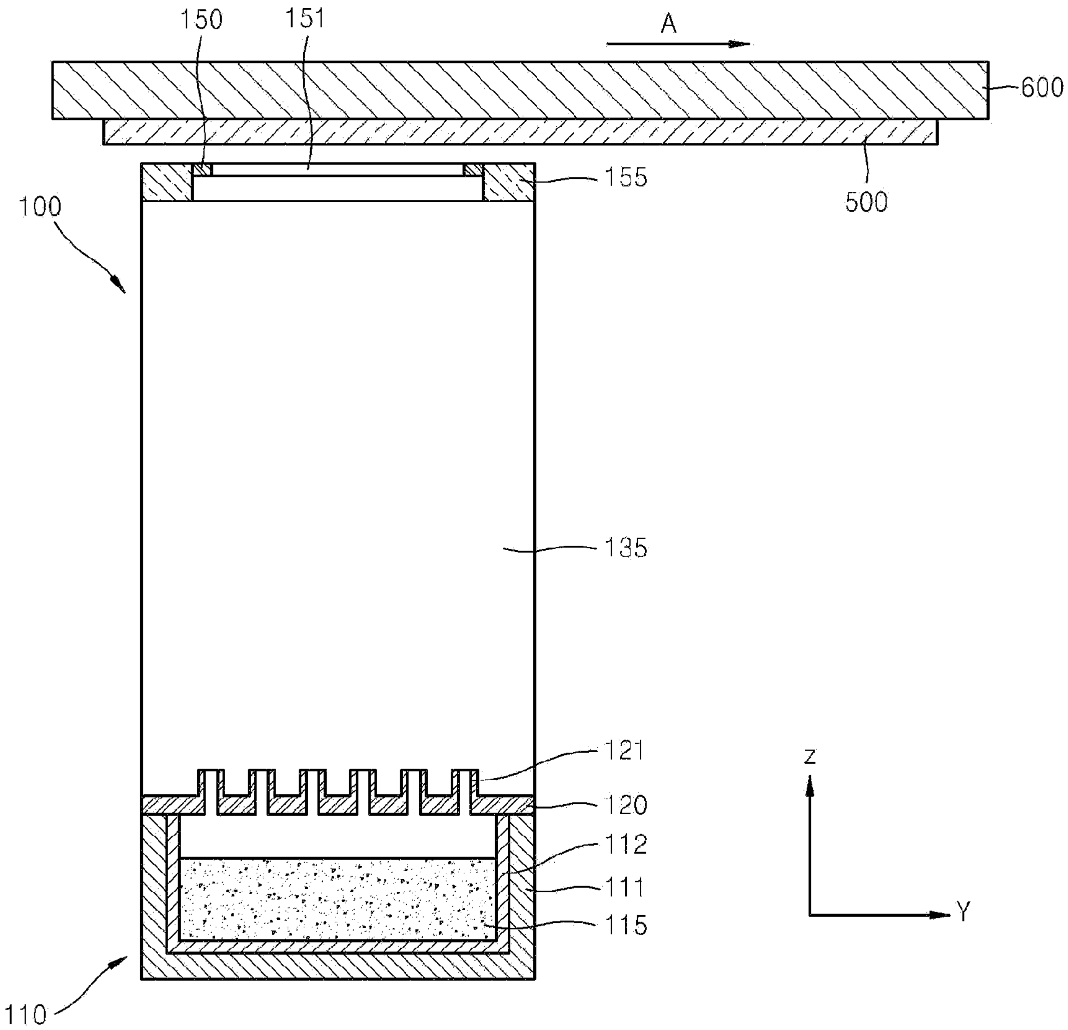


FIG. 9

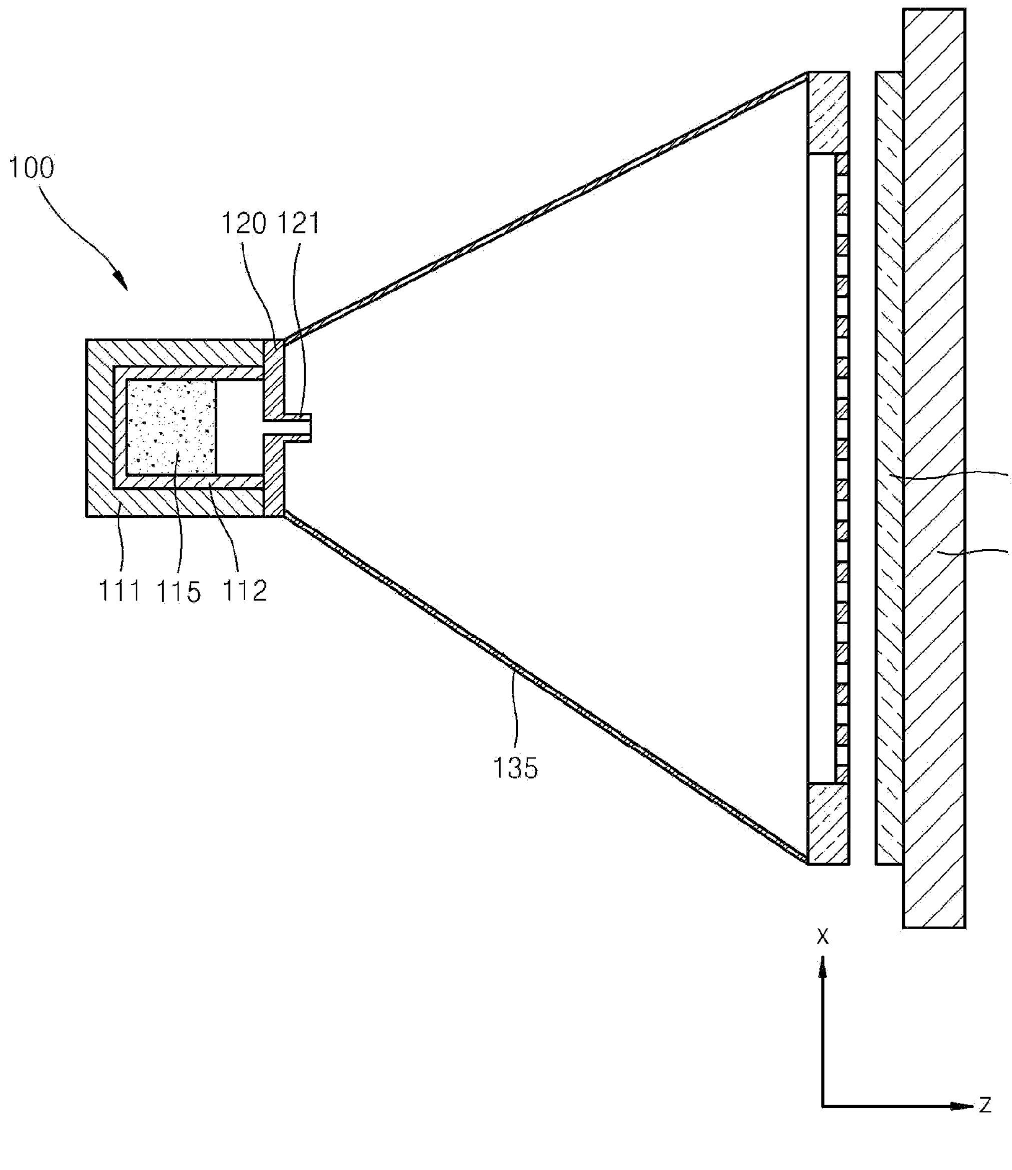


FIG. 10

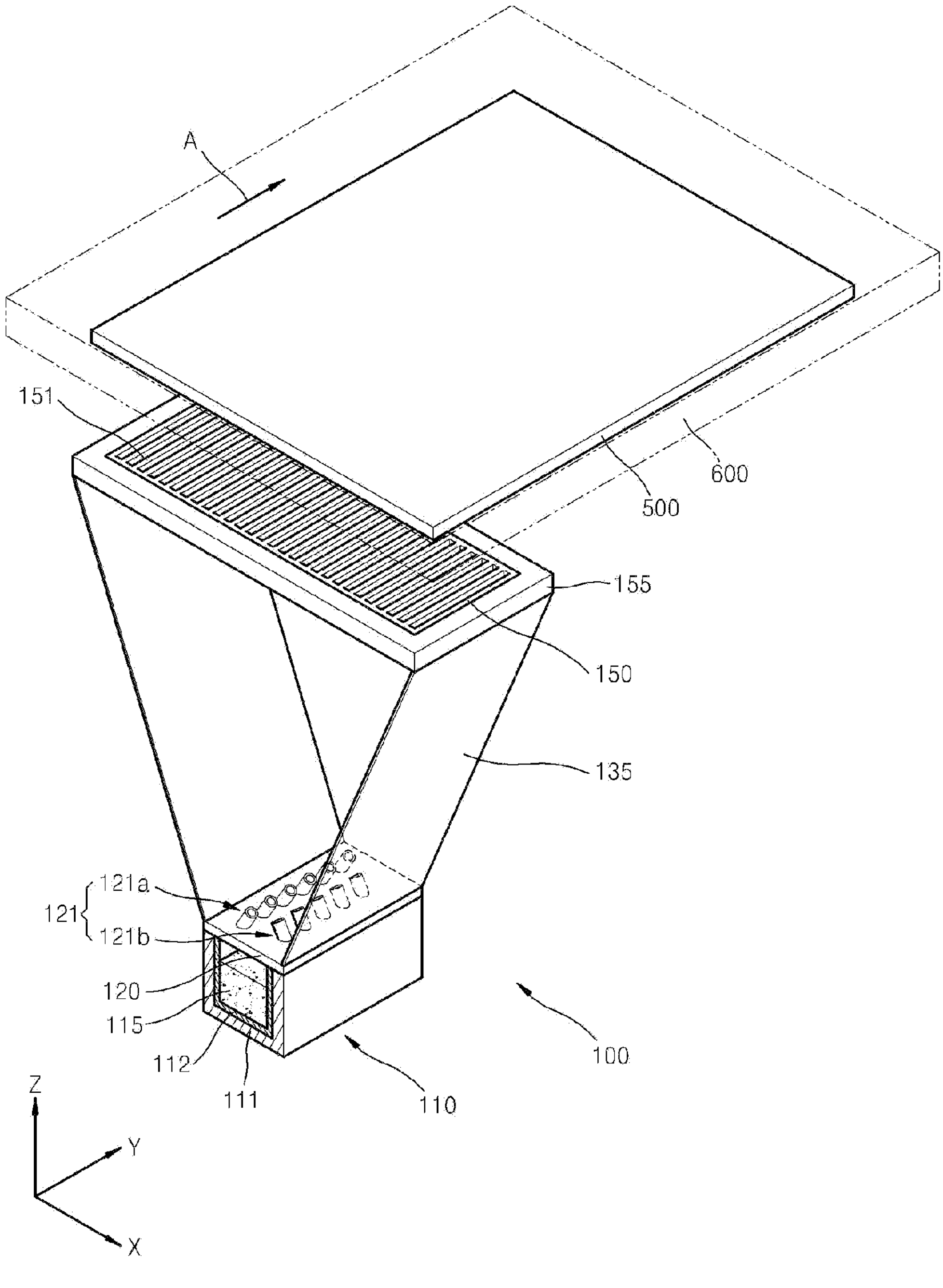

A
151
600
500
155
150
135
121
121a
121b
120
115
112
