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

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

(52) **U.S. Cl.**
CPC ***C23C 16/545*** (2013.01); ***C23C 14/042*** (2013.01); ***C23C 14/56*** (2013.01); *H01L 51/0011* (2013.01)

(58) **Field of Classification Search**
CPC H01L 51/56; H01L 51/44
See application file for complete search history.

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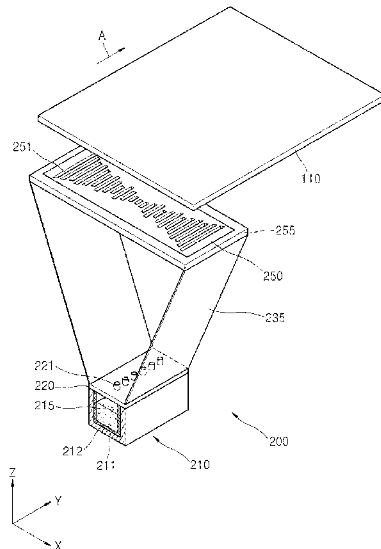
(57) **ABSTRACT**

Disclosed is a thin film deposition apparatus and a method of manufacturing an organic light-emitting display apparatus by using the thin film deposition apparatus. The thin film deposition apparatus and the method of manufacturing the organic light-emitting display apparatus using the thin film deposition apparatus reduce manufacturing time and cost.

