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Kim et al.

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- (54) **ORGANIC LIGHT EMITTING DISPLAY DEVICE**
- (71) Applicant: **Samsung Display Co., Ltd**, Yongin-si, Gyeonggi-do (KR)
- (72) Inventors: **Mu-Gyeom Kim**, Hwaseong-si (KR); **Min-Soo Kim**, Seoul (KR)
- (73) Assignee: **SAMSUNG DISPLAY CO., LTD.** (KR)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days. days.

- (56) **References Cited**
- U.S. PATENT DOCUMENTS

2011/0273082 A1	11/2011	Kim	
2012/0069444 A1	3/2012	Campbell et al.	
2014/0055028 A1*	2/2014	Yi	H05B 33/04 313/498
2016/0109998 A1*	4/2016	Watanabe	G06F 3/0412 349/12
2016/0124557 A1*	5/2016	Choi	G06F 3/0412 345/173
2017/0010734 A1*	1/2017	Liu	G06F 3/044
2017/0078513 A1*	3/2017	Chang	G06F 3/0488
2017/0123543 A1*	5/2017	Choi	G06F 3/0412

* cited by examiner

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Primary Examiner — Allan R Wilson

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(74) *Attorney, Agent, or Firm* — Innovation Counsel, LLP

(65) **Prior Publication Data**
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(57) **ABSTRACT**

An organic light emitting diode (OLED) display device includes a substrate, reflection structure, and a sub-pixel structure. The substrate includes a plurality of sub-pixel regions and a reflection region surrounding the sub-pixel regions. The reflection structure is disposed on the substrate in the reflection region and has a plurality of openings exposing the sub-pixel regions. The reflection structure includes first reflection patterns, second reflection patterns, and connection patterns. The first reflection patterns extend in a first direction parallel to an upper surface of the substrate, and are spaced apart from each other in a second direction perpendicular to the first direction. The second reflection patterns are spaced apart from each other in the first direction between two adjacent first reflection patterns. The connection patterns electrically connect two adjacent second reflection patterns in the second direction. The sub-pixel structure is disposed on the substrate in the sub-pixel region.

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H01L 51/52 (2006.01)

(52) **U.S. Cl.**
 CPC **H01L 27/323** (2013.01); **H01L 27/3258** (2013.01); **H01L 27/3262** (2013.01); **H01L 27/3276** (2013.01); **H01L 51/5246** (2013.01); **H01L 51/5271** (2013.01)

(58) **Field of Classification Search**
 CPC H01L 27/323; H01L 27/3258; H01L 27/3262; H01L 27/3276; H01L 51/5246; H01L 51/5271

See application file for complete search history.

31 Claims, 21 Drawing Sheets

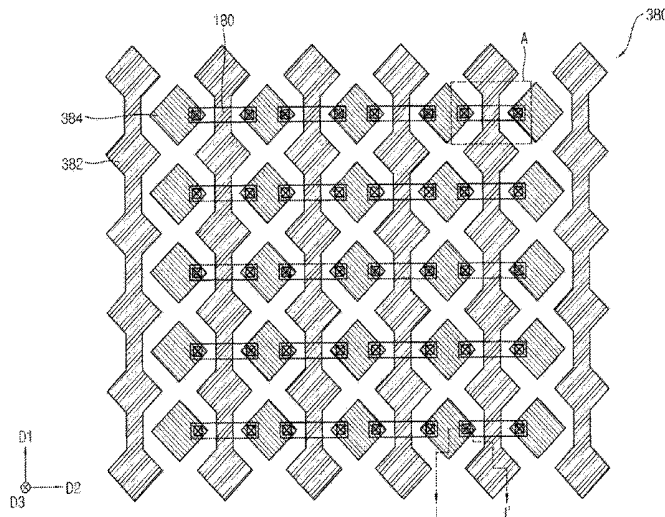
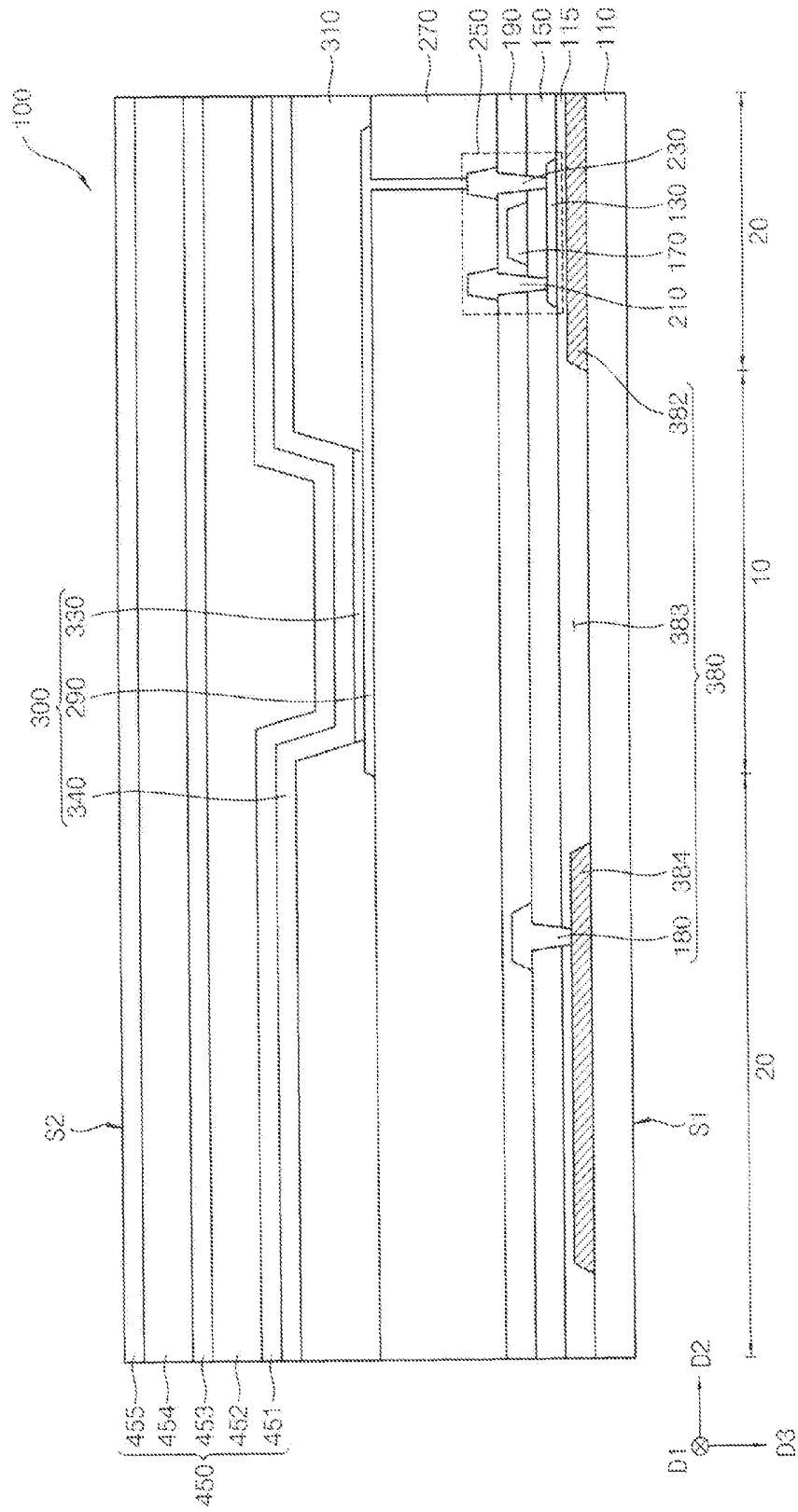