111
110
100
Z
Y
X

FIG. 11

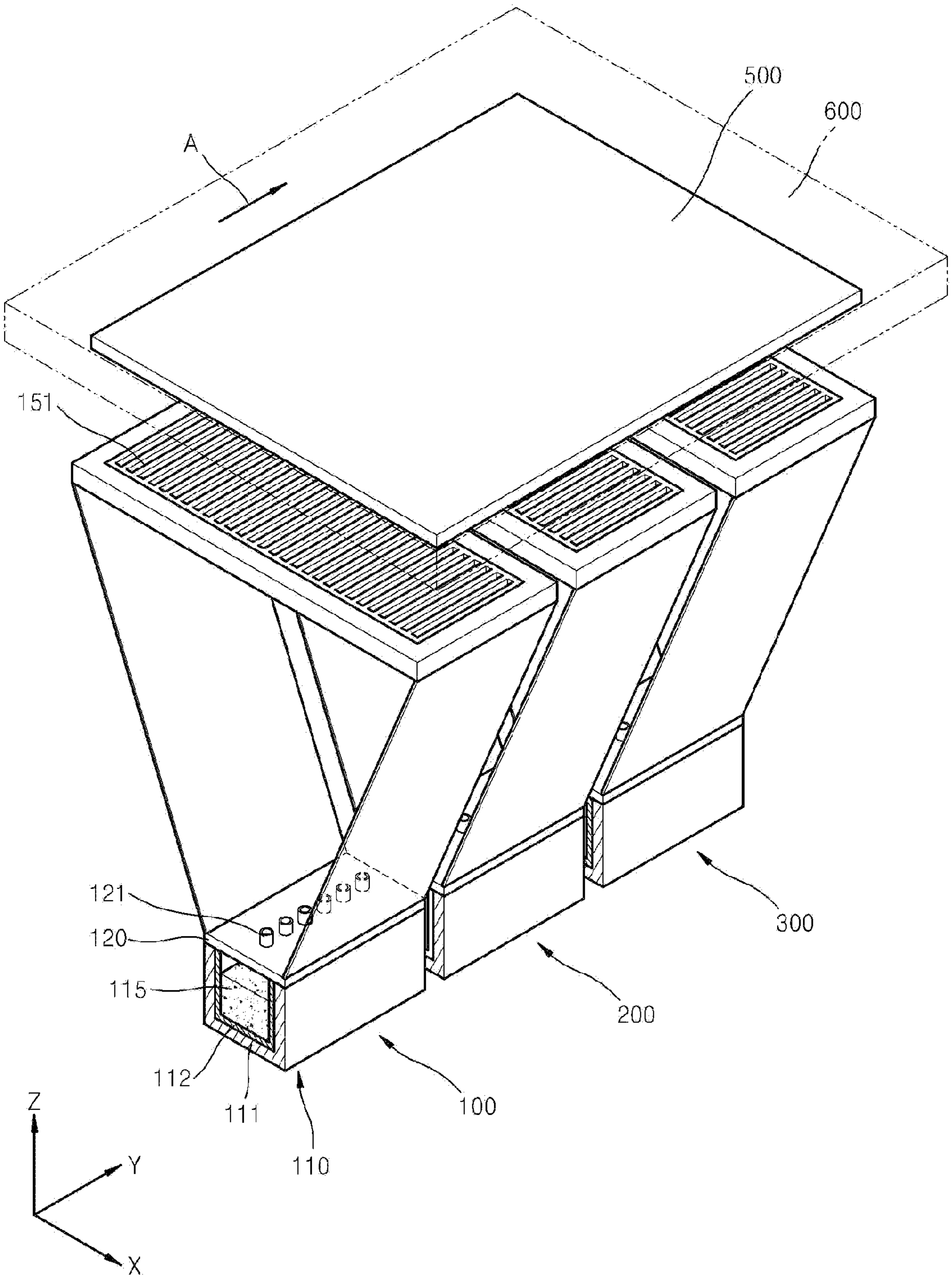


FIG. 12

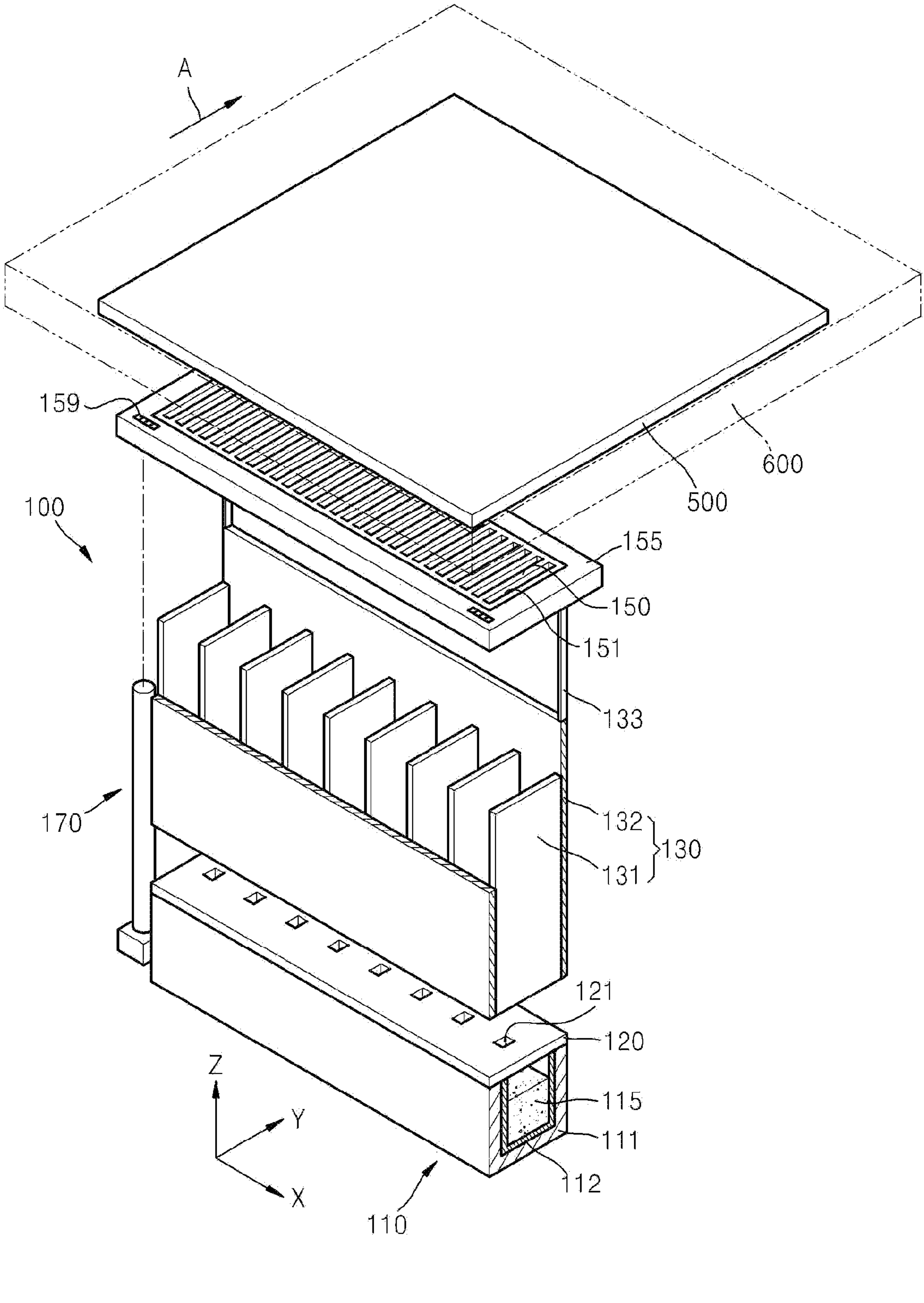

A
159
600
500
100
155
150
151
133
170
132
130
131
121
120
Z
Y
115
111
112
X
