US009659966B2

(12) **United States Patent**
Kwak et al.

(10) **Patent No.: US 9,659,966 B2**
(45) **Date of Patent: May 23, 2017**

(54) **FLEXIBLE DISPLAY SUBSTRATE, FLEXIBLE ORGANIC LIGHT EMITTING DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 25 days.

(21) Appl. No.: **14/106,173**

(22) Filed: **Dec. 13, 2013**

(65) **Prior Publication Data**

US 2014/0217397 A1 Aug. 7, 2014

(30) **Foreign Application Priority Data**

Feb. 1, 2013 (KR) 10-2013-0012032

(51) **Int. Cl.**
H01L 51/05 (2006.01)
B82Y 10/00 (2011.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 27/1218*** (2013.01); ***H01L 27/124*** (2013.01); ***H01L 27/3276*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01L 51/0545; H01L 51/0036; H01L 51/0541; H01L 51/5012; H01L 27/1214;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0280157 A1	12/2005	Roush et al.	
2006/0079039 A1	4/2006	Ohtani et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1770405 A	5/2006
CN	101110443 A	1/2008

(Continued)

OTHER PUBLICATIONS

PCT International Search Report for PCT/KR2013/012240, Apr. 29, 2014, 3 Pages.

(Continued)

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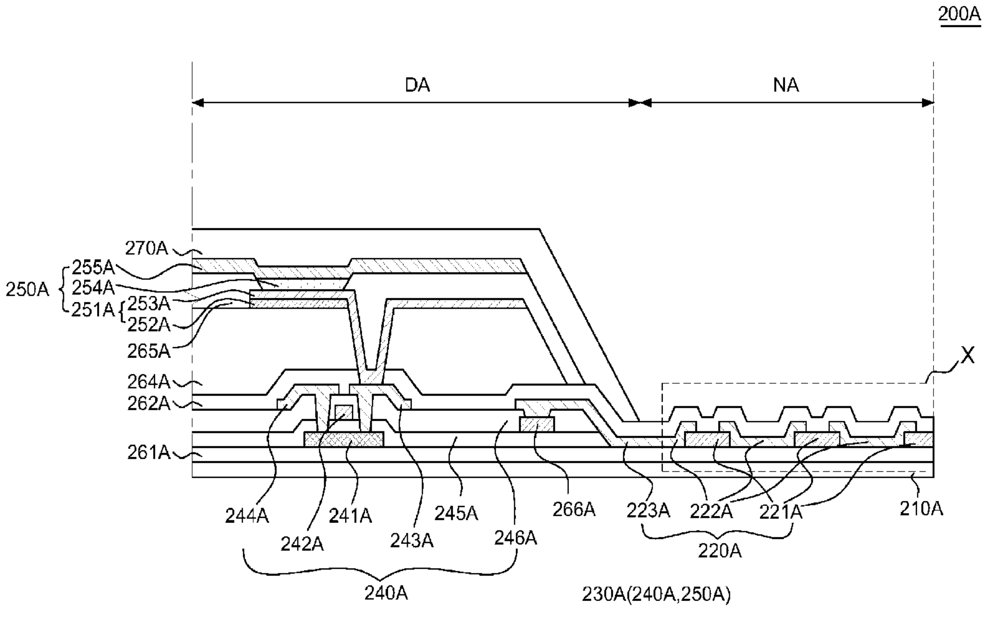
(57) **ABSTRACT**

A flexible display substrate, a flexible organic light emitting display device, and a method of manufacturing the same are provided. The flexible display substrate comprises a flexible substrate including a display area and a non-display area extending from the display area, and a wire formed on the flexible substrate. At least a part of the non-display area of the flexible substrate is formed in a crooked shape in a bending direction, and the wire positioned on at least a part of the non-display area of the flexible substrate includes a plurality of first wire patterns, and a second wire pattern formed on the plurality of first wire patterns and electrically connected with the plurality of first wire patterns.

27 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

H01L 51/00	(2006.01)
H01L 51/50	(2006.01)
H01L 27/12	(2006.01)
H01L 51/56	(2006.01)
B82Y 30/00	(2011.01)
H01L 27/32	(2006.01)
H01L 51/52	(2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/0097*** (2013.01); *H01L 51/5246* (2013.01); *H01L 51/5253* (2013.01); *H01L 2251/5338* (2013.01); *Y02E 10/549* (2013.01)

(58) **Field of Classification Search**
CPC H01L 51/56; B82Y 10/00; B82Y 30/00; Y02E 10/50
USPC 257/43, 40; 438/85, 86, 104, 754, 82, 99
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0019143	A1	1/2007	Chen et al.	
2008/0017855	A1*	1/2008	Kim	G02F 1/1309 257/48
2008/0289859	A1	11/2008	Mikado et al.	
2009/0322979	A1*	12/2009	Kang	G02F 1/1333 349/58
2009/0323009	A1*	12/2009	Paek et al.	349/160
2011/0024162	A1	2/2011	Oikawa	
2012/0033168	A1*	2/2012	Hwang	G02F 1/13338 349/139
2012/0049178	A1*	3/2012	Sugimoto	H01L 27/3258 257/40
2012/0062447	A1	3/2012	Tseng et al.	
2012/0162099	A1*	6/2012	Yoo	G06F 3/0412 345/173
2012/0181544	A1*	7/2012	Lee et al.	257/72
2012/0218219	A1	8/2012	Rappoport et al.	
2012/0235171	A1*	9/2012	Kim	H01L 51/5253 257/88

FOREIGN PATENT DOCUMENTS

JP	2009259929	A	11/2009
KR	10-2008-0050534	A	6/2008
KR	10-2011-0053922	A	5/2011

OTHER PUBLICATIONS

Office Action for Chinese Patent Application No. CN 201380073607.6, Jun. 14, 2016, 27 Pages.

European Search Report for European Patent Application No. EP 13873337.3, Sep. 5, 2016, 8 Pages.

Second Office Action for Chinese Patent Application No. CN 201380073607.6, Jan. 12, 2017, 7 Pages.