5 Claims, 6 Drawing Sheets



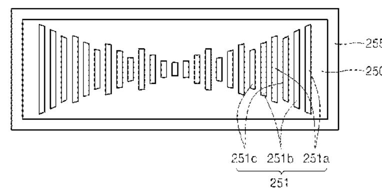


FIG. 1

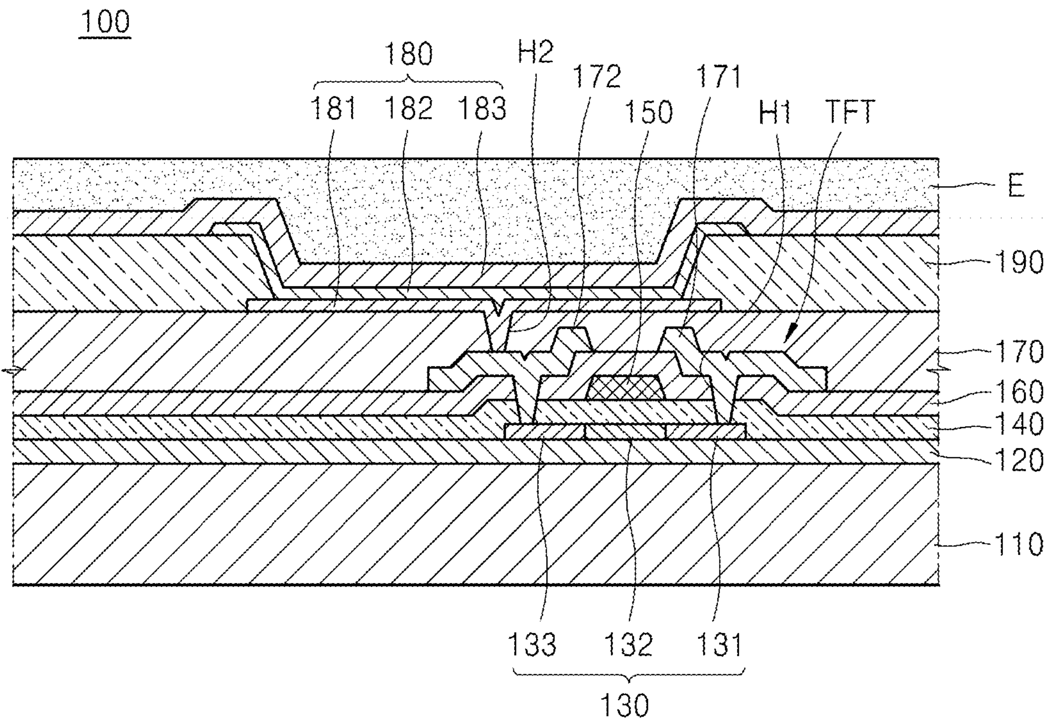


FIG. 2

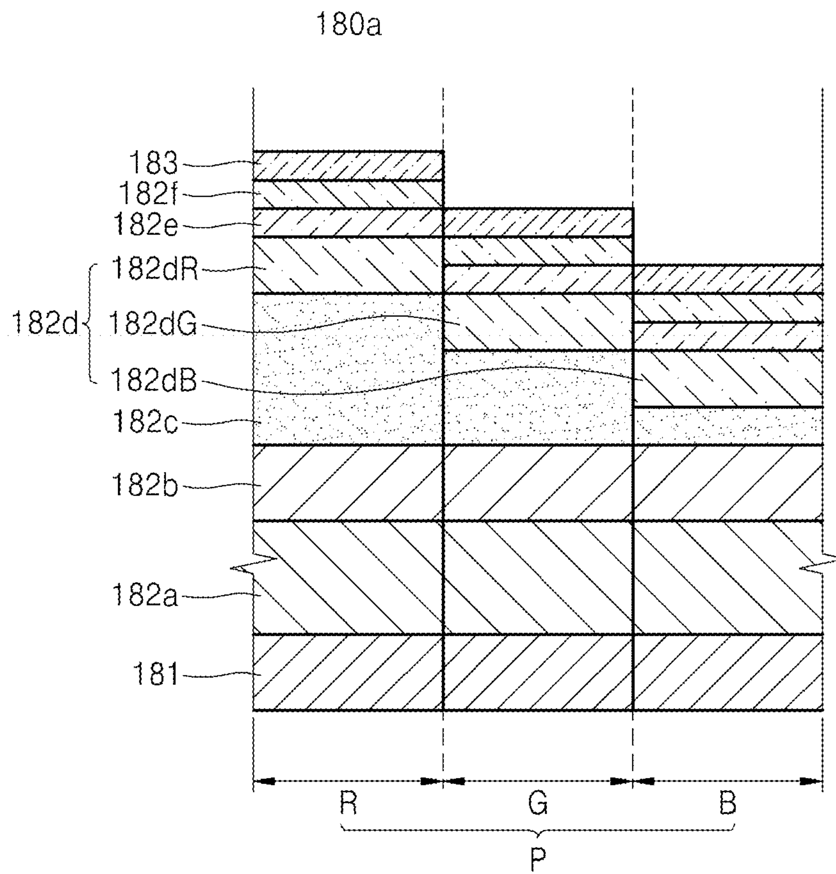


FIG. 3

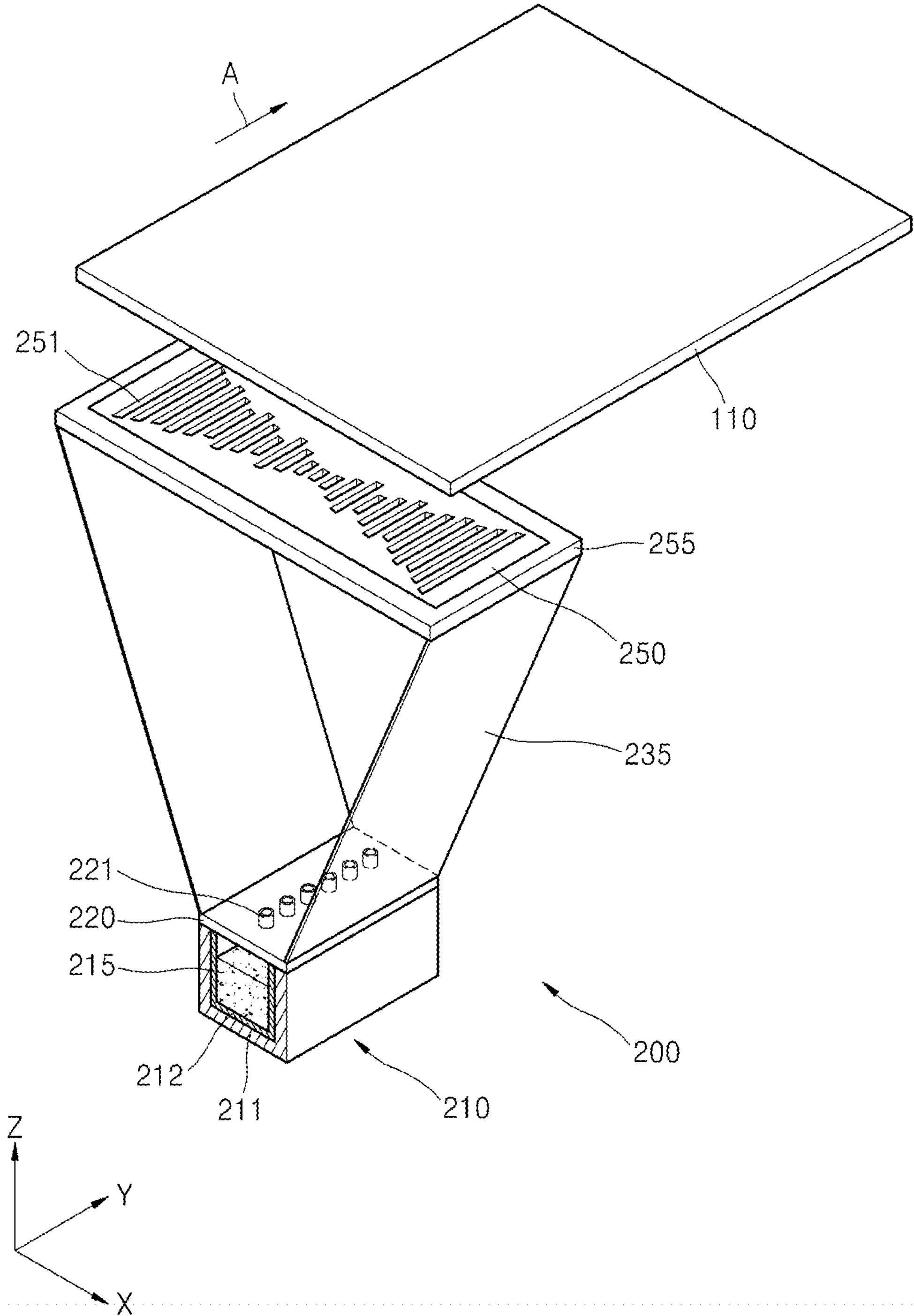


FIG. 4

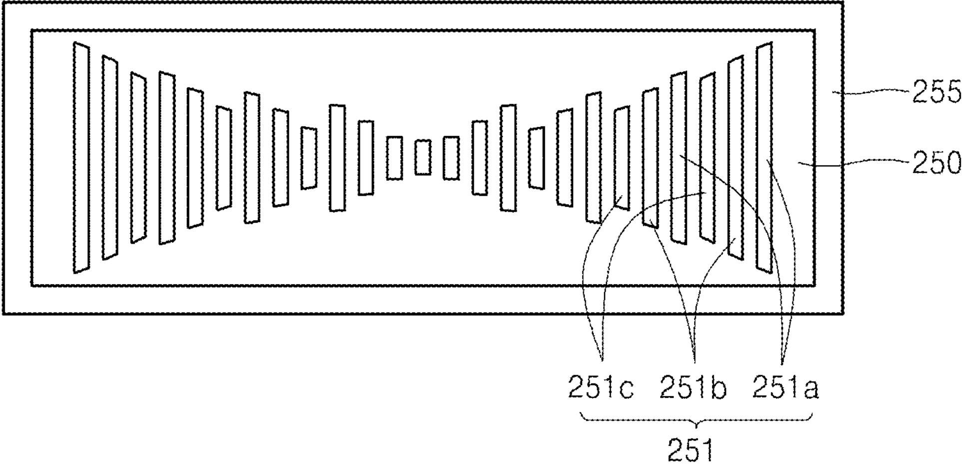


FIG. 5

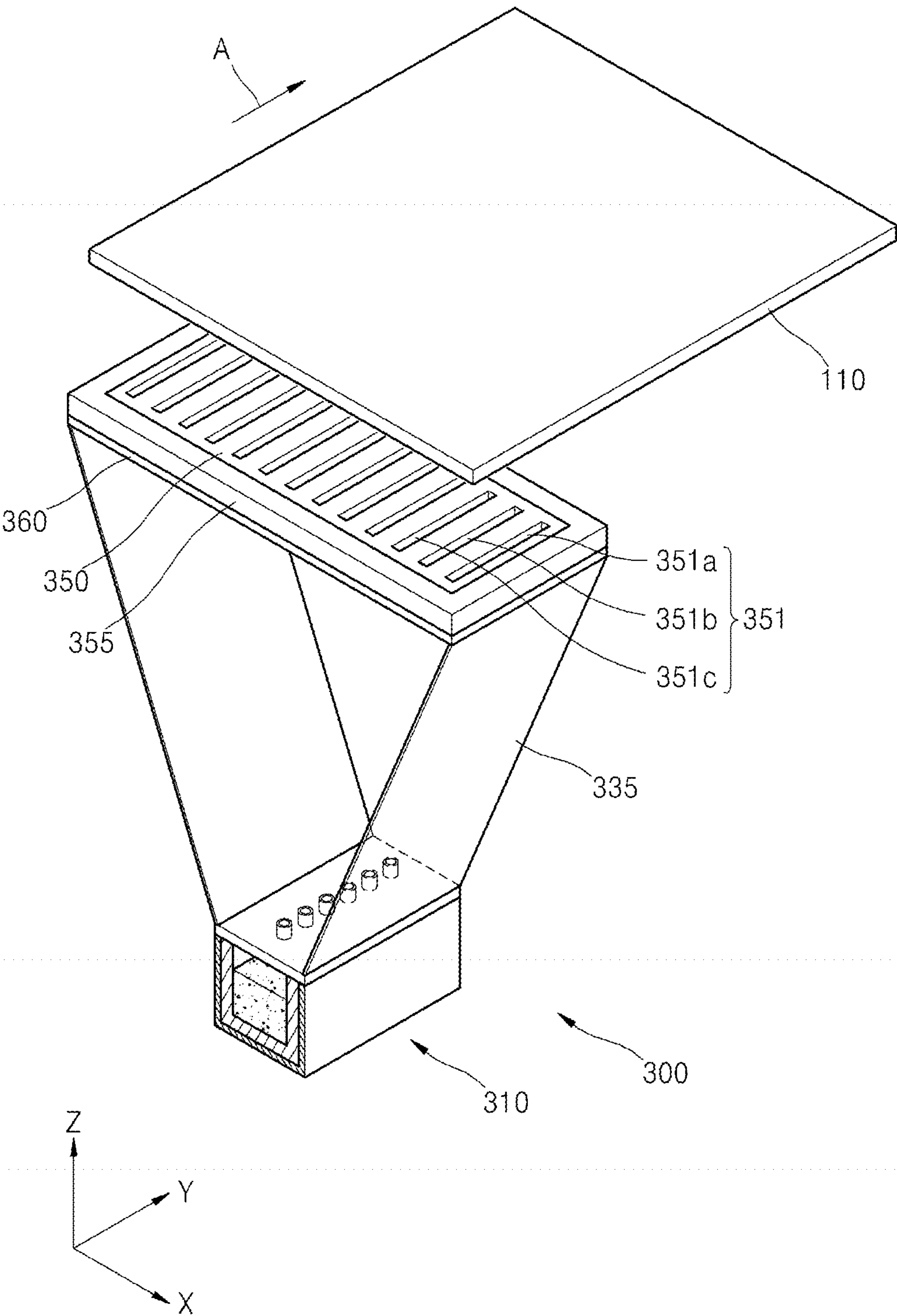
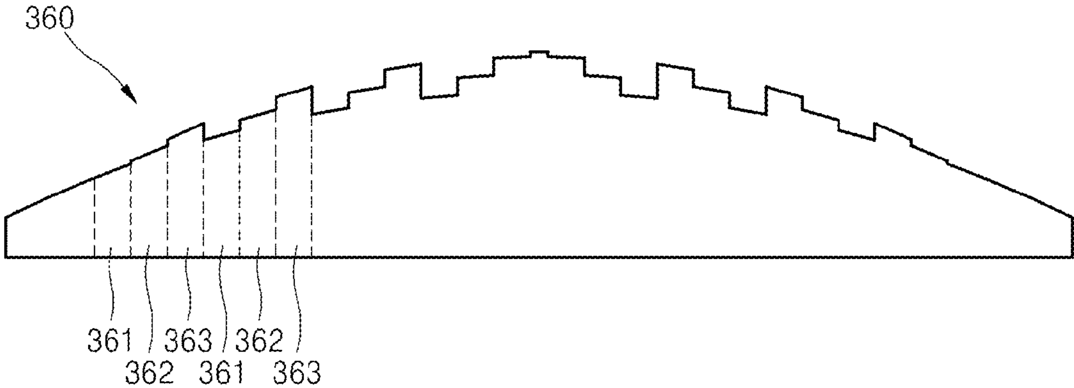


FIG. 6



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

RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 10-2014-0084622, filed on Jul. 7, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

One or more embodiments of the present invention relate to a thin film deposition apparatus and a method of manufacturing an organic light-emitting display apparatus by using the thin film deposition apparatus.