110

FIG. 13

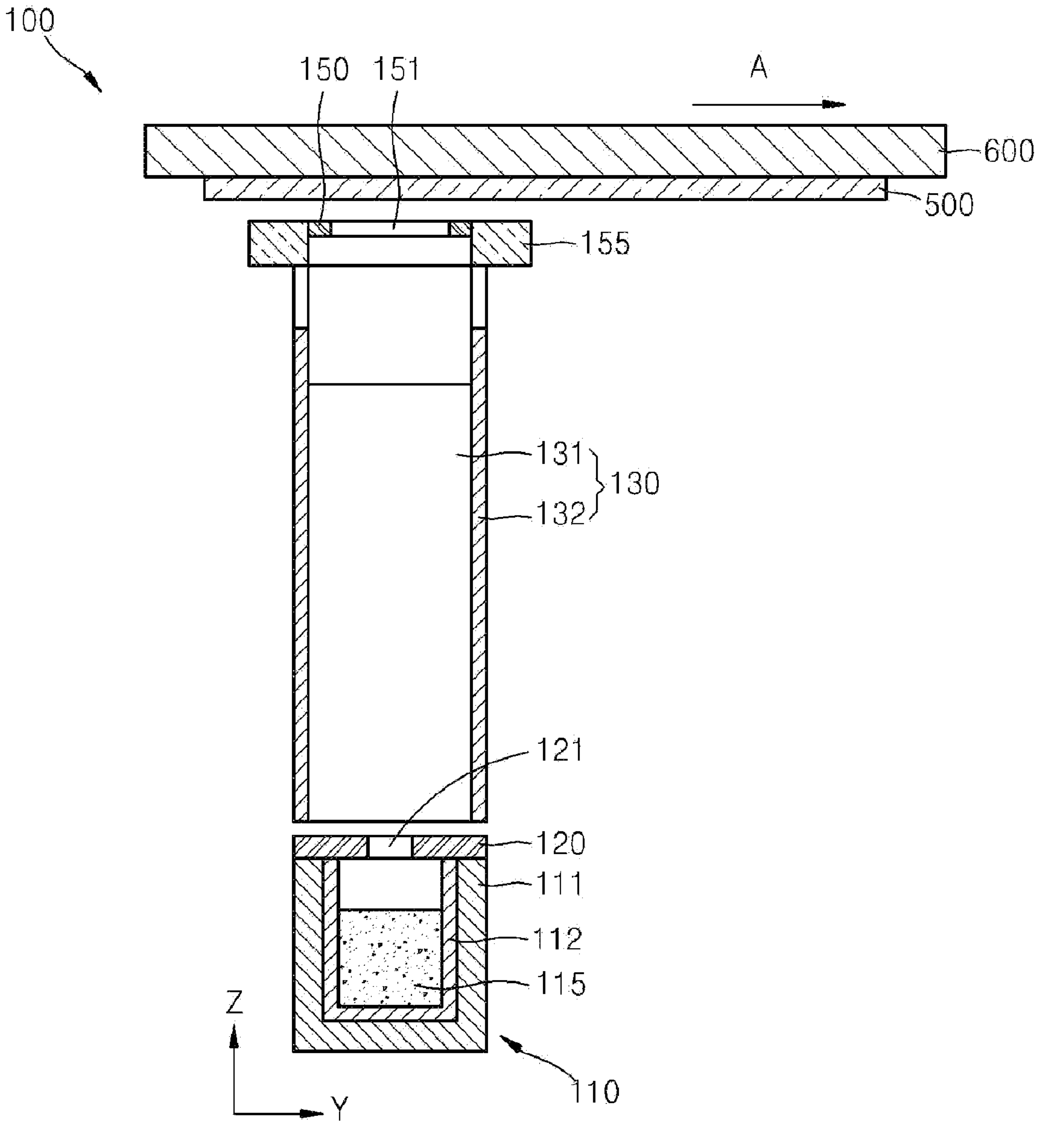


FIG. 14

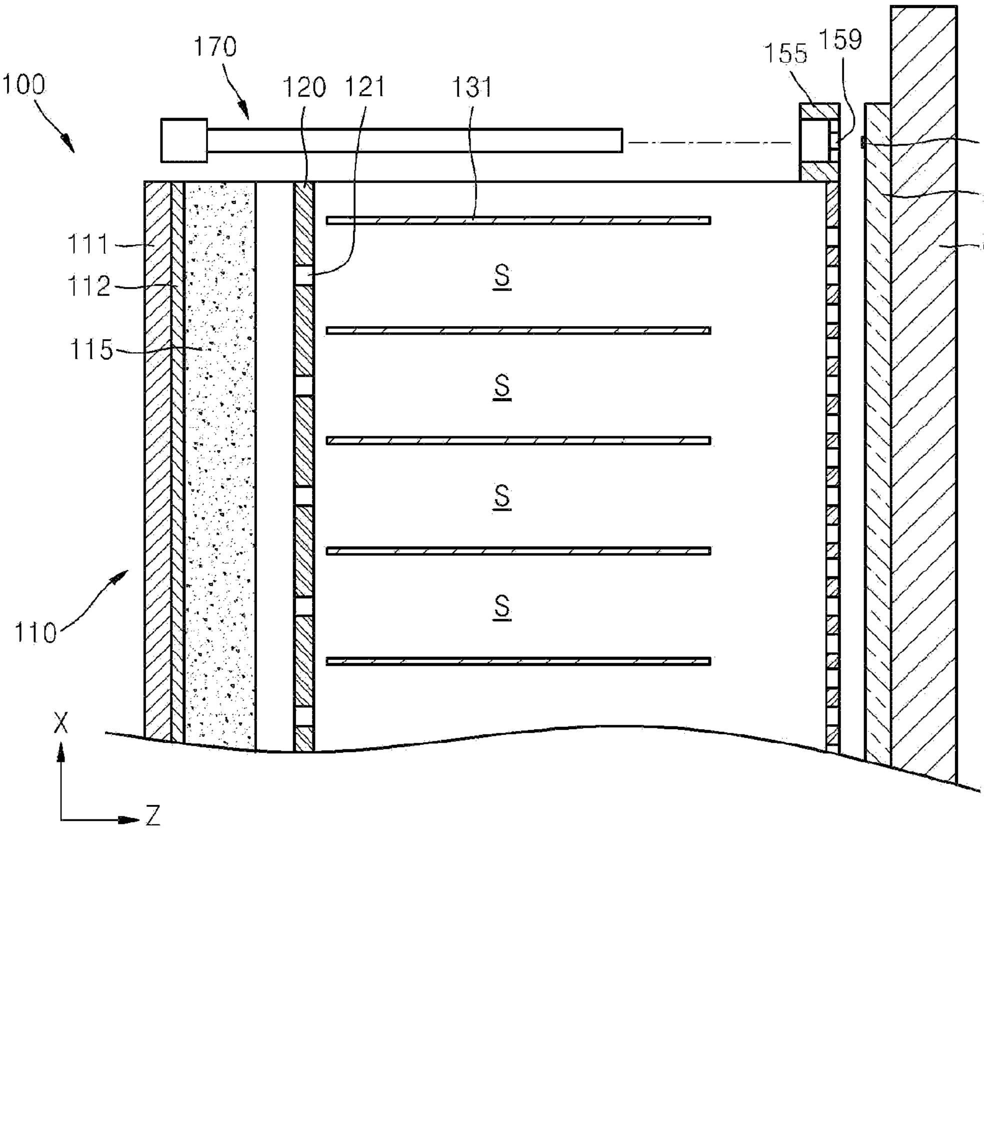


FIG. 15

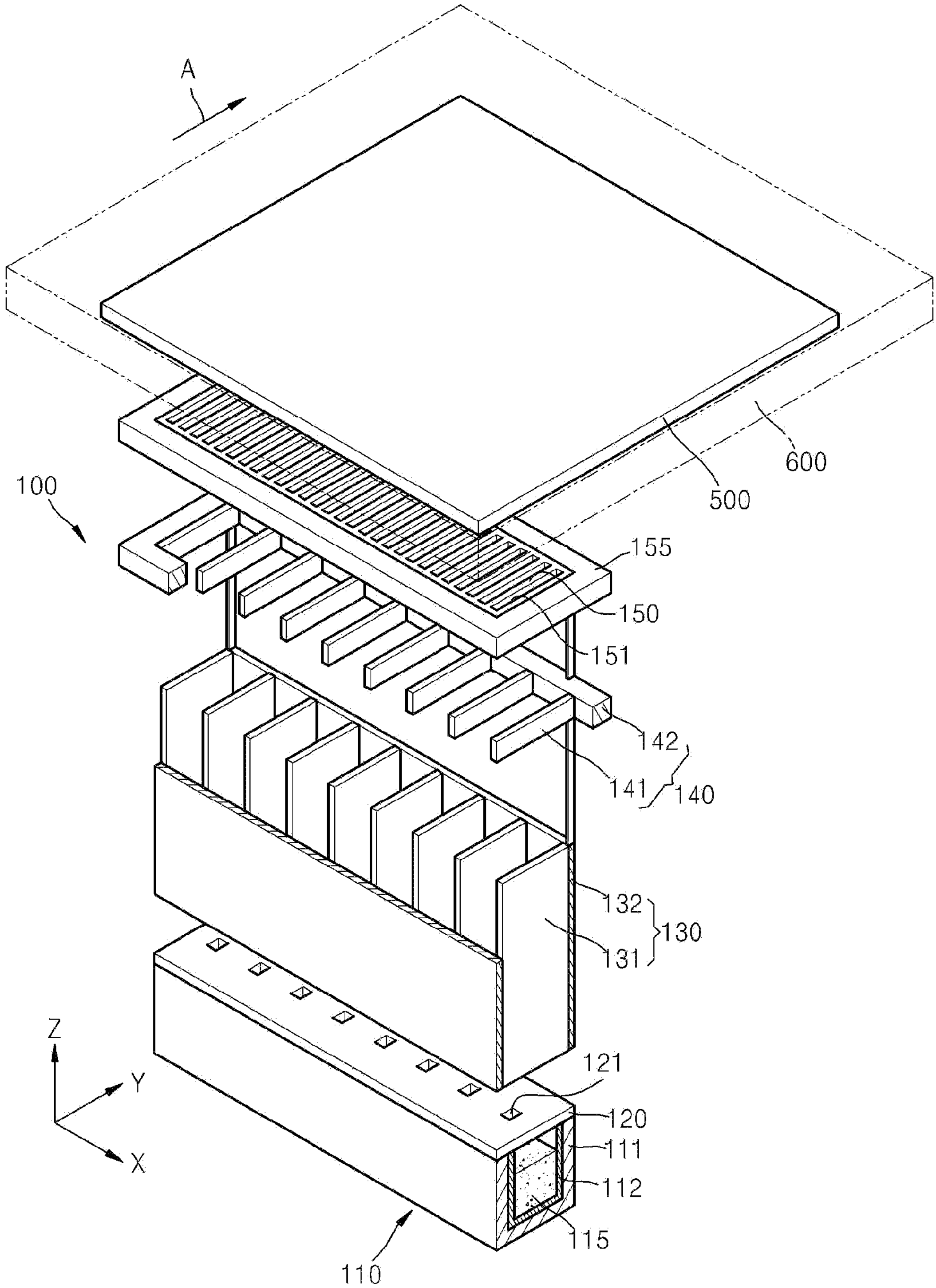
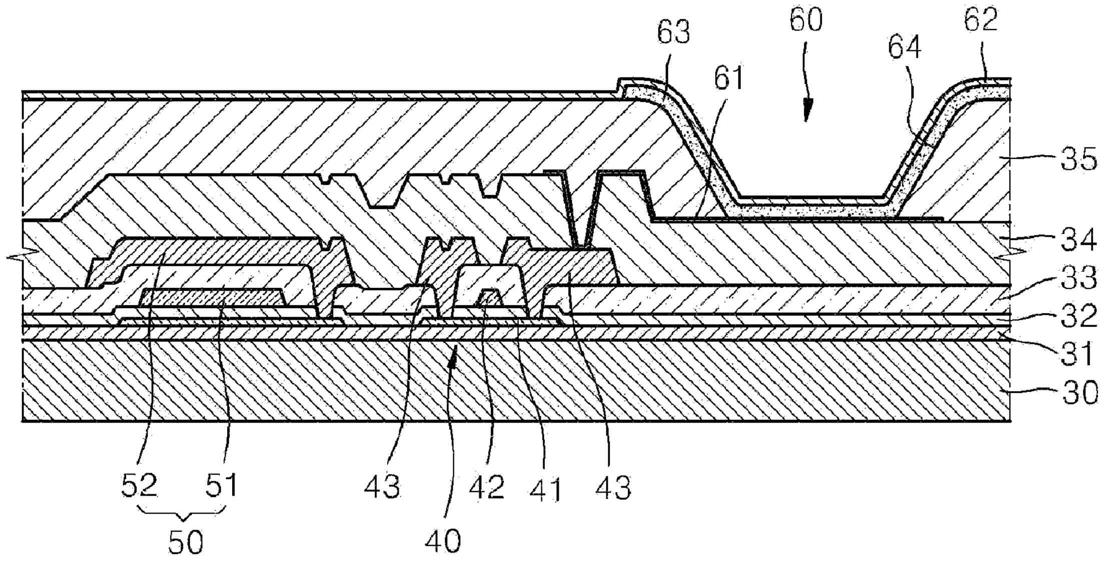