* cited by examiner

FIG. 1A

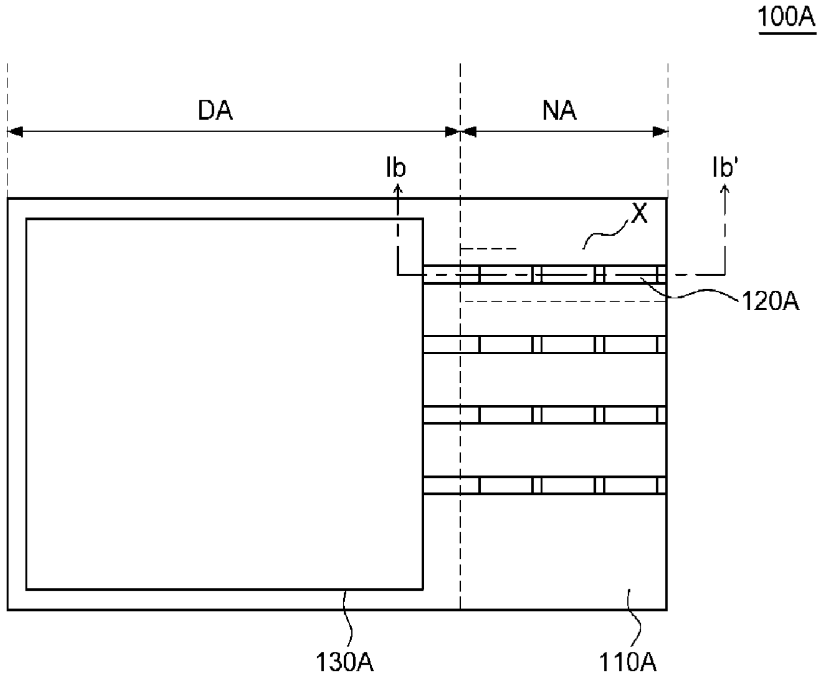


FIG. 1B

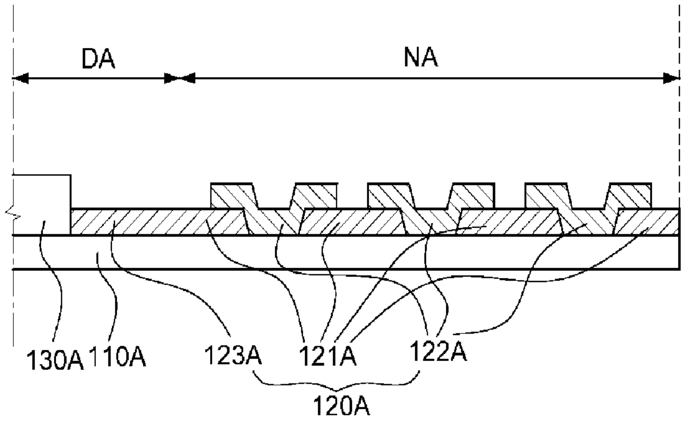


FIG. 1C

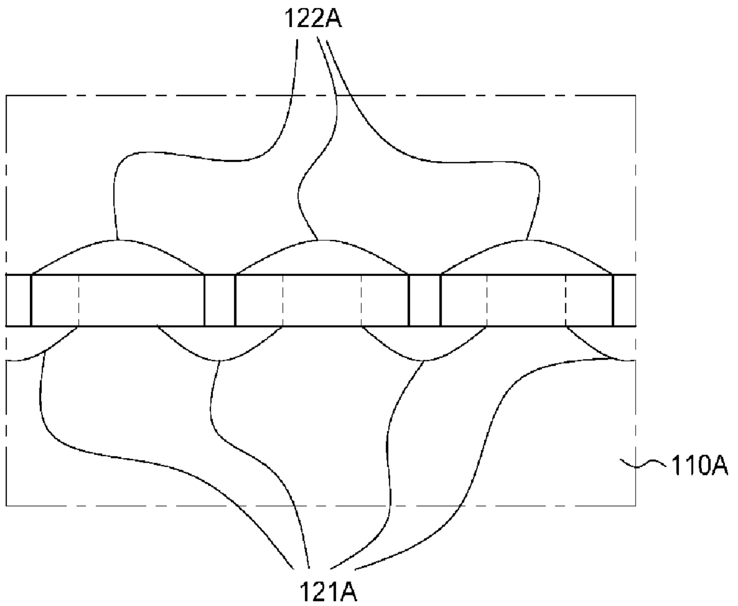


FIG. 1D

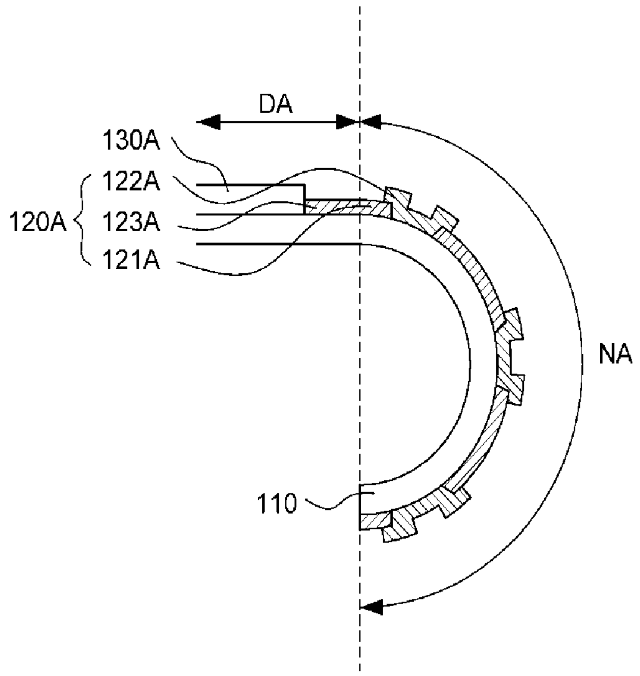