2. Description of the Related Art

Organic light-emitting display devices have wider viewing angles, better contrast characteristics, and faster response speeds than other display devices, and thus have drawn attention as next-generation display devices.

An organic light-emitting display device includes intermediate layers (including an emission layer) disposed between a first electrode and a second electrode. The electrodes and the intermediate layers may be formed using various methods, one of which is an independent 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 that of an organic layer to be formed is disposed to closely contact a substrate on which the organic layer and the like are formed, and an organic layer material is deposited on the FMM to form the organic layer having the desired pattern.

However, the deposition method using such an FMM presents difficulties in manufacturing larger organic light-emitting display devices using a large mother glass. For example, when a large mask is used, the mask may bend due to the weight thereof, thereby distorting a pattern. Such disadvantages are not conducive to the recent trend towards a high-definition pattern.

Moreover, processes of aligning a substrate and an FMM to closely contact each other, performing deposition thereon, and separating the FMM from the substrate are time-consuming, resulting in a long manufacturing time and low production efficiency.

Information disclosed in this Background section is known to the inventors of the present invention before achieving the present invention or is technical information acquired in the process of achieving the present invention. As such, the foregoing discussions are to provide general background information and do not constitute an admission of the prior art.

SUMMARY

One aspect of the invention provides a thin film deposition apparatus for forming a thin film on a substrate, the thin film deposition apparatus comprising: a deposition source configured to contain a deposition material; a deposition source nozzle unit disposed at one side of the deposition source and comprising a plurality of deposition source nozzles; and a mask disposed to face the deposition source, and comprising a plurality of patterning slits through which the deposition material passes to be deposited onto a substrate to form a plurality of sub-pixels, wherein the plurality of patterning slits comprise a first patterning slit through which the deposition material passes for forming a first one of the plurality of sub-pixels, a second patterning slit through which the deposition material passes for forming a second one of the plurality of sub-pixels, and a third patterning slit through which the deposition material passes for forming a third one of the plurality of sub-pixels, and wherein the first patterning slit has a first length extending along the moving direction, and the second patterning slit has a second length extending along the moving direction and substantially different from the first length.

In the foregoing apparatus, the mask may comprise a first sheet comprising a plurality of uniform slits having a substantially same length and a second sheet comprising a hole having a contour, the second sheet overlapping the first sheet and configured to block a portion of each of the uniform slits such that the first sheet and the second sheet collectively form the first, second and third patterning slits. The second sheet may comprise a first shielding unit configured to shield at least a part of a first one of the uniform slits, a second shielding unit configured to shield at least a part of a second one of the uniform slits, and a third shielding unit configured to shield at least a part of a third one of the uniform slits.

Still in the foregoing apparatus, the mask may comprise a single sheet comprising the first patterning slit, the second patterning slit, and the third patterning slit. The first sub-pixel may comprise an intermediate layer comprising an organic emission layer configured to emit red light, the second sub-pixel comprises an intermediate layer comprising an organic emission layer configured to emit green light, and the third sub-pixel comprises an intermediate layer comprising an organic emission layer configured to emit blue light. The first length may be greater than the second length. The third patterning slit has a third length extending along the moving direction, wherein the second length may be greater than the third length.

Yet in the foregoing apparatus, the plurality of patterning slits may comprise an additional first patterning slit spaced apart from the first patterning slit, wherein the first patterning slit is located closer to a center of the mask than the additional, first patterning slit which is longer than the first patterning slit. The plurality of patterning slits may comprise an additional second patterning slit spaced apart from the second patterning slit, wherein the second patterning slit is located closer to a center of the mask than the additional second patterning slit which is longer than the second patterning slit. The plurality of patterning slits may comprise an additional third patterning slit spaced apart from the third patterning slit, wherein the third patterning slit may be located closer to a center of the mask than the additional third patterning slit which is longer than the third patterning slit.

Further in the foregoing apparatus, at least one end of each of the first patterning slit, the second patterning slit, and the third patterning slit may be formed in a circular arc or cosine curve shape. An amount of the deposition material to be deposited on the substrate may be controlled according to the length of each of the first through third patterning slits. One of the thin film deposition apparatus or the substrate moves relative to the other.

Another aspect of the invention provides a method of manufacturing an organic light-emitting display device, the method comprising: providing a thin film deposition apparatus; positioning a substrate such that the substrate is spaced apart from the thin film deposition apparatus; and

depositing a deposition material onto the substrate by discharging the deposition material from the thin film deposition apparatus onto the substrate while moving one of the thin film deposition apparatus or the substrate relative to the other along a moving direction, wherein the depositing of the deposition material discharged from the thin film deposition apparatus onto the substrate comprises: depositing the deposition material through a plurality of patterning slits onto the substrate to form a plurality of sub-pixels, each of which corresponds to one of the plurality of patterning slits, wherein the plurality of patterning slits comprise a first patterning slit through which the deposition material passes for forming a first one of the plurality of sub-pixels, a second patterning slit through which the deposition material passes for forming a second one of the plurality of sub-pixels, and a third patterning slit through which the deposition material passes for forming a third one of the plurality of sub-pixels, and wherein the first patterning slit has a first length extending along the moving direction, and the second patterning slit has a second length extending along the moving direction and substantially different from the first length.

In the foregoing method, the first sub-pixel may comprise an intermediate layer comprising an organic emission layer that is configured to emit red light, the second sub-pixel comprises an intermediate layer comprising an organic emission layer that is configured to emit green light, and the third sub-pixel comprises an intermediate layer comprising an organic emission layer that is configured to emit blue light. The third patterning slit has a third length extending along the moving direction, wherein the first length may be greater than the second length which is greater than the third length. The plurality of patterning slits may comprise an additional first patterning slit for forming another first sub-pixel, an additional second patterning slit for forming another second subpixel, and an additional third patterning slit for forming another third sub-pixel, wherein the first, second and third patterning slits are located closer to a center of a patterning slit sheet comprising the plurality of patterning slits than the additional first, second and third patterning slits, respectively, and the first, second and third patterning slits are shorter than the additional first, second and third patterning slits, respectively. An amount of the deposition material deposited on the substrate is controlled according to the length of each of the first through third patterning slits.

One or more embodiments of the present invention include a thin film deposition apparatus and a method of manufacturing an organic light-emitting display apparatus by using the thin film deposition apparatus.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

According to one or more embodiments of the present invention, a thin film deposition apparatus for forming a thin film on a substrate includes: a deposition source for discharging deposition materials; a deposition source nozzle unit disposed at one side of the deposition source and including a plurality of deposition source nozzles; and a patterning slit sheet disposed to face the deposition source, and including a plurality of patterning slits through which the deposition materials to be deposited onto a plurality of sub-pixels that form a pixel pass, wherein the plurality of patterning slits include a first patterning slit through which deposition materials that form a first sub-pixel pass, a second patterning slit through which deposition materials that form a second sub-pixel pass, and a third patterning slit through which deposition materials that form a third sub-pixel pass, and wherein at least two of a length of a passage area of the first patterning slit through which the deposition materials that form the first sub-pixel pass, a length of a passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass, and a length of a passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass are differently formed.