A
600
500
100
155
150
151
142
141
140
132
130
131
121
120
111
112
115
110
Z
Y
X

FIG. 16



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

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Application No(s). 10-2009-0079768, filed Aug. 27, 2009 and 10-2010-0011481 filed Feb. 8, 2010, in the Korean Intellectual Property Office, the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Aspects of the present invention relate to a thin film deposition apparatus and a method of manufacturing an organic light-emitting display device by using the same, and more particularly, to a thin film deposition apparatus that can be simply applied to the manufacture of large-sized display devices on a mass scale, and a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus.

[0004] 2. Description of the Related Art

[0005] 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.

[0006] 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 electrodes and the intermediate layers may be formed via 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 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.

[0007] However, the deposition method using such an FMM presents problems in manufacturing larger devices using a mother glass having a large size. In more detail, when a large mask is used in a deposition onto a large mother glass, the mask may bend due to self-gravity, thereby distorting a pattern. Such pattern distortion is not conducive for the recent trend towards high-definition patterns.

[0008] On the other hand, according to the conventional deposition method, a metal mask is placed on a surface of a substrate and a magnet is disposed on the other surface of the substrate in a state where edges of the substrate are fixed by an additional chuck, and thus, the metal mask may be adhered onto the surface of the substrate by the magnet. However, in the above deposition method, since the edges of the substrate are only supported, a center portion of the substrate may sag when the substrate has a large area. This sagging of the substrate becomes more severe as the substrate increases in size.

SUMMARY OF THE INVENTION

[0009] In order to address at least the drawbacks of the deposition method using a fine metal mask (FMM) and/or other issues, aspects of the present invention provide a thin film deposition apparatus that may be simply applied to produce large-sized display devices on a mass scale and that may be suitable for high-definition patterning, and a method of manufacturing an organic light-emitting display device by using the thin film deposition apparatus.

[0010] According to an aspect of the present invention, there is provided a thin film deposition apparatus including: an electrostatic chuck comprising a body that contacts a substrate that constitutes a deposition target and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body; a plurality of chambers that are maintained in vacuum states; at least one thin film deposition assembly disposed in one of the plurality of chambers, separated by a predetermined distance from the substrate, and forming a thin film on the substrate supported by the electrostatic chuck; and a carrier that moves the electrostatic chuck through the chambers.

[0011] According to a non-limiting aspect, the battery may be formed in the body.

[0012] According to a non-limiting aspect, the carrier may include: a support that extends through the chambers; a movement bar that engages the support and that supports edges of the electrostatic chuck; and a driving unit disposed between the support and the movement bar to move the movement bar along the support.

[0013] According to a non-limiting aspect, the thin film deposition assembly may include: 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 and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in a second direction perpendicular to the first direction, wherein deposition may be performed while the substrate or the thin film deposition assembly is moved relative to the other in the first direction, and the deposition source, the deposition source nozzle unit, and the patterning slit sheet may be integrally formed as one body.

[0014] According to a non-limiting aspect, the deposition source and the deposition source nozzle unit, and the patterning slit sheet may be integrally connected as one body by a connection member that guides flow of the deposition material.

[0015] According to a non-limiting aspect, the connection member may seal a space between the deposition source nozzle unit disposed at the side of the deposition source, and the patterning slit sheet.

[0016] According to a non-limiting aspect, the plurality of deposition source nozzles may be tilted at a predetermined angle.

[0017] According to a non-limiting aspect, the plurality of deposition source nozzles may include deposition source nozzles arranged in two rows disposed in the first direction, and the each of the deposition source nozzles in each of the two rows may be tilted at the predetermined angle toward a corresponding deposition source nozzle of the other of the two rows.

[0018] According to a non-limiting aspect, the plurality of deposition source nozzles may include deposition source nozzles arranged in two rows disposed in the first direction, the deposition source nozzles of a row located at a first side of the patterning slit sheet may be arranged to face a second side of the patterning slit sheet, and the deposition source nozzles of the other row located at the second side of the patterning slit sheet may be arranged to face the first side of the patterning slit sheet.

[0019] According to a non-limiting aspect, the thin film deposition assembly may include: 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 arranged in the first direction; and a barrier plate assembly comprising 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 the thin film deposition assembly may be spaced apart from the substrate, and the thin film deposition assembly or the substrate fixedly engaged onto the electrostatic chuck may be moved relative to the other.

[0020] According to a non-limiting aspect, the plurality of barrier plates may extend in a second direction substantially perpendicular to the first direction.

[0021] According to a non-limiting aspect, the barrier plate assembly may include a first barrier plate assembly including a plurality of first barrier plates, and a second barrier plate assembly including a plurality of second barrier plates.

[0022] According to a non-limiting aspect, each of the first barrier plates and each of the second barrier plates may extend in a second direction substantially perpendicular to the first direction.

[0023] According to a non-limiting aspect, the first barrier plates may be arranged to respectively correspond to the second barrier plates.

[0024] According to a non-limiting aspect, the deposition source and the barrier plate assembly may be spaced apart from each other.

[0025] According to a non-limiting aspect, the barrier plate assembly and the patterning slit sheet may be space apart from each other.

[0026] According to another aspect of the present invention, there is provided a method of manufacturing an organic light emitting display device, the method including: fixing a substrate that constitutes a deposition target onto an electrostatic chuck, wherein the electrostatic chuck comprises a body that contacts the substrate and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body; transferring the electrostatic chuck on which the substrate is fixedly engaged through a plurality of chambers that are maintained in a vacuum state; and forming an organic layer on the substrate by depositing a deposition material from a thin film deposition assembly disposed in at least one of the chambers wherein the electrostatic chuck on which the substrate is disposed or the thin film deposition assembly is moved relative to the other.

[0027] According to a non-limiting aspect, the battery may be formed in the body.

[0028] According to a non-limiting aspect, the thin film deposition assembly may include: a deposition source that discharges the 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 and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in a second direction perpendicular to the first direction, wherein the deposition source, the deposition source nozzle unit, and the patterning slit sheet may be integrally formed as one body, and the thin film deposition assembly may be spaced apart from the substrate, and the depositing of the deposition material may be performed while the substrate or the thin film deposition assembly is moved relative to the other in the first direction.

[0029] According to a non-limiting aspect, the thin film deposition assembly may include: a deposition source that discharges the 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 and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in the first direction; and a barrier plate assembly comprising a plurality of barrier plates that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and 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 assembly may be separated from the substrate, and the depositing of the deposition material may be performed while the substrate or the thin film deposition assembly is moved relative to the other.

[0030] According to another embodiment of the present invention, there is provided a thin film deposition apparatus including a loading unit that fixes a substrate on which a deposition material is to be deposited onto an electrostatic chuck, wherein the electrostatic chuck includes a body that contacts the substrate and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body; a deposition unit including one or more chambers and at least one thin film deposition assembly disposed in the one or more chambers to deposit a deposition material on the substrate fixed on the electrostatic chuck; an unloading unit that removes the substrate on which deposition has been performed from the electrostatic chuck; a first circulating unit including a first carrier that sequentially moves the electrostatic chuck from the loading unit through the one or more chambers of the deposition unit, and from the deposition unit to the unloading unit; and a second circulating unit including a second carrier that returns the electrostatic chuck from which the substrate has been removed by the unloading unit, to the loading unit.