FIG. 1E

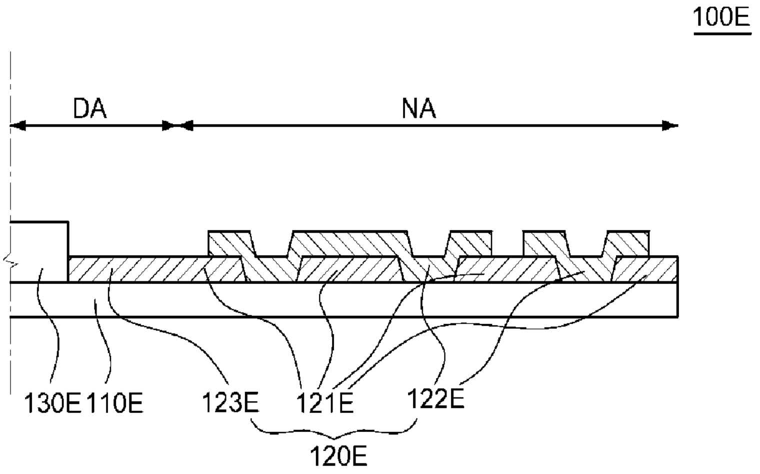


FIG. 1F

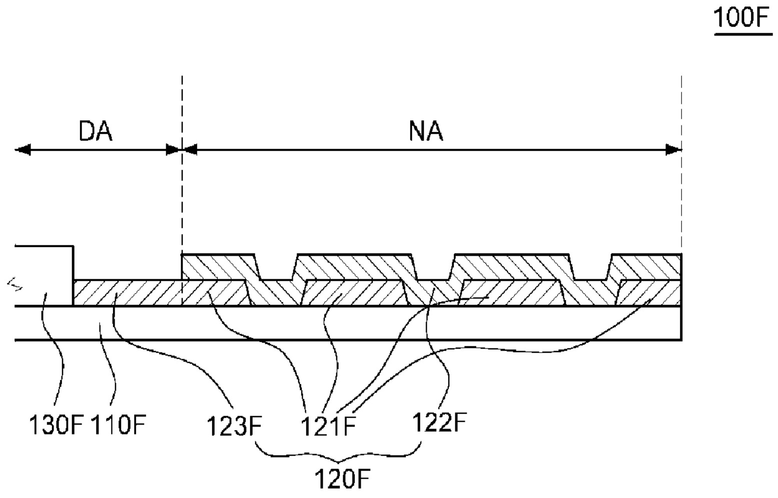


FIG. 1G

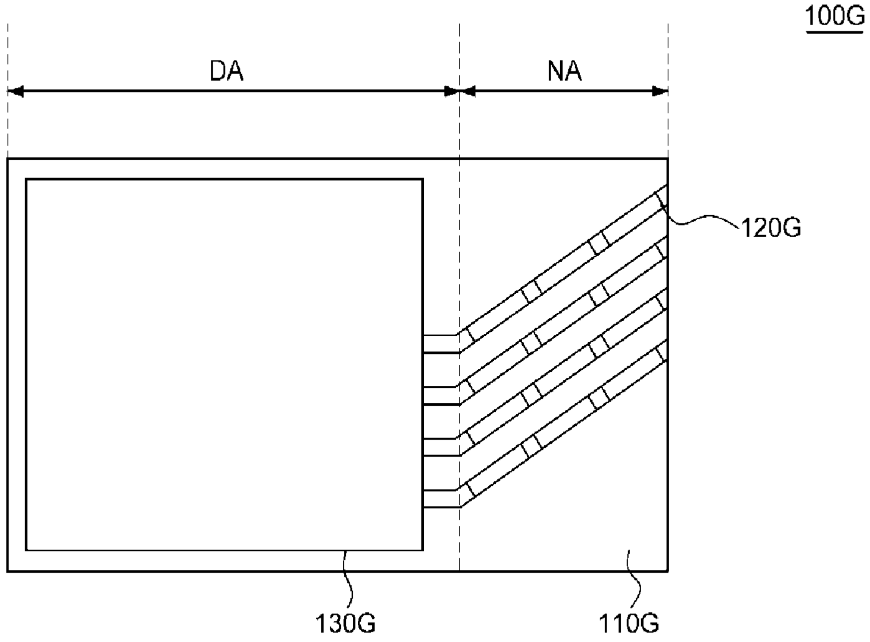


FIG. 1H

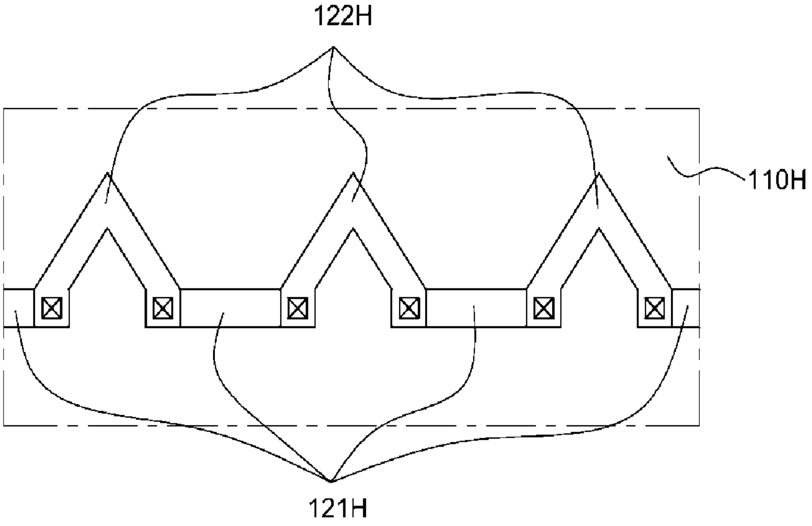