At least two of a length of the first patterning slit, a length of the second patterning slit, and a length of the third patterning slit may be differently formed such that the at least two of the length of the passage area of the first patterning slit through which the deposition materials that form the first sub-pixel pass, the length of the passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass, and the length of the passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass are differently formed.

The thin film deposition apparatus may further include: a correction plate disposed between the deposition source nozzle unit and the patterning slit sheet and for blocking at least a part of the deposition materials discharged from the deposition source, wherein the correction plate shields at least a part of the plurality of patterning slits such that the at least two of the length of the passage area of the first patterning slit through which the deposition materials that form the first sub-pixel pass, the length of the passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass, and the length of the passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass are differently formed.

The first sub-pixel may include an intermediate layer including an organic emission layer that emits red light, the second sub-pixel includes an intermediate layer including an organic emission layer that emits green light, and the third sub-pixel includes an intermediate layer including an organic emission layer that emits blue light.

The length of the passage area of the first patterning slit through which the deposition materials that form the first sub-pixel pass may be greater than the length of the passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass.

The length of the passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass may be greater than the length of the passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass.

The at least one first patterning slit may be a plurality of first patterning slits which are spaced apart from each other, wherein each of the plurality of first patterning slits is spaced further apart from a center of the patterning slit sheet as length of a passage area increases.

The second patterning slit may include a plurality of second patterning slits which are spaced apart from each other, wherein the greater the lengths of passage areas of the plurality of second patterning slits, the farther away from a center the patterning slit sheet.

The third patterning slit may include a plurality of third patterning slits which are spaced apart from each other, wherein the greater the lengths of passage areas of the plurality of third patterning slits, the farther away from a center the patterning slit sheet.

At least one of one end of the passage area of the first patterning slit, one end of the passage area of the second

patterning slit, and one end of the passage area of the third patterning slit may be formed in a circular arc or cosine curve shape.

An amount of the deposition materials deposited on the substrate may be controlled according to the length of the passage area of each of the first through third patterning slits.

The correction plate may include a plurality of first patterning slit shielding units that shield at least a part of the first patterning slit, and are spaced apart from each other, wherein each of the plurality of first patterning slit shielding units is spaced further apart from a center of the patterning slit sheet as length of a passage area is increased.

The correction plate may include a plurality of second patterning slit shielding units that shield at least a part of the second patterning slit, and are spaced apart from each other, wherein the greater the lengths of passage areas of the plurality of second patterning slit'shielding units, the farther away from a center the patterning slit sheet.

The correction plate may include a plurality of third patterning slit shielding units that shield at least a part of the third patterning slit, and are spaced apart from each other, wherein the greater the lengths of passage areas of the plurality of third patterning slit shielding units, the farther away from a center the patterning slit sheet.

One of the thin film deposition apparatus or the substrate may move relative to the other.

According to one or more embodiments of the present invention, a method of manufacturing an organic light-emitting display device by using a thin film deposition apparatus for forming a thin film on a substrate includes: positioning the substrate such that the substrate is spaced apart from the thin film deposition apparatus; and depositing deposition materials onto the substrate by discharging the deposition materials from the thin film deposition apparatus onto the substrate while moving one of the thin film deposition apparatus or the substrate relative to the other, wherein the depositing of the deposition materials discharged from the thin film deposition apparatus onto the substrate includes: depositing the deposition materials, through a plurality of patterning slits, onto a plurality of sub-pixels that form a pixel, wherein the plurality of patterning slits include a first patterning slit through which deposition materials that form a first sub-pixel pass, a second patterning slit through which deposition materials that form a second sub-pixel pass, and a third patterning slit through which deposition materials that form a third sub-pixel pass, and wherein at least two of a length of a passage area of the first patterning slit through which the deposition materials form the first sub-pixel pass, a length of a passage area of the second patterning slit through which the deposition materials that form the second sub-pixel pass, and a length of a passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass are differently formed.

The first sub-pixel may include an intermediate layer including an organic emission layer that emits red light, the second sub-pixel includes an intermediate layer including an organic emission layer that emits green light, and the third sub-pixel includes an intermediate layer including an organic emission layer that emits blue light.

The length of the passage area of the first patterning slit through which the deposition materials form the first sub-pixel pass may be greater than the length of the passage area of the second patterning slit through which the deposition materials that form the first sub-pixel pass, or the length of the passage area of the second patterning slit through which the deposition materials form the second sub-pixel pass is greater than the length of the passage area of the third patterning slit through which the deposition materials that form the third sub-pixel pass.

The at least one first patterning slit may be a plurality of first patterning slits, the at least one second patterning slit may be a plurality of second patterning slits, and the at least one third patterning slit may be a plurality of third patterning slits, wherein at least one of lengths of passage areas of the plurality of first patterning slits, lengths of passage areas of the plurality of second patterning slits, and lengths of passage areas of the plurality of third patterning slits increases from a center of the patterning slit sheet to the outside.

An amount of the deposition materials deposited on the substrate may be controlled according to the length of the passage area of each of the first through third patterning slits.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a cross-sectional view of a sub-pixel of an organic light-emitting display apparatus according to an embodiment of the present invention;

FIG. **2** is a cross-sectional view for comparing relative thicknesses of pixels of an organic light-emitting display apparatus of FIG. **1**;

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

FIG. **4** is a plan view of a patterning slit sheet of FIG. **3**;

FIG. **5** is a perspective view of a thin film deposition apparatus according to another embodiment of the present invention; and

FIG. **6** is a plan view of a correction plate of FIG. **5**.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

It will be understood that although the terms "first", "second", etc. may be used herein to describe various components, these components should not be limited by these terms. These components are only used to distinguish one component from another.

As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

It will be further understood that the terms "comprises" and/or "comprising" used herein specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

It will be understood that when a layer, region, or component is referred to as being "formed on," another layer, region, or component, it can be directly or indirectly formed on the other layer, region, or component. That is, for example, intervening layers, regions, or components may be present.

Sizes of elements in the drawings may be exaggerated for convenience of explanation. In other words, since sizes and thicknesses of components in the drawings are arbitrarily illustrated for convenience of explanation, the following embodiments are not limited thereto.

In the following examples, the x-axis, the y-axis and the z-axis are not limited to three axes of the rectangular coordinate system, and may be interpreted in a broader sense. For example, the x-axis, the y-axis, and the z-axis may be perpendicular to one another, or may represent different directions that are not perpendicular to one another.

When a certain embodiment may be implemented differently, a specific process order may be performed differently from the described order. For example, two consecutively described processes may be performed substantially at the same time or performed in an order opposite to the described order.

FIG. **1** is a cross-sectional view of a sub-pixel of an organic light-emitting display apparatus **100** according to an embodiment of the present invention. FIG. **2** is a cross-sectional view for comparing relative thicknesses of pixels of an organic light-emitting display apparatus **100** of FIG. **1**.

Referring to FIGS. **1** and **2**, the organic light-emitting display apparatus **100** may include a first substrate **110** and an emission unit. The organic light-emitting display apparatus **100** may include a thin film encapsulation layer E formed on the emission unit or a second substrate. In this regard, the second substrate is the same as or similar to that used in a general organic light-emitting display apparatus, and thus a detailed description thereof is omitted. For convenience of description, the thin film encapsulation layer E of the organic light-emitting display apparatus **100** will be described in more detail below.

The emission unit may be formed on the first substrate **110**. In this regard, the emission unit may include a thin film transistor TFT. A passivation layer **170** covering the emission unit and the thin film transistor TFT may be formed. An organic light-emitting device (OLED) **180** may be formed on the passivation layer **170**.

In this regard, the first substrate **110** may use a glass material but is not limited thereto. The first substrate **110** may use a plastic material and a metal material such as stainless steel and Ti. The first substrate **10** may use polyimide (PI). For convenience of description, a case where the first substrate **110** uses the glass material will be described in more detail below.