FIG. 1



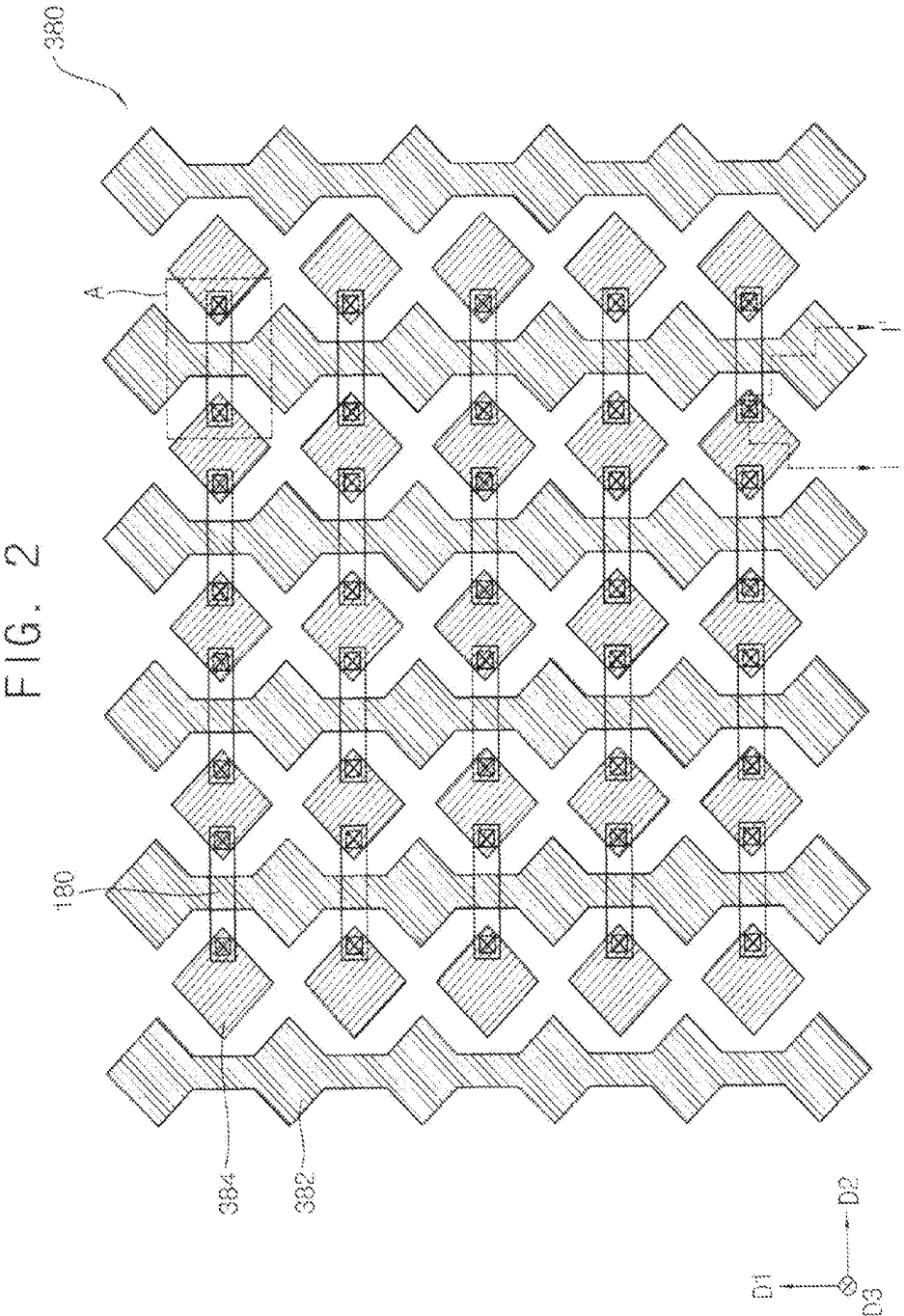


FIG. 3

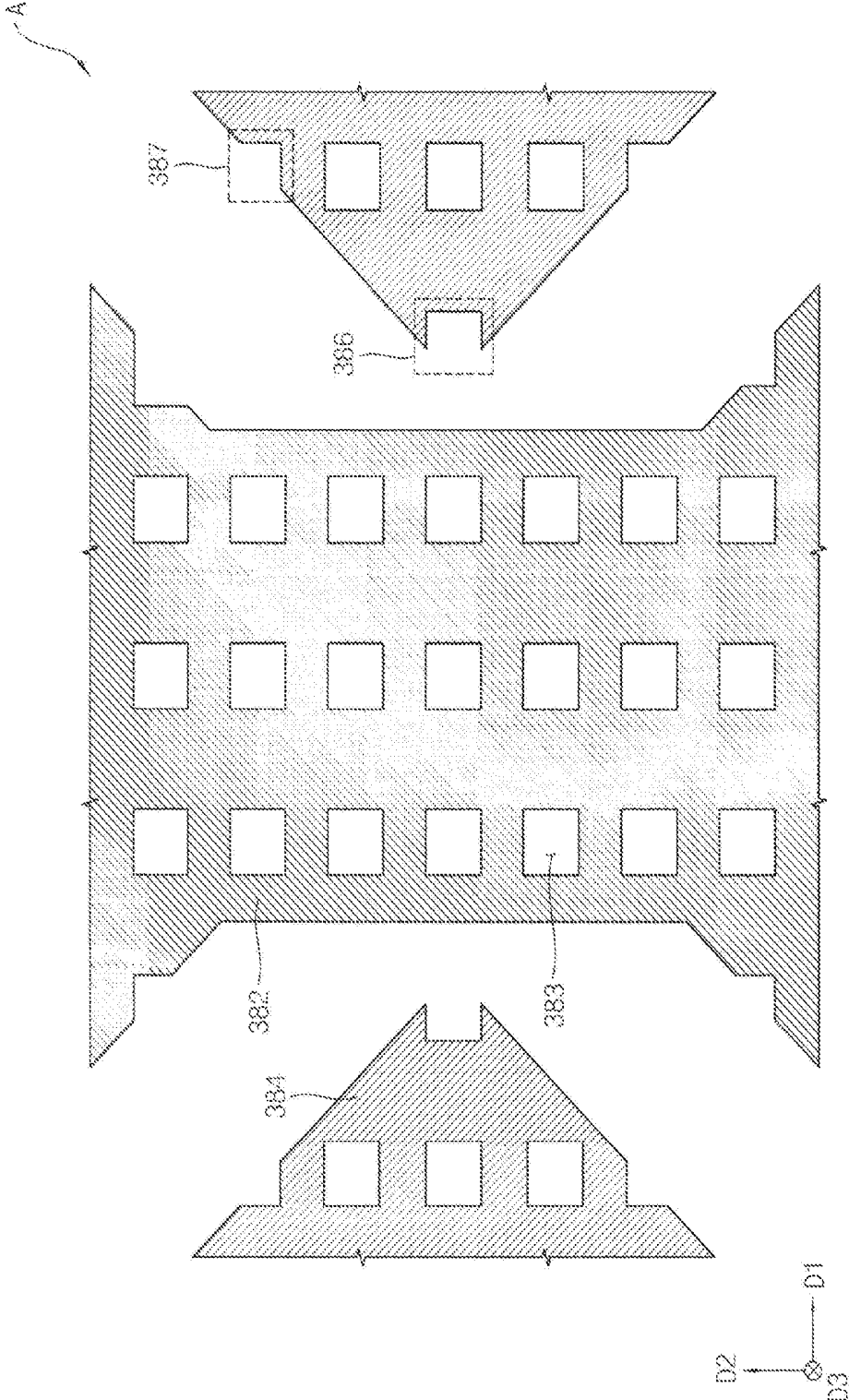


FIG. 4

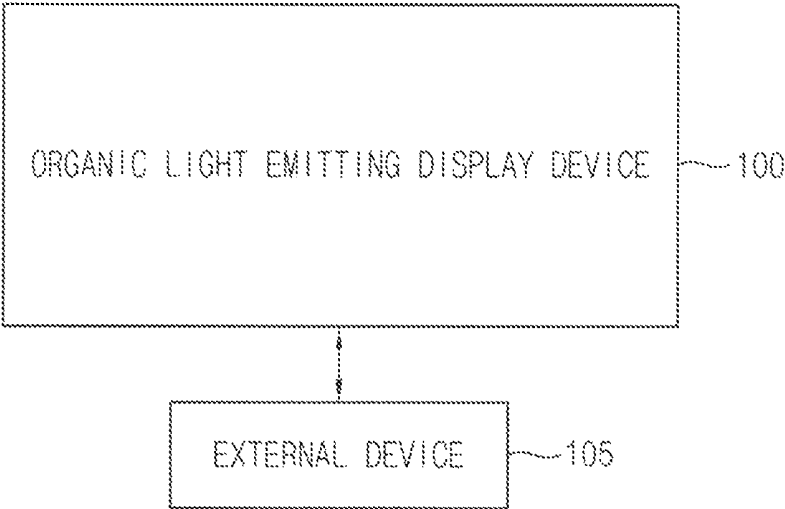


FIG. 5

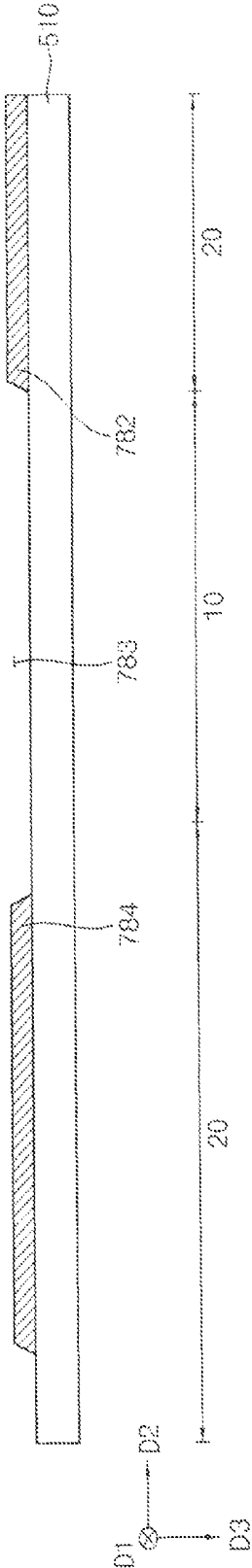


FIG. 6

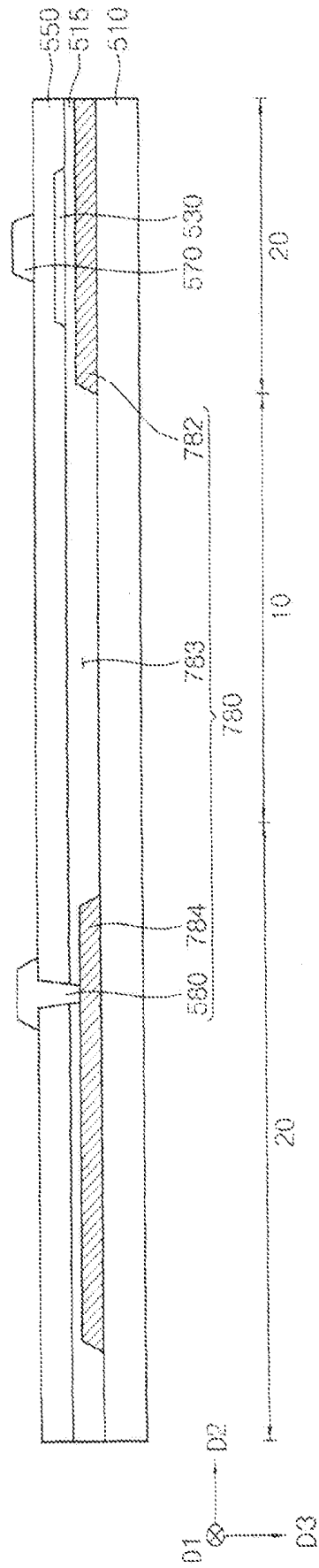


FIG. 7

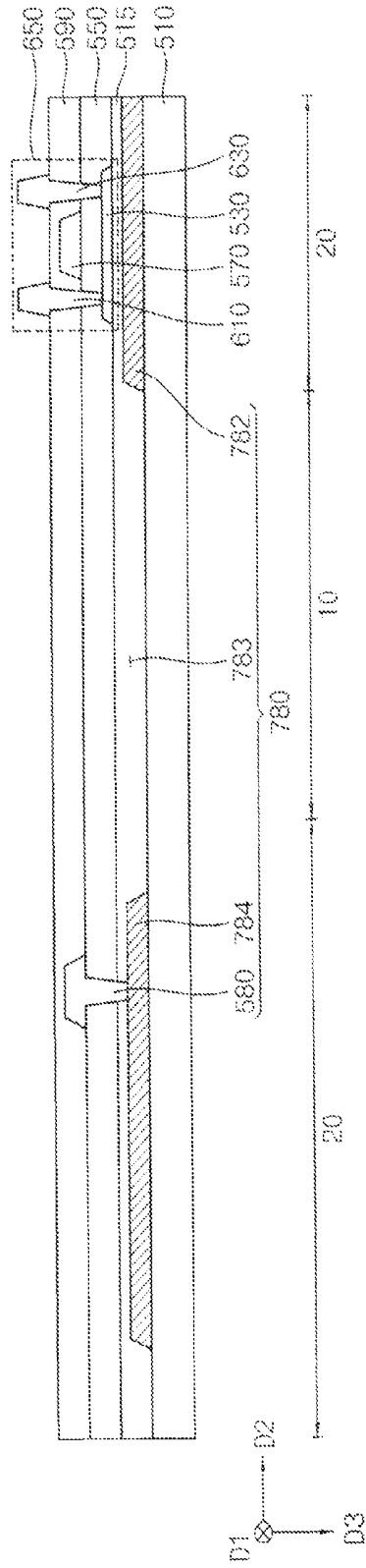


FIG. 8

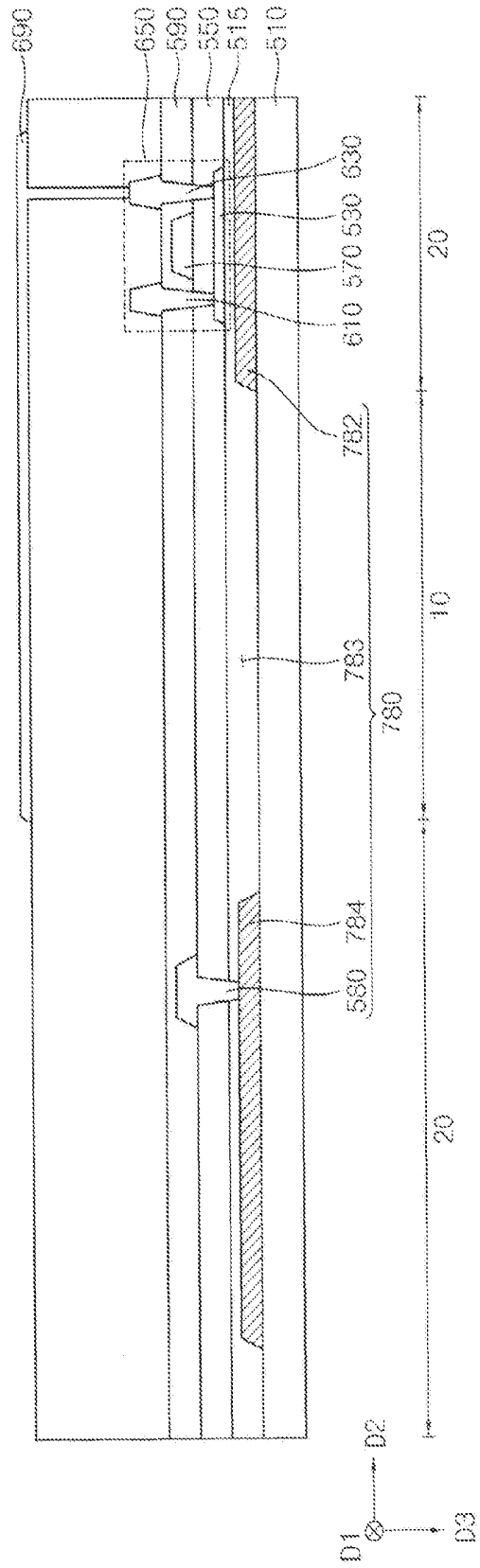


FIG. 9

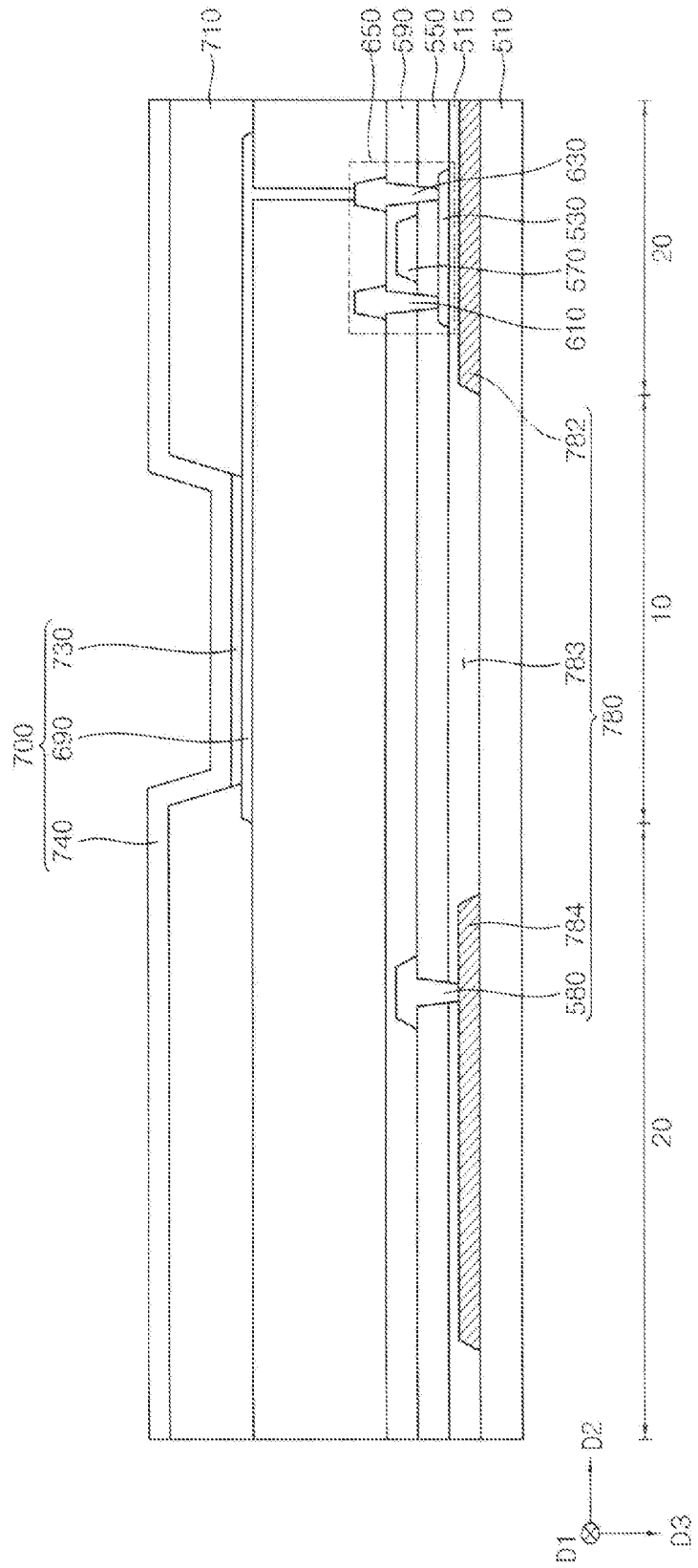


FIG. 10

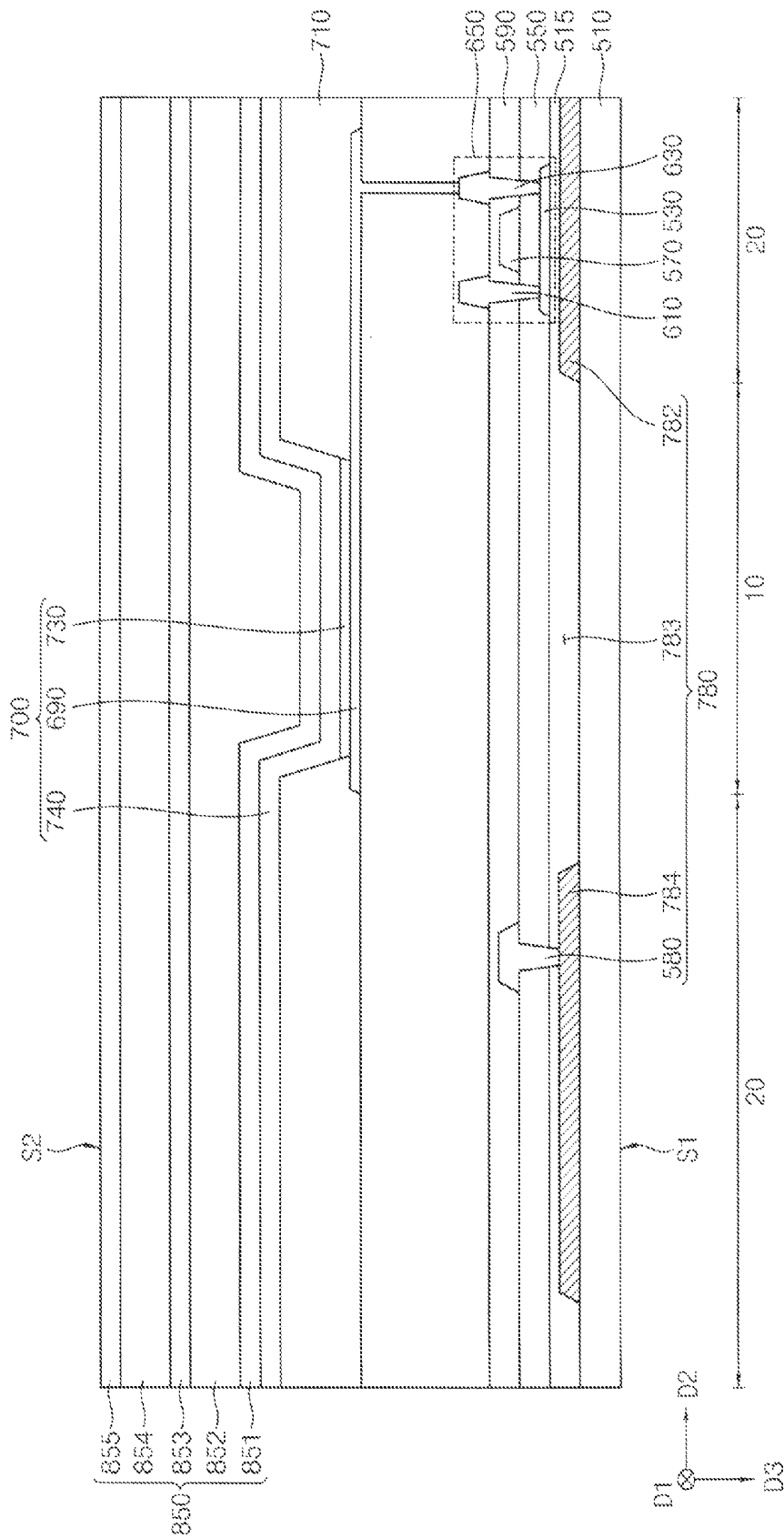


FIG. 12

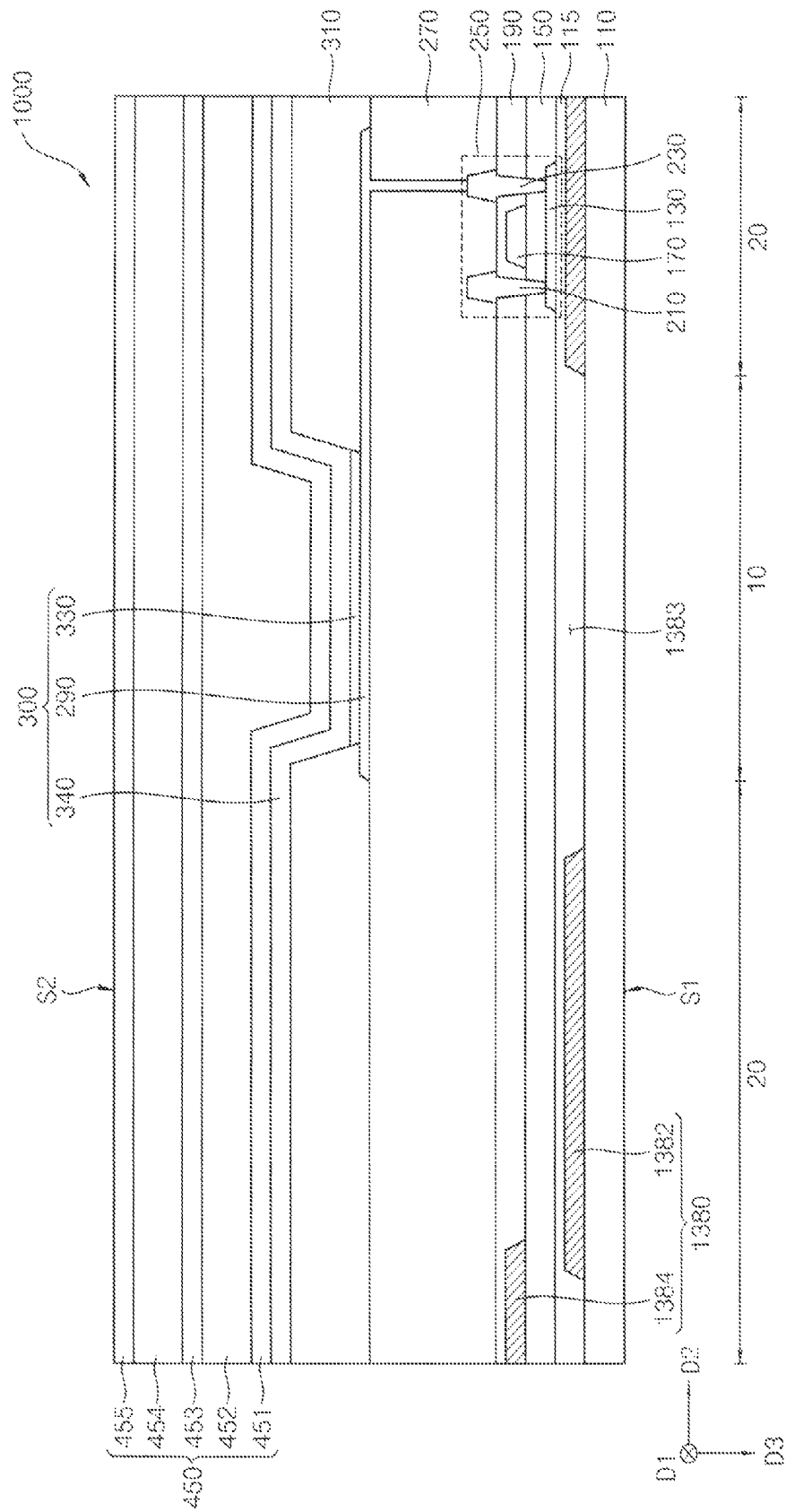


FIG. 13

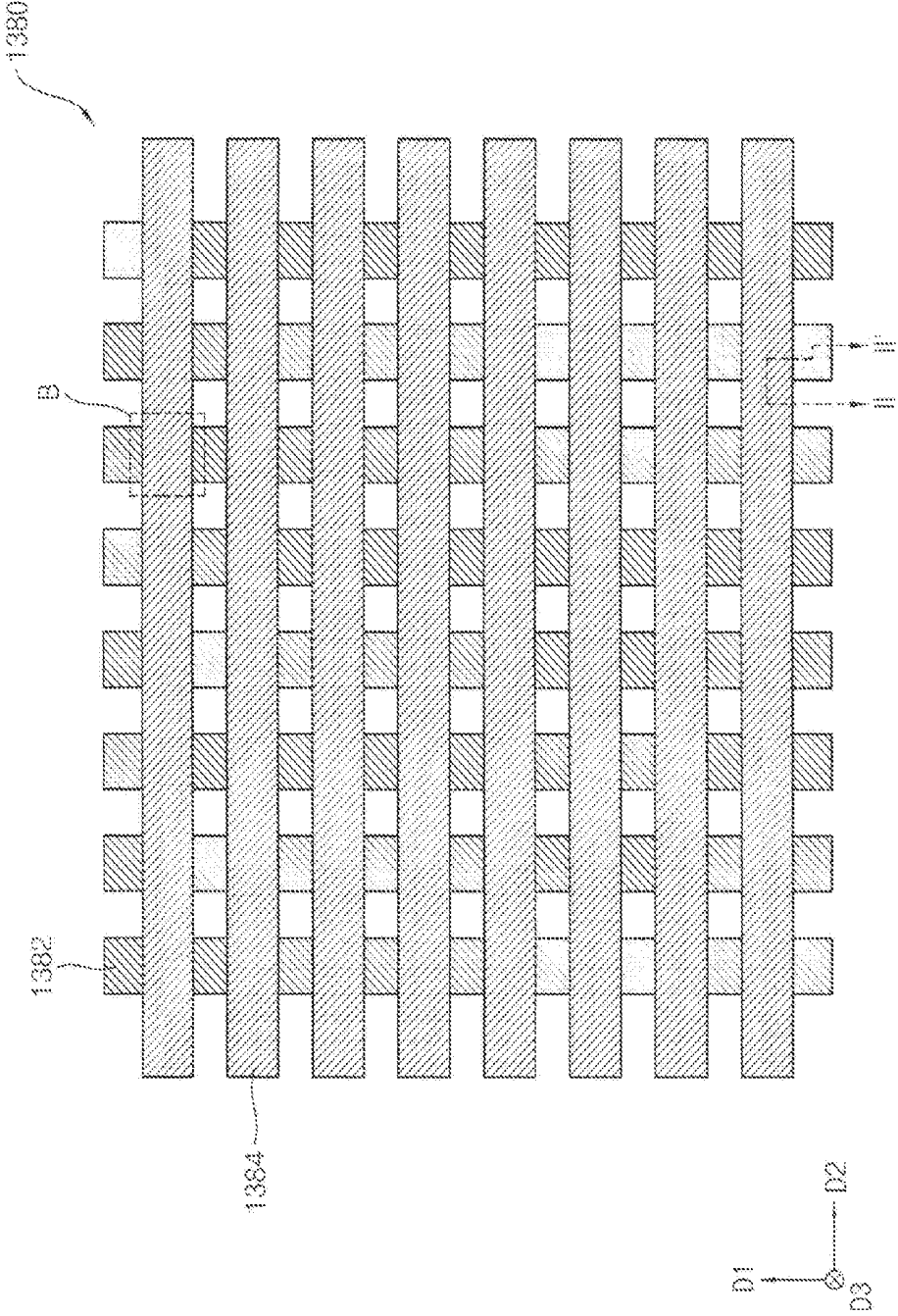


FIG. 14

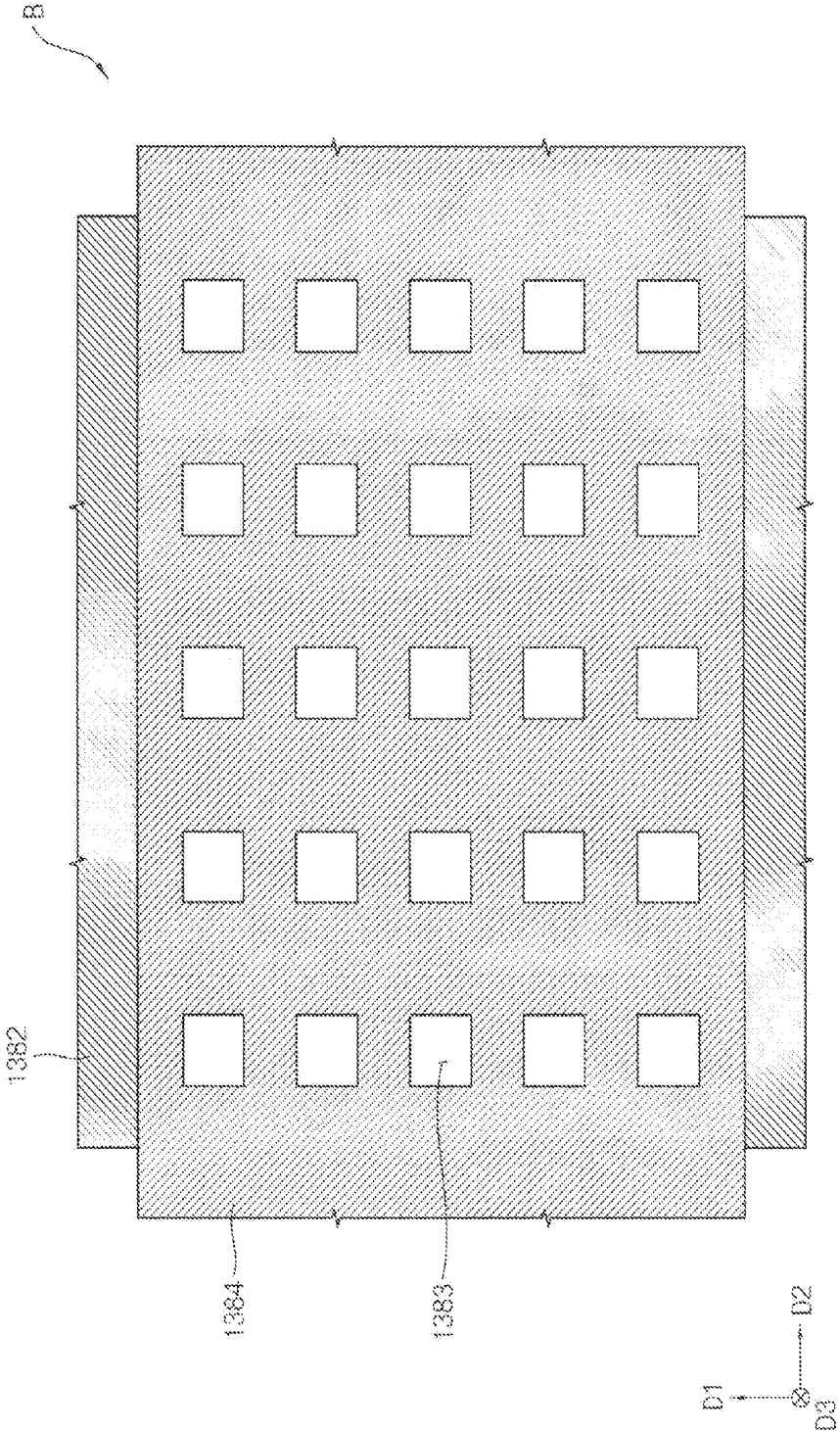


FIG. 15

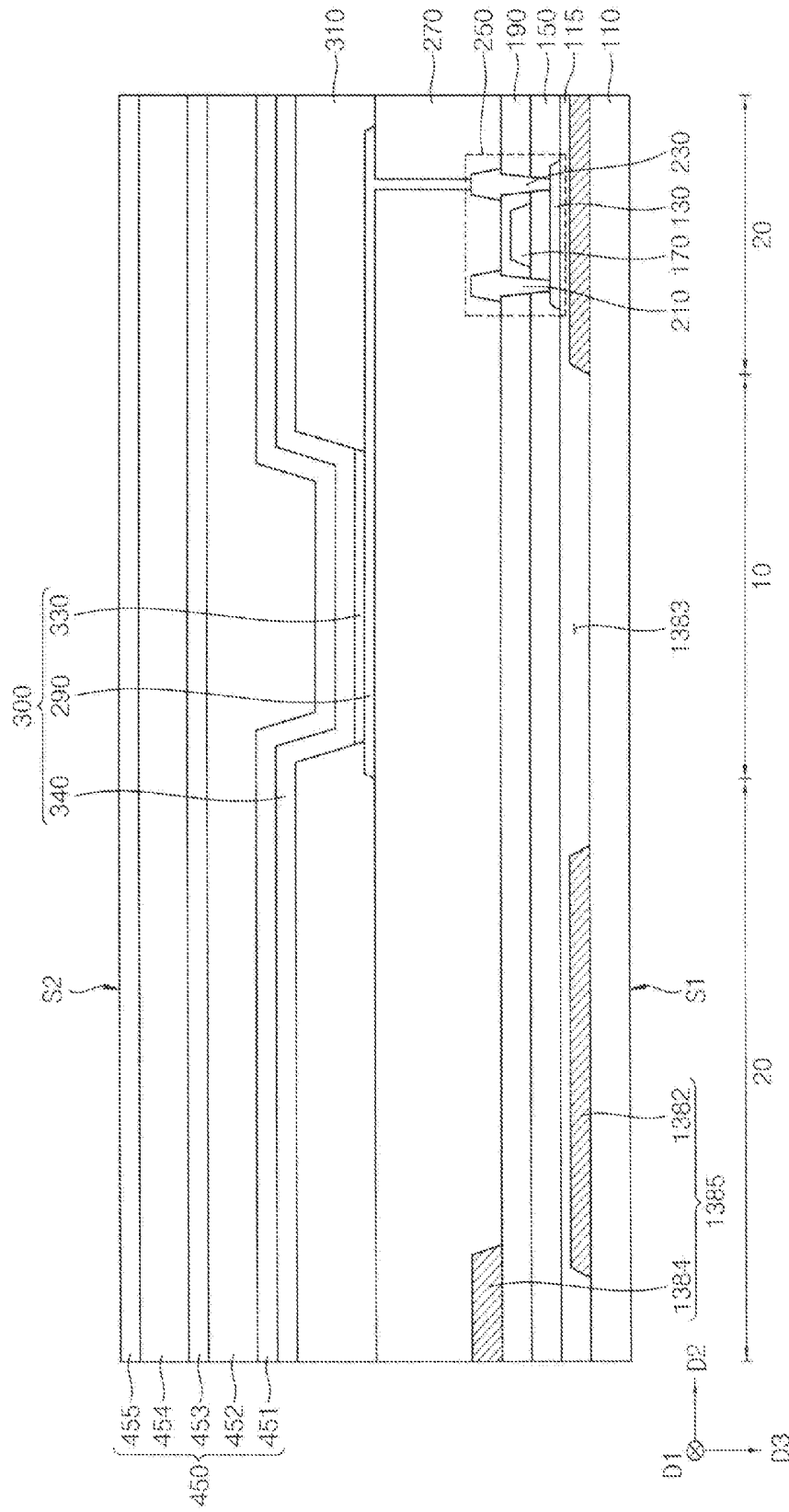


FIG. 16

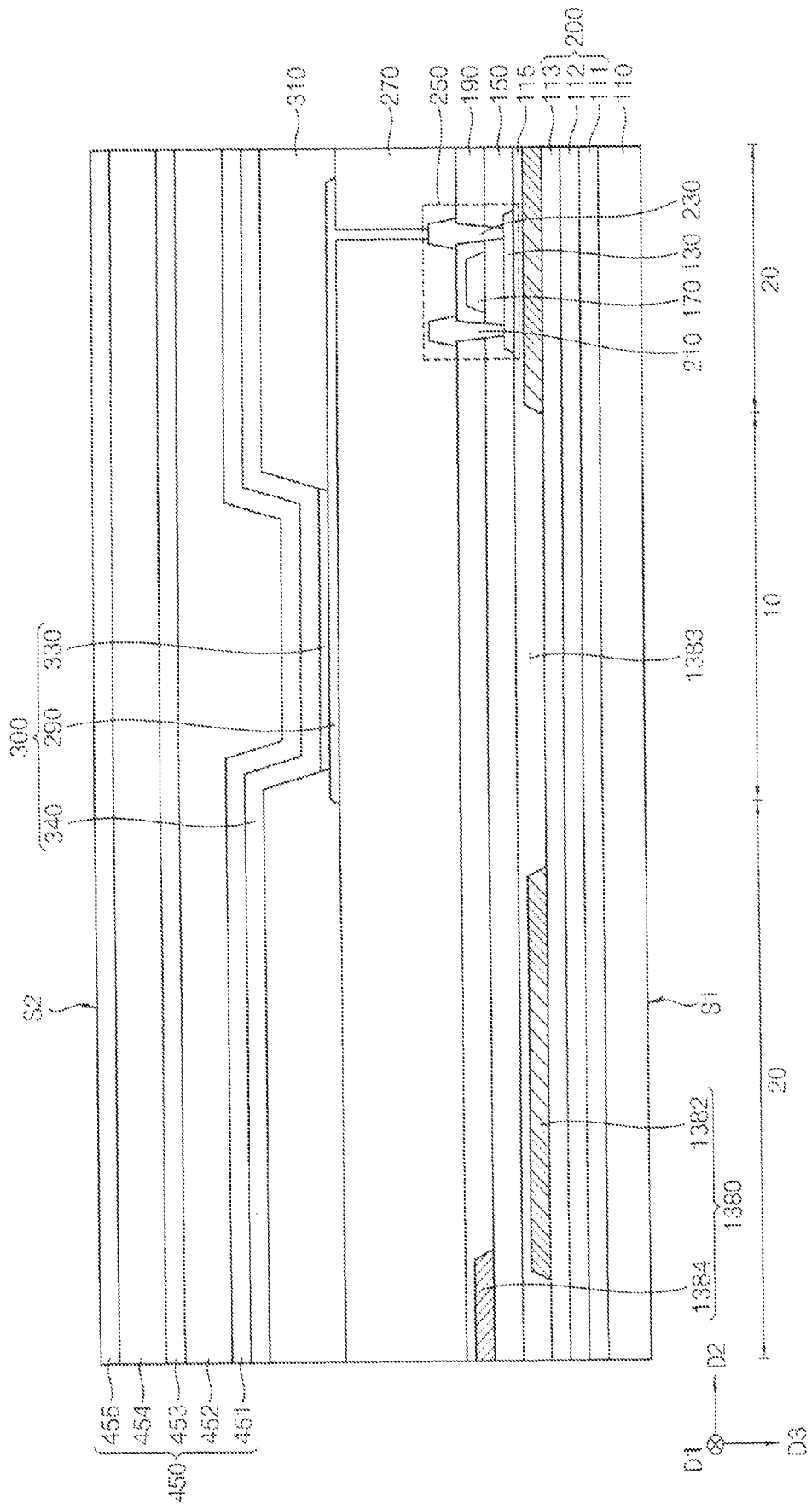


FIG. 17

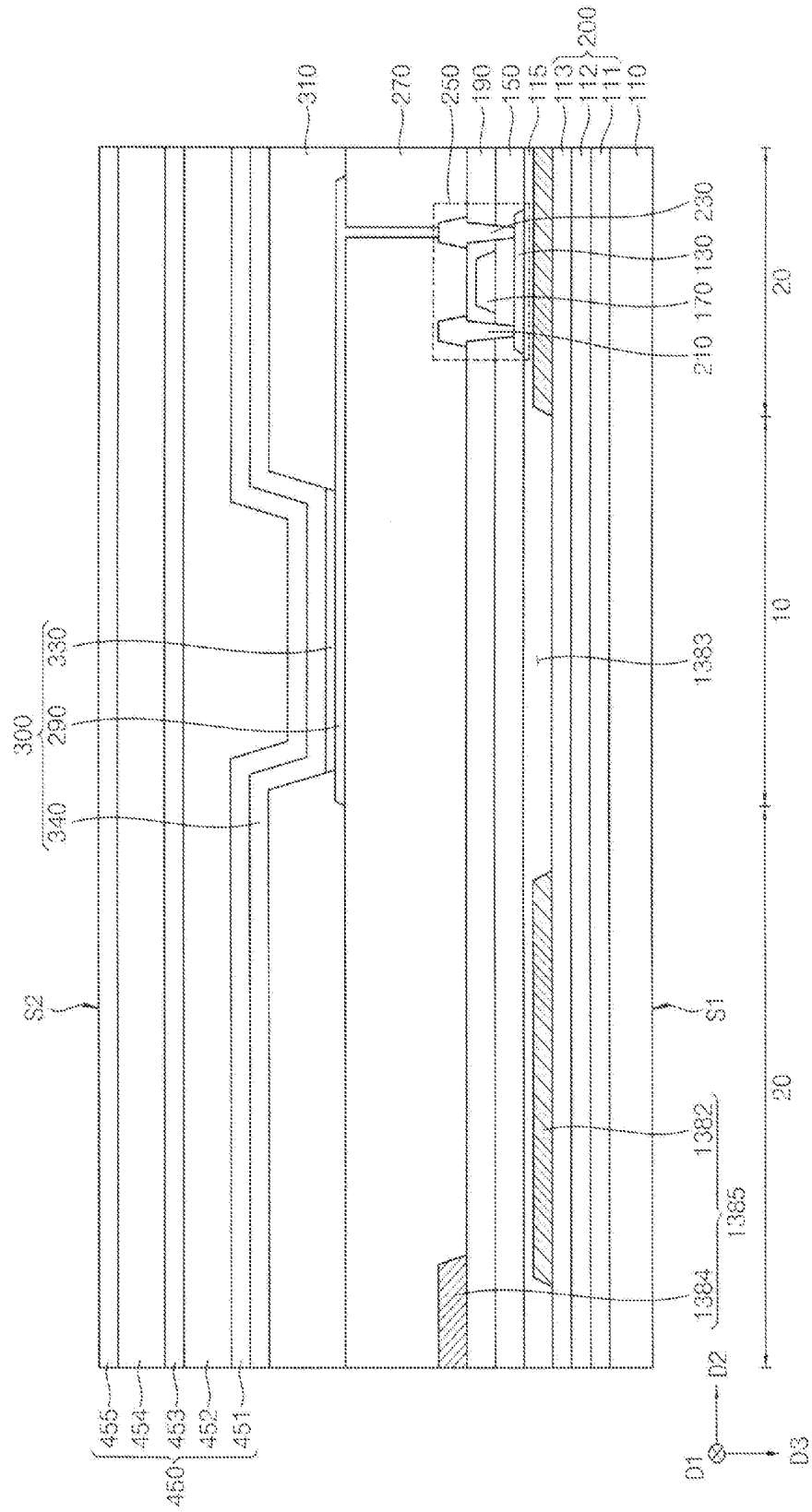


FIG. 18

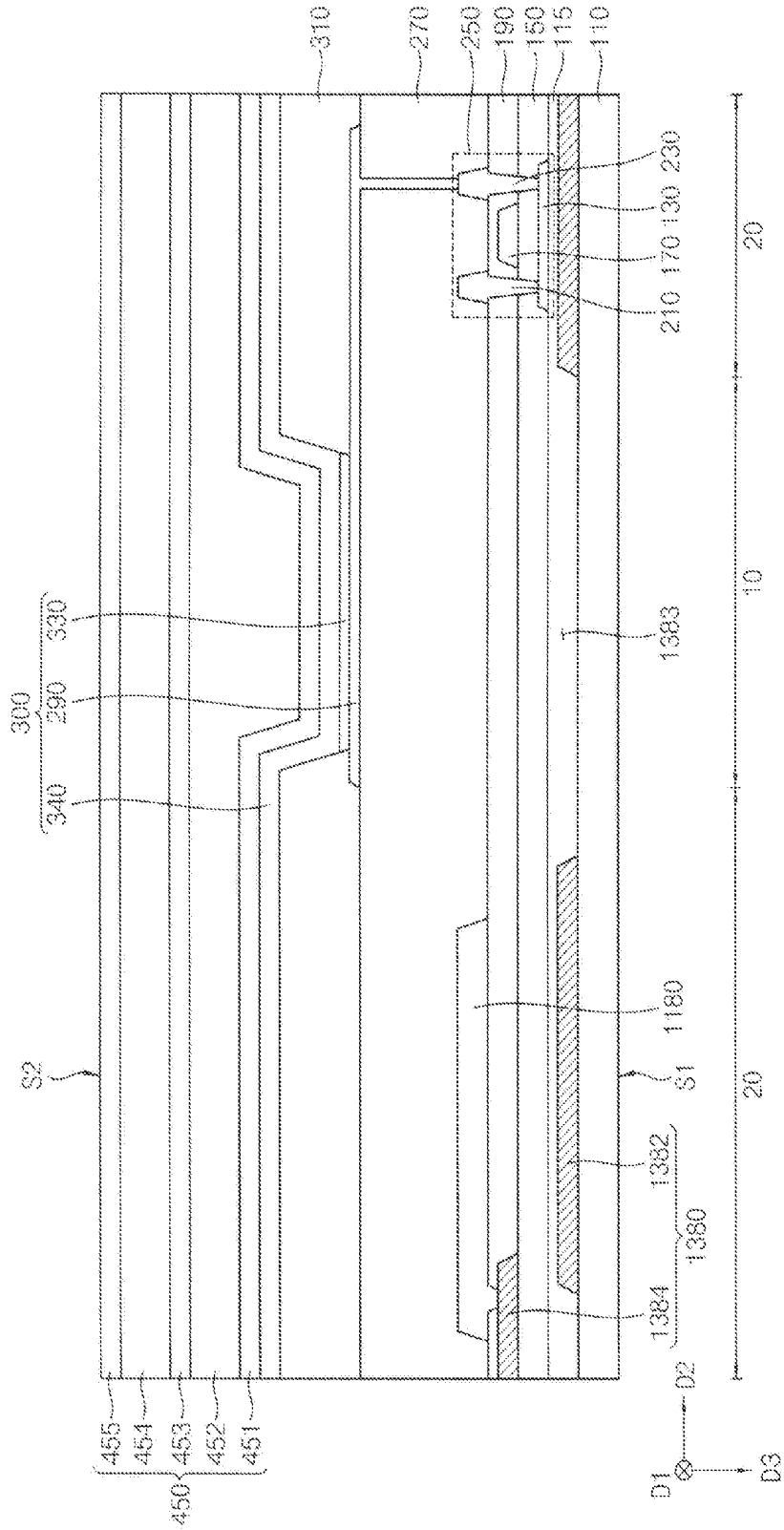


FIG. 20

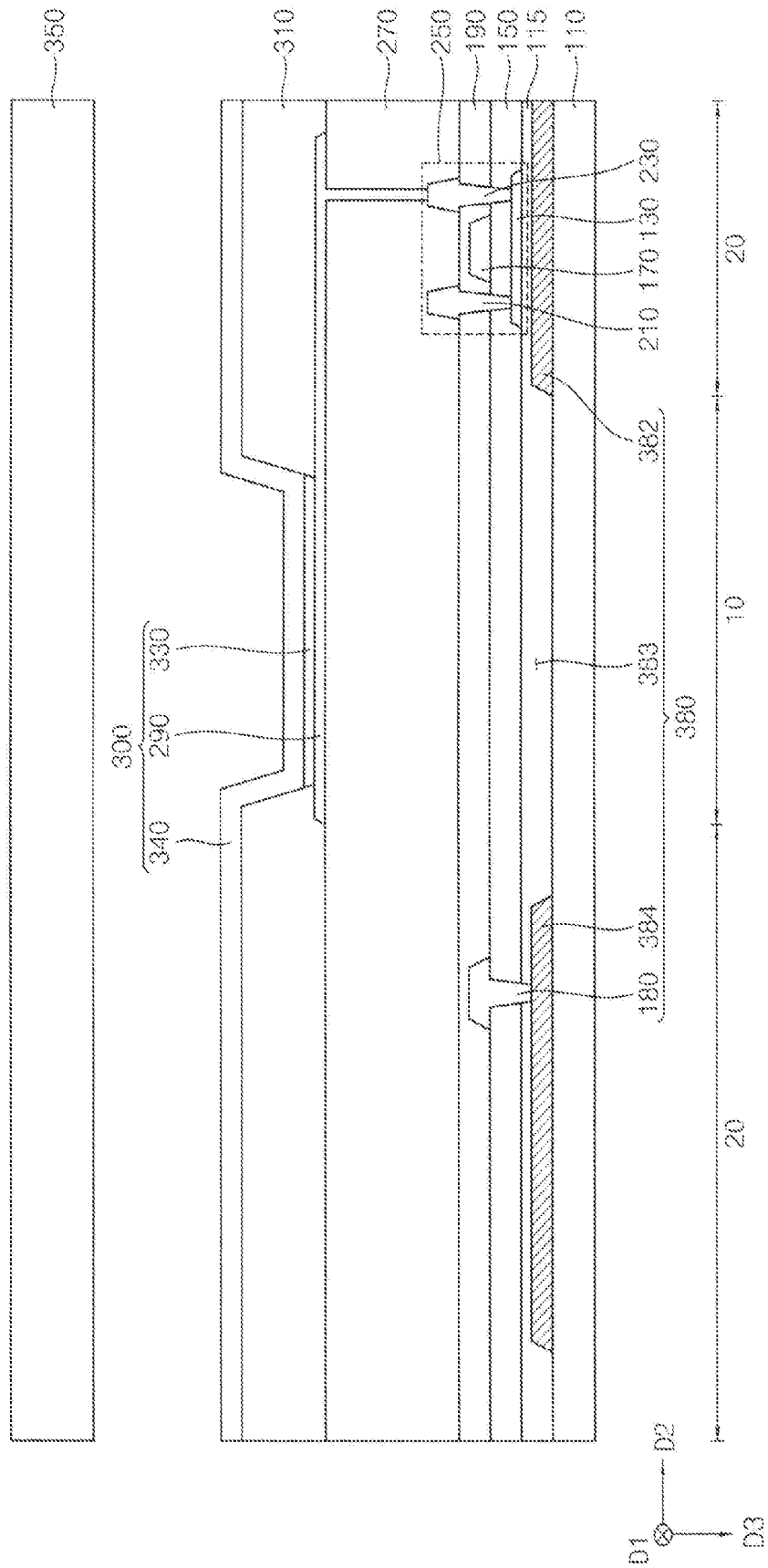
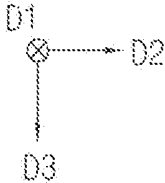
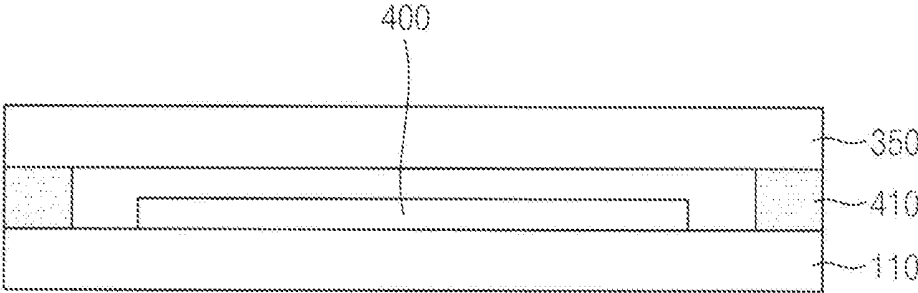


FIG. 21



ORGANIC LIGHT EMITTING DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims priority under 35 USC § 119 to Korean Patent Applications No. 10-2016-0035194, filed on Mar. 24, 2016 in the Korean Intellectual Property Office (KIPO), the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

Example embodiments of the present disclosure relate generally to organic light emitting diode (OLED) display devices, more particularly, to OLED display devices including a reflection region.

2. Description of the Related Art

A flat panel display (FPD) device is widely used as a display device of an electronic device due to its lightweight and thinness compared to a cathode-ray tube (CRT) display device. Typical examples of the FPD device are a liquid crystal display (LCD) device and an organic light emitting diode (OLED) display device. Compared to the LCD device, the OLED device has several advantages such as a higher luminance and a wider viewing angle. In addition, the OLED device can be made thinner because the OLED device does not require a backlight. In the OLED device, electrons and holes are injected into an organic thin layer through a cathode and an anode, and then recombined in the organic thin layer to generate excitons, thereby emitting a light of a certain wavelength.

Recently, a mirror OLED device including a pixel region and a reflection region has been developed. The mirror OLED device is capable of reflecting an image of an object (or a target) that is located in front of the OLED device by the reflection region.

SUMMARY

Some example embodiments of the present disclosure provide an organic light emitting diode (OLED) display device capable of reflecting an image of an object that is located in front of the OLED device.

According to some aspect of example embodiments, an OLED device includes a substrate, a reflection structure, and a sub-pixel structure. The substrate includes a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions. The reflection structure is disposed on the substrate in the reflection region and has a plurality of openings exposing the plurality of sub-pixel regions. The reflection structure includes first reflection patterns, second reflection patterns, and connection patterns. The first reflection patterns extend in a first direction that is parallel to an upper surface of the substrate, and is spaced apart from each other in a second direction that is perpendicular to the first direction. The second reflection patterns are spaced apart from each other in the first direction between two adjacent first reflection patterns among the first reflection patterns. The connection patterns electrically connect two adjacent second reflection patterns in the second direction among the second reflection patterns. The sub-

pixel structure is disposed on the substrate in each of the plurality of sub-pixel regions.

In example embodiments, the reflection structure is disposed between the substrate and the sub-pixel structure.

In example embodiments, the first reflection patterns may be configured to receive a first touch sensing voltage from an external device, and the second reflection patterns may be configured to receive a second touch sensing voltage from the external device. The external device may detect a change of capacitance between the first reflection patterns and the second reflection patterns.

In example embodiments, each of the first reflection patterns may have a planar bar shape and may be regularly arranged in the second direction. Each of the second reflection patterns may have an island shape and may be regularly arranged in the first direction. The first reflection patterns and the second reflection patterns may be spaced apart from each other.

In example embodiments, each of the first and second reflection patterns may have a mesh structure including the plurality of openings.

In example embodiments, at least one groove may be formed in a border of the first reflection pattern and the second reflection pattern.

In example embodiments, the OLED device may further include a thin film encapsulation structure disposed on the sub-pixel structure. Each of the substrate and the thin film encapsulation structure may have a stack structure where at least one organic layer and at least one inorganic layer are alternately stacked, and the stack structure may be flexible. The reflection structure may be in contact with the at least one inorganic layer of the substrate, and the sub-pixel structure may be in contact with the at least one inorganic layer of the thin film encapsulation structure.

In example embodiments, the OLED device may further include an encapsulation substrate and a sealant. The encapsulation substrate may be disposed on the sub-pixel structure. The sealant may be interposed between the substrate and the encapsulation substrate, and may be disposed in outer regions of the substrate and the encapsulation substrate. Each of the substrate and the encapsulation substrate may include rigid materials, and the sealant may include a frit. The substrate and the encapsulation substrate may be combined by the sealant.

In example embodiments, the sub-pixel structure may include a lower electrode, a light emitting layer, and an upper electrode. The lower electrode may be disposed on the substrate and may transmit a light. The light emitting layer may be disposed on the lower electrode. The upper electrode may be disposed on the light emitting layer, and may reflect a light that is emitted from the light emitting layer. A reflectivity of the upper electrode may be greater than a reflectivity of the lower electrode, and the upper electrode may be disposed on the substrate in the sub-pixel region and the reflection region.