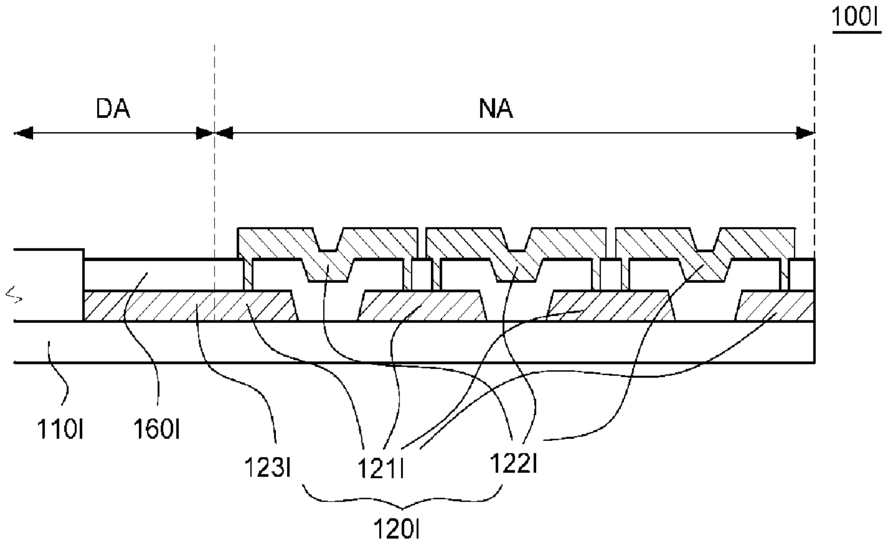
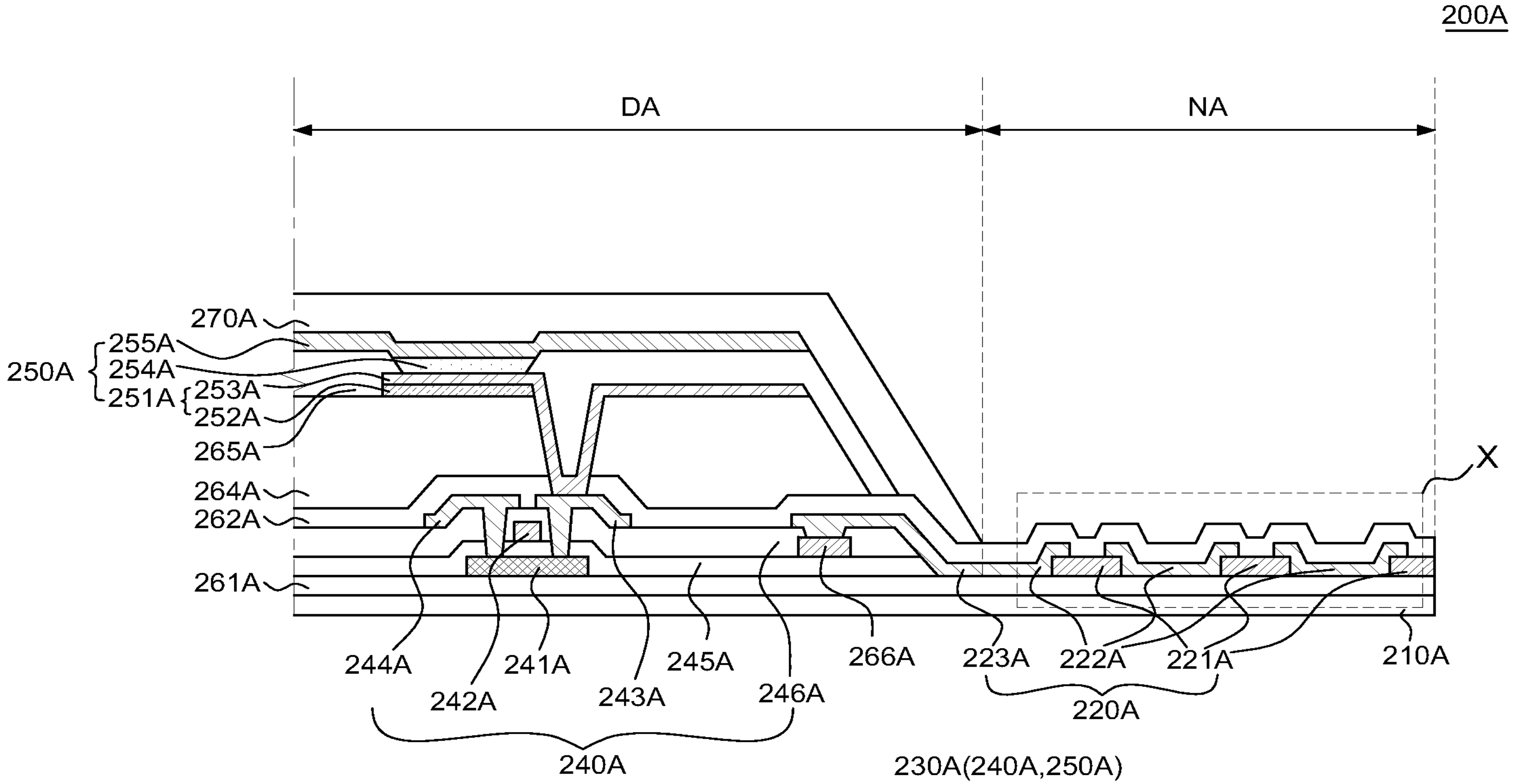


FIG. 1I

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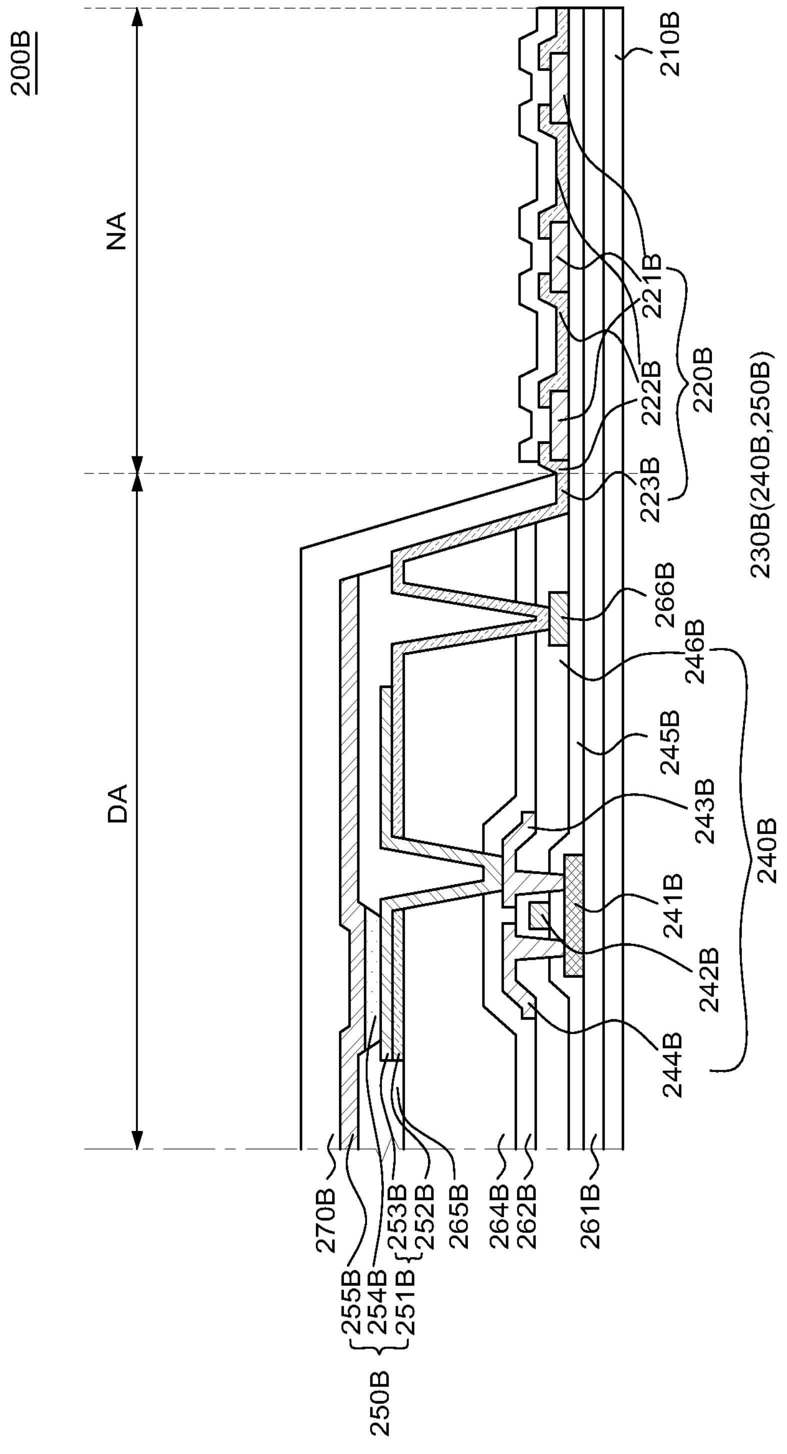
230A(240A,250A)