A buffer layer **120** formed of an organic compound and/or an inorganic compound is further formed on the first substrate **110**, and may be formed of SiOx ($x \geq 1$) and SiNx ($x \geq 1$).

An active layer **130** in a predetermined pattern is formed on the buffer layer **120** and then is buried by a gate insulating layer **140**. The active layer **130** includes a source area **131** and a drain area **133** and further a channel area **132** therebetween.

The active layer **130** may be formed to contain various materials. For example, the active layer **130** may contain an inorganic semiconductor material such as amorphous silicon or crystalline silicon. As another example, the active layer **130** may contain an oxide semiconductor. As another example, the active layer **130** may contain an organic semiconductor material. However, for convenience of description, a case where the active layer **130** is formed of the amorphous silicon will be described in more detail below.

The active layer **130** may be formed by forming an amorphous silicon layer on the buffer layer **120**, crystallizing the amorphous silicon layer, forming a polycrystalline silicon layer, and patterning the polycrystalline silicon layer. The source area **131** and the drain area **133** of the active layer **130** may be doped with impurities according to a type of the thin film transistor TFT such as a driving thin film transistor TFT, a switching thin film transistor TFT, etc.

A gate electrode **150** corresponding to the active layer **130** and an interlayer insulating layer **160** burying the gate electrode **150** are formed on the gate insulating layer **140**.

The interlayer insulating layer **160** and the gate insulating layer **140** are formed in a contact hole H**1**, and then a source electrode **171** and a drain electrode **172** are formed on the interlayer insulating layer **160** such that the source electrode **171** and the drain electrode **172** may respectively contact the source area **131** and the drain area **133**.

The passivation layer **170** is formed on the thin film transistor TFT formed above. A pixel electrode **181** of the OLED **180** is formed on the passivation layer **170**. The pixel electrode **181** contacts the drain electrode **172** of the thin film transistor TFT by a via hole H**2** formed in the passivation layer **170**. The passivation layer **170** may be formed of an inorganic material and/or an organic material and may have a single layer or two or more layer structure. The passivation layer **170** may be formed as a planarization layer to make an upper surface thereof planar irrespective of a curve of a layer of a lower portion, whereas the passivation layer **170** may be formed to be curved along the curve of the layer of the lower portion. The passivation layer **170** may be formed as a transparent insulator so as to achieve a resonance effect.

After the pixel electrode **181** is formed on the passivation layer **170**, a pixel defining layer **190** is formed of an organic material and/or an inorganic material so as to cover the pixel electrode **181** and the passivation layer **170**, and is open such that the pixel electrode **181** is exposed.

An intermediate layer **182** and a facing electrode **183** are formed on at least the pixel electrode **181**.

The pixel electrode **181** functions as an anode and the facing electrode **183** functions as a cathode. The polarities of the pixel electrode **181** and the facing electrode **183** may also be switched.

The pixel electrode **181** and the facing electrode **183** are insulated from each other by the intermediate layer **182**. An organic emission layer **182*d*** emits light by applying voltages having different polarities to the intermediate layer **182**.

The intermediate layer **182** includes the organic emission layer **182*d***. In another example, the intermediate layer **182** includes the organic emission layer **182*d*** and may further include at least one of a hole injection layer (HIL) **182*a***, a hole transport layer (HTL) **182*b***, an electron transport layer (ETL) **182*e***, and an electron injection layer (EIL) **182*f***. However, the present embodiment is not limited thereto, and the intermediate layer **182** includes the organic emission layer **182*d*** and may further include other various functional layers **182*c***. In this regard, the functional layers **182*c*** may be formed in various ways. For example, the functional layers **182*c*** may include an emission supplemental layer that supplements emission. The functional layers **182*c*** may include an auxiliary layer that may increase emission efficiency, color purity, etc. In this regard, the auxiliary layer may be formed of the same material as that of the HTL **182*b***.

In the meantime, a unit pixel P includes a plurality of sub-pixels R, G, and B that may emit lights of various colors. For example, the sub-pixels R, G, and B may emit lights of red, green, and blue colors, respectively. In embodiments, the sub-pixels may emit lights of red, green, blue, and white colors.

The sub-pixels R, G, and B may include the intermediate layer **182** including organic emission layers that emit lights of various colors. For example, each of the sub-pixels R, G, and B includes the intermediate layer **182** including the organic emission layers that emit lights of red, green, and blue colors. However, for convenience of description, the first sub-pixel R that emits red light, the second sub-pixel G that emits green light, and the third sub-pixel B that emits blue light will be described in detail below. For convenience of description, a case where the first sub-pixel R includes a first intermediate layer including a first organic emission layer **182***d*-R that emits the red light, the second sub-pixel G includes a second intermediate layer including a second organic emission layer **182***d*-G that emits the green light, and the third sub-pixel B includes a third intermediate layer including a third organic emission layer **182***d*-B that emits the blue light will be described in detail below.

The first intermediate layer, the second intermediate layer, and the third intermediate layer may be formed to have different thicknesses. For example, at least two of the first intermediate layer, the second intermediate layer, and the third intermediate layer may have different thicknesses. In particular, a thickness of the first intermediate layer may be greater than that of the second intermediate layer. A thickness of the second intermediate layer may be greater than that of the third intermediate layer. In this regard, such different thicknesses may correct an optical thickness of each sub-pixel.

A method of correcting the optical thickness may be performed in various ways. For example, thicknesses of layers that are commonly shared by the first through third intermediate layers may be differently formed or the functional layers **182***c* may be formed in lower sides of the first through third organic emission layers **182***d*-R, **182***d*-G, and **182***d*-B. However, for convenience of description, a case where thicknesses of the functional layers **182***c* that are commonly shared by the first through third intermediate layers may be differently formed will be described in detail below.

In the meantime, the thin film encapsulation layer E may include a plurality of inorganic layers or an inorganic layer and an organic layer.

The organic layer of the thin film encapsulation layer E may be formed of polymer, and may be a single layer or a layer stack formed of any one of polyethylene terephthalate, polyimide, polycarbonate, epoxy, polyethylene, and polyacrylate. The organic layer may be formed of polyacrylate, and in detail, may include a polymerized monomer composition including diacrylate-based monomer and triacrylate-based monomer. The monomer composition may further include monoacrylate-based monomer. Also, the monomer composition may further include a well-known photoinitiator such as trimethyl benzoyl diphenyl phosphine oxide (TPO), but embodiments of the present invention are not limited thereto.

The inorganic layer of the thin film encapsulation layer E may be a single layer or a layer stack including a metal oxide or a metal nitride. In detail, the inorganic layer may include any one of SiNx, Al_2O_3, SiO_2, and TiO_2. The top layer of the thin film encapsulation layer E that is exposed to the outside may be formed of an inorganic layer in order to prevent intrusion of moisture into the organic light-emitting device. The thin film encapsulation layer E may include at least one sandwich structure in which at least one organic layer is inserted between at least two inorganic layers. In another example, the thin film encapsulation layer E may include at least one sandwich structure in which at least one inorganic layer is inserted between at least two organic layers. In another example, the thin film encapsulation layer E may include a sandwich structure in which at least one organic layer is inserted between at least two inorganic layers and a sandwich structure in which at least one inorganic layer is inserted between at least two organic layers.

The thin film encapsulation layer E may include a first inorganic layer, a first organic layer, and a second inorganic layer sequentially formed from the top portion of the OLED **180**. In another example, the thin film encapsulation layer E may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, and a third inorganic layer sequentially formed from the top portion of the OLED **180**. In another example, the thin film encapsulation layer E may include a first inorganic layer, a first organic layer, a second inorganic layer, a second organic layer, a third inorganic layer, a third organic layer, and a fourth inorganic layer sequentially formed from the top portion of the OLED **180**. A halogenized metal layer including lithium fluoride (LiF) may be additionally included between the OLED **180** and the first inorganic layer. The halogenized metal layer may prevent the OLED **180** from being damaged when the first inorganic layer is formed in a sputtering method or a plasma deposition method.

The first organic layer may be smaller than the second inorganic layer, and the second organic layer may be smaller than the third inorganic layer.

