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(54) **ORGANIC LIGHT-EMITTING DISPLAY
DEVICE AND METHOD OF
MANUFACTURING THE SAME**

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438/780

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438/149, 609, 608, 153, 151, 54, 82, 99,
438/725, 780

See application file for complete search history.

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(57) **ABSTRACT**

In an organic light-emitting display device and a method of manufacturing the organic light-emitting display device, the method includes forming thin film transistors (TFTs) on a substrate; and forming organic light emitting diodes (OLEDs), each of the OLEDs including a first electrode having a portion exposed by a pixel defining layer (PDL) on the TFTs, an organic layer on the exposed portion of the first electrode and including an emission layer (EML) configured to emit light having a respective one of a plurality of colors, and a second electrode on the organic layer. The EML is formed in each of a sub-pixel region with one color and other sub-pixel regions with other colors that are formed by forming openings in the PDL. A solution supply unit for sub-pixel region that communicates with the sub-pixel region with one color is formed in the sub-pixel region with one color.

18 Claims, 5 Drawing Sheets

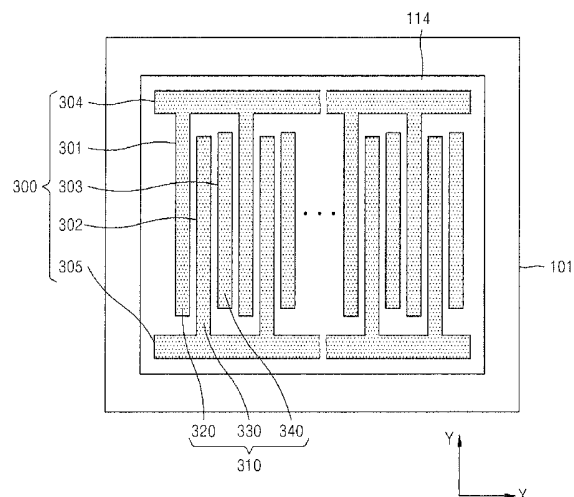
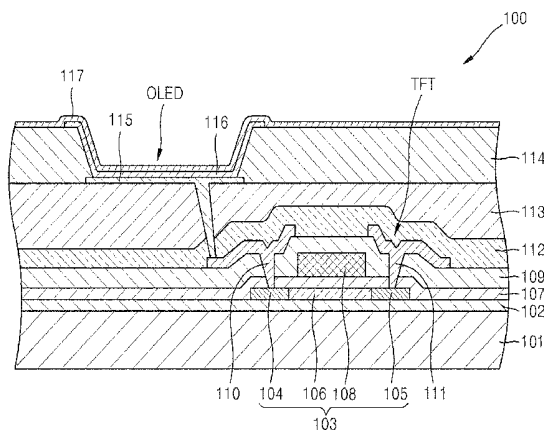