FIG. 2A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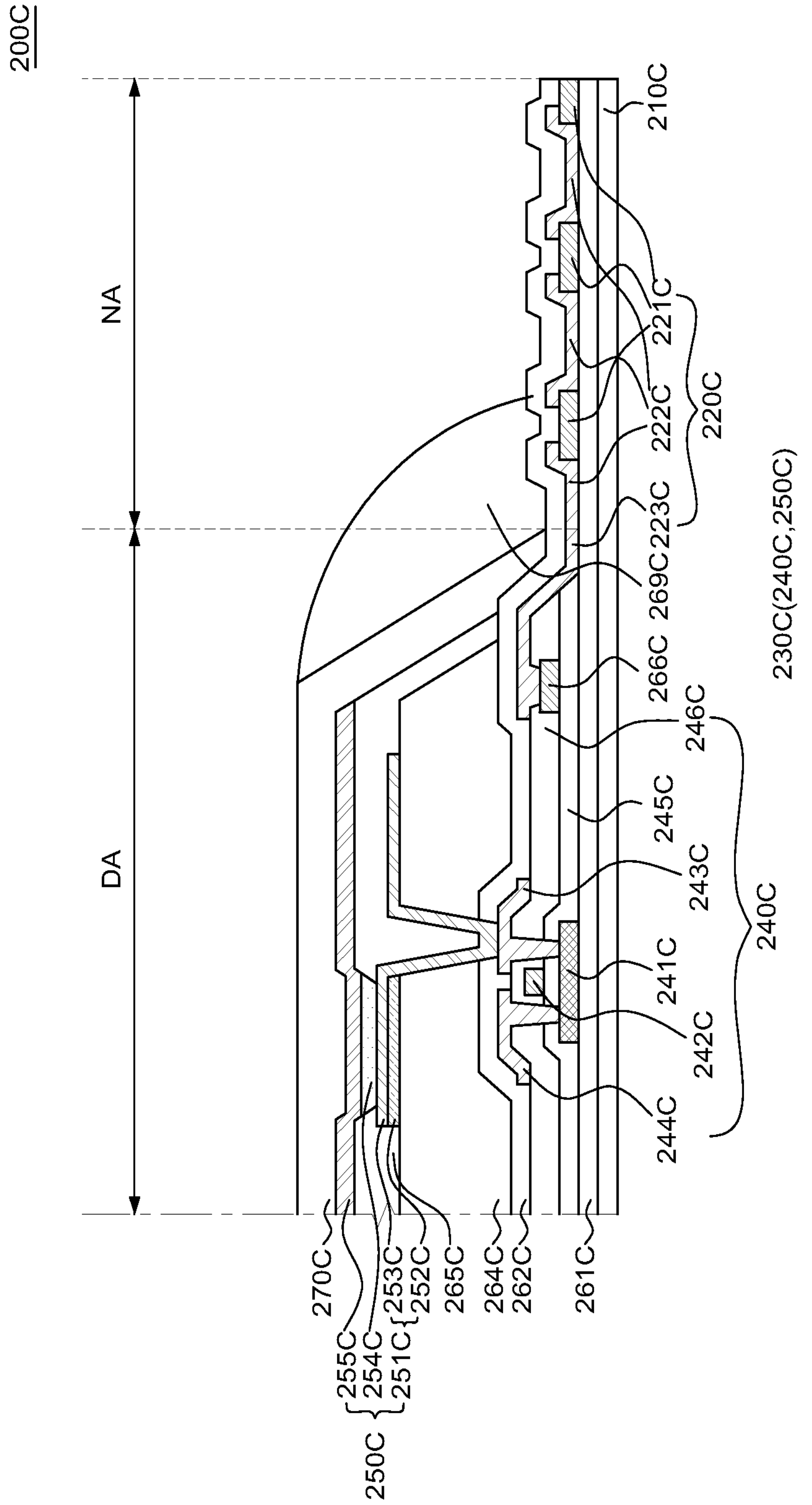
261B
250B

FIG. 2B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220C
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241C
242C
244C
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252C
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264C
262C
261C