In the meantime, a method of forming the intermediate layer **182** by using a thin film deposition apparatus will be described in detail below.

FIG. **3** is a perspective view of a thin film deposition apparatus **200** according to an embodiment of the present invention. FIG. **4** is a plan view of a patterning slit sheet of FIG. **3**.

Referring to FIGS. **3** and **4**, the thin film deposition apparatus **200** includes a deposition source **210**, a deposition source nozzle unit **220**, a patterning slit sheet **250**, and a connection member **235**.

In this regard, all elements illustrated in FIGS. **3** and **4** may be arranged in a chamber in which an appropriate vacuum state is maintained. This is to achieve the linearity of a deposition material.

In more detail, in order to allow a deposition material **215** discharged from the deposition source **210** to pass through the deposition source nozzle unit **220** and the patterning slit sheet **250** and to be deposited on the substrate **110** as a desired pattern, the inside of a chamber basically needs to maintain the same high vacuum state as in a method of depositing a fine metal mask (FMM). Temperatures of the patterning slit sheet **250** and the connection member **235** also need to be sufficiently lower (below about 100° C.) than that of the deposition source **210** in order to maintain a high vacuum state in a space between the deposition source nozzle unit **220** and the patterning slit sheet **250**. If the temperature of the patterning slit sheet **250** is sufficiently low as described above, since the deposition material **215** that is discharged in an unintended direction is absorbed onto a surface of the connection member **235** and the high vacuum state is maintained, no collision between deposition materials occurs, thereby achieving the linearity of the deposition material **215**.

The substrate **110** that is a deposition target is disposed in the chamber. The substrate **110** may be a substrate for a flat panel display device. A large substrate for manufacturing a plurality of flat panel displays may be used as the substrate **110**.

In this regard, a deposition process may be performed while relatively moving the substrate **110** to the thin film deposition apparatus **200**.

In more detail, in a conventional deposition method using an FMM, the size of the FMM needs to be the same as that of a substrate. Thus, as the size of the substrate increases, the FMM also needs to be larger. However, it is difficult to fabricate the FMM and to align the FMM in a precise pattern by elongation of the FMM.

To address the foregoings, in the thin film deposition apparatus **200**, deposition may be performed while moving the thin film deposition apparatus **200** and the substrate **110** relative to each other. In other words, deposition may be continuously performed while moving the substrate **110** which faces the thin film deposition apparatus **200** in a Y-axis direction. That is, deposition is performed in a scanning manner. Although the substrate **110** is moved in the Y-axis direction in the chamber in FIG. **3** when deposition is performed, the present invention is not limited thereto. Deposition may be performed while moving the thin film deposition apparatus **200** in the Y-axis direction while fixing the substrate **110**.

Therefore, the thin film deposition apparatus **200** may form the patterning slit sheet **250** that is much smaller than that used a conventional FMM. That is, in the thin film deposition apparatus **200**, since deposition is continuously performed, i.e., in a scanning manner, while moving the substrate **110** in the Y-axis direction, if a width of the patterning slit sheet **250** in an X-axis direction and a width of the substrate **110** in the X-axis direction are substantially the same, a length of the patterning slit sheet **250** in the Y-axis direction may be much less than that of the substrate **110**. As described above, since the patterning slit sheet **250** may be formed much smaller than the conventional FMM, it is easy to manufacture the patterning slit sheet **250** according to embodiments of the present invention. That is, a small size of the patterning slit sheet **250** is more advantageous in all manufacturing processes, including etching followed by precise elongation, welding, transferring, and washing processes, than the method of depositing the FMM. In addition, this is more advantageous for manufacturing a relatively large display device.

As described above, in order to perform deposition while moving the thin film deposition apparatus **200** and the substrate **110** relative to each other, the thin film deposition apparatus **200** and the substrate **110** may be spaced apart from each other by a certain gap.

In the meantime, the deposition source **210** that accommodates and heats the deposition material **2115** may be disposed in the chamber at a side facing the substrate **110**. As the deposition material **215** accommodated in the deposition source **2110** is vaporized, deposition may be performed on the substrate **110**.

In more detail, the deposition source **210** may include a crucible **211** that is filled with the deposition material **215** and a heater **212** that heats the crucible **211** to vaporize the deposition material **215** filled in the crucible **211** toward one side of the crucible **211**, in particular, toward the deposition source nozzle unit **220**.

The deposition source nozzle unit **220** may be disposed at one side of the deposition source **210**, particularly, facing the substrate **110**. A plurality of deposition source nozzles **221** may be formed in the deposition source nozzle unit **220** in the X-axis direction. In this regard, the deposition source nozzles **221** may be formed at a same gap. The deposition material **215** vaporized in the deposition source **210** passes through the deposition source nozzle unit **220** and faces the substrate **110** that is the deposition target.

The patterning slit sheet **250** and a patterning slit sheet frame **255** may be further disposed between the deposition source **210** and the substrate **110**. The patterning slit sheet frame **255** is approximately formed in a window frame shape. The patterning slit sheet **250** may be coupled to the inside of the patterning slit sheet frame **255**. A plurality of patterning slits **251** may be formed in the patterning slit sheet **250** in the X-axis direction. A length of the patterning slit **251** corresponding to a deposition space may not be the same as illustrated in FIG. **3**. This is to deposit the intermediate layers **182** having different thicknesses while improving uniformity of a thickness of a deposition thin film. This will be described later.

The deposition material **215** vaporized in the deposition source **210** may pass through the deposition source nozzle unit **220** and the patterning slit sheet **250** and face the substrate **110** that is the deposition target. In this regard, the patterning slit sheet **250** may be formed by using the same method as that of forming the conventional FMM, in particular, a stripe type mask, e.g., etching.

In this regard, a total number of the patterning slits **251** may be greater than that of the deposition source nozzles **221**.

In the meantime, the deposition source **210** (and the deposition source nozzle unit **220** combined thereto) and the patterning slit sheet **250** may be spaced apart from each other by a certain gap, and may be connected to each other by using the connection member **235**. That is, the deposition source **210**, the deposition source nozzle unit **220**, and the patterning slit sheet **250** may be connected to each other by using the connection member **235** to be integrally formed. In this regard, the connection member **235** may guide a movement path of a deposition material such that the deposition material discharged via the deposition source nozzle **221** is not dispersed. Although the connection member **235** is formed in left and right directions of the deposition source **210**, the deposition source nozzle unit **220**, and the patterning slit sheet **250** in FIG. **3**, since this is for convenience of illustration, the present invention is not limited thereto. The connection member **235** may be formed in a closed box shape to simultaneously guide the deposition material to move in the X-axis and Y-axis directions.

As described above, deposition is performed while moving the thin film deposition apparatus **200** relative to the substrate **110**. In order for the thin film deposition apparatus **200** to move relative to the substrate **110**, the patterning slit sheet **250** is disposed spaced apart from the substrate **110** by a certain gap.

In more detail, the conventional method of depositing the FMM performs deposition with a mask in close contact with a substrate in order to prevent formation of a shadow on the substrate. However, when the mask is formed in close contact with the substrate, a defect occurs due to the contact between the substrate and the mask. In addition, since the mask may not be moved with respect to the substrate, the mask and the substrate need to be formed in the same size. Accordingly, the mask needs to be large as the size of a display device increases. However, it is difficult to form a large mask.

To address the foregoings, in the thin film deposition apparatus **200** according to an embodiment of the present

invention, the patterning slit sheet **250** needs to be formed spaced apart from the substrate **110** that is the deposition target by a certain gap.

According to embodiments of the present invention, deposition may be performed while moving a mask formed smaller than the substrate with respect to the substrate, thereby facilitating manufacture of the mask. A defect due to contact between the substrate and the mask may be prevented or minimized. It is also unnecessary to take time in closely contacting the substrate with the mask during a deposition process, thereby improving a manufacturing speed.