In example embodiments, the reflection structure may reflect an image of an object that is located in front of a first surface of the OLED device, and the upper electrode may reflect an image of an object that is located in front of a second surface of the OLED device. The second surface may be opposite to the first surface, and the OLED device may display a displaying image in the first surface through the plurality of openings.

In example embodiments, the OLED device may further include a semiconductor and a buffer layer. The semiconductor element may be disposed on the substrate in the reflection region. The buffer layer may be disposed on the

substrate between the reflection structure and the semiconductor element. The semiconductor element includes an active layer disposed on the buffer layer in the reflection region, a gate electrode disposed on the active layer, and source and drain electrodes disposed on the gate electrode.

In example embodiments, the connection patterns and the gate electrode may be simultaneously formed using the same material.

In example embodiments, the OLED device may further include a dielectric mirror structure disposed between the substrate and the reflection structure.

In example embodiments, the dielectric mirror structure may include one or more first dielectric layers and one or more second dielectric layers. The one or more first dielectric layers may have a first refractive index, and the one or more second dielectric layers may be disposed on the one or more first dielectric layers. The one or more second dielectric layers may have a second refractive index that is different from the first refractive index. The one or more first dielectric layers and the one or more second dielectric layers may be alternately stacked.

According to some aspect of example embodiments, an OLED device includes a substrate, reflection structure, and a sub-pixel structure. The substrate includes a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions. The sub-pixel structure may be disposed on the substrate in each of the plurality of sub-pixel regions. The reflection structure is disposed on the substrate in the reflection region and has a plurality of openings, and the plurality of sub-pixel regions may be exposed through the plurality of openings. The reflection structure includes first reflection patterns and second reflection patterns. The first reflection patterns may be arranged in a first direction, and the second reflection patterns may be arranged in the second direction that is perpendicular to the first direction.

In example embodiments, the reflection structure may be disposed between the substrate and the sub-pixel structure.

In example embodiments, the first reflection patterns may be configured to receive a first touch sensing voltage from an external device, and the second reflection patterns may be configured to receive a second touch sensing voltage from the external device. The external device may detect a change of capacitance between the first reflection patterns and the second reflection patterns.

In example embodiments, each of the first and second reflection patterns may have a planar bar shape and may be regularly arranged to each other. Each of the first and second reflection patterns may have a mesh structure including the plurality of openings.

In example embodiments, the first reflection patterns and the second reflection patterns may be crossed to each other in a cross-over regions, and a first group of the plurality of openings of the first reflection patterns and a second group of the plurality of openings of the second reflection patterns that are located in the cross-over region may be overlapped to each other.

In example embodiments, the OLED device may further include a thin film encapsulation structure disposed on the sub-pixel structure. Each of the substrate and the thin film encapsulation structure may have a stack structure where at least one organic layer and at least one inorganic layer are alternately stacked, and the stack structure may be flexible. The reflection structure may be in contact with the at least one inorganic layer of the substrate, and the sub-pixel structure may be in contact with the at least one inorganic layer of the thin film encapsulation structure.

In example embodiments, the OLED device may further include a semiconductor element and a buffer layer. The semiconductor element may be disposed on the substrate in the reflection region. The buffer layer may be disposed on the substrate between the first reflection pattern and the semiconductor element. The semiconductor element may include an active layer disposed on the buffer layer in the reflection region, a gate electrode disposed on the active layer, and source and drain electrodes disposed on the gate electrode. The second reflection patterns and the gate electrode may be simultaneously formed using the same material.

In example embodiments, the OLED device may further include an auxiliary wiring. The auxiliary wiring may be disposed on the second reflection pattern, and may be electrically connected to the second reflection patterns. The auxiliary wiring and the source and drain electrodes may be simultaneously formed using the same materials.

In example embodiments, the OLED device may further include a dielectric mirror structure disposed between the substrate and the reflection structure. The dielectric mirror structure may include one or more first dielectric layers and one or more second dielectric layers. The one or more first dielectric layers may have a first refractive index. The one or more second dielectric layers may be disposed on the one or more first dielectric layers and may have a second refractive index that is different from the first refractive index. The one or more first dielectric layers and the one or more second dielectric layers may be alternately stacked.

According to example embodiments, an OLED device includes a substrate, a sub-pixel structure, and a sensing structure. The substrate may include a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions. The sub-pixel structure may be disposed on the substrate in each of the plurality of sub-pixel regions. The sensing structure may be disposed on the substrate in the reflection region and may have a plurality of openings. The plurality of sub-pixel regions may be exposed through the plurality of openings. The sensing structure may include first sensing patterns and second sensing patterns insulated from the first sensing patterns. The sensing structure may be disposed between the substrate and the sub-pixel structure.