FIG. 2C

FIG. 2D

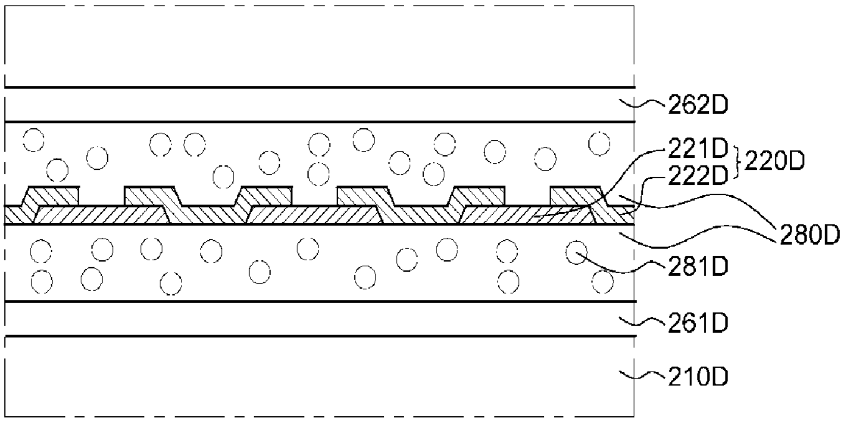
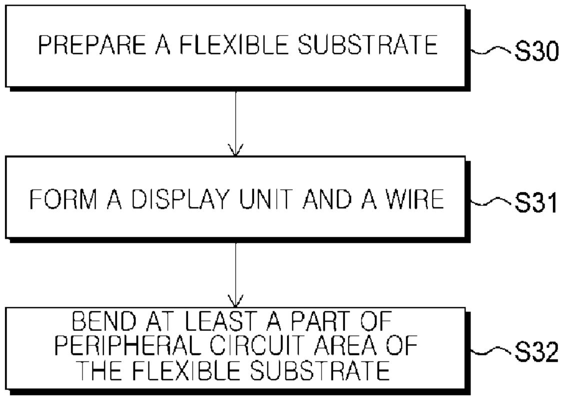


FIG. 3


PREPARE A FLEXIBLE SUBSTRATE
S30
FORM A DISPLAY UNIT AND A WIRE
S31
BEND AT LEAST A PART OF PERIPHERAL CIRCUIT AREA OF THE FLEXIBLE SUBSTRATE
S32

FLEXIBLE DISPLAY SUBSTRATE, FLEXIBLE ORGANIC LIGHT EMITTING DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 2013-0012032, filed on Feb. 1, 2013, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention

The present invention relates to a flexible display device, and more particularly, to a flexible display substrate used in a flexible display device capable of relieving stress concentrating on a wire upon bending a substrate.

2. Discussion of Related Art

Display devices used in monitors of computers, televisions (TVs), and cell phones include organic light emitting display devices (OLEDs) and plasma display panels (PDPs), both of which autonomously emit light, and liquid crystal display devices (LCDs) requiring a separate light source, etc.

Recently, flexible display devices capable of being bent or curved have gained much attention as the next-generation display device. Flexible display devices offer unique features that conventional rigid display devices do not have. Even with limited flexibility, these devices provide a slimmer form factor, lighter weight, higher durability, and most of all, the freedom of design for portable electronic devices such as cell phones and multimedia players. With enhanced flexibility, a range of revolutionary display and lighting opportunities can be created. These opportunities include new electronics products such as TVs with curvature adjustable screen as well as portable electronics with a rollable display screen.

However, many factors need to be considered for the development of next-generation flexible-display technology. In a sense, flexibility means ability to withstand strain from being bent, but many parts of the flexible display devices still face the stability issues. For example, electrodes and wires in the flexible devices are often formed with indium tin oxide (ITO). ITO, however, is brittle and therefore prone to cracking when deformed, whereas the underlying substrate is ductile and flexible. Cracking of the electrodes and wires causes spots of poor or no contact and eventual loss of functionality over large areas of the display devices, and thus is one of the major concerns in flexible display devices. Even when conductive polymers or carbon based coatings are used to form the electrodes/wires, mechanical stress (i.e., tensile/compression stresses) remains.

SUMMARY OF THE INVENTION

Embodiments relate to a flexible display substrate including a flexible substrate and a wire. The flexible substrate has a curved portion that is bent. The wire has a plurality of first wire patterns and a second wire pattern. Each of the plurality of first wire patterns is spaced apart from an adjacent first wire pattern. A second wire pattern electrically connects the plurality of first wire patterns.

In one embodiment, a thin film transistor is formed on the flexible substrate to operate a light emitting element formed on the flexible substrate based on a signal transmitted via the wire.

In one embodiment, the second wire pattern overlaps with at least a portion of each of two of the first wire patterns.

In one embodiment, the portion of each first wire pattern overlaps with the second wire pattern and is in physical contact with the second wire pattern.

In one embodiment, the second wire pattern entirely covers at least one first wire pattern.

In one embodiment, the second wire pattern is in physical contact with all of the first wire patterns.

In one embodiment, the flexible display substrate further includes additional second wire patterns. Each of the additional second wire patterns may electrically connect at least two of the first wire patterns.

In one embodiment, at least two of the additional second wire patterns have different lengths.

In one embodiment, the second wire pattern has greater flexibility than the plurality of first wire patterns.

In one embodiment, two adjacent first wire patterns are spaced apart by a predetermined distance, and the second wire pattern has a length longer than the predetermined distance.

In one embodiment, the flexible display substrate further includes an insulation layer formed between and formed on each of the plurality of first wire patterns. The second wire pattern may be disposed on the insulation layer.

In one embodiment, at least a portion of the wire in the curved portion extends in a direction that is not parallel to a bending direction of the curved portion.

In one embodiment, the second wire pattern includes a plurality of portions. At least one of the plurality of portions extending in a direction that is not parallel to a bending direction of the curved portion.

In one embodiment, the flexible display substrate includes a crack prevention layer disposed on at least one of top and bottom surfaces of the wire.

Embodiments also relate to a flexible display device including a flexible substrate and a conductive line. The flexible substrate includes a substantially flat area extending along a plane, and a bending area adjacent to the substantially flat area and bending away from the plane. The conductive line is disposed on the curved portion of the flexible substrate. The wire includes a first layer of wire segments and a second layer of wire segments electrically connecting the first layer of wire segments. At least part of the second layer formed on the first layer.

In one embodiment, the flexible display device further includes a passivation layer and a crack prevention layer. The passivation layer is formed above the conductive line at an opposite side of the flexible substrate. The crack prevention layer is placed between the passivation layer and the conductive line.

In one embodiment, the crack prevention layer includes at least one of a porous material and nanoparticles.

In one embodiment, the flexible display device further includes a display unit having an anode, a cathode, and a plurality of thin-film-transistors (TFT). Each TFT has a source electrode, a drain electrode and a gate electrode. The first layer or the second layer is formed of the same material as at least one of the anode, the cathode, the source electrode, the drain electrode and the gate electrode.

In one embodiment, the conductive line is connected to at least one of the anode, the cathode, the source electrode, the drain electrode and the gate electrode.

In one embodiment, the flexible display device further includes a separation layer interposed between the first layer of wire segments and the second layer of wire segments. The separation layer has a plurality of contact holes. The first layer is in physically contact with the second layer through the plurality of contact holes.