FIG. 1

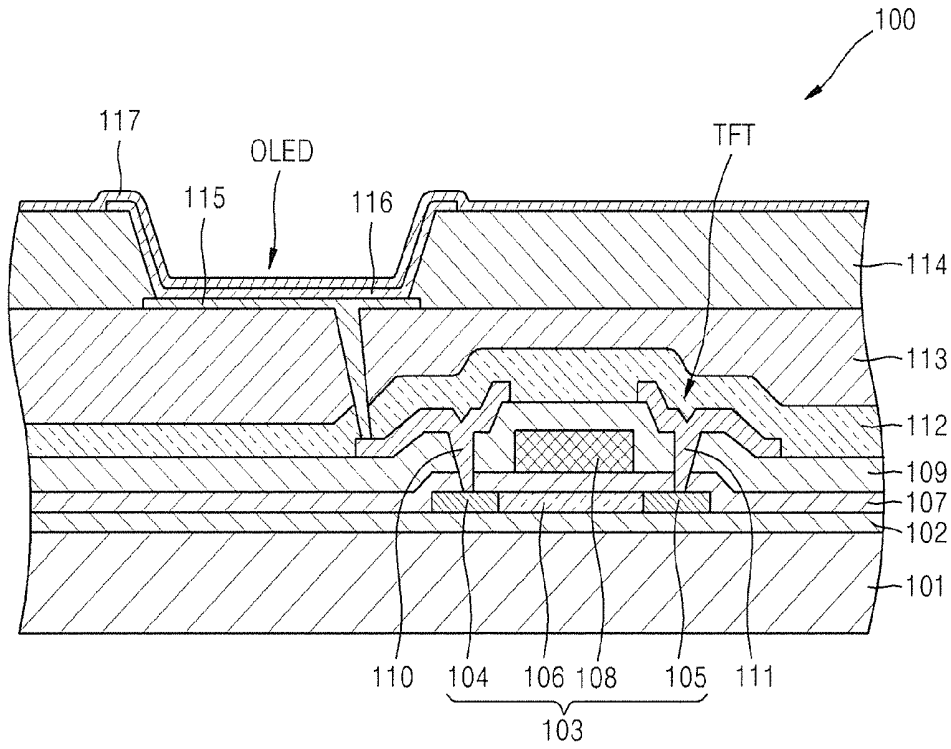


FIG. 2

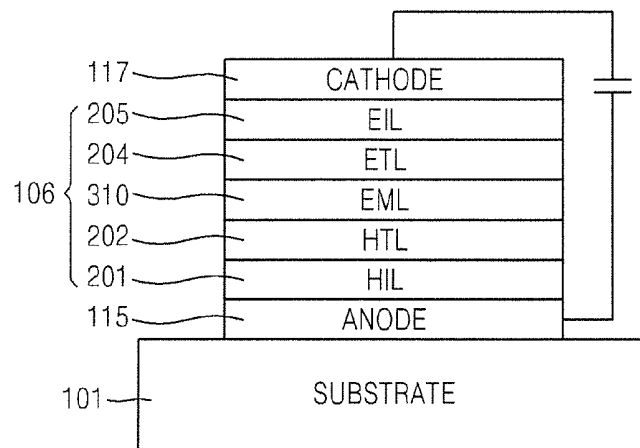


FIG. 3

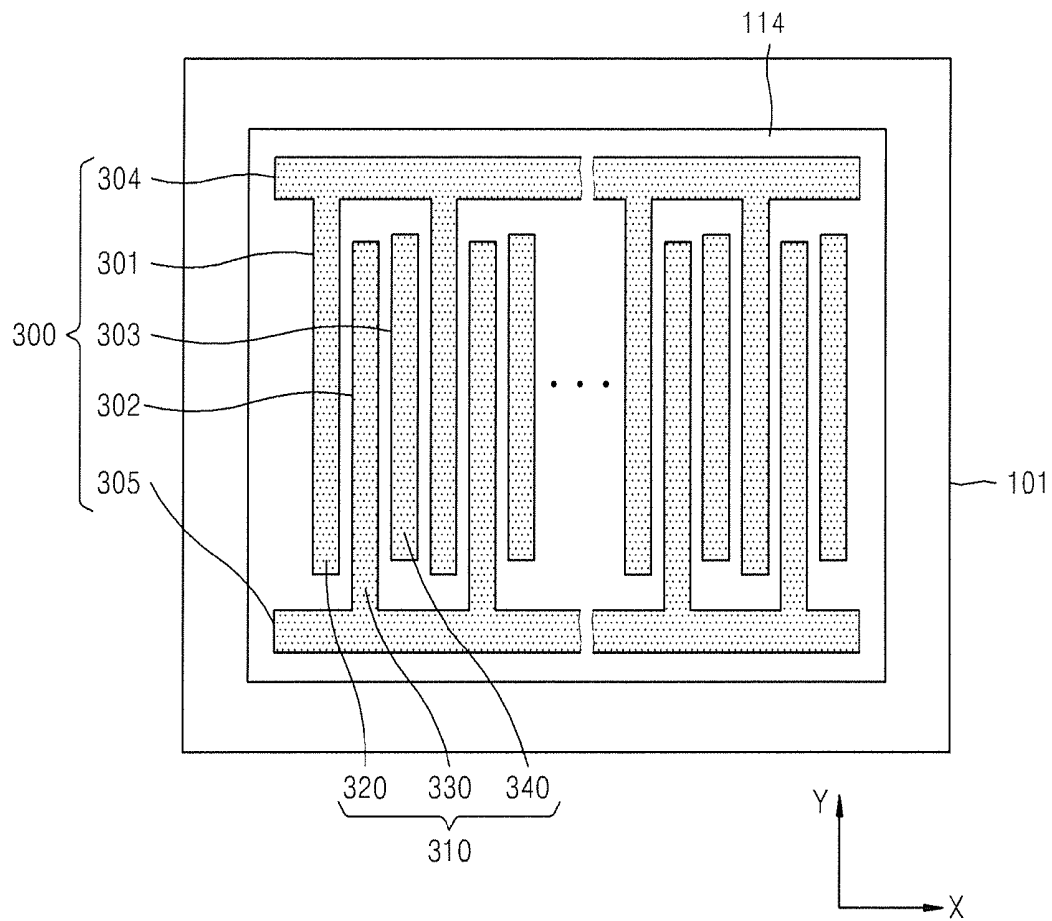


FIG. 4

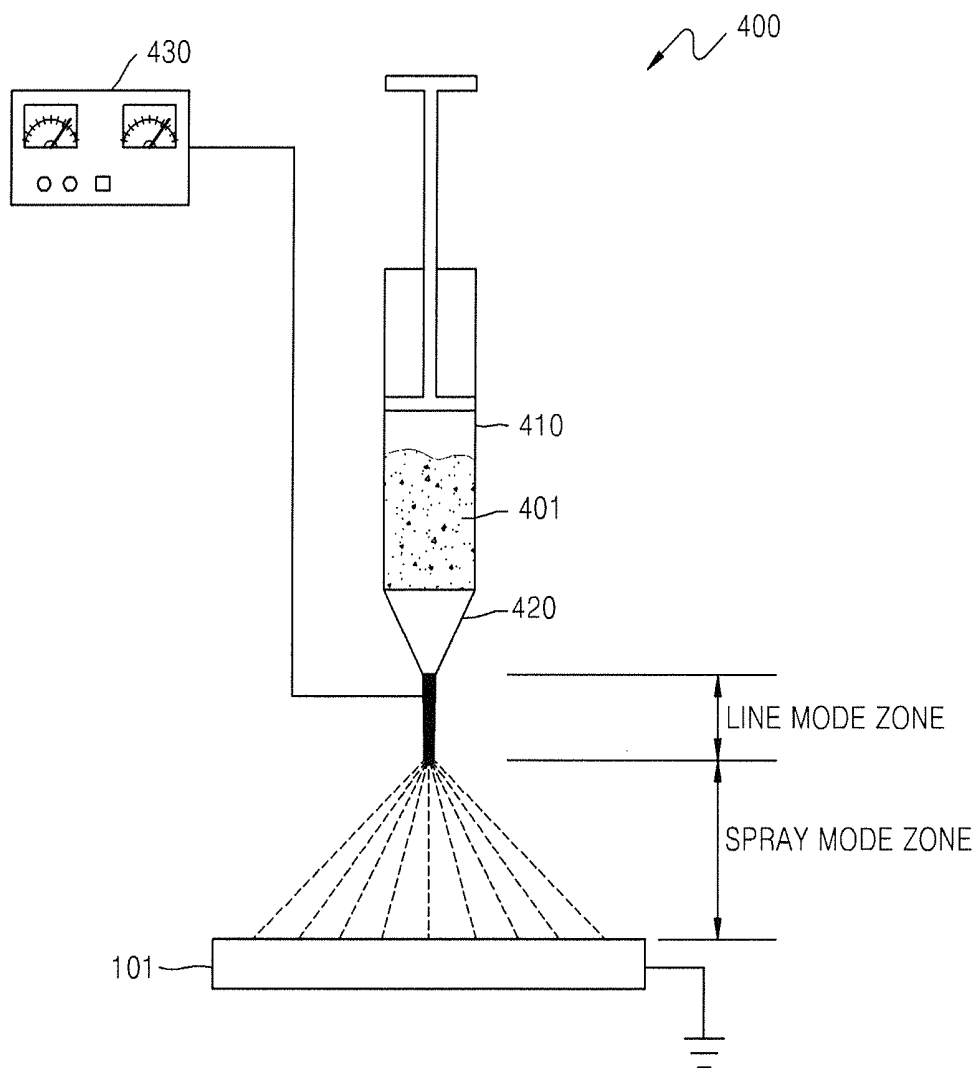


FIG. 5

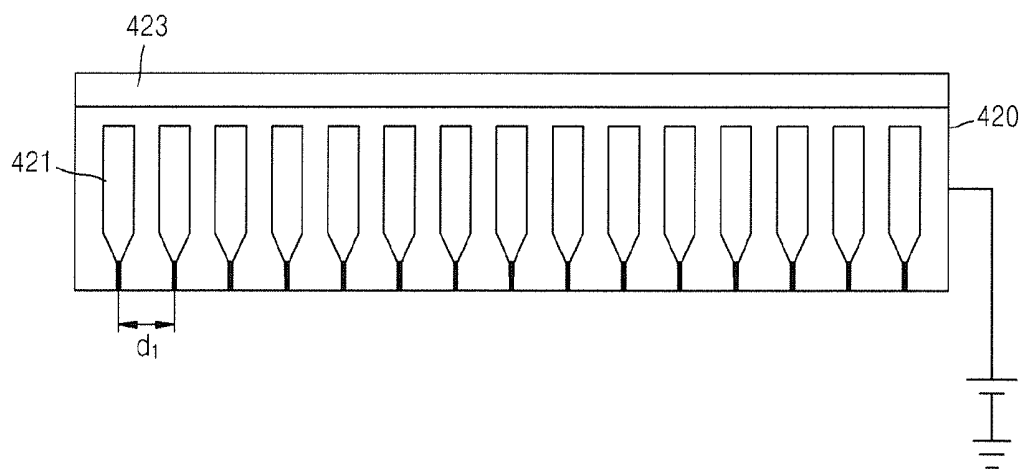


FIG. 6

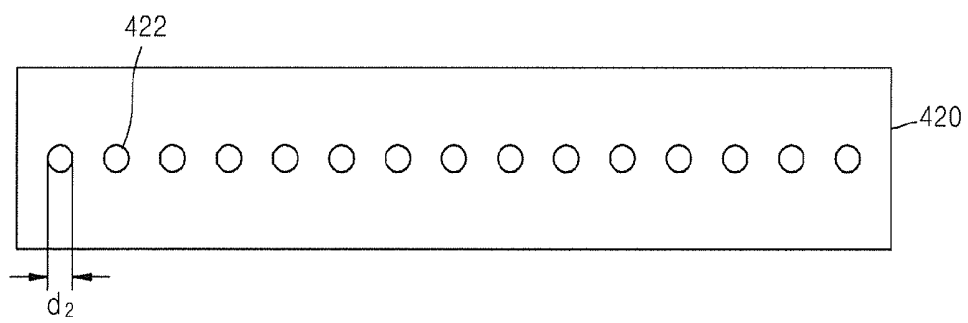
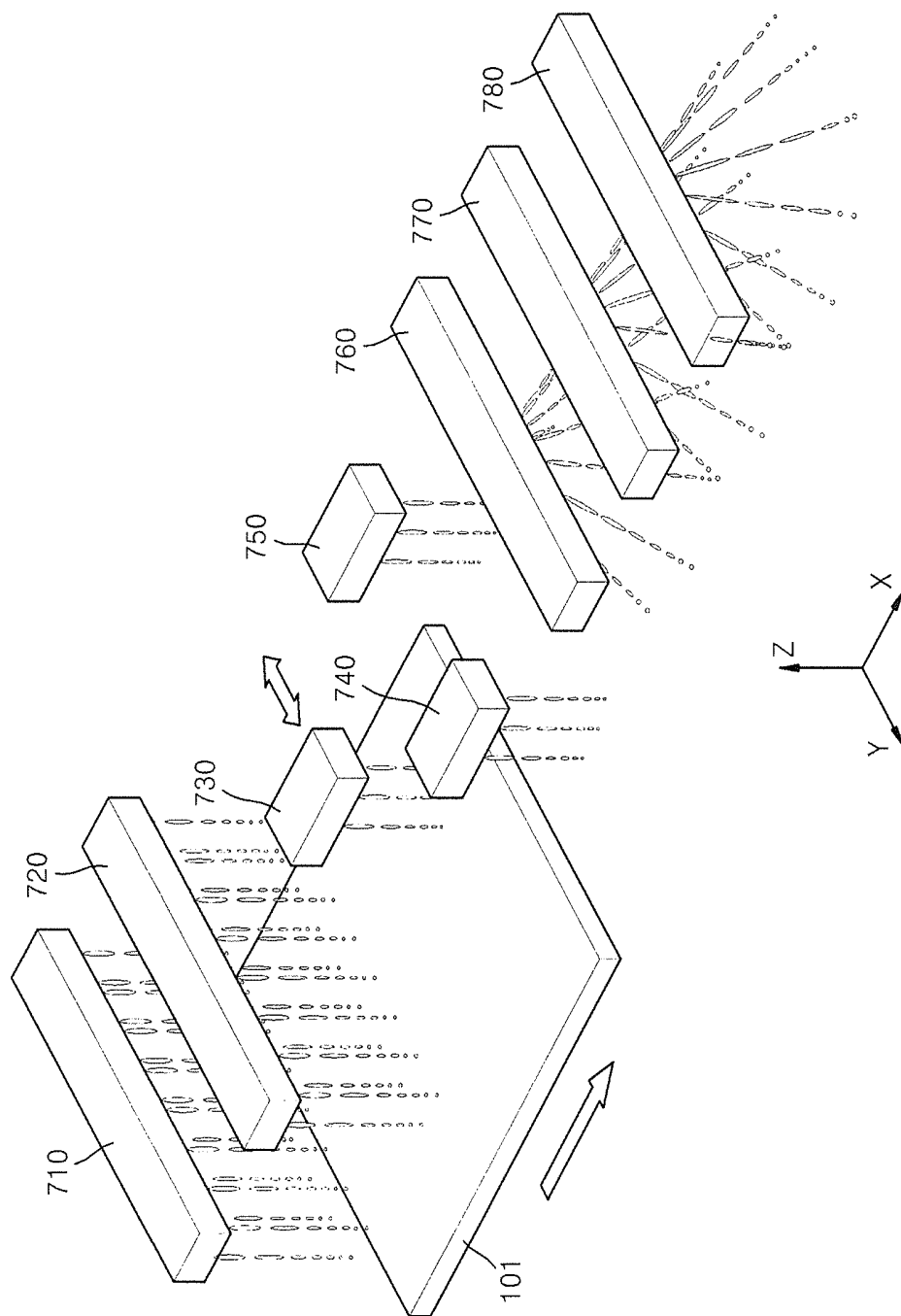


FIG. 7



ORGANIC LIGHT-EMITTING DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2011-0137408, filed on Dec. 19, 2011, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

The present invention relates to an organic light-emitting display device, and a method of manufacturing the organic light-emitting display device.

2. Description of the Related Art

In general, organic light-emitting display devices may be applied to display devices for mobile apparatuses such as digital cameras, video cameras, camcorders, portable information terminals, smart phones, ultra-slim notebooks, tablet person computers, and flexible display apparatuses, or electronic/electric appliances such as ultra-slim televisions.

An organic light-emitting display device has a stack structure in which an emission layer (EML) is placed between an anode and a cathode. However, it is difficult to obtain high efficiency emission via the structure, thus, intermediate layers such as an electron injection layer (EIL), an electron transport layer (ETL), a hole transport layer (HTL), and a hole injection layer (HIL), and/or the like, may be selectively inserted between the anode and the cathode, and used.

In general, the organic light-emitting display device is manufactured by several methods such as a nozzle printing method, a deposition method, and the like. For example, the EML may be formed by the nozzle printing method, and the intermediate layers may be formed by the deposition method. In a case of using the deposition method, a solvent for the intermediate layers, e.g., a