[0031] 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

[0032] 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:

[0033] FIG. **1** is a schematic view of a thin film deposition apparatus according to an embodiment of the present invention;

[0034] FIG. **2** illustrates a modified example of the thin film deposition apparatus of FIG. **1**;

[0035] FIG. **3** is a schematic view of an electrostatic chuck according to an embodiment of the present invention;

[0036] FIG. **4** is a schematic view of an electrostatic chuck according to another embodiment of the present invention;

[0037] FIG. **5** is a cross-sectional view of a first circular unit according to an embodiment of the present invention;

[0038] FIG. **6** is a cross-sectional view of a second circular unit according to an embodiment of the present invention;

[0039] FIG. **7** is a perspective view of a thin film deposition assembly according to an embodiment of the present invention;

[0040] FIG. **8** is a schematic cross-sectional side view of the thin film deposition assembly of FIG. **7**, according to an embodiment of the present invention;

[0041] FIG. **9** is a schematic cross-sectional plan view of the thin film deposition assembly of FIG. **7**, according to an embodiment of the present invention;

[0042] FIG. **10** is a perspective view of a thin film deposition assembly according to another embodiment of the present invention;

[0043] FIG. **11** is a perspective view of a thin film deposition assembly according to another embodiment of the present invention;

[0044] FIG. **12** is a perspective view of a thin film deposition assembly according to another embodiment of the present invention;

[0045] FIG. **13** is a schematic cross-sectional side view of the thin film deposition assembly of FIG. **12**, according to an embodiment of the present invention;

[0046] FIG. **14** is a schematic cross-sectional plan view of the thin film deposition assembly of FIG. **12**, according to an embodiment of the present invention;

[0047] FIG. **15** is a perspective view of a thin film deposition assembly according to another embodiment of the present invention; and

[0048] FIG. **16** is a cross-sectional view of an organic light-emitting display device manufactured by using a thin film deposition assembly, according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0049] 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 aspects of the present invention by referring to the figures

[0050] FIG. **1** is a schematic perspective view of a thin film deposition apparatus according to an embodiment of the present invention. FIG. **2** illustrates a modified example of the thin film deposition apparatus of FIG. **1**. FIG. **3** is a view of an example of an electrostatic chuck **600**.

[0051] Referring to FIG. **1**, the thin film deposition apparatus according to the current embodiment includes a loading unit **710**, a deposition unit **730**, an unloading unit **720**, a first circulating unit **610** and a second circulating unit **620**.

[0052] The loading unit **710** may include a first rack **712**, a transport robot **714**, a transport chamber **716**, and a first inversion chamber **718**.

[0053] A plurality of substrates **500** onto which a deposition material has not yet been applied are stacked up on the first rack **712**. The transport robot **714** picks up one of the substrates **500** from the first rack **712**, disposes it on the electrostatic chuck **600** transferred by the second circulating unit **620**, and moves the electrostatic chuck **600** on which the substrate **500** is disposed into the transport chamber **716**. Although it is not shown in FIGS. **1** and **2**, the transport robot **714** may be disposed in a chamber that has an appropriate degree of vacuum maintained therein.

[0054] The first inversion chamber **718** is disposed adjacent to the transport chamber **716**. The first inversion chamber **718** includes a first inversion robot **719** that inverts the electrostatic chuck **600** and then loads it into the first circulating unit **610** of the deposition unit **730**.

[0055] The electrostatic chuck **600** according to the current embodiment of the present invention includes an electrode **602** to which an electric power is applied in a main body **601** formed of a dielectric material, as shown in FIG. **3**. The electrode **602** is separated by a predetermined distance from a supporting surface **603** that faces the substrate **500**, and an electrostatic force is applied to the supporting surface **603** from the electrode **602** to adhere and fix the substrate **500** thereon.

[0056] The main body **601** includes a predetermined space in which a battery **605** is installed. The battery **605** is electrically connected to the electrode **602** to apply electric power to the electrode **602**.

[0057] A cover **601***a* is installed on an opposite surface of the supporting surface **603** so that the battery **605** may be inserted into or removed from the main body **601**.

[0058] In the electrostatic chuck **600**, an additional power line is not necessary since the power is applied to the electrode **602** from the battery **605** that is installed in the main body **601**. Therefore, it is easy to move the electrostatic chuck **600** that supports the substrate **500** in the chamber or between chambers, and it is easy to provide a thin film deposition apparatus.

[0059] As shown in FIG. **4**, the battery **605** may be installed on an outer portion of the main body **601**. In this case, since the battery **605** is exposed to a deposition environment in the chamber, an additional case for covering the battery **605** may be formed.

[0060] Referring to FIG. **1**, the transport robot **714** places one of the substrates **500** on the surface of the electrostatic chuck **600**, and the electrostatic chuck **600** on which the substrate **500** is disposed is loaded into the transport chamber **716**. The first inversion robot **719** inverts the electrostatic chuck **600** so that the substrate **500** is turned upside down in the deposition unit **730**. In more detail, the electrostatic chuck **600** is inverted so that the substrate **500** will face the thin film deposition assemblies **100**, **200**, **300**, and **400** when the electrostatic chuck **600** and substrate pass through the deposition unit **730**, to be described later. The transport chamber **716** and the first inversion chamber **718** may have an appropriate degree of vacuum maintained therein.

[0061] The unloading unit **720** is constituted to operate in an opposite manner to the loading unit **710** described above. Specifically, a second inversion robot **729** in a second inversion chamber **728** inverts the electrostatic chuck **600**, which has passed through the deposition unit **730** while the substrate **500** is disposed on the electrostatic chuck **600**, and then moves the electrostatic chuck **600** on which the substrate **500** is disposed into an ejection chamber **726**. Then, an ejection robot **724** removes the electrostatic chuck **600** on which the substrate **500** is disposed from the ejection chamber **726**, separates the substrate **500** from the electrostatic chuck **600**, and then loads the substrate **500** into the second rack **722**. The electrostatic chuck **600** separated from the substrate **500** is returned back into the loading unit **710** via the second circulating unit **620**. The second inversion chamber **728** and the ejection chamber **726** may have an appropriate degree of vacuum maintained therein. In addition, although it is not shown in the drawings, the ejection robot **724** may be disposed in a chamber that has an appropriate degree of vacuum maintained therein.

[0062] However, the present invention is not limited to the above description. For example, when disposing the substrate **500** on the electrostatic chuck **600**, the substrate **500** may be fixed onto a bottom surface of the electrostatic chuck **600** and then moved into the deposition unit **730**. (In FIGS. **1** and **2**, terms such as "top surface" and "bottom surface" are with reference to a "top surface" being a surface facing the viewer in FIGS. **1** and **2** and "a bottom surface" as being a surface facing away from the viewer.) In this case, for example, the first inversion chamber **718** and the first inversion robot **719**, and the second inversion chamber **728** and the second inversion robot **729** are not required.

[0063] The deposition unit **730** includes at least one deposition chamber. As illustrated in FIG. **1**, the deposition unit **730** may include a first chamber **731**. As a non-limiting example, first to fourth thin film deposition assemblies **100**, **200**, **300**, and **400** may be disposed in the first chamber **731**. Although FIG. **1** illustrates that a total of four thin film deposition assemblies, i.e., the first to fourth thin film deposition assemblies **100** to **400**, are installed in the first chamber **731**, the total number of thin film deposition assemblies that may be installed in the first chamber **731** may vary according to a deposition material and deposition conditions. The first chamber **731** is maintained in a vacuum state during a deposition process.

[0064] In the thin film deposition apparatus illustrated in FIG. **2**, a deposition unit **730** may include a first chamber **731** and a second chamber **732** that are connected to each other. In this case, first and second thin film deposition assemblies **100** and **200** may be disposed in the first chamber **731**, and third and fourth thin film deposition assemblies **300** and **400** may be disposed in the second chamber **732**. In this regard, the number of chambers may be increased.

[0065] In the embodiment illustrated in FIG. **1**, the electrostatic chuck **600** on which the substrate **500** is disposed may be moved at least to the deposition unit **730** or may be moved sequentially to the loading unit **710**, the deposition unit **730**, and the unloading unit **720**, by the first circulating unit **610**. The electrostatic chuck **600** that is separated from the substrate **500** in the unloading unit **720** is moved back to the loading unit **710** by the second circulating unit **620**.

[0066] FIG. **5** is a cross-sectional view of the first circulating unit **610**, according to an embodiment of the present invention.

[0067] The first circulating unit **610** includes a first carrier **611** that moves the electrostatic chuck **600** on which the substrate **500** is disposed.

[0068] The first carrier **611** includes a first support **613**, a second support **614**, a movement bar **615**, and a first driving unit **616**.

[0069] The first support **613** and the second support **614** are installed to extend through a chamber in the deposition unit **730**, for example, the first chamber **731** in the embodiment shown in FIG. **1**, and the first chamber **731** and the second chamber **732** in the embodiment shown in FIG. **2**.

[0070] The first support **613** is disposed vertically in the first chamber **731**, and the second support **614** is horizontally disposed below the first support **613** in the first chamber **731**. (In FIGS. **5** and **6**, the term "vertically" refers to a direction between a thin film deposition assembly, such as thin film deposition assembly **100**, and the substrate **500** and "horizontally" refers to a direction perpendicular to such vertical direction and perpendicular to a direction of motion of the substrate through the deposition unit **730**. In more detail, the vertical direction and the horizontal direction in FIGS. **5** and **6** correspond to the Z direction and the X direction, respectively, as shown in FIGS. **7** to **15**. As illustrated in FIG. **5**, 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**.

[0071] 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** supports an edge of the electrostatic chuck **600**. The electrostatic chuck **600** is supported by the movement bar **615** and the electrostatic chuck **600** and the movement bar **615** together are movable along the first support **613**. A portion of the movement bar **615** supporting the electrostatic chuck **600** is bent toward the thin film deposition assembly **100**, and thus can reduce the distance between the substrate **500** and the thin film deposition assembly **100**.

[0072] The first driving unit **616** is disposed between the movement bar **615** and the first support **613** and moves the movement bar **615** along the first support **613**. The first driving unit **616** may include a roller **617** rolling along the first support **613**. In this regard, the first support **613** may be in the form of a rail extending in a direction perpendicular to the X and Z directions as described above, or in other words, in a direction perpendicular to the plane of the cross-sectional view of FIG. **5**. 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 include any driving element, in addition to the roller **617**, provided that it can move the movement bar **615**.

[0073] FIG. **6** is a cross-sectional view of the second circulating unit **620**, according to an embodiment of the present invention.

[0074] The second circulating unit **620** includes a second carrier **621** that moves the electrostatic chuck **600** from which the substrate **500** is separated.

[0075] The second carrier **621** includes a first support **623**, the movement bar **615**, and the first driving unit **616**.