In example embodiments, the sensing structure may further include connection patterns electrically connecting two adjacent second sensing patterns in a second direction among the second sensing patterns. The first sensing patterns may extend in a first direction that is perpendicular to the second direction and may be spaced apart from each other in the second direction. The second sensing patterns may be spaced apart from each other in the first direction and the second direction.

In example embodiments, the first sensing patterns may be arranged in a first direction, and the second sensing patterns may be arranged in a second direction that is perpendicular to the first direction.

In example embodiments, each of the first sensing patterns and the second sensing patterns may reflect light entering through the substrate.

In example embodiments, the first sensing patterns may be applied with a first voltage and the second sensing patterns may be applied with a second voltage. A change of capacitance between the first sensing patterns and the second sensing patterns may be detected to determine a position of touch.

In example embodiments, the first voltage may be a sensing input signal and the second voltage may be a sensing output signal.

In example embodiments, the change of capacitance between the first sensing patterns and the second sensing patterns may measure a pressure of touch.

In example embodiments, the OLED device may further include a circuit that is configured to generate the first voltage and the second voltage

An OLED device according to example embodiments includes the reflection structure having the first reflection patterns and the second reflection patterns that may serve as touch sensor electrodes. The reflection structure may reflect an image of an object that is located in front of the OLED device. Accordingly, the OLED device may serve as a mirror OLED device of a bottom emission structure having a relatively thin thickness because the OLED device does not include a touch screen panel. In addition, as the OLED device includes the flexible substrate and the encapsulation substrate, the OLED device may have a curved shape. Further, an image of an object that is located in front of the back of the OLED device may be reflected from the upper electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments can be understood in more detail from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view illustrating an organic light emitting diode (OLED) display device in accordance with example embodiments;

FIG. 2 is a planar view describing a reflection structure included in the OLED device of FIG. 1;

FIG. 3 is an enlarged planar view corresponding to region 'A' of FIG. 2;

FIG. 4 is a block diagram for describing an external device electrically connected to a reflection structure included in the OLED device of FIG. 1

FIGS. 5, 6, 7, 8, 9, and 10 are cross-sectional views illustrating a method of manufacturing an OLED device in accordance with example embodiments;

FIG. 11 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 12 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 13 is a planar view describing a reflection structure included in the OLED device of FIG. 12;

FIG. 14 is an enlarged planar view corresponding to region 'B' of FIG. 13;

FIG. 15 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 16 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 17 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 18 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 19 is a cross-sectional view illustrating an OLED device in accordance with example embodiments;

FIG. 20 is a cross-sectional view illustrating an OLED device in accordance with example embodiments; and

FIG. 21 is a cross-sectional view describing a sealant included in the OLED device of FIG. 20.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments of the present disclosure will be explained in detail with reference to the accompanying drawings.

FIG. 1 is a cross-sectional view illustrating an organic light emitting diode (OLED) display device in accordance with example embodiments, and FIG. 2 is a planar view describing a reflection structure included in the OLED device of FIG. 1. FIG. 3 is an enlarged planar view corresponding to region 'A' of FIG. 2, and FIG. 4 is a block diagram for describing an external device electrically connected to a reflection structure included in the OLED device of FIG. 1. FIG. 1 may correspond to a cross-sectional view taken along line I-I' of FIG. 2.

Referring to FIGS. 1, 2, 3, and 4, an OLED device 100 may include a substrate 110, a reflection structure 380, a buffer layer 115, a semiconductor element 250, a planarization layer 270, a sub-pixel structure 300, a pixel defining layer 310, and a thin film encapsulation (TFE) structure 450. Here, the semiconductor element 250 may include an active layer 130, a gate insulation layer 150, a gate electrode 170, an insulating interlayer 190, a source electrode 210, and a drain electrode 230. The sub-pixel structure 300 may include a lower electrode 290, a light emitting layer 330, and an upper electrode 340. In addition, the reflection structure 380 may include a plurality of first reflection patterns 382, a plurality of second reflection patterns 384, and a plurality of connection patterns 180. As illustrated in FIGS. 2 and 3, each of the first reflection patterns 382 may extend in a first direction D1 that is parallel to an upper surface of the substrate 110, and may be spaced apart from each other in a second direction D2 that is substantially perpendicular to the first direction D1. Each of the second reflection patterns 384 may be spaced apart from each other in the first direction D1 between adjacent two of the first reflection patterns 382 among a plurality of the first reflection patterns 382. The connection pattern 180 may electrically connect adjacent two second reflection patterns 384 in the second direction D2 among a plurality of the second reflection patterns 384. In addition, touch sensing voltages may be applied to the reflection structure 380, and the OLED device 100 may sense a user's touch on the surface of the OLED device 100 using a change by detecting a change of capacitance.