solvent of a solution for the HTL, may dissolve the EML in a deposition process, such that an interface characteristic may deteriorate. Also, by using both the nozzle printing method and the deposition method, the investment costs may be increased, a large space for equipments may be required, and it may be difficult or impossible to arrange in-line based equipment.

SUMMARY

Embodiments according to the present invention provide an organic light-emitting display device of which organic light emitting diodes (OLEDs) are manufactured by a solubility process using an electrostatic spraying method, and a method of manufacturing the organic light-emitting display device.

According to an aspect of embodiments according to the present invention, there is provided a method of manufacturing an organic light-emitting display device, the method including forming a plurality of thin film transistors (TFTs) on a substrate; and forming a plurality of organic light emitting diodes (OLEDs), each of the OLEDs including a first electrode having a portion exposed by a pixel defining layer (PDL) on the TFT, an organic layer on the exposed portion of the first electrode and including an emission layer (EML) configured to emit light having at least one of a plurality of colors, and a second electrode on the organic layer, wherein

the EML is formed in each of a sub-pixel region with one color and other sub-pixel regions with other colors, from among a plurality of sub-pixel regions, the plurality of sub-pixel regions being formed by forming openings in the PDL, a solution supply unit that communicates with the sub-pixel region with one color is formed in the sub-pixel region with one color, and emission layer raw materials for the plurality of colors are supplied to the sub-pixel region with one color and the other sub-pixel regions with other colors via the solution supply unit, whereby the EML is formed.