[0076] The third support **623** extends in a similar manner to the first support **613** of the first carrier **611**. The third support

623 supports the movement bar 615 having the first driving unit 616, and the electrostatic chuck 600 that has been separated from the substrate 500 is mounted on the movement bar 615. Structures of the movement bar 615 and the first driving unit 616 have already been described above, and thus descriptions thereof will not be provided here.

[0077] The system for moving the electrostatic chuck 600 is not limited to the above embodiment, and the electrostatic chuck 600 may be simply moved along a rail by using an additional roller or a chain system.

[0078] Hereinafter, an embodiment of the thin film deposition assembly 100 disposed in the first chamber 731 will be described.

[0079] FIG. 7 is a schematic perspective view of a thin film deposition assembly 100 according to an embodiment of the present invention, FIG. 8 is a schematic side view of the thin film deposition apparatus 100, and FIG. 9 is a schematic plan view of the thin film deposition apparatus 100.

[0080] Referring to FIGS. 7 through 9, 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, and a patterning slit sheet 150.

[0081] 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 500 in a desired pattern, it is desirable to maintain the first chamber 731 in a high-vacuum state as in a deposition method using a fine metal mask (FMM). In addition, the temperature of the patterning slit sheet 150 should be sufficiently lower than the temperature of the deposition source 110. In this regard, the temperature of the patterning slit sheet 150 may be about 100° C. or less. The temperature of the patterning slit sheet 150 should be sufficiently low so as to reduce thermal expansion of the patterning slit sheet 150.

[0082] The substrate 500, which constitutes a deposition target on which a deposition material 115 is to be deposited, is disposed in the first chamber 731. 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 400. Other substrates may also be employed. The substrate 500 may be affixed to the electrostatic chuck 600 as described above.

[0083] In the current embodiment of the present invention, deposition may be performed while the substrate 500 or the thin film deposition assembly 100 is moved relative to the other. Herein, where it is stated that the substrate or thin film deposition assembly are moved relative to the other, it is to be understood that such statement encompasses an embodiment in which only the substrate is moved and the thin film deposition assembly remains stationary, an embodiment in which only the thin film deposition assembly is moved and the substrate remains stationary and an embodiment in which both the thin film deposition assembly and the substrate are moved.

[0084] 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 when larger substrates are used. However, it is difficult to manufacture a large FMM and to extend an FMM to be accurately aligned with a pattern.

[0085] In order to overcome this problem, in the thin film deposition assembly 100 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 more detail, deposition may be continuously performed while the substrate 500, which is disposed 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 500 is moved in a direction of arrow A in FIG. 7.

[0086] 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 more detail, 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, lengths of the patterning slit sheet 950 in the X-axis and Y-axis directions may be significantly less than the lengths of the substrate 500 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 used in aspects of 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 other subsequent processes, such as precise extension, welding, moving, and cleaning processes, compared using a larger FMM according to the conventional deposition method. Accordingly, the use of the patterning slit sheet 150 is more advantageous than the use of a conventional FMM for manufacturing a relatively large display device.

[0087] The deposition source 110, which contains and heats the deposition material 115, is disposed in an opposite side of the thin film deposition assembly 100 from a side in which the substrate 500 is disposed. When the deposition material 115 contained in the deposition source 110 is vaporized, the deposition material 115 is deposited on the substrate 500.

[0088] In particular, the deposition source 110 includes a crucible 112 that is filled with the deposition material 115, and a heater (not shown) that heats the crucible 112 to vaporize the deposition material 115 that is contained in the crucible 112, such that the deposition material 115 is directed towards the deposition source nozzle unit 120. The cooling block 111 prevents the radiation of heat from the crucible 112 to the outside, i.e., into the first chamber 731. The heater may be incorporated in the cooling block 111.

[0089] 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 500. The deposition source nozzle unit 120 includes a plurality of deposition source nozzles 121 arranged at equal intervals in the Y-axis direction, i.e., a scanning direction of the substrate 500. The deposition material 115 that is vaporized in the deposition source 110, passes through the deposition source nozzle unit 120 towards the substrate 500. As described above, when the deposition source nozzle unit 120 includes the plurality of deposition source nozzles 121 arranged in the Y-axis direction, that is, the scanning direction of the substrate 500, the size of a pattern formed of the deposition material discharged through the patterning slits 151 of the patterning slit sheet 150 is affected by the size of each of the deposition source nozzles 121 (since there is only one line of deposition nozzles in the X-axis direction), and thus no shadow zone may be formed on the substrate **500**. In addition, since the plurality of deposition source nozzles **121** are arranged in the scanning direction of the substrate **500**, even if there is a difference in flux between the deposition source nozzles **121**, the difference may be compensated for and deposition uniformity may be maintained constant.

[0090] 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 **500**. 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 **500**. 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 this regard, the total number of patterning slits **151** may be greater than the total number of deposition source nozzles **121**.

[0091] In addition, the deposition source **110** and the deposition source nozzle unit **120** coupled to the deposition source **110** may be disposed to be spaced apart from the patterning slit sheet **150** by a predetermined distance. Alternatively, the deposition source **110** and the deposition source nozzle unit **120** coupled to the deposition source **110** may be connected to the patterning slit sheet **150** by a first connection member **135**. That is, the deposition source **110**, the deposition source nozzle unit **120**, and the patterning slit sheet **150** may be integrally formed as one body by being connected to each other via the first connection member **135**. The first connection member **135** guides the deposition material **121**, which is discharged through the deposition source nozzles **921**, to move straight, not to deviate in the X-axis direction. In FIG. **7**, the first connection members **135** are formed on left and right sides of the deposition source **110**, the deposition source nozzle unit **120**, and the patterning slit sheet **150** to guide the deposition material **115** not to deviate in the X-axis direction; however, aspects of the present invention are not limited thereto. That is, the first connection member **135** may be formed as a sealed box to guide flow of the deposition material **915** both in the X-axis and Y-axis directions.

[0092] As described above, the thin film deposition assembly **100** according to the current embodiment of the present invention performs deposition while being moved relative to the substrate **500**. In order to move the thin film deposition assembly **100** relative to the substrate **500**, the patterning slit sheet **150** is spaced apart from the substrate **500** by a predetermined distance.

[0093] 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.

[0094] In order to overcome this problem, 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 spaced apart from the substrate **500** by a predetermined distance.

[0095] As described above, according to aspects 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 occur in the conventional deposition method, may be prevented. Furthermore, since it is unnecessary to dispose the FMM in close contact with the substrate during a deposition process, the manufacturing time may be reduced.

[0096] FIG. **10** is a perspective view of a thin film deposition assembly according to another embodiment of the present invention. Referring to FIG. **10**, 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**, and a patterning slit sheet **150**. In particular, the deposition source **110** includes a crucible **112** that is filled with the deposition material **115**, and a cooling block **111** including a heater that heats the crucible **112** to vaporize the deposition material **115** that is contained in the crucible **112**, so as to move the vaporized deposition material **115** to the deposition source nozzle unit **120**. The deposition source nozzle unit **120**, which has a planar shape, is disposed at a side of the deposition source **110**. The deposition source nozzle unit **120** includes a plurality of deposition source nozzles **121** arranged in the Y-axis direction. The patterning slit sheet **150** and a frame **155** are further disposed between the deposition source **110** and the substrate **500**. The patterning slit sheet **150** includes a plurality of patterning slits **151** arranged in the X-axis direction. In addition, the deposition source **110** and the deposition source nozzle unit **120** may be connected to the patterning slit sheet **150** by the second connection member **133**.

[0097] In the current embodiment, a plurality of deposition source nozzles **121** formed on the deposition source nozzle unit **120** are tilted at a predetermined angle, unlike the thin film deposition assembly described with reference to FIGS. **7** to **9**. In particular, the deposition source nozzles **121** may include deposition source nozzles **121***a* and **121***b* arranged in respective rows. The deposition source nozzles **121***a* and **121***b* may be arranged in respective rows to alternate in a zigzag pattern. The deposition source nozzles **121***a* and **121***b* may be tilted at a predetermined angle on an XZ plane.

[0098] In the current embodiment of the present invention, the deposition source nozzles **121***a* and **121***b* are arranged to tilt at a predetermined angle toward each other. The deposition source nozzles **121***a* in a first row and the deposition source nozzles **121***b* in a second row may tilt at the predetermined angle to face each other. That is, the deposition source nozzles **121***a* of the first row in a left part of the deposition source nozzle unit **120** may tilt to face a right side portion of the patterning slit sheet **150**, and the deposition source nozzles **121***b* of the second row in a right part of the deposition source nozzle unit **120** may tilt to face a left side portion of the patterning slit sheet **150**.

[0099] Due to the structure of the thin film deposition assembly **100** according to the current embodiment, the deposition of the deposition material **115** may be adjusted to lessen a thickness variation between the center and the end portions of the substrate **500** and improve thickness uniformity of the deposition film. Moreover, utilization efficiency of the deposition material **115** may also be improved.

[0100] FIG. **11** is a perspective view of a thin film deposition apparatus according to another embodiment of the present invention. Referring to FIG. **11**, the thin film deposition apparatus according to the current embodiment of the present invention includes a plurality of thin film deposition assemblies **100**, **200**, **300**, each of which has the structure of the thin film deposition assembly **100** illustrated in FIGS. **7** through **9**. In other words, the thin film deposition apparatus according to the current embodiment of the present invention may include a multi-deposition source that simultaneously discharges deposition materials for forming an R emission layer, a G emission layer, and a B emission layer.

[0101] In particular, the thin film deposition apparatus according to the current embodiment of the present invention includes a first thin film deposition assembly **100**, a second thin film deposition assembly **200**, and a third thin film deposition assembly **300**. Each of the first thin film deposition assembly **100**, the second thin film deposition assembly **200**, and the third thin film deposition assembly **300** has the same structure as the thin film deposition assembly described with reference to FIGS. **7** through **9**, and thus a detailed description thereof will not be repeated here.

[0102] The deposition sources **110** of the first thin film deposition assembly **100**, the second thin film deposition assembly **200** and the third thin film deposition assembly **300** may contain different deposition materials, respectively. The first thin film deposition assembly **100** may contain a deposition material for forming the R emission layer, the second thin film deposition assembly **200** may contain a deposition material for forming the G emission layer, and the third thin film deposition assembly **300** may contain a deposition material for forming the B emission layer.