The OLED device 100 may include a sub-pixel region 10 and a reflection region 20. The sub-pixel region 10 may be located between the sub-pixel regions 10. The sub-pixel structure 300 may be disposed in the sub-pixel region 10, and a displaying image may be displayed in a third direction D3 (i.e., a direction that is perpendicular to the first direction D1 and the second direction D2) from the TFE structure 450 into the substrate 110. In addition, the reflection structure 380 and the semiconductor element 250 may be disposed in the reflection region 20, and an image of an object that is located in front (i.e., a first (lower) surface of the substrate 110) of the OLED device 100 may be displayed in the third direction D3 on the reflection structure 380. As the OLED device 100 includes the reflection structure 380 capable of reflecting the image of the object that is located in front of the OLED device 100 and serving as a touch sensing electrode, the OLED device 100 may serve as a mirror OLED device of a bottom emission structure capable of sensing a touch input of the user.

Referring again to FIG. 1, the substrate 110 may be formed of a transparent material. In example embodiments, the substrate 110 may be formed of a flexible transparent material such as a flexible transparent resin substrate (e.g., a polyimide substrate). The polyimide substrate may include at least one polyimide layer and at least one barrier layer. Since the polyimide substrate is relatively thin and flexible, the polyimide substrate may be disposed on a rigid glass

substrate to help support the formation of an upper structure (e.g., the reflection structure **380**, the semiconductor element **250**, and the sub-pixel structure **300**). The substrate **110** may have a structure in which one or more polyimide layers and one or more barrier layers are alternately stacked on the rigid glass substrate. In a manufacturing the OLED device **100**, after the buffer layer **115** is provided on the barrier layer of the polyimide substrate, the upper structure may be disposed on the buffer layer **115**. After the upper structure is formed on the buffer layer **115**, the rigid glass substrate under which the polyimide substrate is disposed may be removed. It may be difficult to directly form the upper structure on the polyimide substrate because the polyimide substrate is relatively thin and flexible. Accordingly, the upper structure is formed on the polyimide substrate and the rigid glass substrate, and then the polyimide substrate may serve as the substrate **110** of the OLED device **100** after the removal of the rigid glass substrate. As the OLED device **100** includes the sub-pixel region **10** and the reflection region **20**, the substrate **110** may also include the sub-pixel region **10** and the reflection region **20**.

The polyimide layer may include a random copolymer or block copolymer. The polyimide layer may have a high transparency, a low coefficient of thermal expansion, and a high glass transition temperature. Since the polyimide layer includes an imide radical, the polyimide layer may have an excellent heat resistance, chemical resistance, wear resistance, and electrical characteristics.

The barrier layer may include an organic material or an inorganic material. Examples of the organic material include, but are not limited to, a photoresist, a polyacryl-based resin, a polyimide-based resin, a polyamide-based resin, a siloxane-based resin, an acryl-based resin, and an epoxy-based resin. Examples of the inorganic materials include, but are not limited to, a silicon compound, and a metal oxide. For example, the barrier layer may include, but are not limited to, silicon oxide (SiOx), silicon nitride (SiNx), silicon oxynitride (SiOxNy), silicon oxycarbide (SiOxCy), silicon carbon nitride (SiCxNy), aluminum oxide (AlOx), aluminum nitride (AlNx), tantalum oxide (TaOx), hafnium oxide (HfOx), zirconium oxide (ZrOx), and titanium oxide (TiOx). In example embodiments, the barrier layer may include essentially an inorganic material. The barrier layer may block water or moisture from permeating into the sub-pixel structure **300** via the polyimide layer. That is, the barrier layer and the TFE structure **450** may protect the sub-pixel structure **300**. Alternatively, the substrate **110** may include a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a soda lime glass substrate, a non-alkali substrate, or the like.

Referring to FIGS. **1**, **2**, **3**, and **4**, the reflection structure **380** may be disposed on the substrate **110** in the reflection region **20**. The reflection structure **380** may include a plurality of first reflection patterns **382** and a plurality of second reflection patterns **384**. The first reflection patterns **382** and the second reflection patterns **384** may be disposed on the barrier layer of the substrate **10**, and the barrier layer may be an inorganic layer. Each of the first reflection patterns **382** may extend in the first direction D1. In addition, each of the first reflection patterns **382** may be spaced apart from each other in the second direction D2, and may be regularly arranged. Further, each of the first reflection patterns **382** may have a substantially planar shape of a bar including a plurality of protrusion portions. The second reflection patterns **384** may be regularly arranged in the first direction D1 between adjacent first reflection patterns **382**

among the plurality of first reflection patterns **382**, and may have an island shape. For example, the island shape of the second reflection pattern **384** may be a planar square, and may be disposed between the protrusion portions of adjacent first reflection patterns **382**. The connection pattern **180** may be in contact with and electrically connected to adjacent two second reflection patterns **384** in the second direction D2 among the plurality of second reflection patterns **384**. The first reflection patterns **382** and the second reflection patterns **384** may be spaced apart from each other, and may be located at the same level on the substrate **10**. While the connection pattern **180** may be located at different levels with the first and second reflection patterns **382** and **384**. For example, the connection pattern **180** may be disposed on the first and second reflection patterns **382** and **384**. As described above, since the OLED device **100** includes the reflection structure **380**, an image of an object that is located in front of the first surface S1 of the OLED device **100** may be reflected in the third direction D3.

In example embodiments, as illustrated in FIGS. **2** and **3**, each of the first reflection patterns **382** and the second reflection patterns **384** may have a mesh structure including a plurality of openings **383**. The sub-pixel region **10** may correspond to each of the openings **383**, and the sub-pixel structure **300** may be disposed in a region corresponding to each of the openings **383**. That is, a first group of sub-pixel regions **10** may be located in the openings **383** included in the first reflection pattern **382**, and a second group of sub-pixel regions **10** may be located in the openings **383** included in the second reflection pattern **384**. As described above, as the OLED device **100** includes the openings **383** of the reflection structure **380**, a light emitted from the sub-pixel structure **300** may be emitted via the openings **383** in the third direction D3. In example embodiments, as illustrated in FIG. **3**, grooves **386** and **387** may be formed in a border or an edge of the first reflection pattern **382** and the second reflection pattern **384** where at least a lateral portion of the opening **383** is opened. The grooves **386** and **387** may be formed to expose the corresponding sub-pixel regions **10**.

In example embodiments, as illustrated FIG. **4**, the OLED device **100** may electrically connect the first and second reflection patterns **382** and **384** and an external device **105** through a touch sensor wiring (not shown), and may provide first and second touch sensing voltages generated from the external device **105** to the first and second reflection patterns **382** and **384**, respectively. The external device **105** may detect a change of capacitance between the first reflection pattern **382** and the second reflection pattern **384**. The external device **105** may provide the first touch sensing voltage that is a sensing input signal to the first reflection pattern **382** and receive the second touch sensing voltage that is a sensing output signal through the second reflection pattern **384**. Here, the first touch sensing voltage may have a voltage level that is periodically changed (or a periodically variable voltage level), and the second touch sensing voltage may have a direct current voltage level. For example, when the user of the OLED device **100** contacts the first surface S1 (e.g., a contact of a user's finger, a portion of a user's body, a touch pen.), a capacitance between the first reflection pattern **382** and the second reflection pattern **384** that are corresponding to (or adjacent to) the contact surface may be changed. In other word, a change of capacitance may be generated between a portion of the body that is contacted to the first surface S1 and the first and second reflection patterns **382** and **384**, and the external device **105** may receive the sensing output signal that is changed by the changed capacitance through the touch sensor wiring. Thus,

the external device **105** may detect the changed sensing output signal. That is, the external device **105** and the OLED device **100** may sense a contact position of the user's touch using the first and second touch sensing voltages. Each of the first reflection pattern **382** and the second reflection pattern **384** may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. For example, each of the first reflection patterns **382** and the second reflection patterns **384** may be formed of gold (Au), silver (Ag), aluminum (Al), an alloy of aluminum, aluminum nitride (AlN_x), silver (Ag), an alloy of silver, tungsten (W), tungsten nitride (WN_x), copper (Cu), an alloy of copper, nickel (Ni), palladium (Pd), magnesium (Mg), Calcium (Ca), Lithium (Li), chrome (Cr), chrome nitride (CrN_x), molybdenum (Mo), an alloy of molybdenum, titanium (Ti), titanium nitride (TiN_x), platinum (Pt), tantalum (Ta), tantalum nitride (TaN_x), neodymium (Nd), scandium (Sc), strontium ruthenium oxide (SRO), zinc oxide (ZnO_x), stannum oxide (SnO_x), indium oxide (InO_x), gallium oxide (GaO_x), indium tin oxide (ITO), or indium zinc oxide (IZO). These may be used alone or in a suitable combination thereof. Alternatively, each of the first reflection patterns **382** and the second reflection patterns **384** may have a multi-layered structure.

Accordingly, although the first and second reflection patterns **382** and **384** having a respective thickness are disposed, the OLED device **100** may display the displaying image in the third direction D3 via the openings **383**. The thicknesses of the first and second reflection patterns **382** and **384** are determined to be thick enough to reflect light such that the OLED device **100** may reflect an image of an object that is located in front of the first surface S1 of the OLED device **100** in the third direction D3. In addition, the OLED device **100** may detect a contact position of the user through the reflection structure **380** and the external device **105**.

In FIG. 4, the external device **105** is disposed outside of the OLED device **100**, but the present disclosure is not limited thereto. In some example embodiments, the external device **105** may be disposed inside of the OLED device **100** or integrated into the OLED device **100**.

In addition, the OLED device **100** may employ a mutual-capacitance sensing method, but the present disclosure is not limited thereto. In some example embodiments, the OLED device **100** may use a self-capacitance sensing method.

Referring again to FIG. 1, the buffer layer **115** may be disposed on the substrate **110** and the reflection structure **380**. The buffer layer **115** may be disposed on the entire substrate **110** covering the first reflection pattern **382** and the second reflection pattern **384** in the reflection region **20** on the substrate **110**. For example, the buffer layer **115** may cover the first reflection pattern **382** and the second reflection pattern **384** to provide a substantially even surface without a step around the first reflection pattern **382** and the second reflection pattern **384**. Alternatively, the buffer layer **115** may cover the first reflection pattern **382** and the second reflection pattern **384**, and may be disposed with a substantially uniform thickness along a profile of the first reflection pattern **382** and the second reflection pattern **384**. The buffer layer **115** may prevent diffusion of metal atoms and/or impurities into the substrate **110** into the semiconductor element **250**. Additionally, the buffer layer **115** may control a rate of a heat transfer in a crystallization process for forming the active layer **130**, thereby obtaining a substantially uniform active layer. Furthermore, the buffer layer **115** may improve a surface flatness of the substrate **110** when a surface of the substrate **110** is relatively uneven. According

to a type of the substrate **110**, at least two buffer layers **115** may be provided on the substrate **110**, or the buffer layer **115** may not be disposed. In some example embodiments, the buffer layer **115** may include one or more of SiO_x, SiN_x, and SiO_xN_y.

The active layer **130** may be disposed on the buffer layer **115** in the reflection region **20**. For example, the active layer **130** may include one or more of an oxide semiconductor, an inorganic semiconductor (e.g., amorphous silicon and polysilicon), and an organic semiconductor.

The gate insulation layer **150** may be disposed on the buffer layer **115** and the active layer **130**. The gate insulation layer **150** may cover the active layer **130** in the reflection region **20** on the buffer layer **115**, and may be disposed on the entire substrate **110**. For example, the gate insulation layer **150** may cover the active layer **130** to provide a substantially even surface without a step around the active layer **130**. Alternatively, the gate insulation layer **150** may cover the active layer **130**, and may be disposed with a substantially uniform thickness along a profile of the active layer **130**. The gate insulation layer **150** may include one or more of a silicon compound and a metal oxide.

The gate electrode **170** and the connection pattern **180** may be disposed on the gate insulation layer **150**. The gate electrode **170** may be disposed on a portion of the gate insulation layer **150** in the reflection region **20** to overlap the active layer **130** in a planar view. The gate electrode **170** may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. These may be used alone or in a suitable combination thereof. Alternatively, the gate electrode **170** may have a multi-layered structure.

The connection pattern **180** may be disposed on a portion of the gate insulation layer **150** in the reflection region **20** to overlap the second reflection patterns **384** in a planar view. The connection pattern **180** may be in contact with the second reflection patterns **384** via a contact hole formed by partially removing the gate insulation layer **150** and the buffer layer **115**. As illustrated in FIG. 2, the connection pattern **180** may electrically connect adjacent two the second reflection patterns **384** among a plurality of the second reflection patterns **384**. The connection pattern **180** may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. These may be used alone or in a suitable combination thereof. Alternatively, the connection pattern **180** may have a multi-layered structure. In example embodiments, the connection pattern **180** and the gate electrode **170** may be simultaneously formed using the same material.

The insulating interlayer **190** may be disposed on the gate insulation layer **150**, the gate electrode **170**, and the connection pattern **180**. The insulating interlayer **190** may cover the gate electrode **170** and the connection pattern **180** in the reflection region **20**, and may be disposed on the entire substrate **110**. For example, the insulating interlayer **190** may cover the gate electrode **170** and the connection pattern **180** to provide a substantially even surface without a step around the gate electrode **170** and the connection pattern **180**. Alternatively, the insulating interlayer **190** may cover the gate electrode **170** and the connection pattern **180**, and may be disposed with a substantially uniform thickness along a profile of the gate electrode **170** and the connection pattern **180**. The insulating interlayer **190** may include one or more of a silicon compound and a metal oxide.

The source electrode **210** and the drain electrode **230** may be disposed on the insulating interlayer **190** in the reflection region **20**. The source electrode **210** may be in contact with

a first side of the active layer **130** via a first contact hole formed by removing a portion of the gate insulation layer **150** and the insulating interlayer **190**. The drain electrode **230** may be in contact with a second side of the active layer **130** via a second contact hole formed by removing a portion of the gate insulation layer **150** and the insulating interlayer **190**. Each of the source and drain electrodes **210** and **230** may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. These may be used alone or in a suitable combination thereof. Alternatively, each of the source and drain electrodes **210** and **230** may have a multi-layered structure. Accordingly, the semiconductor element **250** including the active layer **130**, the gate insulation layer **150**, the gate electrode **170**, the insulating interlayer **190**, the source electrode **210**, and the drain electrode **230** may be disposed.

In example embodiments, the semiconductor element **250** of the OLED device **100** has a top gate structure, but the present disclosure is not limited thereto. In some example embodiments, the semiconductor element **250** may have a bottom gate structure.

The planarization layer **270** may be disposed on the insulating interlayer **190** and the source and drain electrodes **210** and **230**. For example, the planarization layer **270** may be disposed with a relatively large thickness to cover the insulating interlayer **190** and the source and drain electrodes **210** and **230**. In this case, the planarization layer **270** may have a substantially even upper surface, and a planarization process may be further performed on the planarization layer **270** to implement the even upper surface of the planarization layer **270**. The planarization layer **270** may include one or more of an organic material and inorganic material.

The lower electrode **290** may be disposed on the planarization layer **270** in the sub-pixel region **10** and a portion of the reflection region **20**. For example, a thickness of the lower electrode **290** may be less than that of the upper electrode **340** such that a light emitted from the light emitting layer **330** is transmitted in the third direction **D3**. The lower electrode **290** may be in contact with the drain electrode **230** via a contact hole formed by removing a portion of the planarization layer **270**. In addition, the lower electrode **290** may be electrically connected to the semiconductor element **250**. The lower electrode **290** may be substantially transparent. For example, the lower electrode **290** may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. In some example embodiments, the lower electrode **290** may have a multi-layered structure.

The pixel defining layer **310** may be disposed on a portion of the lower electrode **290** and the planarization layer **270**. For example, the pixel defining layer **310** may cover both lateral portions of the lower electrode **290** such that a portion of an upper surface of the lower electrode **290** is exposed. The pixel defining layer **310** may include an organic material or an inorganic material.

The light emitting layer **330** may be disposed on the lower electrode **290** at the portion exposed by the pixel defining layer **310**. The light emitting layer **330** may have a multi-layered structure including one or more of an emission layer (EL), a hole injection layer (HIL), a hole transfer layer (HTL), an electron transfer layer (ETL), and an electron injection layer (EIL). The HIL, the HTL, the EL, the ETL, and the EIL may be sequentially disposed between the lower electrode **290** and the upper electrode **340**. The EL of the light emitting layer **330** may be formed using at least one of light emitting materials capable of generating different col-

ors of light (e.g., a red color of light, a blue color of light, and a green color of light). Alternatively, the EL of the light emitting layer **330** may generally generate a white color of light by stacking a plurality of light emitting materials capable of generating different colors of light such as a red color of light, a green color of light, and a blue color of light. In this case, a color filter may be disposed under the light emitting layer **330** to overlap the light emitting layer **330** on the insulating interlayer **190**. The color filter may include at least one selected from a red color filter, a green color filter, and a blue color filter. Alternatively, the color filter may include a yellow color filter, a cyan color filter, and a magenta color filter. The color filter may include a photo-sensitive resin or a color photoresist.

The upper electrode **340** may be disposed on the pixel defining layer **310** and the light emitting layer **330** in the sub-pixel region **10** and the reflection region **20**. The upper electrode **340** may be entirely disposed on the pixel defining layer **310** and the light emitting layer **330**. The OLED device **100** may display a displaying image toward the third direction **D3** in the sub-pixel region **10** (e.g., a bottom emission structure). Thus, a reflectivity of the upper electrode **340** may be greater than that of the lower electrode **290** such that a light emitted from the light emitting layer **330** is reflected from the upper electrode **340** in the third direction **D3**. The reflectivity of the upper electrode **340** and the lower electrode **290** may be varied by changing the material properties and/or the thickness of the upper electrode **340** and the lower electrode **290**. In example embodiments, the upper electrode **340** may reflect an image of an object that is located in front of a second surface **S2** of the OLED device **100**, and the second surface **S2** of the OLED device **100** may be opposite to the first surface **S1** of the OLED device **100**. For example, when the TFE structure **450** is transparent, an image of an object that is located in a direction **-D3** that is opposite to the third direction **D3** may be displayed on the upper electrode **340**. That is, the OLED device **100** may reflect the image of the object in both directions (e.g., **D3** and **-D3**) or on the both surfaces (e.g., the first and second surfaces **S1** and **S2**). In some example embodiments, when the upper electrode **340** transmits a portion of a light and reflects a remaining portion of the light, the OLED device **100** may display the displaying image on the both surfaces. In this case, the OLED device **100** may reflect the image of the object in the both surfaces and may display the displaying image on the both surfaces. The upper electrode **340** may include one or more of a metal, a metal alloy, metal nitride, and conductive metal oxide. For example, the upper electrode **340** may be formed of Au, Ag, Al, Pt, Ni, Ti, Pd, Mg, Ca, Li, Cr, Ta, W, Cu, Mo, Sc, Nd, Iridium (Ir), an alloy of aluminum, AlNx, an alloy of silver, WNx, an alloy of copper, CrNx, an alloy of molybdenum, TiNx, TaNx, SRO, etc. These may be used alone or in a suitable combination thereof. Alternatively, the upper electrode **340** may have a multi-layered structure.