At least one of the emission layer raw materials may be sprayed into the solution supply unit via a nozzle unit having a power applied thereto, and the at least one of the emission layer raw materials may move to the sub-pixel region that communicates with the solution supply unit, whereby the EML may be formed.

The EML may be formed by charging the at least one of the emission layer raw materials including a liquid emission layer raw material; and forming droplets by spraying the charged liquid emission layer raw material via the nozzle unit, and then forming the EML via the solution supply unit.

The charging the liquid emission layer raw material may include applying an electrical potential difference to the liquid emission layer raw material.

A positive voltage may be applied to the nozzle unit, whereby the liquid emission layer raw material may be positively charged and then may be sprayed via the nozzle unit, and the substrate may be electrically coupled to a ground voltage source.

The EML may include a first-color emission layer, a second-color emission layer, and a third-color emission layer, the first-color emission layer may be formed in a first sub-pixel region of the sub-pixel regions, and the first sub-pixel region may communicate with a first sub-pixel region solution supply unit, the second-color emission layer may be formed in a second sub-pixel region of the sub-pixel regions, and the second sub-pixel region may communicate with a second sub-pixel region solution supply unit for second sub-pixel region, the third-color emission layer may be formed in a third sub-pixel region of the sub-pixel regions, and a first-color emission layer raw material and a second-color emission layer raw material that are in a liquid state and are charged may be sprayed via the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively, may move to the first sub-pixel region and the second sub-pixel region, respectively, due to a repulsive force, and then may form the first-color emission layer and the second-color emission layer, respectively.

A plurality of the first sub-pixel regions, a plurality of the second sub-pixel regions, and a plurality of the third sub-pixel regions may be alternately formed along one direction of the substrate, the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit may be formed on side ends of the substrate, all of the plurality of the first sub-pixel regions may communicate with the first sub-pixel region solution supply unit, and all of the plurality of the second sub-pixel regions may communicate with the second sub-pixel region solution supply unit.

The first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit may extend along one direction of the substrate, and the plurality of the first sub-pixel regions and the plurality of the second sub-pixel regions may be formed in a direction crossing the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively.

The spraying the first-color emission layer raw material and the second-color emission layer raw material may

include: fixing the nozzle unit having a power applied thereto; and moving the substrate along one direction and concurrently spraying the first-color emission layer raw material and the second-color emission layer raw material, which are in the liquid state, via the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively.

A third-color emission layer raw material may be sprayed on the third sub-pixel region via the nozzle unit, whereby the third-color emission layer is formed in the third sub-pixel region.

The spraying the third-color emission layer raw material may include fixing the substrate; and moving the nozzle unit along another direction of the substrate and concurrently spraying the third-color emission layer raw material on the third sub-pixel region in which the third-color emission layer is formed.

The first-color emission layer may include a red emission layer, the second-color emission layer may include a green emission layer; and the third-color emission layer may include a blue emission layer.

The liquid emission layer raw material may include nanometer-size particles.

The second electrode may be formed by spraying a second electrode raw material on the substrate via the nozzle unit having a power applied thereto.

The second electrode raw material that is sprayed may have nanometer-size particles.

The organic layer may further include at least one layer of a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), or an electron injection layer (EIL), and the at least one layer may be formed by spraying a corresponding raw material.

The at least one layer may include the HIL or the HTL, and a hole injection layer raw material or a hole transport layer raw material may be coated on a substantially entire surface of the substrate by using a slit coater.

The at least one layer may include the ETL, and an electron transport layer raw material having a nanometer size may be sprayed on the substrate via the nozzle unit having a power applied thereto.

According to another aspect of embodiments according to the present invention, there is provided an organic light-emitting display device including a substrate; a thin film transistor (TFT) on the substrate; a pixel defining layer (PDL) on the TFT; and an organic light emitting diode (OLED) including a first electrode in a region that is exposed by patterning the PDL, an organic layer having a respective one of a plurality of emission layers (EMLs), and a second electrode, wherein the plurality of EMLs are formed respectively in a sub-pixel region with one color and other sub-pixel regions with other colors that are formed by patterning the PDL, and a solution supply unit that communicates with the sub-pixel region with one color is on the substrate.

The plurality of EMLs may include a first-color emission layer, a second-color emission layer, and a third-color emission layer, the first-color emission layer may be in a first sub-pixel region and the first sub-pixel region may communicate with a first sub-pixel region solution supply unit, the second-color emission layer may be in a second sub-pixel region and the second sub-pixel region may communicate with a second sub-pixel region solution supply unit, the third-color emission layer may be in a third sub-pixel region.

A plurality of the first sub-pixel regions, a plurality of the second sub-pixel regions, and a plurality of the third sub-pixel regions may be alternately formed along one direction of the substrate, the first sub-pixel region solution supply unit and

the second sub-pixel region solution supply unit may be on side ends of the substrate, all of the plurality of the first sub-pixel regions may communicate with the first sub-pixel region solution supply unit, and all of the plurality of the second sub-pixel regions may communicate with the second sub-pixel region solution supply unit.

The first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit may be formed in a stripe shape along one direction of the substrate, and the plurality of the first sub-pixel regions and the plurality of the second sub-pixel regions may be formed in a direction crossing the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively.

The first-color emission layer may include a red emission layer, the second-color emission layer may include a green emission layer; and the third-color emission layer may include a blue emission layer.

The first-color emission layer and the second-color emission layer may include nanometer-size particles.

The organic layer may further include at least one layer of a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), or an electron injection layer (EIL).

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and aspects of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a diagram illustrating an example of a sub-pixel of an organic light-emitting display device according to an embodiment of the present invention;

FIG. 2 illustrates an organic light emitting diode (OLED) of FIG. 1;

FIG. 3 illustrates a pattern structure of a sub-pixel region of the organic light-emitting display device of FIG. 1;

FIG. 4 is a diagram illustrating a nozzle device, according to an embodiment of the present invention;

FIG. 5 is a diagram illustrating a nozzle unit of the nozzle device of FIG. 4;

FIG. 6 is a bottom view of the nozzle unit of FIG. 5; and FIG. 7 illustrates processes for manufacturing layers of the OLED of FIG. 1.

DETAILED DESCRIPTION

The present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms, and should not be construed as being limited to the embodiments set forth herein. Thus, the invention may include all revisions, equivalents, or substitutions which are included in the concept and the technical scope related to the invention. In the description of embodiments of the present invention, certain detailed explanations of related art may be omitted when it is deemed that they may unnecessarily obscure the essence of the invention.

While such terms as "first," "second," etc., may be used to describe various components, such components should not be limited to the above terms. The above terms are generally used to distinguish one component from another.

The terms used in the present specification are merely used to describe particular embodiments, and are not intended to limit the present invention. An expression used in the singular encompasses the expression of the plural, unless it has a

clearly different meaning in the context. In the present specification, it is to be understood that the terms such as "including" or "having," etc., are intended to indicate the existence of the features, numbers, steps, actions, components, parts, or combinations thereof disclosed in the specification, and are not intended to preclude the possibility that one or more other features, numbers, steps, actions, components, parts, or combinations thereof may exist or may be added.

Hereinafter, the present invention will be described in detail by explaining exemplary embodiments of the invention with reference to the attached drawings. Like reference numerals in the drawings denote like elements.

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.