[0103] 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 the current embodiment of the present invention is used, 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 a reduced number of chambers, so that equipment costs are also markedly reduced.

[0104] Although not illustrated, a patterning slit sheet of the first thin film deposition assembly **100**, a patterning slit sheet of the second thin film deposition assembly **200**, a patterning slit sheet of the third thin film deposition assembly **300** 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 **150**, **250** and **350** not to overlap on the substrate **400**. In other words, when the first thin film deposition assembly **100**, the second thin film deposition assembly **200**, and the third thin film deposition assembly **200** are used to deposit the R emission layer, the G emission layer and the B emission layer, respectively, patterning slits **151** of the first thin film deposition assembly **100**, patterning slits **251** of the second thin film deposition assembly **200**, and patterning slits **351** of the second thin film deposition assembly **300** are arranged not to be aligned with respect to each other, in order to form the R emission layer, the G emission layer and the B emission layer in different regions of the substrate **500**.

[0105] 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 of the respective first, second, and third thin film deposition assemblies **100**, **200**, and **300** may be set to be different.

[0106] Although the thin film deposition apparatus according to the current embodiment of the present invention includes three thin film deposition assemblies, the present invention is not limited thereto. In other words, a thin film deposition apparatus according to another embodiment of the present invention may include a plurality of thin film deposition assemblies, each of which contains a different deposition material. For example, a thin film deposition apparatus according to another embodiment of the present invention may include five thin film deposition assemblies respectively containing materials for an R emission layer, a G emission layer, a B emission layer, an auxiliary layer (R') of the R emission layer, and an auxiliary layer (G') of the G emission layer. Moreover, thin film deposition assemblies **100**, **200**, **300** may be located in a single deposition chamber **731** as shown in FIG. **1** or in separate deposition chambers **731** and **732** housed in a single deposition unit **730** as shown in FIG. **2** through which a circulating unit **610** conveys an electrostatic chuck **600** to which a substrate **500** is affixed.

[0107] 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.

[0108] FIG. **12** is a schematic perspective view of a thin film deposition assembly **100** according to an embodiment of the present invention, FIG. **13** is a schematic cross-sectional side view of the thin film deposition assembly **100** of FIG. **12**, and FIG. **14** is a schematic cross-sectional plan view of the thin film deposition assembly **100** of FIG. **12**.

[0109] Referring to FIGS. **12** through **14**, 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 patterning slits **151**.

[0110] Although a chamber is not illustrated in FIGS. **12** through **14** 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 **100**.

[0111] In the chamber in which the thin film deposition assembly **100** is disposed, the substrate **500**, which constitutes a deposition target on which the deposition material **115** is to be deposited, is transferred by the electrostatic chuck **600**. 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**. Other substrates may also be employed.

[0112] In an embodiment, the substrate **500** or the thin film deposition assembly **100** may be moved relative to the other.

For example, as illustrated in FIG. **12**, the substrate **500** may be moved in a direction of an arrow A, relative to the thin film deposition assembly **100**.

[0113] 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**, deposition is continuously performed, i.e., in a scanning manner, while the substrate **500** is moved in the Y-axis direction. Thus, a length of the patterning slit sheet **150** in the Y-axis direction may be significantly less than a length of the substrate **500** in the Y-axis direction. A width of the patterning slit sheet **150** in the X-axis direction and a width of the substrate **500** in the X-axis direction may be 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 each other.

[0114] 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 aspects of 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 other subsequent processes, such as precise extension, welding, moving, and cleaning processes, compared to the conventional deposition method using the larger FMM. Accordingly, the use of the patterning slit sheet **150** is more advantageous than the use of a conventional FMM for manufacturing a relatively large display device.

[0115] The deposition source **110** that contains and heats the deposition material **115** is disposed in an opposite side of the first chamber from the side in which the substrate **500** is disposed.

[0116] 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 **112** outside, i.e., into the first chamber. The cooling block **111** may include a heater (not shown) that heats the crucible **111**.

[0117] 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 **500**. 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 nozzles **121** of the deposition source nozzle unit **120** towards the substrate **500**, which constitutes a target on which the deposition material **115** is to be deposited.

[0118] The barrier plate assembly **130** is disposed at a side of the deposition source nozzle unit **120** between the deposition source nozzle unit **120** and the patterning slit sheet **150**. 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 a Y-Z plane in FIG. **12**, and may have a rectangular shape. 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. **14**). In the thin film deposition assembly **100** according to the current embodiment of the present invention, as illustrated in FIG. **14**, 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.

[0119] 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**. However, the present invention is not limited to this structure. For example, a plurality of deposition source nozzles **121** may be disposed between two adjacent barrier plates **131**. In this case, the deposition source nozzles **121** may be also respectively located at the midpoint between two adjacent barrier plates **131**.

[0120] 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, and not to deviate in the X-axis direction.

[0121] 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 **500** compared to a case where no barrier plates are installed. Thus, the thin film deposition assembly **100** and the substrate **500** can be spaced apart from each other by a predetermined distance. This will be described later in detail.

[0122] 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**, and prevents deviation of the deposition material in the Y-axis direction.

[0123] The deposition source nozzle unit **120** and the barrier plate assembly **130** may be separated from each other by a predetermined distance. This separation may prevent the heat radiated from the deposition source unit **110** from being conducted to the barrier plate assembly **130**. However, aspects of the present invention are not limited to this feature. For example, 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.

[0124] 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** of the thin film deposition apparatus 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 is not deposited on the substrate **500** 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** is present on 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, a reuse rate of the deposition material **115** is increased, so that the deposition efficiency is improved, and thus the manufacturing costs are reduced.

[0125] 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 **500**. 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 patterning slits **151** extend as openings in the Y-axis direction. The deposition material **115** that has been vaporized in the deposition source **110** and passed through the deposition source nozzle **121** passes through the patterning slits **151** towards the substrate **500**.

[0126] 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** into a stripe pattern.

[0127] In the thin film deposition assembly **100** according to the current embodiment of the present invention, 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**.

[0128] In addition, the barrier plate assembly **130** and the patterning slit sheet **150** may be disposed to be spaced apart from each other by a predetermined distance. Alternatively, the barrier plate assembly **130** and the patterning slit sheet **150** may be connected by a second connection member **133**. 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 separated from each other by a predetermined distance.

[0129] As described above, the thin film deposition assembly **100** according to the current embodiment of the present invention performs deposition while the thin film deposition assembly **100** or the substrate **500** is moved relative to the other. In order to move the thin film deposition assembly **100** relative to the substrate **500**, the patterning slit sheet **150** is spaced apart from the substrate **500** by a predetermined distance. 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 spaced 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 that may be formed on the substrate **500** is sharply reduced.

[0130] 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 become larger. However, it is not easy to manufacture such a large mask.

[0131] In order to overcome this problem, 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 spaced apart from the substrate **500** by a predetermined distance. The formation of a desirable deposition pattern may be facilitated by installing the barrier plates **131** to reduce the size of the shadow zone formed on the substrate **500**.

[0132] As described above, when the patterning slit sheet **150** is manufactured to be smaller than the substrate **500**, the patterning slit sheet **150** may be moved relative to the substrate **500** during deposition. Thus, it is no longer necessary to manufacture a large FMM as used in the conventional deposition method. In addition, since the substrate **500** and the patterning slit sheet **150** are spaced apart 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.

[0133] As shown in FIG. **12**, the thin film deposition assembly **100** may also include one or more alignment devices **170** and one or more alignment targets **159** that assist in alignment of the patterning slit sheet **150** with respect to the substrate **100**.

[0134] FIG. **15** is a schematic perspective view of a modified example of the thin film deposition assembly **100** of FIG. **12**.

[0135] Referring to FIG. **15**, the thin film deposition assembly **100** according to the current embodiment includes a deposition source **110**, a deposition source nozzle unit **120**, a first barrier plate assembly **130**, a second barrier plate assembly **140**, and a patterning slit sheet **150**.

[0136] Although a chamber is not illustrated in FIG. **15** 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 assembly **100**.

[0137] The substrate **500**, which constitutes a target on which a deposition material **115** is to be deposited, is disposed in the chamber. The deposition source **115** that contains and heats the deposition material **115** is disposed in an opposite side of the chamber to the side in which the substrate **500** is disposed.

[0138] Detailed structures of the deposition source **110** and the patterning slit sheet **150** are the same as those of FIG. **12** and thus, detailed descriptions thereof will not be repeated here. The first barrier plate assembly **130** is the same the barrier plate assembly **130** of FIG. **4** and thus, a detailed description thereof will not be repeated here.

[0139] The second barrier plate assembly **140** is disposed at a side of the first barrier plate assembly **130**. The second barrier plate assembly **140** includes a plurality of second barrier plates **141** and a second barrier plate frame **141** that constitutes an outer plate of the second barrier plates **142**.

[0140] The plurality of second barrier plates **141** may be arranged parallel to each other at equal intervals in the X-axis direction. In addition, each of the second barrier plates **141** may be formed to extend in the YZ plane in FIG. **11**, i.e., perpendicular to the X-axis direction.

[0141] The plurality of first barrier plates **131** and second barrier plates **141** arranged as described above partition the space between the deposition source nozzle unit **120** and the patterning slit sheet **150**. The deposition space is divided by the first barrier plates **131** and the second barrier plates **141** into sub-deposition spaces that respectively correspond to the deposition source nozzles **121** through which the deposition material **115** is discharged.

[0142] The second barrier plates **141** may be disposed to correspond to the first barrier plates **131**. The second barrier plates **141** may be respectively disposed to be parallel to and to be on the same plane as the first barrier plates **131**. Each pair of the corresponding first and second barrier plates **131** and **141** may be located on the same plane. Although the first barrier plates **131** and the second barrier plates **141** are respectively illustrated as having the same thickness in the Y-axis direction, aspects of the present invention are not limited thereto. The second barrier plates **141**, which may be accurately aligned with the patterning slit sheet **151**, may be formed to be relatively thin, whereas the first barrier plates **131**, which do not need to be precisely aligned with the patterning slit sheet **151**, may be formed to be relatively thick. This makes it easier to manufacture the thin film deposition assembly **100**.