In the meantime, the patterning slit sheet **250** may include the plurality of patterning slits **251**. In this regard, the patterning slits **251** may include a first patterning slit **251***a* through which a deposition material for forming the first sub-pixel R passes, a second patterning slit **251***b* through which a deposition material for forming the second sub-pixel G passes, and a third patterning slit **251***c* through which a deposition material for forming the third sub-pixel B passes. In this regard, the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may form one group. In particular, the deposition materials that pass through the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* respectively form the first sub-pixel R, the second sub-pixel G, and the third sub-pixel B, thereby forming the unit pixel P.

The deposition material may be one of various materials described above. For example, the deposition material may be one of materials for forming the organic emission layer **182***d*. The deposition material may be one of materials for forming the functional layers **182***c*. In addition, the deposition material may include all materials that may be deposited via the thin film deposition apparatus **200** onto layers forming the intermediate layers **182**.

Passage areas through which the deposition material passes may be formed in the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c*. In this regard, the passage area formed in the first patterning slit **251***a* may be a length of the first patterning slit **251***a*. The passage area formed in the second patterning slit **251***b* may be a length of the second patterning slit **251***b*. The passage area formed in the third patterning slit **251***c* may be a length of the third patterning slit **251***c*.

At least two of the lengths of the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may be different from each other. For example, the length of the first patterning slit **251***a* may be greater than that of the second patterning slit **251***b*. The length of the second patterning slit **251***b* may be also greater than that of the third patterning slit **251***c*.

When the at least two of the lengths of the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* are different from each other, different amounts of the deposition material may pass through the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c*. In more detail, since the length of the first patterning slit **251***a* is greater than that of the second patterning slit **251***b*, an amount of the deposition material that passes through the first patterning slit **251***a* may be greater than that of the deposition material that passes through the second patterning slit **251***b*. Also, since the length of the second patterning slit **251***b* may be also greater than that of the third patterning slit **251***c*, an amount of the deposition material that passes through the second patterning slit **251***b* may be also greater than that of the deposition material that passes through the third patterning slit **251***c*. In this regard, the lengths of the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may be formed such that the greatest amount of the deposition material passes through the first patterning slit **251***a*, and the second largest amount of the deposition material passes through the second patterning slit **251***b*, and the smallest amount of the deposition material passes through the third patterning slit **251***c*.

In the meantime, the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may form a group as described above and may be included in the patterning slit sheet **250**. In this regard, gaps between the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may be the same. A plurality of each of the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may be provided.

At least one of both ends of the plurality of first patterning slits **251***a* may be formed in an arcuate or cosine curve shape. For example, the plurality of first patterning slits **251***a* may have different lengths, and lengths y of the first patterning slits **251***a* may be increased from a center (x=0) to the outside.

In more detail, the farther away from the center of the patterning slit sheet **250**, the greater the lengths of the first patterning slits **251***a*. That is, the length of the first patterning slit **251***a* that is the closest to the center of the patterning slit sheet **250** may be the smallest among the lengths of the plurality of first patterning slits **251***a* formed in the patterning slit sheet **250**, and the farther away from the first patterning slit **251***a* that is the closest to the center of the patterning slit sheet **250**, the greater the length of the first patterning slit **251***a*.

As described above, the mask having the first patterning slits **251***a* may function to block a part of the deposition material from the deposition source nozzles **221** (see FIG. **3**) to the patterning slit sheet **250**. In more detail, a deposition film deposited by the thin film deposition apparatus **200** has a center portion in a convex shape, and thus a part of the deposition material toward the center portion needs to be blocked to make the center portion uniform. Thus, the part of the deposition material may be blocked by forming different lengths of the first patterning slits **251***a*. In this regard, since the patterning slit sheet **250** is formed in such a way that lengths of the first patterning slits **251***a* may be increased from a center portion of the deposition space S toward both end portions thereof, a small amount of the deposition material passes through the first patterning slit **251***a* corresponding to the center portion having a relatively small length, and a great amount of the deposition material passes through the first patterning slit **251***a* corresponding to an end portion of the patterning slit sheet **250** having a relatively great length. In this case, different lengths of the first patterning slits **251***a* may be generally formed such that film thicknesses of both end portions of the patterning slit sheet **250** may be an entire film thickness.

As such, the deposition film deposited by the thin film deposition apparatus **200** may be corrected to have a uniform shape by forming the first patterning slits **251***a* to have different lengths. That is, the amount of the deposition material may be adjusted so that the thickness of the deposition material is uniform. The adjustment may be made by enabling a small amount of the deposition material to pass through patterning slit by reducing the lengths of patterning slits on which a large amount of the deposition

material is deposited and increasing the lengths of the patterning slits on which a small amount of the deposition material is deposited.

Therefore, uniformity of a thin film deposited on a substrate by using the first patterning slits **251***a* is formed within the error range of about 1%~2%, thereby improving product quality and reliability.

The above phenomenon may be the same as or similar to that in the second patterning slit **251***b* and the third patterning slit **251***c*. Thus, lengths of the second patterning slit **251***b* and the third patterning slit **251***c* may be formed to be similar to that of the first patterning slit **251***a*. In this regard, curvature radii or cosine values of the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* may be differently formed as described above.

In the meantime, upon reviewing a method of forming the intermediate layer **182** by using the thin film deposition apparatus **200** described above, each layer may be formed on the substrate **110**, the HIL **182***a* and the HTL **182***b* may be formed on the pixel electrode **181**, and then the substrate **110** may be injected into a chamber. Thereafter, the deposition material may be deposited on the substrate **110** via the patterning slit sheet **250** while moving the substrate **110** in a direction A of FIG. **3**.

When the deposition material passes through the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c*, a thickness of the functional layer **182***c* may be different. In particular, in this case, the thickness of the functional layer **182***c* in which the first organic emission layer **182***d*-R is to be formed may be the largest, the thickness of the functional layer **182***c* in which the second organic emission layer **182***d*-G is to be formed may be the second largest, and the thickness of the functional layer **182***c* in which the third organic emission layer **182***d*-B is to be formed may be the smallest. The thickness of the functional layer **182***c* in which the first organic emission layer **182***d*-R is to be formed, formed by the patterning slit sheet **250**, is the same over an entire area of the patterning slit sheet **250**, and the thickness of the functional layer **182***c* in which the second organic emission layer **182***d*-G is to be formed and the thickness of the functional layer **182***c* in which the third organic emission layer **182***d*-B is to be formed may also be the same over the entire area of the patterning slit sheet **250**.

If the functional layers **182***c* of the first through third sub-pixels R, G, and B are formed as described above, the first organic emission layer **182***d*-R, the second organic emission layer **182***d*-G, and the third organic emission layer **182***d*-B may be formed. In this regard, the first organic emission layer **182***d*-R, the second organic emission layer **182***d*-G, and the third organic emission layer **182***d*-B may use different masks, and a deposition method thereof may be similar to the method of forming the functional layers **182***c*.

Thereafter, other layers such as the ETL **182***e* and the EIL **182***f* may be stacked on the organic emission layers **182***d*, thereby manufacturing the organic light-emitting display apparatus **100**.

When the organic light-emitting display apparatus **100** is manufactured by using the thin film deposition apparatus **200** as described above, an optical thickness of each of the organic emission layers **182***d* may be corrected. In particular, a thickness of the intermediate layer **182** according to locations of the organic emission layers **182***d* may be achieved by a simple and quick manufacture process.

FIG. **5** is a perspective view of a thin film deposition apparatus **300** according to another embodiment of the present invention. FIG. **6** is a plan view of a correction plate **360** of FIG. **5**.

Referring to FIGS. **5** and **6**, the thin film deposition apparatus **300** may include a deposition source **310**, a deposition source nozzle unit **320**, a patterning slit sheet **350**, a connection member **335**, and the correction plate **360**. In this regard, the deposition source **310**, the deposition source nozzle unit **320**, and the connection member **335** are the same as or similar to those described above, and thus detailed descriptions thereof are omitted.

The patterning slit sheet **350** may be installed on a patterning slit sheet frame **355**. In this regard, the patterning slit sheet frame **355** is the same as or similar to that described above, and thus a detailed description thereof is omitted.

The patterning slit sheet **350** may include a plurality of patterning slits **351**. In this regard, the patterning slits **351** may be formed in the same size. The patterning slits **351** may be spaced apart from each other.