The TFE structure **450** may be disposed on the upper electrode **340**. For example, the first encapsulation layer **451** may be disposed on the sub-pixel structure **300**. The TFE structure **450** may include at least one first encapsulation layer and at least one second encapsulation layer. For example, the second encapsulation layer **452** may be disposed on the first encapsulation layer **451**. The first encapsulation layers **451**, **453**, and **455** and the second encapsulation layers **452** and **454** may be alternately and repeatedly arranged. The first encapsulation layer **451** may cover the upper electrode **340**, and may be disposed with a substantially uniform thickness along a profile of the upper elec-

trode **340**. The first encapsulation layer **451** may prevent the sub-pixel structure **300** from being deteriorated by the permeation of moisture, water, oxygen, etc. In addition, the first encapsulation layer **451** may protect the sub-pixel structure **300** from an external impact. The first encapsulation layer **451** may include an inorganic material.

The second encapsulation layer **452** may be disposed on the first encapsulation layer **451**. The second encapsulation layer **452** may improve a surface flatness of the OLED device **100**, and may protect the sub-pixel structure **300** disposed in the sub-pixel region **10**. The second encapsulation layer **452** may include an organic material.

The first encapsulation layer **453** may be disposed on the second encapsulation layer **452**. The first encapsulation layer **453** may cover the second encapsulation layer **452**, and may be disposed with a substantially uniform thickness along a profile of the second encapsulation layer **452**. The first encapsulation layer **453** together with the first encapsulation layer **451** and the second encapsulation layer **452** may prevent the sub-pixel structure **300** from being deteriorated by the permeation of moisture, water, oxygen, etc. In addition, the first encapsulation layer **453** together with the first encapsulation layer **451** and the second encapsulation layer **452** may protect the pixel structure from an external impact. The first encapsulation layer **453** may include an inorganic material.

The second encapsulation layer **454** may be disposed on the first encapsulation layer **453**. The second encapsulation layer **454** may perform functions substantially the same as or similar to those of the second encapsulation layer **452**, and the second encapsulation layer **454** may include a material substantially the same as or similar to that of the second encapsulation layer **452**. The first encapsulation layer **455** may be disposed on the second encapsulation layer **454**. The first encapsulation layer **455** may perform functions substantially the same as or similar to those of the first encapsulation layers **451** and **453**, and the first encapsulation layer **455** may include a material substantially the same as or similar to that of the first encapsulation layers **451** and **453**. As described above, the OLED device **100** includes the flexible substrate **110** and the TFE structure **450**, and may have a curved shape. Since the reflection structure **380** having a thickness that is thick enough to reflect light is disposed in the reflection region **20**, the reflection region **20** may not be readily bent. However, the openings **383** of the reflection structure **380** disposed in the sub-pixel region **10** allows the sub-pixel region **10** to be bent. Accordingly, the OLED device **100** may have a substantially curved shape.

In some example embodiments, the TFE structure **450** may have a triple-layered structure having the first encapsulation layer **451**, the second encapsulation layer **452**, and the first encapsulation layer **453**. In other example embodiments, the TFE structure **450** may have a septuple-layered structure including the first encapsulation layer **451**, the second encapsulation layer **452**, the first encapsulation layer **453**, the second encapsulation layer **454**, the first encapsulation layer **455**, an extra first encapsulation layer, and an extra second encapsulation layer. Alternatively, when the substrate **110** is formed as a rigid substrate, the TFE structure **450** may include one or more of a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a sodalime glass substrate, and a non-alkali substrate.

The OLED device **100** in accordance with example embodiments includes the reflection structure **380** and the upper electrode **340**. The displaying image may be displayed via the openings **383**, and the image of an object that is

located in front of the first surface **S1** of the OLED device **100** may be reflected from the reflection structure **380**. In some example embodiments, the first reflection patterns **382**, the second reflection patterns **384**, and the connection pattern **180** included in the reflection structure **380** may serve as touch sensing electrodes to detect a contact position of a user's touch on the OLED device **100**. Further, the image of the object that is located in front of the second surface **S2** of the OLED device **100** may be reflected from the upper electrode **340**. Accordingly, the OLED device **100** may serve as a mirror OLED device of a bottom emission structure having a relatively thin thickness because the OLED device **100** does not include a touch screen panel. In addition, the OLED device **100** including the flexible substrate **110** and the TFE structure **450** may be made to have a curved shape.

FIGS. **5**, **6**, **7**, **8**, **9**, and **10** are cross-sectional views illustrating a method of manufacturing an OLED device in accordance with example embodiments.

Referring to FIG. **5**, a substrate **510** including a sub-pixel region **10** and a reflection region **20** may be provided. The substrate **510** may be formed of a transparent material. The substrate **510** may be formed using a flexible transparent material such as a flexible transparent resin substrate (e.g., a polyimide substrate). In this case, the polyimide substrate may include at least one polyimide layer and at least one barrier layer.

The polyimide layer may be formed using a random copolymer or a block copolymer. The polyimide layer may have a high transparency, a low coefficient of thermal expansion, and a high glass transition temperature. Since the polyimide layer includes an imide radical, the polyimide layer may have an excellent heat resistance, chemical resistance, wear resistance, and electrical characteristics.

The barrier layer may be formed using an organic material or an inorganic material. Examples of the organic materials may include, but are not limited to, a photoresist, a polyacryl-based resin, a polyimide-based resin, a polyamide-based resin, a siloxane-based resin, an acryl-based resin, and an epoxy-based resin. An example of the inorganic materials may include, but are not limited to, silicon compound, metal oxide. For example, the buffer layer **115** may include SiOx, SiNx, SiOxNy, SiOxCy, SiCxNy, AlOx, AlNx, TaOx, HfOx, ZrOx, TiOx, etc. In example embodiments, the barrier layer may include essentially an inorganic material. The barrier layer may block water or moisture from permeating via the polyimide layer. Alternatively, the substrate **510** may be formed of a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a soda lime glass substrate, or a non-alkali substrate.

A first reflection pattern **782** and a second reflection pattern **784** may be formed on the substrate **510** in the reflection region **20**. Each of the first reflection patterns **782** may extend in the first direction **D1**. In addition, each of the first reflection patterns **782** may be spaced apart from each other in the second direction **D2**, and may be regularly arranged. Further, each of the first reflection patterns **782** may have a substantially planar shape of a bar including a plurality of protrusion portions. The second reflection patterns **784** may be regularly arranged in the first direction **D1** between adjacent first reflection patterns **782** among the plurality of first reflection patterns **782**, and may have an island shape. The first reflection patterns **782** and the second reflection patterns **784** may be spaced apart from each other, and may be located at the same level. The first reflection pattern **782** and the second reflection pattern **784** may reflect

an image of an object that is located in front of a first surface S1 (e.g., a lower surface of the substrate 510) of an OLED device.

Each the first reflection pattern 782 and the second reflection pattern 784 may include a plurality of openings 783, similar to the plurality of openings 383 of FIG. 3. Here, the sub-pixel region 10 may correspond to the opening 783. For example, the sub-pixel structures may be formed in the openings 783, respectively. That is, a first group of sub-pixel regions 10 may be located in the openings 783 included in the first reflection pattern 782, and a second group of sub-pixel regions 10 may be located in the openings 783 included in the second reflection pattern 784. In example embodiments, grooves may be formed in a border or an edge) of the first reflection pattern 782 and the second reflection pattern 784 where at least of a lateral portion of the opening 783 is opened. The grooves may be formed to expose the corresponding sub-pixel regions 10.

In example embodiments, the OLED device may electrically connect the first and second reflection patterns 782 and 784 and an external device (e.g., the external device 105 of FIG. 4) through a touch sensor wiring (not shown), and may provide first and second touch sensing voltages generated from the external device to the first and second reflection patterns 782 and 784, respectively. In addition, the external device may detect a change of capacitance between the first reflection pattern 782 and the second reflection pattern 784. For example, the external device may provide the first touch sensing voltage that is a sensing input signal to the first reflection pattern 782 and receive the second touch sensing voltage that is a sensing output signal through the second reflection pattern 784. Here, the first touch sensing voltage may have a voltage level that is periodically changed, and the second touch sensing voltage may have a direct current voltage level.

Each of the first reflection pattern 782 and the second reflection pattern 784 may be formed using one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. For example, each of the first reflection pattern 382 and the second reflection pattern 384 may be formed of Au, Ag, Al, an alloy of aluminum, AlNx, Ag, an alloy of silver, W, WNx, Cu, an alloy of copper, Ni, Pd, Mg, Ca, Li, Cr, CrNx, Mo, an alloy of molybdenum, Ti, TiNx, Pt, Ta, TaNx, Nd, Sc, SRO, ZnOx, SnOx, InOx, GaOx, ITO, or IZO. These may be used alone or in a suitable combination thereof. Alternatively, each of the first reflection pattern 782 and the second reflection pattern 784 may have a multi-layered structure.

Referring to FIG. 6, a buffer layer 515 may be formed on the substrate 510, the first reflection pattern 782, and the second reflection pattern 784. The buffer layer 515 may be disposed on the substrate 510 covering the first reflection pattern 782 and the second reflection pattern 784 in the reflection region 20 on the substrate 510. For example, the buffer layer 515 may cover the first reflection pattern 782 and the second reflection pattern 784 to provide a substantially even surface without a step around the first reflection pattern 782 and the second reflection pattern 784. Alternatively, the buffer layer 515 may cover the first reflection pattern 782 and the second reflection pattern 784, and may be formed with a substantially uniform thickness along a profile of the first reflection pattern 782 and the second reflection pattern 784. The buffer layer 515 may prevent diffusion of metal atoms and/or impurities into the substrate 510. Additionally, the buffer layer 515 may control a rate of a heat transfer in a crystallization process for forming an active layer, thereby obtaining a substantially uniform active

layer. Furthermore, the buffer layer 515 may improve a surface flatness of the substrate 510 when a surface of the substrate 510 is relatively uneven. According to a type of the substrate 510, at least two buffer layers 515 may be provided on the substrate 510, or the buffer layer 515 may not be disposed. In some example embodiments, the buffer layer 515 may be formed of SiOx, SiNx, or SiOxNy.

An active layer 530 may be disposed on the buffer layer 515 in the reflection region 20. For example, the active layer 530 may be formed of an oxide semiconductor, an inorganic semiconductor, or an organic semiconductor.

A gate insulation layer 550 may be formed on the buffer layer 515 and the active layer 530. The gate insulation layer 550 may cover the active layer 530 in the reflection region 20 on the buffer layer 515, and may be formed on the entire substrate 510. For example, the gate insulation layer 550 may cover the active layer 530 to provide a substantially even surface without a step around the active layer 530. Alternatively, the gate insulation layer 550 may cover the active layer 530, and may be formed with a substantially uniform thickness along a profile of the active layer 530. The gate insulation layer 550 may be formed of a silicon compound or a metal oxide.

A gate electrode 570 and a connection pattern 580 may be formed on the gate insulation layer 550. For example, after a preliminary electrode is formed on the gate insulation layer 550 having an opening (or a contact hole) that exposes a portion of the second reflection pattern 784, the gate electrode 570 and the conductive pattern 580 may be formed by partially removing the preliminary electrode. That is, the conductive pattern 580 and the gate electrode 570 may be simultaneously formed using the same material.

The gate electrode 570 may be formed on a portion of the gate insulation layer 550 in the reflection region 20 to overlap the active layer 530 in a planar view. The connection pattern 580 may be formed on a portion of the gate insulation layer 550 in the reflection region 20 to overlap the second reflection pattern 784 in a planar view. The connection pattern 580 may electrically connect adjacent two second reflection patterns 784 among a plurality of the second reflection patterns 784. Each of the gate electrode 570 and the connection pattern 580 may be formed using one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. These may be used alone or in a suitable combination thereof. Alternatively, each of the gate electrode 570 and the connection pattern 580 may have a multi-layered structure. Accordingly, a reflection structure 780 including the first reflection pattern 782, the second reflection pattern 784, and the connection pattern 580 may be formed.

Referring to FIG. 7, an insulating interlayer 590 may be formed on the gate insulation layer 550, the gate electrode 570, and the connection pattern 580. The insulating interlayer 590 may cover the gate electrode 570 and the connection pattern 580 in the reflection region 20, and may be formed on the entire substrate 510. For example, the insulating interlayer 590 may cover the gate electrode 570 and the connection pattern 580 to provide a substantially even surface without a step around the gate electrode 570 and the connection pattern 580. Alternatively, the insulating interlayer 590 may cover the gate electrode 570 and the connection pattern 580, and may be formed with a substantially uniform thickness along a profile of the gate electrode 570 and the connection pattern 580. The insulating interlayer 590 may be formed of a silicon compound or a metal oxide.

A source electrode 610 and a drain electrode 630 may be formed on the insulating interlayer 590 in the reflection

region 20. The source electrode 610 may be in contact with a first side of the active layer 530 via a first contact hole formed by removing a portion of the gate insulation layer 550 and the insulating interlayer 590. The drain electrode 630 may be in contact with a second side of the active layer 530 via a second contact hole formed by removing a portion of the gate insulation layer 550 and the insulating interlayer 590. Each of the source and drain electrodes 610 and 630 may be formed using one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. These may be used alone or in a suitable combination thereof. Alternatively, each of the source and drain electrodes 610 and 630 may have a multi-layered structure. Accordingly, a semiconductor element 650 including the active layer 530, the gate insulation layer 550, the gate electrode 570, the insulating interlayer 590, the source electrode 610, and the drain electrode 630 may be formed.

Referring to FIG. 8, a planarization layer 670 may be formed on the insulating interlayer 590 and the source and drain electrodes 610 and 630. For example, the planarization layer 670 may be disposed with a relatively large thickness to cover the insulating interlayer 590 and the source and drain electrodes 610 and 630. In this case, the planarization layer 670 may have a substantially even upper surface, and a planarization process may be further performed on the planarization layer 670 to implement the even upper surface of the planarization layer 670. The planarization layer 670 may be formed using an organic material or an inorganic material.

A lower electrode 690 may be formed on the planarization layer 670 in the sub-pixel region 10 and a portion of the reflection region 20. For example, a reflectivity of the lower electrode 690 may be less than that of an upper electrode such that a light emitted from a light emitting layer is transmitted in a third direction D3 that is perpendicular to the first and second directions D1 and D2. The lower electrode 690 may be in contact with the drain electrode 630 via a contact hole formed by removing a portion of the planarization layer 670. In addition, the lower electrode 690 may be electrically connected to the semiconductor element 650. The lower electrode 690 may be substantially transparent. For example, the lower electrode 690 may be formed of a metal, a metal alloy, metal nitride, conductive metal oxide, or a transparent conductive material. In some example embodiments, the lower electrode 690 may have a multi-layered structure.

Referring to FIG. 9, a pixel defining layer 710 may be formed on a portion of the lower electrode 690 and the planarization layer 670. For example, the pixel defining layer 710 may cover both lateral portions of the lower electrode 690 such that a portion of an upper surface of the lower electrode 690 is exposed. The pixel defining layer 710 may be formed using an organic material or an inorganic material.

The light emitting layer 730 may be formed on the lower electrode 690 at the portion exposed by the pixel defining layer 710. The light emitting layer 730 may have a multi-layered structure including one or more of an EL, an HIL, an HTL, an ETL, and an EIL. The HIL, the HTL, the EL, the ETL, and the EIL may be sequentially formed between the lower electrode 690 and an upper electrode 740. The EL of the light emitting layer 730 may be formed using at least one of light emitting materials capable of generating different colors of light (e.g., a red color of light, a blue color of light, and a green color of light). Alternatively, the EL of the light emitting layer 730 may generally generate a white color of

light by stacking a plurality of light emitting materials capable of generating different colors of light such as a red color of light, a green color of light, and a blue color of light. In this case, a color filter may be formed under the light emitting layer 730 to overlap the light emitting layer 730 on the insulating interlayer 590. The color filter may include at least one selected from a red color filter, a green color filter, and a blue color filter. Alternatively, the color filter may include a yellow color filter, a cyan color filter, and a magenta color filter. The color filter may be formed using a photosensitive resin or a color photoresist.

The upper electrode 740 may be formed on the pixel defining layer 710 and the light emitting layer 730 in the sub-pixel region 10 and the reflection region 20. The upper electrode 740 may be entirely formed on the pixel defining layer 710 and the light emitting layer 730. The OLED device may display a displaying image toward the third direction D3 in the sub-pixel region 10. Thus, a reflectivity of the upper electrode 740 may be greater than that of the lower electrode 690 such that a light emitted from the light emitting layer 730 is reflected from the upper electrode 740 in the third direction D3. In example embodiments, the upper electrode 740 may reflect an image of an object that is located in front of a second surface S2 of the OLED device, and the second surface S2 of the OLED device may be opposite to the first surface S1 of the OLED device. The upper electrode 740 may be formed of a metal, a metal alloy, metal nitride, or conductive metal oxide. These may be used alone or in a suitable combination thereof. Alternatively, the upper electrode 740 may have a multi-layered structure. Accordingly, a sub-pixel structure 700 including the lower electrode 690, the light emitting layer 730, and the upper electrode 740 may be formed.

Referring to FIG. 10, a TFE structure 850 may be formed on the upper electrode 740. The TFE structure 850 may include at least one first encapsulation layer and at least one second encapsulation layer. For example, the second encapsulation layer 852 may be disposed on the first encapsulation layer 851. The first encapsulation layers 851, 853, and 855 and the second encapsulation layers 852 and 854 may be alternately and repeatedly arranged. The first encapsulation layer 851 may cover the upper electrode 740, and may be formed with a substantially uniform thickness along a profile of the upper electrode 740. The first encapsulation layer 851 may prevent the sub-pixel structure 700 from being deteriorated by the permeation of moisture, water, oxygen, etc. In addition, the first encapsulation layer 851 may protect the sub-pixel structure 700 from an external impact. The first encapsulation layer 851 may be formed of an inorganic material.

The second encapsulation layer 852 may be formed on the first encapsulation layer 851. The second encapsulation layer 852 may improve a surface flatness of the OLED device, and may protect the sub-pixel structure 700 formed in the sub-pixel region 10. The second encapsulation layer 852 may be formed of an organic material.

The first encapsulation layer 853 may be formed on the second encapsulation layer 852. The first encapsulation layer 853 may cover the second encapsulation layer 852, and may be formed with a substantially uniform thickness along a profile of the second encapsulation layer 852. The first encapsulation layer 853 together with the first encapsulation layer 851 and the second encapsulation layer 852 may prevent the sub-pixel structure 700 from being deteriorated by the permeation of moisture, water, oxygen, etc. In addition, the first encapsulation layer 853 together with the first encapsulation layer 851 and the second encapsulation layer

852 may protect the pixel structure from an external impact. The first encapsulation layer **853** may be formed using inorganic materials.