[0143] As illustrated in FIG. **1**, a plurality of thin film deposition assemblies, which each have the same structure as the thin film deposition assembly **100** described above with respect to FIGS. **12** and **15**, may be successively disposed in the first chamber **731**. In this case, the thin film deposition assemblies **100**, **200**, **300** and **400** may be used to deposit different deposition materials, respectively. For example, the thin film deposition assemblies **100**, **200**, **300** and **400** may have different patterning slit patterns, so that pixels of different colors, for example, red, green and blue, may be simultaneously defined through a film deposition process. Moreover, the thin film deposition assemblies **100**, **200**, **300**, **400** may be located in a single deposition chamber **731** as shown in FIG. **1** or in separate deposition chambers **731** and **732** housed in a single deposition unit **730** as shown in FIG. **2** through which a circulating unit **610** conveys an electrostatic chuck **600** to which a substrate **500** is affixed.

[0144] FIG. **16** is a cross-sectional view of an active matrix organic light-emitting display device fabricated by using a thin film deposition apparatus, according to an embodiment of the present invention. It is to be understood that where is stated herein that one layer is "formed on" or "disposed on" a second layer, the first layer may be formed or disposed directly on the second layer or there may be intervening layers between the first layer and the second layer. 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.

[0145] Referring to FIG. **16**, the active matrix organic light-emitting display device according to the current embodiment is formed on a substrate **30**. The substrate **30** may be formed of a transparent material, such as, 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**.

[0146] A thin film transistor (TFT) **40**, a capacitor **50**, and an organic light-emitting diode (OLED) **60** are disposed on the insulating layer **31**, as illustrated in FIG. **16**.

[0147] 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.

[0148] 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**.

[0149] 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 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 passivation layer **34** so as to planarize the passivation layer **34**.

[0150] In addition, the OLED **60** displays predetermined image information by emitting red, green, or blue light according to a flow of current. The OLED **60** includes a first electrode **61** disposed on the passivation layer **34**. The first electrode **61** is electrically connected to the drain electrode **43** of the TFT **40**.

[0151] 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 organic light-emitting layer **63** is formed in a region defined by the opening **64**. A second electrode **62** is formed on the organic light-emitting layer **63**.

[0152] 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** in which the first electrode **61** is formed, and in particular, the surface of the passivation layer **34**.

[0153] The first electrode **61** and the second electrode **62** are insulated from each other, and respectively apply voltages of opposite polarities to the organic light-emitting layer **63** to induce light emission.

[0154] The organic light-emitting 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 organic light-emitting 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 (NPB), tris-8-hydroxyquinoline aluminum (Alq3), and the like.

[0155] An organic light-emitting layer **63** containing such low-molecular weight organic materials may be formed by depositing organic materials by vacuum deposition using one of the thin film deposition apparatuses described above with reference to FIGS. **1** through **15**. After the opening **64** is formed in the pixel defining layer **35**, the substrate **30** is transferred to the first chamber **731**, as illustrated in FIG. **1** or **2** (the substrate **30** is FIG. **16** may be a substrate **500** as shown in FIGS. **1** and **2**). Target organic materials are deposited by the first to forth thin film deposition assemblies **100** to **400**.

[0156] After the organic light-emitting layer **63** is formed, the second electrode **62** may be formed by the same deposition method as used to form the organic light-emitting layer **63**.

[0157] The first electrode **61** may function as an anode, and the second electrode **62** may function 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.

[0158] The first electrode **61** may be formed as a transparent electrode or a reflective electrode. A transparent electrode may be formed of indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium oxide (In_2O_3). 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 first electrode **61** may be formed by forming a layer by, for example, sputtering, and then patterning the layer by, for example, photolithography.

[0159] 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 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 light-emitting 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 compound thereof on the entire surface of the organic light-emitting layer **63**. The second electrode **62** may be formed by using the same deposition method as used to form the organic light-emitting layer **63** described above.

[0160] 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.

[0161] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A thin film deposition apparatus comprising:

an electrostatic chuck comprising a body that contacts a substrate that constitutes a deposition target and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body;

a plurality of chambers that are maintained in vacuum states;

at least one thin film deposition assembly disposed in one of the plurality of chambers, separated by a predetermined distance from the substrate, and positioned to form a thin film on the substrate supported by the electrostatic chuck; and

a carrier that moves the electrostatic chuck through the chambers.

2. The thin film deposition apparatus of claim **1**, wherein the battery is formed in the body.

3. The thin film deposition apparatus of claim **1**, wherein the carrier comprises:

a support that extends through the chambers;

a movement bar that engages the support and that supports edges of the electrostatic chuck; and

a driving unit disposed between the support and the movement bar to move the movement bar along the support.

4. The thin film deposition apparatus of claim **1**, 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; and

a patterning slit sheet disposed opposite to and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in a second direction perpendicular to the first direction,

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

the deposition source, the deposition source nozzle unit, and the patterning slit sheet are integrally formed as one body.

5. The thin film deposition apparatus of claim **4**, wherein the deposition source and the deposition source nozzle unit, and the patterning slit sheet are integrally connected as one body by a connection member that guides flow of the deposition material.

6. The thin film deposition apparatus of claim **5**, wherein the connection member seals a space between the deposition source nozzle unit disposed at the side of the deposition source, and the patterning slit sheet.

7. The thin film deposition apparatus of claim **4**, wherein the plurality of deposition source nozzles are tilted at a predetermined angle.

8. The thin film deposition apparatus of claim **7**, wherein the plurality of deposition source nozzles include deposition source nozzles arranged in two rows disposed in the first direction, and wherein each of the deposition source nozzles in each of the two rows is tilted at the predetermined angle toward a corresponding deposition source nozzle of the other of the two rows.

9. The thin film deposition apparatus of claim **7**, wherein the plurality of deposition source nozzles include deposition source nozzles arranged in two rows disposed in the first direction,

the deposition source nozzles of a row located at a first side of the patterning slit sheet are arranged to face a second side of the patterning slit sheet, and the deposition source nozzles of the other row located at the second side of the patterning slit sheet are arranged to face the first side of the patterning slit sheet.

10. The thin film deposition apparatus of claim **1**, 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 arranged in the first direction; and

a barrier plate assembly comprising 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 spaced apart from the substrate, and the thin film deposition assembly or the substrate fixedly engaged onto the electrostatic chuck is moved relative to the other.

11. The thin film deposition apparatus of claim **10**, wherein the plurality of barrier plates extend in a second direction substantially perpendicular to the first direction.

12. The thin film deposition apparatus of claim **10**, 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.

13. The thin film deposition apparatus of claim **12**, wherein each of the first barrier plates and each of the second barrier plates extend in a second direction substantially perpendicular to the first direction.

14. The thin film deposition apparatus of claim **13**, wherein the first barrier plates are arranged to respectively correspond to the second barrier plates.

15. The thin film deposition apparatus of claim **10**, wherein the deposition source and the barrier plate assembly are spaced apart from each other.

16. The thin film deposition apparatus of claim **10**, wherein the barrier plate assembly and the patterning slit sheet are spaced apart from each other.

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

fixing a substrate that constitutes a deposition target onto an electrostatic chuck, wherein the electrostatic chuck comprises a body that contacts the substrate and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body;

transferring the electrostatic chuck on which the substrate is fixedly engaged through a plurality of chambers that are maintained in a vacuum state; and

forming an organic layer on the substrate by depositing a deposition material from a thin film deposition assembly disposed in at least one of the chambers, wherein the electrostatic chuck on which the substrate is disposed or the thin film deposition assembly is moved relative to the other.

18. The method of claim **17**, wherein the battery is formed in the body.

19. The method of claim **17**, wherein the thin film deposition assembly comprises:

a deposition source that discharges the 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 and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in a second direction perpendicular to the first direction,

wherein the deposition source, the deposition source nozzle unit, and the patterning slit sheet are integrally formed as one body,

the thin film deposition assembly is spaced apart from the substrate, and

the depositing of the deposition material is performed while the substrate or the thin film deposition assembly is moved relative to the other in the first direction.

20. The method of claim **17**, wherein the thin film deposition assembly comprises:

a deposition source that discharges the 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 and spaced apart from the deposition source nozzle unit and including a plurality of patterning slits arranged in the first direction; and

a barrier plate assembly comprising a plurality of barrier plates that are disposed between the deposition source nozzle unit and the patterning slit sheet in the first direction, and 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 assembly spaced apart from the substrate, and the depositing of the deposition material is performed while the substrate or the thin film deposition assembly is moved relative to the other.

21. A thin film deposition apparatus comprising:

a loading unit that fixes a substrate on which a deposition material is to be deposited onto an electrostatic chuck, wherein the electrostatic chuck comprises a body that contacts the substrate and that includes a supporting surface that fixedly engages the substrate by an electrostatic force, an electrode installed in the body to generate the electrostatic force on the supporting surface, and a battery that is electrically connected to the electrode in the body;

a deposition unit comprising one or more chambers and at least one thin film deposition assembly disposed in the one or more chambers to deposit a deposition material on the substrate fixed on the electrostatic chuck;

an unloading unit that removes the substrate on which deposition has been performed from the electrostatic chuck;

a first circulating unit including a first carrier that sequentially moves the electrostatic chuck from the loading unit through the one or more chambers of the deposition unit, and from the deposition unit to the unloading unit; and

a second circulating unit including a second carrier that returns the electrostatic chuck from which the substrate has been removed by the unloading unit, to the loading unit.

22. The thin film deposition apparatus of claim **21**, wherein the battery is formed in the body.

23. The thin film deposition apparatus of claim **21**, wherein the first carrier comprises:

a support that extends through the one or more chambers;

a movement bar that engages the support and that supports edges of the electrostatic chuck; and

a driving unit disposed between the support and the movement bar to move the movement bar along the support.

24. The thin film deposition apparatus of claim **21**, wherein the second carrier comprises:

a support that extends between the unloading unit the loading unit at an exterior of the deposition unit;

a movement bar that engages the support and that supports edges of the electrostatic chuck; and

a driving unit disposed between the support and the movement bar to move the movement bar along the support.

* * * * *

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