In one embodiment, the flexible display device further includes a buffer layer interposed between the conductive line and the flexible substrate, and a crack prevention layer interposed between the buffer layer and the conductive line.

Embodiments also relate to a method of fabricating a flexible display device. A plurality of first wire segments that are physically separated on at least a bending area of a flexible substrate are formed. A second wire segment is formed to bridge the first wire segments on at least the bending area of the flexible substrate. A display unit is formed on a flat area adjacent to the bending area, the display unit having an anode, a cathode, an organic light emitting diode between the anode and the cathode, and a plurality of thin-film-transistors (TFT). Each TFT has a source electrode, a drain electrode and a gate electrode. The first wire segments or the second wire segment are formed of the same material as any one of the anode, the cathode, the source electrode, the drain electrode and the gate electrode. The flexible substrate is bent at the bending area away from a plane along which the flat area of the flexible substrate extends.

In one embodiment, the first wire segments are formed by etching a layer of metal on the flexible substrate.

Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of the embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which constitute a part of this specification, illustrate various embodiments of the present invention.

FIG. **1**A is a top view showing an unbent state of a flexible display substrate according to an exemplary embodiment of the present invention.

FIG. **1**B is a cross-sectional view of the flexible display substrate taken along line Ib-Ib' shown in FIG. **1**A.

FIG. **1**C is an enlarged diagram of an area X shown in FIG. **1**A.

FIG. **1**D is a cross-sectional view illustrating an exemplary embodiment of the invention along with a flexible display substrate in a bent state.

FIGS. **1**E and **1**F are cross-sectional views of the flexible display substrates according to various exemplary embodiments of the present invention.

FIG. **1**G is a top view showing an unbent state of the flexible display substrate according to another exemplary embodiment of the present invention.

FIG. **1**H is an enlarged diagram of the flexible display substrate according to an exemplary embodiment of the present invention.

FIG. **1**I is a cross-sectional view of the flexible display substrate according to an exemplary embodiment of the present invention.

FIGS. **2**A to **2**C are cross-sectional views showing unbent states of flexible organic light emitting display devices according to various exemplary embodiments of the present invention.

FIG. **2**D is an enlarged diagram of an area X shown in FIG. **2**A according to an embodiment of the present invention.

FIG. **3** is a flowchart illustrating a method of manufacturing a flexible organic light emitting display device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Exemplary embodiments of the present invention will be described in detail below with reference to the accompanying drawings. It is noted that the drawings of the present application are provided for illustrative purposes only and, as such, the drawings are not drawn to scale. In the following description, numerous specific details are set forth, such as particular structures, components, materials, dimensions, processing steps and techniques, in order to provide an understanding of the various embodiments of the present disclosure. However, it will be appreciated by one of ordinary skill in the art that the various embodiments of the present disclosure may be practiced without these specific details. In other instances, well-known structures or processing steps have not been described in detail in order to avoid obscuring the present disclosure.

It will be understood that when an element as a layer, region or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

It will also be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present.

Further, it will be understood that when an element is referred to as being "overlapped" with another element, one element can be positioned above the other element or below the other element. Moreover, although some of the elements are designated with numerical terms (e.g., first, second, third, etc.), it should be understood that such designations are only used to specify one element from a group of similar elements, but not to limit the element in any specific order. As such, an element designated as a first element could be termed as a second element or as third element without departing from the scope of exemplary embodiments.

In this specification, an organic light emitting display device with a top emission mode refers to an organic light emitting display device, wherein light emitted from the organic light emitting diode radiates from an upper portion of the organic light emitting display device. That is, the organic light emitting display device with a top emission mode refers to an organic light emitting display device, wherein light emitted from the organic light emitting diode radiates in a direction of a top surface of a substrate having a thin film transistor formed therein for driving the organic light emitting display device.

On the other hand, an organic light emitting display device with a bottom emission mode refers to an organic light emitting display device, wherein light emitted from the organic light emitting diode radiates from a lower portion of the organic light emitting display device. That is, the organic light emitting display device with a bottom emission mode refers to an organic light emitting display device, wherein light emitted from the organic light emitting diode radiates in a direction of a bottom surface of a substrate having a thin film transistor formed therein for driving the organic light emitting display device.

Further, an organic light emitting display device with a dual emission mode refers to an organic light emitting display device, wherein light emitted from the organic light emitting diode radiates from upper and lower portions of the organic light emitting display device. A thin film transistor, an anode, and a cathode may be configured depending on the mode of emission, so that light from the light emitting element is not interfered.

In the present disclosure, a flexible display device refers to a display device endowed with flexibility, and may be used to have the same meaning as a bendable display device, a rollable display device, an unbreakable display device, or a foldable display device. In this specification, a flexible organic light emitting display device is one example of various flexible display devices.

In this specification, a transparent display device refers to a transparent display device that is at least a part of a screen of a display device viewed by a user. In this specification, transparency of the transparent display device refers to a degree of transparency at which a user at least recognizes an object behind a display device. In this specification, the transparent display device includes a display area and a non-display area. The display area is an area on which an image is displayed, and the non-display area is an area on which no image is displayed, such as a bezel area. To maximize transmittance of the display area, the transparent display device is configured to dispose opaque components, such as a battery, a printed circuit board (PCB), and a metal frame, under the non-display area rather than the display area. In this specification, the transparent display device refers to a display device having transmissivity of, for example, equal to or greater than at least 20%. In this specification, the term “transmissivity” means a value obtained by dividing an intensity of light, which passes through the transparent display device except for light which is incident on a transmissive region of the transparent display device and reflected on the interface between respective layers of the transparent display device, by an intensity of the entire incident light.

In this specification, front and rear surfaces of the transparent display device are defined based on light emitted from the transparent display device. In this specification, the front surface of the transparent display device means a surface on which light from the transparent display device is emitted, and the rear surface of the transparent display device means a surface opposite to the surface on which the light from the transparent display device is emitted.

The features of various exemplary embodiments of the present invention may be partially or entirely bound or combined with each other, and be technically engaged and driven using various methods as apparent to those skilled in the art, and the exemplary embodiments may be independently practiced alone or in combination.

Hereinafter, various exemplary embodiments of the present invention will be described in further detail with reference to the accompanying drawings.