The second encapsulation layer **854** may be formed on the first encapsulation layer **853**. The second encapsulation layer **854** may perform functions substantially the same as or similar to those of the second encapsulation layer **852**, and the second encapsulation layer **854** may be formed using a material substantially the same as or similar to that of the second encapsulation layer **852**. A first encapsulation layer **855** may be formed on the second encapsulation layer **854**. The first encapsulation layer **855** may perform functions substantially the same as or similar to those of the first encapsulation layers **851** and **853**, and the first encapsulation layer **855** may be formed using a material substantially the same as or similar to that of the first encapsulation layers **851** and **853**. As described above, the OLED device includes the flexible substrate **510** and the TFE structure **850**, and may have a curved shape.

In some example embodiments, the TFE structure **850** may have a triple-layered structure having the first encapsulation layer **851**, the second encapsulation layer **852**, and the first encapsulation layer **853**. In other example embodiments, the TFE structure **850** may have a septuple-layered structure including the first encapsulation layer **851**, the second encapsulation layer **852**, the first encapsulation layer **853**, the second encapsulation layer **854**, the first encapsulation layer **855**, an extra first encapsulation layer, and an extra second encapsulation layer. Alternatively, when the substrate **510** is formed as a rigid substrate, the TFE structure **850** may include one or more of a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a sodalime glass substrate, and a non-alkali substrate. Accordingly, the OLED device **100** illustrated in FIG. 1 may be manufactured.

FIG. 11 is a cross-sectional view illustrating an OLED device in accordance with example embodiments. An OLED device illustrated in FIG. 11 may have a configuration substantially the same as or similar to that of the OLED device **100** described with reference to FIGS. 1, 2, 3, and 4 except a dielectric mirror structure **200**. In FIG. 11, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. 1, 2, 3, and 4 may not be repeated.

Referring to FIGS. 1, 2, 3, 4, and 11, an OLED device may include a substrate **110**, a dielectric mirror structure **200**, a reflection structure **380**, a buffer layer **115**, a semiconductor element **250**, a planarization layer **270**, a sub-pixel structure **300**, a pixel defining layer **310**, and a TFE structure **450**. Here, the semiconductor element **250** may include an active layer **130**, a gate insulation layer **150**, a gate electrode **170**, an insulating interlayer **190**, a source electrode **210**, and a drain electrode **230**. The sub-pixel structure **300** may include a lower electrode **290**, a light emitting layer **330**, and an upper electrode **340**. In addition, the reflection structure **380** may include a plurality of first reflection patterns **382**, a plurality of second reflection patterns **384**, and a plurality of connection patterns **180**. Further, the dielectric mirror structure **200** may include a first dielectric layer **111**, a second dielectric layer **112**, and a third dielectric layer **113**.

The first dielectric layer **111** may be disposed on the substrate **110** covering the entire substrate **110**. In example embodiments, the first dielectric layer **111** may have a first refractive index. For example, the first dielectric layer **111** may have the first refractive index by controlling a weight ratio of materials included in the first dielectric layer **111**, or by controlling a thickness of the first dielectric layer **111**.

The first dielectric layer **111** may also serve as an additional barrier layer or an additional buffer layer. For example, the first dielectric layer **111** may include one or more of a silicon compound and metal oxide. For example, the first dielectric layer **111** may be formed of SiOx, SiNx, SiOxNy, SiOxCy, SiCxNy, AlOx, AlNx, TaOx, HfOx, ZrOx, or TiOx.

The second dielectric layer **112** may be disposed on the first dielectric layer **111** covering the entire first dielectric layer **111**. In example embodiments, the second dielectric layer **112** may have a second refractive index that is different from the first refractive index. The second dielectric layer **112** may have the second refractive index by controlling a weight ratio of materials included in the second dielectric layer **112**, or by controlling a thickness of the second dielectric layer **112**. For example, the first refractive index may be a high refractive index, and the second refractive index may be a low refractive index. Alternatively, the first refractive index may be a low refractive index, and the second refractive index may be a high refractive index. The second dielectric layer **112** may also serve as an additional barrier layer and an additional buffer layer. The second dielectric layer **112** may include silicon compound, metal oxide, etc. For example, the second dielectric layer **112** may be formed of SiOx, SiNx, SiOxNy, SiOxCy, SiCxNy, AlOx, AlNx, TaOx, HfOx, ZrOx, or TiOx.

The third dielectric layer **113** may be disposed on the second dielectric layer **112** covering the entire second dielectric layer **112**. In example embodiments, the third dielectric layer **113** may have the first refractive index. For example, the third dielectric layer **113** and the first dielectric layer **111** may be substantially the same. The third dielectric layer **113** may also serve as an additional barrier layer or an additional buffer layer. The third dielectric layer **113** may include a silicon compound or metal oxide. Accordingly, the dielectric mirror structure **200** including the first dielectric layer **111**, the second dielectric layer **112**, and the third dielectric layer **113** may be disposed. Alternatively, an additional dielectric layer may be disposed on the third dielectric layer **113**. For example, the additional dielectric layer and the second dielectric layer **112** may have the same refractive index.

As described above, the dielectric mirror structure **200** may have a stack structure that the high refractive index layer and the low refractive index layer are alternately stacked. For example, an external light may pass through the substrate **110** in a direction $-D3$ (e.g., a direction from the substrate **110** into the TFE structure **450**) that is opposite to the third direction $D3$. A portion of the external light passing through the substrate **110** may be reflected as a predetermined color by optical interference in boundary surfaces between the first, second, and third dielectric layers **111**, **112**, and **113**. In particular, the dielectric mirror structure **200** may selectively reflect a light corresponding to a wavelength generating constructive or destructive optical interferences among the external light incident from the outside. In addition, a remaining portion of the external light passing through the substrate **110** may be reflected from the reflection patterns **382** and **384** toward the third direction $D3$ in the reflection region **20**. Accordingly, an image of an object that is located in front of the OLED device may be reflected as a predetermined reflection color. For example, the first dielectric layer **111** is formed with a thickness of about 50 Angstroms by using TiOx, and the second dielectric layer **112** is formed with a thickness of about 300 Angstroms by using SiOx. In addition, the third dielectric layer **113** is formed with a thickness of about 350 Angstroms by using TiOx. In this case, the front of the OLED device may be

shown as a substantially blue color. Alternatively, the first dielectric layer **111** is formed with a thickness of about 100 Angstroms by using TiOx, and the second dielectric layer **112** is formed with a thickness of about 300 Angstroms by using SiOx. In addition, the third dielectric layer **113** is formed with a thickness of about 1000 Angstroms by using TiOx. In this case, the front of the OLED device may be shown as a substantially brown color. In some example embodiments, the first dielectric layer **111** is formed with a thickness of about 200 Angstroms by using TiOx, and the second dielectric layer **112** is formed with a thickness of about 400 Angstroms by using SiOx. In addition, the third dielectric layer **113** is formed with a thickness of about 100 Angstroms by using TiOx. In this case, the front of the OLED device may be shown as a substantially silver color.

In example embodiments, when the semiconductor element **250** is not activated, the light emitting layer **330** may not emit a light (e.g., a turned-off state of the OLED device). In this case, an external light may pass through the substrate **110** in a direction $-D3$ that is opposite to the third direction $D3$. A portion of the external light passing through the substrate **110** may be reflected as a predetermined color by optical interference in boundary surfaces of the first, second, and third dielectric layers **111**, **112**, and **113**. In particular, the dielectric mirror structure **200** may selectively reflect a light corresponding to a wavelength generating a constructive optical interference or a destructive optical interference among the external light incident from the outside. In addition, a remaining portion of the external light passing through the substrate **110** may be reflected from the upper electrode **740** toward the first direction $D1$ in the sub-pixel region **10**. Accordingly, an image of an object that is located in front of the OLED device may be reflected as a predetermined reflection color.

FIG. **12** is a cross-sectional view illustrating an OLED device in accordance with example embodiments, and FIG. **13** is a planar view describing a reflection structure included in the OLED device of FIG. **12**. FIG. **14** is an enlarged planar view corresponding to region B' of FIG. **13**. An OLED device **1000** illustrated in FIGS. **12**, **13**, and **14** may have a configuration substantially the same as or similar to that of the OLED device **100** described with reference to FIGS. **1**, **2**, **3**, and **4** except a reflection structure **1380**. In FIGS. **12**, **13**, and **14**, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. **1**, **2**, **3**, and **4** may not be repeated. FIG. **12** may correspond to a cross-sectional view taken along line II-IF of FIG. **13**.

Referring to FIGS. **1**, **2**, **3**, and **4**, an OLED device **1000** may include a substrate **110**, a reflection structure **1380**, a buffer layer **115**, a semiconductor element **250**, a planarization layer **270**, a sub-pixel structure **300**, a pixel defining layer **310**, and a TFE structure **450**. Here, the semiconductor element **250** may include an active layer **130**, a gate insulation layer **150**, a gate electrode **170**, an insulating inter-layer **190**, a source electrode **210**, and a drain electrode **230**. The sub-pixel structure **300** may include a lower electrode **290**, a light emitting layer **330**, and an upper electrode **340**. In addition, the reflection structure **1380** may include a plurality of first reflection patterns **1382** and a plurality of second reflection patterns **1384**.

As illustrated in FIGS. **13** and **14**, each of the first reflection patterns **1382** may extend in a first direction $D1$ that is parallel to an upper surface of the substrate **110**, and may be spaced apart from each other in a second direction $D2$ that is substantially perpendicular to the first direction $D1$. Each of the second reflection patterns **1384** may extend

in the second direction $D2$ on the first reflection patterns **1382**, and may be spaced apart from each other in the first direction $D1$. In addition, touch sensing voltages may be applied to the reflection structure **1380**, and the OLED device **1000** may sense a user's touch on the surface of the OLED device **1000** by detecting a change of capacitance.

Each of the first and second reflection patterns **1382** and **1384** may have a planar shape of a bar, and may cross or intersect each other and be regularly arranged. In addition, the first reflection pattern **1382** may be located at different levels with the second reflection pattern **1384** on the substrate **110**. For example, the second reflection pattern **1384** may be disposed on the first reflection pattern **1382**. As described above, as the OLED device **1000** includes the reflection structure **1380**, an image of an object that is located in front of the first surface $S1$ of the OLED device **1000** may be reflected in the third direction $D3$.

In example embodiments, as illustrated in FIGS. **13** and **14**, each of the first reflection patterns **1382** and the second reflection patterns **1384** may have a mesh structure including a plurality of openings **1383**. The sub-pixel region **10** may correspond to each of the openings **1383**, and the sub-pixel structures **300** may be disposed in a region corresponding to each of the openings **1383**. That is, a first group of sub-pixel regions **10** may be located in the openings **1383** included in the first reflection pattern **1382**, and a second group of sub-pixel regions **10** may be located in the openings **1383** included in the second reflection pattern **1384**. As described above, as the OLED device **1000** includes the openings **1383** of the reflection structure **1380**, a light emitted from the sub-pixel structure **300** may be emitted via the openings **1383** in the third direction $D3$. In example embodiments, as illustrated in FIG. **14**, the openings **1383** located in a portion crossing the first reflection pattern **1382** and the second reflection pattern **1384** may be overlapped to each other such that the sub-pixel region **10** is exposed. Alternatively, a size of each of the openings **1383** located in a portion crossing the first reflection pattern **1382** and the second reflection pattern **1384** may be different from each other.

In example embodiments, the OLED device **1000** may electrically connect the first and second reflection patterns **1382** and **1384** and an external device (e.g., external device **105** of FIG. **4**) through a touch sensor wiring (not shown), and may provide first and second touch sensing voltages generated from the external device to the first and second reflection patterns **1382** and **1384**, respectively. The external device may detect a change of capacitance between the first reflection pattern **1382** and the second reflection pattern **1384**. The external device may provide the first touch sensing voltage that is a sensing input signal to the first reflection pattern **1382** and receive the second touch sensing voltage that is a sensing output signal through the second reflection pattern **1384**. Here, the first touch sensing voltage may have a voltage level that is periodically changed, and the second touch sensing voltage may have a direct current voltage level. For example, when the user of the OLED device **1000** contacts the first surface $S1$, a capacitance between the first reflection pattern **1382** and the second reflection pattern **1384** that are corresponding to the contact surface may be changed. In other word, a change of capacitance may be generated between a portion of the body that is contacted to the first surface $S1$ and the first and second reflection patterns **1382** and **1384**, and the external device may receive the sensing output signal that is changed by the changed capacitance, through the touch sensor wiring. Thus, the external device may detect the changed sensing output signal. That is, the external device and the OLED device

1000 may sense a contact position of the user's touch using the first and second touch sensing voltages. After a contact of the user and the OLED device 1000 is ended (e.g., the user and the OLED device 1000 are electrically separated), the external device may provide the first and second touch sensing voltages to the first and second reflection patterns 1382 and 1384, respectively. Each of the first reflection pattern 1382 and the second reflection pattern 1384 may include one or more of a metal, a metal alloy, metal nitride, conductive metal oxide, and a transparent conductive material. For example, each of the first reflection patterns 1382 and the second reflection patterns 1384 may be formed of Au, Ag, Al, Pt, Ni, Ti, Pd, Mg, Ca, Li, Cr, Ta, W, Cu, Mo, Sc, Nd, Ir, an alloy of aluminum, AlN_x, an alloy of silver, WN_x, an alloy of copper, CrN_x, an alloy of molybdenum, TiN_x, TaN_x, or SRO. These may be used alone or in a suitable combination thereof. Alternatively, each of the first reflection pattern 1382 and the second reflection pattern 1384 may have a multi-layered structure.

Accordingly, although the first and second reflection patterns 1382 and 1384 having a large thickness are disposed, the OLED device 1000 may display the displaying image in the third direction D3 via the openings 1383. The thicknesses of the first and second reflection patterns 382 and 384 are determined to be thick enough to reflect light such that the OLED device 1000 may reflect an image of an object that is located in front of the first surface S1 of the OLED device 1000 in the third direction D3. In addition, the OLED device 1000 may detect a contact position of the user through the reflection structure 1380 and the external device.

FIG. 15 is a cross-sectional view illustrating an OLED device in accordance with example embodiments. An OLED device illustrated in FIG. 15 may have a configuration substantially the same as or similar to that of the OLED device 1000 described with reference to FIGS. 12, 13, and 14 except a reflection structure 1385. In FIG. 15, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. 12, 13, and 14 may not be repeated.

Referring to FIGS. 12, 13, 14, and 15, the reflection structure 1385 may include a first reflection pattern 1382 and a second reflection pattern 1384. The first reflection pattern 1382 may be disposed on the substrate 110, and the second reflection pattern 1384 may be disposed on the insulating interlayer 190. For example, after a preliminary electrode is formed on the insulating interlayer 190, the source electrode 210, and the drain electrode 230, and the second reflection pattern 1384 may be formed by partially removing the preliminary electrode. That is, the source electrode 210, the drain electrode 230, and the second reflection pattern 1384 may be simultaneously formed using the same material.

FIG. 16 is a cross-sectional view illustrating an OLED device in accordance with example embodiments. An OLED device illustrated in FIG. 16 may have a configuration substantially the same as or similar to that of the OLED device 1000 described with reference to FIGS. 12, 13, and 14 except a dielectric mirror structure 200. In FIG. 16, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. 12, 13, and 14 may not be repeated.

Referring to FIGS. 12, 13, 14, and 16, an OLED device may include a substrate 110, a dielectric mirror structure 200, a reflection structure 1380, a buffer layer 115, a semiconductor element 250, a planarization layer 270, a sub-pixel structure 300, a pixel defining layer 310, and a TFE structure 450. Here, the semiconductor element 250 may include an active layer 130, a gate insulation layer 150,

a gate electrode 170, an insulating interlayer 190, a source electrode 210, and a drain electrode 230. The sub-pixel structure 300 may include a lower electrode 290, a light emitting layer 330, and an upper electrode 340. In addition, the reflection structure 1380 may include a plurality of first reflection patterns 1382 and a plurality of second reflection patterns 1384. Further, the dielectric mirror structure 200 may include a first dielectric layer 111, a second dielectric layer 112, and a third dielectric layer 113.

The first dielectric layer 111 may be disposed on the substrate 110 covering the entire substrate 110. In example embodiments, the first dielectric layer 111 may have a first refractive index. For example, the first dielectric layer 111 may have the first refractive index by controlling a weight ratio of materials included in the first dielectric layer 111, or by controlling a thickness of the first dielectric layer 111. The first dielectric layer 111 may include one or more of a silicon compound and metal oxide.

The second dielectric layer 112 may be disposed on the first dielectric layer 111 covering the entire first dielectric layer 111. In example embodiments, the second dielectric layer 112 may have a second refractive index that is different from the first refractive index. The second dielectric layer 112 may have the second refractive index by controlling a weight ratio of materials included in the second dielectric layer 112, or by controlling a thickness of the second dielectric layer 112. For example, the first refractive index may be a high refractive index, and the second refractive index may be a low refractive index. The second dielectric layer 112 may include one or more of a silicon compound and metal oxide.

The third dielectric layer 113 may be disposed on the second dielectric layer 112 covering the entire second dielectric layer 112. In example embodiments, the third dielectric layer 113 may have the first refractive index. For example, the third dielectric layer 113 and the first dielectric layer 111 may be substantially the same. The third dielectric layer 113 may include one or more of a silicon compound and metal oxide. Alternatively, an additional dielectric layer may be disposed on the third dielectric layer 113. For example, the additional dielectric layer and the second dielectric layer 112 may have the same refractive index.

FIG. 17 is a cross-sectional view illustrating an OLED device in accordance with example embodiments. An OLED device illustrated in FIG. 17 may have a configuration substantially the same as or similar to that of the OLED device 1000 described with reference to FIGS. 12, 13, and 14 except a reflection structure 1385 and a dielectric mirror structure 200. In FIG. 17, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. 12, 13, and 14 may not be repeated.

Referring to FIGS. 12, 13, 14, and 17, an OLED device may include a substrate 110, a dielectric mirror structure 200, a reflection structure 1385, a buffer layer 115, a semiconductor element 250, a planarization layer 270, a sub-pixel structure 300, a pixel defining layer 310, and a TFE structure 450. Here, the semiconductor element 250 may include an active layer 130, a gate insulation layer 150, a gate electrode 170, an insulating interlayer 190, a source electrode 210, and a drain electrode 230. The sub-pixel structure 300 may include a lower electrode 290, a light emitting layer 330, and an upper electrode 340. In addition, the reflection structure 1385 may include a plurality of first reflection patterns 1382 and a plurality of second reflection patterns 1384. Further, the dielectric mirror structure 200

may include a first dielectric layer **111**, a second dielectric layer **112**, and a third dielectric layer **113**.