Each of the patterning slits **351** may include a first patterning slit **351***a*, a second patterning slit **351***b*, and a third patterning slit **351***c* that are formed corresponding to the first sub-pixel R, the second sub-pixel G, and the third sub-pixel B, respectively.

The correction plate **360** may be installed in a top surface or a bottom surface of the patterning slit sheet **350** to shield at least a part of the patterning slit **351**. In this regard, the correction plate **360** may define a passage area of the first patterning slit **351***a*, a passage area of the second patterning slit **351***b*, and a passage area of the third patterning slit **351***c* by shielding the at least a part of the patterning slit **351**.

In more detail, the correction plate **360** may include a first patterning slit shield unit **361** that shields at least a part of the first patterning slit **351***a* to define the passage area of the first patterning slit **351***a*. The correction plate **360** may include a second patterning slit shield unit **362** that defines the passage area of the second patterning slit **351***b* and a third patterning slit shield unit **363** that defines the passage area of the third patterning slit **351***c*.

In this regard, the first patterning slit shield unit **361**, the second patterning slit shield unit **362**, and the third patterning slit shield unit **363** may differently form at least two of lengths of the passage areas of the first patterning slit **351***a*, the second patterning slit **351***b*, and the third patterning slit **351***c*. The first patterning slit shield unit **361**, the second patterning slit shield unit **362**, and the third patterning slit shield unit **363** may form the passage areas of the first patterning slit **351***a*, the second patterning slit **351***b*, and the third patterning slit **351***c* such that the first patterning slit **351***a*, the second patterning slit **351***b*, and the third patterning slit **351***c* may be the same as the first patterning slit **251***a*, the second patterning slit **251***b*, and the third patterning slit **251***c* described with reference to FIGS. **3** and **4** above by shielding the first patterning slit **351***a*, the second patterning slit **351***b*, and the third patterning slit **351***c*.

The first patterning slit shield unit **361**, the second patterning slit shield unit **362**, and the third patterning slit shield unit **363** may form one group: A plurality of groups may be connected such that the groups may correspond to a length of the patterning slit sheet **350**.

In particular, a plurality of first patterning slit shield units **361** may be provided and may have lengths that are reduced from a center of the patterning slit sheet **350** to the outside. In particular, outer surfaces of the first patterning slit shield units **361** may be formed in a circular arc or cosine shape.

The second patterning slit shield unit **362** and the third patterning slit shield unit **363** may be formed to be similar to the first patterning slit shield units **361**. In this regard, a length of the second patterning slit shield unit **362** may be greater than that of the first patterning slit shield units **361**, and a length of the third patterning slit shield unit **363** may be greater than that of the second patterning slit shield unit **362**. Thus, the passage area of the first patterning slit **351***a* may be greater than that of the second patterning slit **351***b*, and the passage area of the second patterning slit **351***b* may be greater than that of the third patterning slit **351***c*.

In the meantime, a method of forming the intermediate layer **182** by using the thin film deposition apparatus **300** formed as described above may be similar to that described above. In more detail, the substrate **110** is injected into a chamber so as to allow the thin film deposition apparatus **300** to be spaced apart from the substrate **110** and then is scanned in one direction to deposit a deposition material. In this regard, various layers may be previously formed on the substrate **110** as described above.

When the deposition material is deposited as described above, an amount of the deposition material that passes through the first patterning slit **351***a*, the second patterning slit **351***b*, and the third patterning slit **351***c* may be different as described above. In this regard, the functional layer **182***c* in which the first organic emission layer **182***d*-R that is red may be deposited to have the greatest thickness, the functional layer **182***c* in which the second organic emission layer **182***d*-G that is green may be deposited to have a middle thickness, and the functional layer **182***c* in which the third organic emission layer **182***d*-B that is blue may be deposited to have the smallest thickness.

The thicknesses of functional layers **182***c* of the first sub-pixel R, the second sub-pixel G, and the third sub-pixel B are differently formed and then, the organic emission layers **182***d*, the ETL **182***e*, the EIL **182***f*, and the facing electrode **183** may be sequentially formed. Thereafter, the thin film encapsulation layer E may be formed on the facing electrode **183**, thereby completely manufacturing the organic light-emitting display apparatus **100**.

Therefore, the thin film deposition apparatus **200** and the method of manufacturing the organic light-emitting display apparatus **100** using the thin film deposition apparatus **200** do not use a separate mask to form the functional layers **182***c*, thereby reducing manufacturing time and cost.

Furthermore, the thin film deposition apparatus **200** and the method of manufacturing the organic light-emitting display apparatus **100** using the thin film deposition apparatus **200** may uniformly form the intermediate layer **182** in each of sub-pixels in an entire area of the organic light-emitting display apparatus **100**, thereby securing product quality and reliability.

As described above, according to the one or more of the above embodiments of the present invention, a thin film deposition apparatus and a method of manufacturing an organic light-emitting display apparatus by using the thin film deposition apparatus improve productivity.

It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

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

What is claimed is:

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

providing a thin film deposition apparatus;

positioning a substrate such that the substrate is spaced apart from the thin film deposition apparatus; and

depositing a deposition material onto the substrate by discharging the deposition material from the thin film deposition apparatus onto the substrate while moving one of the thin film deposition apparatus or the substrate relative to the other along a moving direction,

wherein the depositing of the deposition material discharged from the thin film deposition apparatus onto the substrate comprises: depositing the deposition material through a plurality of patterning slits onto the substrate to form a plurality of sub-pixels, each of which corresponds to one of the plurality of patterning slits,

wherein the plurality of patterning slits comprise a first patterning slit through which the deposition material passes for forming a first one of the plurality of sub-pixels, a second patterning slit through which the deposition material passes for forming a second one of the plurality of sub-pixels, and a third patterning slit through which the deposition material passes for forming a third one of the plurality of sub-pixels,

wherein the first patterning slit has a first length extending along the moving direction, and the second patterning slit has a second length extending along the moving direction and substantially different from the first length, and

wherein the first, second and third patterning slits are arranged to be spaced apart from each other.

2. The method of claim **1**, wherein the first sub-pixel comprises an intermediate layer comprising an organic emission layer that is configured to emit red light, the second sub-pixel comprises an intermediate layer comprising an organic emission layer that is configured to emit green light, and the third sub-pixel comprises an intermediate layer comprising an organic emission layer that is configured to emit blue light.

3. The method of claim **2**, wherein the third patterning slit has a third length extending along the moving direction, wherein the first length is greater than the second length which is greater than the third length.

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

providing a thin film deposition apparatus;

positioning a substrate such that the substrate is spaced apart from the thin film deposition apparatus; and

depositing a deposition material onto the substrate by discharging the deposition material from the thin film deposition apparatus onto the substrate while moving one of the thin film deposition apparatus or the substrate relative to the other along a moving direction,

wherein the depositing of the deposition material discharged from the thin film deposition apparatus onto the substrate comprises: depositing the deposition material through a plurality of patterning slits onto the substrate to form a plurality of sub-pixels, each of which corresponds to one of the plurality of patterning slits,

wherein the plurality of patterning slits comprise a first patterning slit through which the deposition material passes for forming a first one of the plurality of

sub-pixels, a second patterning slit through which the deposition material passes for forming a second one of the plurality of sub-pixels, and a third patterning slit through which the deposition material passes for forming a third one of the plurality sub-pixels,

wherein the first patterning slit has a first length extending along the moving direction, and the second patterning slit has a second length extending along the moving direction and substantially different from the first length,

wherein the plurality of patterning slits comprises an additional first patterning slit for forming another first subpixel, an additional second patterning slit for forming another second subpixel, and an additional third patterning slit for forming another third subpixel, and

wherein the first, second and third patterning slits are located closer to a center of a patterning slit sheet comprising the plurality of patterning slits than the additional first, second and third patterning slits, respectively, and the first, second and third patterning slits are shorter than the additional first, second and third patterning slits, respectively.

5. The method of claim **1**, wherein an amount of the deposition materials deposited on the substrate is controlled according to the length of each of the first through third patterning slits.

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