FIG. 1 is a diagram illustrating an example of a sub-pixel of an organic light-emitting display device 100 according to an embodiment of the present invention. FIG. 2 illustrates an organic light emitting diode (OLED) of FIG. 1.

Here, the sub-pixel has at least one thin film transistor (TFT), and the OLED. A structure of the TFT is not limited to a structure shown in FIG. 1, and the number and structure of the TFT may vary.

Referring to FIGS. 1 and 2, the organic light-emitting display device 100 includes a first substrate 101. The first substrate 101 may be formed as an insulating substrate formed of a glass, plastic, and/or the like.

A buffer layer 102 is formed on the first substrate 101. The buffer layer 102 has a structure in which an organic material or an inorganic material is layered, or the organic material and the inorganic material are alternately stacked. The buffer layer 102 functions to block oxygen and moistures and to prevent moisture or foreign substances, which are generated from the first substrate 101, from being diffused to the OLED.

A semiconductor active layer 103 having a pattern (e.g., predetermined pattern) is formed on the buffer layer 102. When the semiconductor active layer 103 is to be formed of polysilicon, first, amorphous silicon may be formed and then may be crystallized to be changed into the polysilicon.

In order to crystallize amorphous silicon, various methods such as a rapid thermal annealing (RTA) method, a solid phase crystallization (SPC) method, an excimer laser annealing (ELA) method, a metal induced crystallization (MIC) method, a metal induced lateral crystallization (MILC) method, a sequential lateral solidification (SLS) method, or the like, may be used.

In the semiconductor active layer 103, a source region 104 and a drain region 105 that are obtained by doping N-type or P-type ions (or impurities), are formed. A region between the source region 104 and the drain region 105 corresponds to a channel region 106 in which none of impurities is doped.

A gate insulating layer 107 is deposited on the semiconductor active layer 103. The gate insulating layer 107 is formed as a single layer formed of SiO₂ or is formed as a double-layer formed of SiO₂ and SiN_x.

A gate electrode 108 is formed on a region (e.g., predetermined region) of the gate insulating layer 107. The gate electrode 108 is electrically coupled (e.g., connected) to a gate line (not shown) for applying a TFT-on signal or a TFT-off signal. The gate electrode 108 may be formed of a single metal material or a plurality of metal materials, and may be formed as a single layer including Mo, MoW, Cr, Al, an Al alloy, Mg, Al, Ni, W, or Au, or a multi-layer including a composition or combinations thereof.

An interlayer insulating layer 109 is formed on the gate electrode 108. A source electrode 110 is electrically coupled

to the source region 104 via a contact hole, and a drain electrode 111 is electrically coupled to the drain region 105 via another contact hole.

A passivation layer 112 formed of SiO₂, SiN_x or the like is formed on the source electrode 110 and the drain electrode 111. A planarization layer 113 formed of an organic material such as acryl, polyimide, or benzocyclobutene (BCB), is formed on the passivation layer 112.

A first electrode 115 is formed on the planarization layer 113. A portion of the first electrode 115 is covered by a pixel defining layer (PDL) 114 that is an insulating layer formed of an organic material, and the rest of the first electrode 115 is exposed. The first electrode 115 is electrically coupled to the source electrode 110 or the drain electrode 111.

An organic layer 116 is formed on a region of the first electrode 115, which is exposed by etching a portion of the PDL 114. A second electrode 117 is formed on the organic layer 116.

The first electrode 115 and the second electrode 117 are insulated from each other by the organic layer 116. Voltages having different polarities are applied to the first electrode 115 and the second electrode 117 so as to allow light emission to occur in the organic layer 116.

The OLED displays image information (e.g., predetermined image information) by emitting one of red, green, and blue rays according to a flow of a current. The OLED includes the first electrode 115 that is electrically coupled to the source electrode 110 or the drain electrode 111, and receives a positive power therefrom, the second electrode 117 that is arranged to cover an entire pixel and receives a negative power, and the organic layer 116 that is disposed between the first electrode 115 and the second electrode 117 and emits light. Here, the first electrode 115 functions as an anode and the second electrode 117 functions as a cathode. However, the present invention is not limited thereto, and polarities of the first electrode 115 and the second electrode 117 may be switched.

The first electrode 115 may be formed as a transparent electrode or a reflective electrode.

When the first electrode 115 is used as the transparent electrode, the first electrode 115 may include, for example, ITO, IZO, ZnO, or In₂O₃, and when the first electrode 115 is used as the reflective electrode, the first electrode 115 may be formed in a manner that a reflective layer is formed of a material selected from the group consisting of Ag, Mg, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, and a composition or combinations thereof, and then ITO, IZO, ZnO, or In₂O₃ may be formed thereon.

The second electrode 117 may be formed as a transparent electrode or a reflective electrode.

When the second electrode 117 is used as the transparent electrode, the second electrode 117 may be formed in a manner that metal having a small work function and including a material selected from the group consisting of Li, Ca, LiF/Ca, LiF/Al, Al, Ag, Mg, and a composition or combinations thereof, is formed toward the organic layer 116. Then an auxiliary electrode layer may be formed thereon by using a transparent electrode forming material, or a bus electrode line may be formed thereon.

When the second electrode 117 is used as the reflective electrode, a material selected from the group consisting of Li, Ca, LiF/Ca, LiF/Al, Al, Ag, Mg, and a composition or combinations thereof may be formed on an entire surface.

When the first electrode 115 is formed as the transparent electrode or the reflective electrode, the first electrode 115 may have a shape corresponding to an opening of each sub-pixel. The second electrode 117 that is formed as the trans-

parent electrode or the reflective electrode may be formed on an entire region of a display area. However, it is not necessary to form the second electrode **117** on the entire region, thus, the second electrode **117** may be formed by using various patterns. Here, the present invention is not limited to the present embodiment, and positions of the first electrode **115** and the second electrode **117** may be switched with each other.

The organic layer **116** may be formed of a low-molecule organic layer or a polymer organic layer.

In a case where the low-molecule organic layer is used, as illustrated in FIG. 2, the organic layer **116** may have a single-layer or multiple-layer (e.g., multi-layer) structure in which a hole injection layer (HIL) **201**, a hole transport layer (HTL) **202**, an emission layer (EML) **310**, an electron transport layer (ETL) **204**, an electron injection layer (EIL) **205**, and/or the like are stacked. In a case where the polymer organic layer is used, in general, the organic layer **116** may include an HTL and an EML.

However, the structure of the organic layer **116** according to the embodiments of the present invention, is not limited thereto and thus may vary.

A second substrate may be further formed on the OLED. The second substrate may be formed of a glass substrate or a flexible substrate, or may be formed by coating an insulating material.

FIG. 3 illustrates a pattern structure of a sub-pixel region **300** of the organic light-emitting display device **100** of FIG. 1.

Referring to FIG. 3, the sub-pixel region **300** is formed on the first substrate **101** by patterning the PDL **114**. The sub-pixel region **300** has a plurality of patterns according to emission colors.

According to the present embodiment, the sub-pixel region **300** includes a red sub-pixel region **301**, a green sub-pixel region **302**, and a blue sub-pixel region **303**.

The red sub-pixel region **301**, the green sub-pixel region **302**, and the blue sub-pixel region **303** may be formed by boring (e.g., forming openings in) the PDL **114**.