The first dielectric layer **111** may be disposed on the substrate **110**. In example embodiments, the first dielectric layer **111** may have a first refractive index. The first dielectric layer **111** may include one or more of a silicon compound and metal oxide.

The second dielectric layer **112** may be disposed on the first dielectric layer **111**. In example embodiments, the second dielectric layer **112** may have a second refractive index that is different from the first refractive index. For example, the first refractive index may be a high refractive index, and the second refractive index may be a low refractive index. The second dielectric layer **112** may include one or more of a silicon compound and metal oxide.

The third dielectric layer **113** may be disposed on the second dielectric layer **112**. In example embodiments, the third dielectric layer **113** may have the first refractive index. For example, the third dielectric layer **113** and the first dielectric layer **111** may be substantially the same.

The reflection structure **1385** may include a first reflection pattern **1382** and a second reflection pattern **1384**. The first reflection pattern **1382** may be disposed on the substrate **110**, and the second reflection pattern **1384** may be disposed on the insulating interlayer **190**. For example, after a preliminary electrode is formed on the insulating interlayer **190**, the source electrode **210**, and the drain electrode **230**, and the second reflection pattern **1384** may be formed by partially removing the preliminary electrode. That is, the source electrode **210**, the drain electrode **230**, and the second reflection pattern **1384** may be simultaneously formed using the same material.

FIG. **18** is a cross-sectional view illustrating an OLED device in accordance with example embodiments, and FIG. **19** is a cross-sectional view illustrating an OLED device in accordance with example embodiments. OLED devices illustrated in FIGS. **18** and **19** may have a configuration substantially the same as or similar to that of the OLED device **1000** described with reference to FIGS. **12**, **13**, and **14** except a first auxiliary wiring **1180** and a second auxiliary wiring **1190**. In FIGS. **18** and **19**, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. **12**, **13**, and **14** may not be repeated.

Referring to FIGS. **12**, **13**, **14**, and **18**, an OLED device may include a substrate **110**, a reflection structure **1380**, a buffer layer **115**, a semiconductor element **250**, a first auxiliary wiring **1180**, a planarization layer **270**, a sub-pixel structure **300**, a pixel defining layer **310**, and a TFE structure **450**. Here, the semiconductor element **250** may include an active layer **130**, a gate insulation layer **150**, a gate electrode **170**, an insulating interlayer **190**, a source electrode **210**, and a drain electrode **230**. The sub-pixel structure **300** may include a lower electrode **290**, a light emitting layer **330**, and an upper electrode **340**. In addition, the reflection structure **1380** may include a plurality of first reflection patterns **1382** and a plurality of second reflection patterns **1384**.

The first auxiliary wiring **1180** may be disposed on the insulating interlayer **190** overlapping the reflection structure **1380** in the reflection region **20**. The first auxiliary wiring **1180** may be in contact with the second reflection pattern **1384** via a contact hole formed by removing a portion of the insulating interlayer **190**. The first auxiliary wiring **1180** may be electrically connected to the second reflection pattern **1384** such that a wiring resistance of the second reflection pattern **1384** is reduced. Alternatively, the reflection structure **1380** may serve as a touch sensing electrode,

and an external device may detect a pressure or force sensing and/or sense a pressure or force touch using a capacitor formed between the first reflection pattern **1382** and the first auxiliary wiring **1180**.

In some example embodiments, the first auxiliary wiring **1180** may be in contact with the first reflection pattern **1382** via a contact hole formed removing each portion of the insulating interlayer **190**, the gate insulation layer **150**, and the buffer layer **115**, and the first auxiliary wiring **1180** may be electrically connected to the first reflection pattern **1382** such that a wiring resistance of the first reflection pattern **1382** is reduced.

In some example embodiments, as illustrated in FIG. **19**, the OLED device may further include a second auxiliary wiring **1190** disposed on the planarization layer **270**. The second auxiliary wiring **1190** may be in contact with the first auxiliary wiring **1180** via a contact hole by removing a portion of the insulating interlayer **190**. That is, the second auxiliary wiring **1190** may be electrically connected to the first auxiliary wiring **1180** and the second reflection pattern **1384**.

FIG. **20** is a cross-sectional view illustrating an OLED device in accordance with example embodiments, and FIG. **21** is a cross-sectional view describing a sealant included in the OLED device of FIG. **20**. OLED devices illustrated in FIGS. **20** and **21** may have a configuration substantially the same as or similar to that of the OLED device **100** described with reference to FIGS. **1**, **2**, **3**, and **4** except a substrate **110**, a sealant **410**, and an encapsulation substrate **350**. In FIGS. **20** and **21**, detailed descriptions for elements that are substantially the same as or similar to elements described with reference to FIGS. **1**, **2**, **3**, and **4** may not be repeated.

Referring to FIGS. **20** and **21**, an OLED device may include a substrate **110**, a reflection structure **380**, a buffer layer **115**, a semiconductor element **250**, a planarization layer **270**, a sub-pixel structure **300**, a pixel defining layer **310**, a sealant **410**, and an encapsulation substrate **350**. Here, the semiconductor element **250** may include an active layer **130**, a gate insulation layer **150**, a gate electrode **170**, an insulating interlayer **190**, a source electrode **210**, and a drain electrode **230**. The sub-pixel structure **300** may include a lower electrode **290**, a light emitting layer **330**, and an upper electrode **340**. In addition, the reflection structure **380** may include a plurality of first reflection patterns **382**, a plurality of second reflection patterns **384**, and a plurality of connection patterns **180**.

The substrate **110** may be formed of a transparent material. In example embodiments, the substrate **110** may include a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a soda lime glass substrate, a non-alkali substrate, or the like.

The encapsulation substrate **350** may be disposed on the upper electrode **340**. The encapsulation substrate **350** and the substrate **110** may have the same material. For example, the encapsulation substrate **350** may include a quartz substrate, a synthetic quartz substrate, a calcium fluoride substrate, a fluoride-doped quartz substrate, a soda lime glass substrate, a non-alkali substrate, or the like.

As illustrated in FIG. **21**, a display panel **400** may be disposed between the substrate **110** and the encapsulation substrate **350**. For example, the display panel **400** may include the reflection structure **380**, the buffer layer **115**, a plurality of semiconductor elements **250**, the planarization layer **270**, a plurality of sub-pixel structures **300**, and the pixel defining layer **310** that are disposed on the substrate **110**.

The sealant **410** may be interposed between the substrate **110** and the encapsulation substrate **350**, and may be disposed in outer regions of the substrate **110** and the encapsulation substrate **350**. The outer regions of the substrate **110** and the encapsulation substrate **350** where the sealant **410** is disposed may generally correspond to the boundary regions of the substrate **110** and the encapsulation substrate **350**. In some cases, small edge portions of the substrate **110** and/or the encapsulation substrate **350** may extend out beyond the outer regions of the substrate **110** and/or the encapsulation substrate **350**. An encapsulation process may be performed to combine the substrate **110** and the encapsulation substrate **350**. In this case, the sealant **410** may be interposed in the outer regions between the substrate **110** and the encapsulation substrate **350**.

The sealant may include a frit, or the like. For example, the substrate **110** and the encapsulation substrate **350** may be combined to each other through a laser irradiation process. Here, the laser may be irradiated into the sealant **410**. In the laser irradiation process, a phase of the sealant **410** may be changed from a solid phase to a liquid phase. Then, the sealant **410** of the liquid phase may be cured to the solid phase again after a predetermined time. In accordance with the phase change of the sealant **410**, the substrate **110** may be combined with the encapsulation substrate **350**. The sealed structure of the substrate **110** and the encapsulation substrate **350** may protect the OLED device from permeation of water, moisture, oxygen, etc. The OLED device may not be deteriorated by the water, the moisture, the oxygen, etc.

The present disclosure may be applied to various types and applications of display devices including an organic light emitting diode (OLED) display device. For example, the present disclosure may be applied to a vehicle-display device, a ship-display device, an aircraft-display device, a portable communication device, a display device for display or for information transfer, a medical-display device, etc.

The foregoing is illustrative of example embodiments and is not to be construed as limiting thereof. Although some example embodiments have been described, those skilled in the art will readily appreciate that other variations and/or modifications are possible in the example embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such variations and/or modifications are intended to be included within the scope of the present disclosure. Therefore, it is to be understood that the foregoing is illustrative of various example embodiments and is not to be construed as limited to the specific example embodiments disclosed, and that modifications to the disclosed example embodiments, as well as other example embodiments, are intended to be included within the scope of the present disclosure.

What is claimed is:

1. An organic light emitting diode (OLED) display device, comprising:

a substrate including a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions;

a reflection structure disposed on the substrate in the reflection region and having a plurality of openings exposing the plurality of sub-pixel regions, wherein the reflection structure includes:

first reflection patterns extending in a first direction that is parallel to an upper surface of the substrate and being spaced apart from each other in a second direction that is perpendicular to the first direction;

second reflection patterns being spaced apart from each other in the first direction between two adjacent first reflection patterns among the first reflection patterns; and

connection patterns electrically connecting two adjacent second reflection patterns in the second direction among the second reflection patterns; and a sub-pixel structure disposed on the substrate in each of the plurality of sub-pixel regions,

wherein the reflection structure reflects an image of an object that is located in front of a first surface of the OLED device, and

wherein the OLED device displays a displaying image in the first surface through the plurality of openings.

2. The OLED device of claim 1, wherein the reflection structure is disposed between the substrate and the sub-pixel structure.

3. The OLED device of claim 1, wherein the first reflection patterns are configured to receive a first touch sensing voltage from an external device, and the second reflection patterns are configured to receive a second touch sensing voltage from the external device, and

wherein the external device detects a change of capacitance between the first reflection patterns and the second reflection patterns.

4. The OLED device of claim 1, wherein each of the first reflection patterns has a planar bar shape and is regularly arranged in the second direction,

wherein each of the second reflection patterns has an island shape and is regularly arranged in the first direction, and

wherein the first reflection patterns and the second reflection patterns are spaced apart from each other.

5. The OLED device of claim 1, wherein each of the first and second reflection patterns has a mesh structure including the plurality of openings.

6. The OLED device of claim 1, further comprising: a thin film encapsulation structure disposed on the sub-pixel structure,

wherein each of the substrate and the thin film encapsulation structure has a stack structure where at least one organic layer and at least one inorganic layer are alternately stacked, and the stack structure is flexible, and

wherein the reflection structure is in contact with the at least one inorganic layer of the substrate, and the sub-pixel structure is in contact with the at least one inorganic layer of the thin film encapsulation structure.

7. The OLED device of claim 1, further comprising: an encapsulation substrate disposed on the sub-pixel structure; and

a sealant interposed between the substrate and the encapsulation substrate, the sealant being disposed in outer regions of the substrate and the encapsulation substrate, wherein each of the substrate and the encapsulation substrate includes rigid materials, and the sealant includes a frit, and

wherein the substrate and the encapsulation substrate are combined by the sealant.

8. The OLED device of claim 1, wherein the sub-pixel structure includes:

a lower electrode disposed on the substrate, the lower electrode transmitting a light;

a light emitting layer disposed on the lower electrode; and an upper electrode disposed on the light emitting layer, the upper electrode reflecting a light that is emitted from the light emitting layer,

wherein a reflectivity of the upper electrode is greater than a reflectivity of the lower electrode, and the upper electrode is disposed on the substrate in the sub-pixel region and the reflection region.

9. The OLED device of claim 8, wherein the upper electrode reflects an image of an object that is located in front of a second surface of the OLED device,

wherein the second surface is opposite to the first surface.

10. The OLED device of claim 1, further comprising:

a semiconductor element disposed on the substrate in the reflection region; and

a buffer layer disposed on the substrate between the reflection structure and the semiconductor element, wherein the semiconductor element includes:

an active layer disposed on the buffer layer in the reflection region;

a gate electrode disposed on the active layer; and source and drain electrodes disposed on the gate electrode.

11. The OLED device of claim 10, wherein the connection patterns and the gate electrode are simultaneously formed using the same material.

12. The OLED device of claim 1, further comprising:

a dielectric mirror structure disposed between the substrate and the reflection structure.

13. The OLED device of claim 12, wherein the dielectric mirror structure includes:

one or more first dielectric layers having a first refractive index; and

one or more second dielectric layers disposed on the one or more first dielectric layers, the one or more second dielectric layers having a second refractive index that is different from the first refractive index, and

wherein the one or more first dielectric layers and the more second dielectric layers are alternately stacked.

14. An organic light emitting diode (OLED) display device, comprising:

a substrate including a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions;

a reflection structure disposed on the substrate in the reflection region and having a plurality of openings exposing the plurality of sub-pixel regions, wherein the reflection structure includes:

first reflection patterns extending in a first direction that is parallel to an upper surface of the substrate and being spaced apart from each other in a second direction that is perpendicular to the first direction; second reflection patterns being spaced apart from each other in the first direction between two adjacent first reflection patterns among the first reflection patterns; and

connection patterns electrically connecting two adjacent second reflection patterns in the second direction among the second reflection patterns; and

a sub-pixel structure disposed on the substrate in each of the plurality of sub-pixel regions,

wherein at least one groove is formed in a border of the first reflection pattern and the second reflection pattern.

15. An OLED display device, comprising:

a substrate including a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions;

a sub-pixel structure disposed on the substrate in each of the plurality of sub-pixel regions; and

a reflection structure disposed on the substrate in the reflection region and having a plurality of openings, the plurality of sub-pixel regions being exposed through the plurality of openings,

wherein the reflection structure includes first reflection patterns arranged in a first direction and

second reflection patterns arranged in the second direction that is perpendicular to the first direction,

wherein the reflection structure reflects an image of an object that is located in front of a first surface of the OLED device, and

wherein the OLED device displays a displaying image in the first surface through the plurality of openings.

16. The OLED device of claim 15, wherein the reflection structure is disposed between the substrate and the sub-pixel structure.

17. The OLED device of claim 15, wherein the first reflection patterns are configured to receive a first touch sensing voltage from an external device, and the second reflection patterns are configured to receive a second touch sensing voltage from the external device, and

wherein the external device detects a change of capacitance between the first reflection patterns and the second reflection patterns.

18. The OLED device of claim 15, wherein each of the first and second reflection patterns has a planar bar shape and is regularly arranged to each other, and

wherein each of the first and second reflection patterns has a mesh structure including the plurality of openings.

19. The OLED device of claim 18, wherein the first reflection patterns and the second reflection patterns are crossed in a cross-over region, and wherein a first group of the plurality of openings of the first reflection patterns and a second group of the plurality of openings of the second reflection patterns that are located in the cross-over region are overlapped to each other.

20. The OLED device of claim 15, further comprising: a thin film encapsulation structure disposed on the sub-pixel structure,

wherein each of the substrate and the thin film encapsulation structure has a stack structure where at least one organic layer and at least one inorganic layer are alternately stacked, and the stack structure is flexible, and

wherein the reflection structure is in contact with the at least one inorganic layer of the substrate, and the sub-pixel structure is in contact with the at least one inorganic layer of the thin film encapsulation structure.

21. The OLED device of claim 15, further comprising: a semiconductor element disposed on the substrate in the reflection region; and

a buffer layer disposed on the substrate between the first reflection pattern and the semiconductor element,

wherein the semiconductor element includes: an active layer disposed on the buffer layer in the reflection region;

a gate electrode disposed on the active layer; and source and drain electrodes disposed on the gate electrode, and

wherein the second reflection patterns and the gate electrode are simultaneously formed using the same material.

22. The OLED device of claim 21, further comprising: an auxiliary wiring disposed on the second reflection pattern, the auxiliary wiring being electrically connected to the second reflection patterns,

31

wherein the auxiliary wiring and the source and drain electrodes are simultaneously formed using the same materials.

23. The OLED device of claim 15, further comprising: a dielectric mirror structure disposed between the substrate and the reflection structure,

wherein the dielectric mirror structure includes: one or more first dielectric layers having a first refractive index; and

one or more second dielectric layers disposed on the one or more first dielectric layers, the one or more second dielectric layers having a second refractive index that is different from the first refractive index, and

wherein the one or more first dielectric layers and the one or more second dielectric layers are alternately stacked.

24. An OLED device, comprising:

a substrate including a plurality of sub-pixel regions and a reflection region surrounding the plurality of sub-pixel regions;

a sub-pixel structure disposed on the substrate in each of the plurality of sub-pixel regions; and

a sensing structure disposed on the substrate in the reflection region and having a plurality of openings, the plurality of sub-pixel regions being exposed through the plurality of openings,

wherein the sensing structure includes first sensing patterns and second sensing patterns insulated from the first sensing patterns,

wherein the sensing structure is disposed between the substrate and the sub-pixel structure,

wherein the sensing structure reflects an image of an object that is located in front of a first surface of the OLED device, and

32

wherein the OLED device displays a displaying image in the first surface through the plurality of openings.

25. The OLED device of claim 24, wherein the sensing structure further comprising connection patterns electrically connecting two adjacent second sensing patterns in a second direction among the second sensing patterns, wherein the first sensing patterns extend in a first direction that is perpendicular to the second direction and are spaced apart from each other in the second direction, and wherein the second sensing patterns are spaced apart from each other in the first direction and the second direction.

26. The OLED device of claim 24, wherein the first sensing patterns are arranged in a first direction, and the second sensing patterns are arranged in a second direction that is perpendicular to the first direction.

27. The OLED device of claim 24, wherein each of the first sensing patterns and the second sensing patterns reflect light entering through the substrate.

28. The OLED device of claim 24, wherein the first sensing patterns are applied with a first voltage and the second sensing patterns are applied with a second voltage, and wherein a change of capacitance between the first sensing patterns and the second sensing patterns is detected to determine a position of touch.

29. The OLED device of claim 28, wherein the first voltage is a sensing input signal and the second voltage is a sensing output signal.

30. The OLED device of claim 28, wherein the change of capacitance between the first sensing patterns and the second sensing patterns measures a pressure of touch.

31. The OLED device of claim 28, further comprising a circuit that is configured to generate the first voltage and the second voltage.

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专利名称(译)	有机发光显示装置		
公开(公告)号	US9991318	公开(公告)日	2018-06-05
申请号	US15/257147	申请日	2016-09-06
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	KIM MU GYEOM KIM MIN SOO		
发明人	KIM, MU-GYEOM KIM, MIN-SOO		
IPC分类号	H01L27/32 H01L51/52		
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摘要(译)

有机发光二极管 (OLED) 显示装置包括基板, 反射结构和子像素结构。基板包括多个子像素区域和围绕子像素区域的反射区域。反射结构设置在反射区域中的基板上, 并具有暴露子像素区域的多个开口。反射结构包括第一反射图案, 第二反射图案和连接图案。第一反射图案在平行于基板的的上表面的第一方向上延伸, 并且在垂直于第一方向的第二方向上彼此间隔开。第二反射图案在两个相邻的第一反射图案之间沿第一方向彼此间隔开。连接图案在第二方向上电连接两个相邻的第二反射图案。子像素结构设置在子像素区域中的基板上。