A red emission layer **320** that is a first emission layer is formed in the red sub-pixel region **301**, a green emission layer **330** that is a second emission layer is formed in the green sub-pixel region **302**, and a blue emission layer **340** that is a third emission layer is formed in the blue sub-pixel region **303**.

Although not illustrated, the first electrode **115** may be patterned for each of the red sub-pixel region **301**, the green sub-pixel region **302**, and the blue sub-pixel region **303** below the red emission layer **320**, the green emission layer **330**, and the blue emission layer **340**, respectively.

Also, the HIL **201** and the HTL **202** may be formed between the first electrode **115** and the EML **310**, and the ETL **204** and the EIL **205** may be formed on the EML **310**.

The second electrode **117** may be formed on an outermost layer of the EML **310**.

Here, the red sub-pixel region **301**, the green sub-pixel region **302**, and the blue sub-pixel region **303** are alternately formed along one direction (i.e., an X-axis direction) of the first substrate **101**. Accordingly, the red emission layer **320**, the green emission layer **330**, and the blue emission layer **340** are alternately formed in the red sub-pixel region **301**, the green sub-pixel region **302**, and the blue sub-pixel region **303**, respectively, along the one direction of the first substrate **101**.

Here, a solution supply unit for red sub-pixel region **304** and a solution supply unit for green sub-pixel region **305** that communicate with the red sub-pixel region **301** and the green sub-pixel region **302** are formed at side ends (i.e., side ends along a Y-axis direction) of the first substrate **101**.

That is, the solution supply unit for red sub-pixel region **304** is formed on one side of the first substrate **101**, and the solution supply unit for green sub-pixel region **305** facing the solution supply unit for red sub-pixel region **304** is formed on the other side of first substrate **101**.

The solution supply unit for red sub-pixel region **304** and the solution supply unit for green sub-pixel region **305** extend in one direction (i.e., the X-axis direction) of the first substrate **101**. The solution supply unit for red sub-pixel region **304** and the solution supply unit for green sub-pixel region **305** may be formed by boring (e.g., forming openings in) a portion of the PDL **114**.

The solution supply unit for red sub-pixel region **304** communicates with the red sub-pixel region **301** in which the red emission layer **320** is formed, and the solution supply unit for green sub-pixel region **305** communicates with the green sub-pixel region **302** in which the green emission layer **330** is formed.

For the communication, an end of the red sub-pixel region **301** that is patterned on the first substrate **101** may be connected to the solution supply unit for red sub-pixel region **304** in the Y-direction. The red sub-pixel region **301** and the solution supply unit for red sub-pixel region **304** may be patterned (e.g., arranged) in a direction crossing each other.

Also, an end of the green sub-pixel region **302** may be connected to the solution supply unit for green sub-pixel region **305** in the Y-direction. The green sub-pixel region **302** and the solution supply unit for green sub-pixel region **305** may be arranged in a direction crossing each other.

Here, in order to form each of the red emission layer **320** and the green emission layer **330**, a red emission layer raw material and a green emission layer raw material may be supplied to the red sub-pixel region **301** and the green sub-pixel region **302**, respectively, via the solution supply unit for red sub-pixel region **304** and the solution supply unit for green sub-pixel region **305**, by performing an electrostatic spraying method using a nozzle device.

This will now be described in detail.

FIG. 4 is a diagram illustrating a nozzle device **400**, according to an embodiment of the present invention. FIG. 5 is a diagram illustrating a nozzle unit **420** of the nozzle device **400** of FIG. 4. FIG. 6 is a bottom view of the nozzle unit **420** of FIG. 5.

Referring to FIGS. 4 through 6, the nozzle device **400** includes a main-body unit (e.g., main body) **410** that stores an emission layer raw material **401**. The nozzle unit **420** is mounted at an end of the main-body unit **410**. The nozzle unit **420** may be a multi-nozzle (e.g., may include multiple nozzles) but a type of the nozzle unit **420** is not limited thereto. In the nozzle unit **420**, a plurality of nozzles **421** are arranged at regular intervals. In one embodiment, a distance **d1** between the nozzles **421** may be between 200 μm and 450 μm . In one embodiment, a diameter **d2** of a spray opening **422** of the nozzle **421** may be between 50 μm and 150 μm .

A nozzle cover **423** is formed on the nozzle unit **420**, and when the nozzle cover **423** is open, the emission layer raw material **401** in a liquid state may be concurrently (e.g., simultaneously) supplied to the nozzles **421**. The emission layer raw material **401** moves along an internal path of each nozzle **421** having a capillary tube shape, and then is sprayed on the first substrate **101** via the spray opening **422**.

Here, power (e.g., a predetermined power) is applied to the nozzle unit **420**, so that the emission layer raw material **401** in the liquid state is sprayed on a desired region of the first substrate **101** by the electrostatic spraying method. For this,

the nozzle unit **420** is formed of a material such as aluminum, copper, platinum, gold, silver, SUS, and/or the like, that has conductivity.

Also, a power supply unit **430** (e.g., power supply) is coupled to the nozzle unit **420**. When the nozzle unit **420** receives power from the power supply unit **430**, the nozzle unit **420** may positively charge the emission layer raw material **401** in the liquid state while the emission layer raw material **401** is sprayed via the spray opening **422**. Here, a positive voltage is applied to all of the nozzles **421**. Also, the first substrate **101** is electrically coupled to a ground voltage source.

Accordingly, when the emission layer raw material **401** in the liquid state that is positively charged is sprayed on a desired region of the first substrate **101** via the spray opening **422** of each nozzle **421**, a repulsive force acts between the emission layer raw materials **401**. Thus, the emission layer raw materials **401** do not collide with each other but repel each other.

A power having a voltage between 50V and 5 KV may be applied from the power supply unit **430** to the nozzle device **400**, and in this regard, the nozzle device **400** may divide a dispensing mode into a line mode zone and a spray mode zone according to a strength of the applied power and may spray the emission layer raw materials **401**. For example, when the strength of the applied power is reduced, the nozzle device **400** may spray the emission layer raw materials **401** in the line mode zone, and when the strength of the applied power is increased, the nozzle device **400** may spray the emission layer raw materials **401** in the spray mode zone.

A method of manufacturing the OLED of the organic light-emitting display device **100** according to the present embodiment will now be described with reference to FIGS. **1** through **7**.

Here, in order to form, the red sub-pixel region **301** for forming the red emission layer **320**, the solution supply unit for red sub-pixel region **304** that communicates with the red sub-pixel region **301**, the green sub-pixel region **302** for forming the green emission layer **330**, the solution supply unit for green sub-pixel region **305** that communicates with the green sub-pixel region **302**, and the blue sub-pixel region **303** for forming the blue emission layer **340**, a portion of the PDL **114** on the first substrate **101** is patterned (or removed to form openings) to have a particular shape.

The organic layer **116** is formed on an exposed portion of the patterned first electrode **115** in each of the red sub-pixel region **301**, the green sub-pixel region **302**, and the blue sub-pixel region **303**.

First, the HIL **201** is formed on the first electrode **115** by using a slit coater for hole injection layer **710** that stores a hole injection layer raw material in a liquid state.

The HTL **202** is formed on the HIL **201** by using a slit coater for hole transport layer **720** that stores a hole transport layer raw material in a liquid state.

The HIL **201** and the HTL **202** are common layers that may not be required to be patterned, so that, the hole injection layer raw material and the hole transport layer raw material may be completely sprayed on the first substrate **101** by using the slit coater for hole injection layer **710** and the slit coater for hole transport layer **720**.

Here, the slit coater for hole injection layer **710** and the slit coater for hole transport layer **720** are in a stop state. On the other hand, the first substrate **101** moves along an X-axis direction. Each of the HIL **201** and the HTL **202** may be formed to have a thickness equal to or less than 120 nm.

Afterwards, the EML **310** may be formed on the HTL **202**.

In order to form the blue emission layer **340**, a blue emission layer raw material is sprayed on the blue sub-pixel region **303** by using a nozzle device for blue emission layer **730**.

Here, the nozzle device for blue emission layer **730** is disposed in a direction crossing the slit coater for hole injection layer **710** and the slit coater for hole transport layer **720**. The nozzle device for blue emission layer **730** sprays the blue emission layer raw material in the blue sub-pixel region **303** while the nozzle device for blue emission layer **730** moves along a Y-axis direction of the first substrate **101**. On the other hand, the first substrate **101** is fixed.

In order to form the red emission layer **320** and the green emission layer **330**, a nozzle device for red emission layer **740** and a nozzle device for green emission layer **750** are used. Here, the nozzle device for red emission layer **740** and the nozzle device for green emission layer **750** are fixed. On the other hand, the first substrate **101** moves along the X-axis direction.

Operational principles with respect to the nozzle device for red emission layer **740** and the nozzle device for green emission layer **750** are substantially the same, thus, hereinafter, a case in which the red emission layer **320** is formed by using the nozzle device for red emission layer **740** will now be described. Also, because the manufacturing procedure for forming the green emission layer **330** by using the nozzle device for green emission layer **750** is substantially the same, detailed descriptions thereof are omitted here. Here, it is assumed that the nozzle device **400** shown in FIGS. **4** through **6** is applied to the nozzle device for red emission layer **740** of FIG. **7**.

First, a positive voltage (e.g., positive voltage having a predetermined level) is applied from the power supply unit **430** to the nozzle unit **420**. Here, the first substrate **101** is electrically coupled to a ground voltage source. Accordingly, an electrical potential difference occurs between the nozzle unit **420** and the first substrate **101**, and the red emission layer raw materials that are positively charged via the spray opening **422** of the nozzle unit **420** are sprayed to the solution supply unit for red sub-pixel region **304** via the spray openings **422** of the nozzles **421**. Here, the red emission layer raw materials may be supplied in a line mode via the spray openings **422**.

Because a voltage (e.g., a predetermined voltage) is applied to the red emission layer raw materials that are sprayed into the solution supply unit for red sub-pixel region **304**, the red emission layer raw materials form minute droplets, each having a very small size (e.g., a nanometer size). When the minute droplets reach the inside of the solution supply unit for red sub-pixel region **304**, a solvent included in the red emission layer raw materials **401** in a liquid state completely vaporizes, so that only a solute is left.

Here, because all of the red emission layer raw materials **401** are positively charged, a repulsive force acts between the red emission layer raw materials **401**. Thus, the droplets by the red emission layer raw materials **401** that are sprayed into the solution supply unit for red sub-pixel region **304** repel each other and thus move to the red sub-pixel region **301** that communicates with the solution supply unit for red sub-pixel region **304**. Accordingly, the red emission layer **320** is formed in the red sub-pixel region **301**.

Also, the green emission layer raw materials, each having a very small size (e.g., a nanometer size), are sprayed to the solution supply unit for green sub-pixel region **305** by using the nozzle device for green emission layer **750**, and then the green emission layer raw materials move to the green sub-pixel region **302** due to a repulsive force between droplets by the green emission layer raw materials, wherein the green

sub-pixel region **302** communicates with the solution supply unit for green sub-pixel region **305**. Accordingly, the green emission layer **330** is formed in the green sub-pixel region **302**.

Next, the ETL **204** is formed on the EML **310**. The ETL **204** is formed by using a nozzle device for electron transport layer **760** that stores an electron transport layer raw material.

The EIL **205** is formed on the ETL **204**. The EIL **205** is formed by using a nozzle device for electron injection layer **770** that stores an electron injection layer raw material.

The ETL **204** and the EIL **205** are common layers that may not be required to be patterned, so that, the electron transport layer raw material and the electron injection layer raw material may be completely sprayed on the first substrate **101** by using the nozzle device for electron transport layer **760** and the nozzle device for electron injection layer **770**.

Here, because the EML **310** is not cross-linked, a surface of the EML **310** may be dissolved by the electron transport layer raw material. Thus, an interface between the ETL **204** and the EML **310** may be intermixed, and roughness may increase, such that a characteristic of the OLED may deteriorate.

In order to prevent the deterioration, similar to a case of forming the EML **310**, the ETL **204** may be formed by spraying the electron transport layer raw materials having a very small size (e.g., a nanometer size) by the electrostatic spraying method. In order to form the red emission layer **320** and the green emission layer **330**, the red emission layer raw materials and the green emission layer raw materials may be sprayed to desired regions of the solution supply unit for red sub-pixel region **304** and the solution supply unit for green sub-pixel region **305**, respectively, so that the nozzle device for red emission layer **740** and the nozzle device for green emission layer **750** may spray the red emission layer raw materials and the green emission layer raw materials in a line mode.

However, because the ETL **204** is not patterned and may be formed on an entire surface of the first substrate **101**, the nozzle device for electron transport layer **760** may spray the electron transport layer raw materials in a spray mode by increasing a voltage. By doing so, a coating operation may be possible while a shock (or impact) to the surface of the EML **310** is reduced or minimized. Also, it is not necessary to pattern the EIL **205**, thus, the electron injection layer raw materials having a very small size (e.g., a nanometer size) may be sprayed on the first substrate **101** by using the nozzle device for electron injection layer **770**.

Afterwards, the second electrode **117** is formed on the EIL **205**. The second electrode **117** may be formed by using a nozzle device for second electrode **780** that stores a second electrode raw material.

The second electrode **117** is a common layer that may not be required to be patterned. Thus, the second electrode raw material having a very small size (e.g., a nanometer size), such as a silver ink, may be sprayed on the first substrate **101** by using the nozzle device for second electrode **780** in a spray mode. Afterwards, in order to increase conductivity of the second electrode **117**, an annealing process may be performed at a temperature about 50° C.

As described above, the HIL **201**, the HTL **202**, the EML **310**, the ETL **204**, the EIL **205**, and the second electrode **117** may be manufactured together via solubility processes using the nozzle devices that store liquid raw materials.

According to the organic light-emitting display device and the method of manufacturing the organic light-emitting display device, when the OLED is formed, the organic layer, the

cathode, or the like may be manufactured together via the solubility processes, so that a deposition process may be omitted.

Also, because the OLED is manufactured via the solubility process, a large substrate may be manufactured, so that the productivity may be improved and the manufacturing costs may be reduced.

Also, because complicated equipment such as a vacuum apparatus for the deposition process is not necessary and the manufacturing procedure is performed in an atmosphere environment, the manufacturing procedure may be simplified, and an in-line based system may be formed.

Also, because commercially available mother glasses may be used or mother glasses may be produced in large scale with relative ease, the manufacturing costs may be saved.

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

What is claimed is:

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

forming a plurality of thin film transistors (TFTs) on a substrate;

forming a plurality of organic light emitting diodes (OLEDs), each of the OLEDs comprising a first electrode having a portion exposed by a pixel defining layer (PDL) on the TFTs, an organic layer on the exposed portion of the first electrode and comprising an emission layer (EML) configured to emit light having at least one of a plurality of colors, and a second electrode on the organic layer;

forming the EML in each of a sub-pixel region with one color and other sub-pixel regions with other colors, the sub-pixel regions being formed by forming openings in the PDL;

forming a solution supply unit in the PDL that fluidly communicates with the sub-pixel region with one color; and

supplying emission layer raw materials for the plurality of colors to the sub-pixel region with one color and the other sub-pixel regions with other colors via the solution supply unit, thereby forming the EML.

2. The method of claim 1, wherein at least one of the emission layer raw materials is sprayed into the solution supply unit via a nozzle unit having a power applied thereto, and

the at least one of the emission layer raw materials moves to the sub-pixel region that communicates with the solution supply unit, whereby the EML is formed.

3. The method of claim 2, wherein the EML is formed by charging the at least one of the emission layer raw materials comprising a liquid emission layer raw material; and

forming droplets by spraying the charged liquid emission layer raw material via the nozzle unit, and then forming the EML via the solution supply unit.

4. The method of claim 3, wherein the charging of the liquid emission layer raw material comprises applying an electrical potential difference to the liquid emission layer raw material.

5. The method of claim 4, wherein a positive voltage is applied to the nozzle unit, whereby the liquid emission layer raw material is positively charged and then is sprayed via the nozzle unit, and

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the substrate is electrically coupled to a ground voltage source.

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

forming a plurality of thin film transistors (TFTs) on a substrate; and

forming a plurality of organic light emitting diodes (OLEDs), each of the OLEDs comprising a first electrode having a portion exposed by a pixel defining layer (PDL) on the TFTs, an organic layer on the exposed portion of the first electrode and comprising an emission layer (EML) configured to emit light having at least one of a plurality of colors, and a second electrode on the organic layer,

wherein the EML is formed in each of a sub-pixel region with one color and other subpixel regions with other colors, the sub-pixel regions being formed by forming openings in the PDL,

wherein a solution supply unit that communicates with the sub-pixel region with one color is formed in the sub-pixel region with one color,

wherein emission layer raw materials for the plurality of colors are supplied to the subpixel region with one color and the other sub-pixel regions with other colors via the solution supply unit, whereby the EML is formed,

wherein at least one of the emission layer raw materials is sprayed into the solution supply unit via a nozzle unit having a power applied thereto,

wherein the at least one of the emission layer raw materials moves to the sub-pixel region that communicates with the solution supply unit, whereby the EML is formed,

wherein the EML is formed by charging the at least one of the emission layer raw materials comprising a liquid emission layer raw material,

wherein droplets are formed by spraying the charged liquid emission layer raw material via the nozzle unit, and then forming the EML via the solution supply unit,

wherein the EML comprises a first-color emission layer, a second-color emission layer, and a third-color emission layer,

wherein the first-color emission layer is formed in a first sub-pixel region of the sub-pixel regions, and the first sub-pixel region communicates with a first sub-pixel region solution supply unit,

wherein, the second-color emission layer is formed in a second sub-pixel region of the sub-pixel regions, and the second sub-pixel region communicates with a second sub-pixel region solution supply unit,

wherein the third-color emission layer is formed in a third sub-pixel region of the subpixel regions, and

wherein a first-color emission layer raw material and a second-color emission layer raw material, from among the emission layer raw materials, that are in a liquid state and are charged are sprayed via the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively, move to the first sub-pixel region and the second sub-pixel region, respectively, due to a repulsive force, and then form the first-color emission layer and the second-color emission layer, respectively.

7. The method of claim 6, wherein a plurality of the first sub-pixel regions, a plurality of the second sub-pixel regions, and a plurality of the third sub-pixel regions, from among the sub-pixel regions, are alternately formed along one direction of the substrate,

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the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit are formed on side ends of the substrate,

all of the plurality of the first sub-pixel regions communicate with the first sub-pixel region solution supply unit, and

all of the plurality of the second sub-pixel regions communicate with the second subpixel region solution supply unit.

8. The method of claim 6, wherein the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit extend along one direction of the substrate, and the plurality of the first sub-pixel regions and the plurality of the second sub-pixel regions are formed in a direction crossing the first sub-pixel region solution supply unit and the second sub-pixel region solution supply, respectively.

9. The method of claim 6, wherein the spraying of the first-color emission layer raw material and the second-color emission layer raw material comprises:

fixing the nozzle unit having a power applied thereto; and moving the substrate along one direction and concurrently spraying the first-color emission layer raw material and the second-color emission layer raw material, which are in the liquid state, via the first sub-pixel region solution supply unit and the second sub-pixel region solution supply unit, respectively.

10. The method of claim 6, wherein a third-color emission layer raw material from among the emission layer raw materials is sprayed on the third sub-pixel region via the nozzle unit, whereby the third-color emission layer is formed in the third sub-pixel region.

11. The method of claim 10, wherein the spraying of the third-color emission layer raw material comprises:

fixing the substrate; and moving the nozzle unit along another direction of the substrate and concurrently spraying the third-color emission layer raw material on the third sub-pixel region in which the third-color emission layer is formed.

12. The method of claim 6, wherein the first-color emission layer comprises a red emission layer,

the second-color emission layer comprises a green emission layer; and

the third-color emission layer comprises a blue emission layer.

13. The method of claim 3, wherein the liquid emission layer raw material comprises nanometer-size particles.

14. The method of claim 1, wherein the second electrode is formed by spraying a second electrode raw material on the substrate via a nozzle unit having a power applied thereto.

15. The method of claim 14, wherein the second electrode raw material comprises nanometer-size particles.

16. The method of claim 1, wherein the organic layer further comprises at least one layer of a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), or an electron injection layer (EIL), and the at least one layer is formed by spraying a corresponding raw material.

17. The method of claim 16, wherein the at least one layer comprises the HIL or the HTL, and

a hole injection layer raw material or a hole transport layer raw material is coated on a substantially entire surface of the substrate by using a slit coater.

18. The method of claim 16, wherein the at least one layer comprises the ETL, and

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an electron transport layer raw material having a nanometer size is sprayed on the substrate via a nozzle unit having a power applied thereto.

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专利名称(译)	有机发光显示装置及其制造方法		
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摘要(译)

在有机发光显示装置和制造有机发光显示装置的方法中，该方法包括在基板上形成薄膜晶体管（TFT）；形成有机发光二极管（OLED），每个OLED包括具有由TFT上的像素限定层（PDL）暴露的部分的第一电极，在第一电极的暴露部分上的有机层并且包括发光层（EML）被配置为发射具有多种颜色中的相应一种颜色的光，并且在有机层上发射第二电极。EML形成在具有一种颜色的子像素区域和具有通过在PDL中形成开口而形成的其他颜色的其他颜色的每个子像素区域中。用于以一种颜色与子像素区域通信的子像素区域的溶液供应单元在一个子像素区域中形成一种颜色。