FIG. **1**A is a top view showing an unbent state of a flexible display substrate according to one exemplary embodiment of the present invention. FIG. **1**B is a cross-sectional view of the flexible display substrate taken along line Ib-Ib' shown in FIG. **1**A. FIG. **1**C is an enlarged diagram of an area X shown in FIG. **1**A. FIG. **1**D is a cross-sectional view showing a bent state of the flexible display substrate according to one exemplary embodiment of the present invention. Referring to FIGS. **1**A to **1**D, a flexible display substrate **100**A includes a flexible substrate **110**A, a wire **120**A, and a display unit **130**A.

The flexible substrate **110**A is a substrate configured to support various components of the flexible display. Here, the flexible substrate **110**A is endowed with flexibility. The flexible substrate **110**A may also be referred to as a flexible substrate, a first flexible substrate, or a flexible member. When the flexible substrate **110**A is formed of a plastic, the flexible substrate **110**A may also be referred to as a plastic film, a plastic substrate, or a first flexible substrate. FIGS. **1**A and **1**B show that the flexible substrate **110**A is illustrated in the form of a rectangular shape. However, it should be understood that the flexible substrate **120** may have various shapes, but the present invention is not limited thereto.

The flexible substrate **110**A may be formed of a flexible material. For example, the flexible substrate **110**A may be any one or more of materials including, but not limited to, a polyester-based polymer, a silicone-based polymer, an acrylic polymer, a polyolefin-based polymer, and a copolymer thereof. More particularly, the flexible substrate **110**A may be formed of one or combination of materials such as polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polysilane, polysiloxane, polysilazane, polycarbosilane, polyacrylate, polymethacrylate, polymethylacrylate, polyethylacrylate, polyethylmethacrylate, a cyclic olefin copolymer (COC), a cyclic olefin polymer (COP), polyethylene (PE), polypropylene (PP), polyimide (PI), polymethylmethacrylate (PMMA), polystyrene (PS), polyacetal (POM), polyether ether ketone (PEEK), polyestersulfone (PES), polytetrafluoroethylene (PTFE), polyvinylchloride (PVC), polycarbonate (PC), polyvinylidenefluoride (PVDF), a perfluoroalkyl polymer (PFA), a styrene acrylonitrile copolymer (SAN), and a combination thereof. The material of flexible substrate **110**A is not limited to the above, but it can be formed of various other transparent flexible material based on the application of the flexible display substrate **100**A as well as the type of flexible display device employing the display substrate **110**A.

The flexible substrate **110**A includes a display area DA and a non-display area NA. The display area DA of the flexible substrate **110**A refers to an area on which an image is actually displayed, and the non-display area NA of the flexible substrate **110**A refers to an area on which no image is displayed.

The non-display area NA of the flexible substrate **110**A is an area extending from the display area DA of the flexible substrate **110**A. The non-display area NA of the flexible substrate **110**A extends from one side of the display area DA of the flexible substrate **110**A. For example, the display area DA of the flexible substrate **110**A may be formed in a polygonal shape, and the non-display area NA of the flexible substrate **110**A may extend from one side of the display area DA of the flexible substrate **110**A. For the sake of convenience of description, FIGS. **1**A to **1**D show that the non-display area NA of the flexible substrate **110**A extends from one side of the display area DA of the flexible substrate **110**A, but the present invention is not limited thereto. For example, the non-display areas NA of the flexible substrate **110**A may extend from a plurality of sides of the display area DA of the flexible substrate **110**A.

The non-display area NA of the flexible substrate **110**A is positioned at a peripheral or edge portion of the display area DA of the flexible substrate **110**A, and various circuits for displaying an image are disposed on the non-display area NA of the flexible substrate **110**A. Therefore, the non-display area NA of the flexible substrate **110**A may also be referred to as a peripheral area, a peripheral circuit area, an edge area, or a bezel area.

A display unit **130**A is disposed at all or part of the display area DA of the flexible substrate **110**A. The display unit **130**A is an element configured to actually display an image, and may also be referred to as an image display unit or a display panel. The display unit **130**A may be used without limitation as long as it can be configured to display an image. In this specification, however, the display unit **130**A that is an organic light emitting diode in which an image is displayed through an organic light emitting layer will be described.

Various elements on which no image is displayed may be disposed at the non-display area NA of the flexible substrate **110**A. The elements disposed at the non-display area NA of the flexible substrate **110**A may include various ICs such as gate driver ICs or data driver ICs, and drive circuit units. Here, the various ICs and drive circuit units may be embedded in the flexible substrate **110**A using a gate-in-panel (GIP) method, or be connected to the flexible substrate **110**A using a tape-carrier-package (TCP) or chip-on-film (COF) method.

The flexible substrate **110**A includes a substantially flat area, which extends in a plane. The flexible substrate **110**A further includes a bending area curved in a bending direction such that it is bending away from the plane. Accordingly, some parts of the display area or non-display area NA of the flexible substrate **110**A may include a curved portion in the bending direction, which may be referred to as a bending area. Since the non-display area NA of the flexible substrate **110**A is not an area on which an image is displayed, an image does not need to be viewed from a top surface of the flexible substrate **110**A, and at least a part of the non-display area NA of the flexible substrate **110**A may be bent. For the sake of convenience of description, FIGS. **1**A to **1**D illustrate non-display area NA of the flexible substrate **110**A being the bending area BA, but it should be appreciated that the present invention is applicable to any area of the flexible display substrate. For example, only a part of the non-display area NA of the flexible substrate **110**A may correspond to the bending area. For the sake of convenience of description, FIG. **1**A shows that the non-display area NA of the flexible substrate **110**A is slightly narrower than the display area DA of the flexible substrate **110**A. However, the non-display area NA of the flexible substrate **110**A may actually correspond to an area much narrower than the display area DA of the flexible substrate **110**A.

The bending area that is at least a part of the non-display area NA of the flexible substrate **110**A is formed in a curved shape in a bending direction. FIGS. **1**A to **1**D show that the bending direction is a horizontal direction of the flexible substrate **110**A, and the bending area that is at least a part of the non-display area NA of the flexible substrate **110**A is bent in a horizontal direction of the flexible substrate **110**A.

A wire **120**A is formed on the flexible substrate **110**A. The wire **120**A may electrically connect a display unit **130**A, which may be formed on the display area DA of the flexible substrate **110**A, with a drive circuit unit, a gate driver IC, or a data driver IC, which may be formed on the non-display area NA of the flexible substrate **110**A, to send a signal. The wire **120**A includes a plurality of first wire patterns **121**A disposed on at least a part of the non-display area NA of the flexible substrate **110**A and a second wire pattern **122**A disposed on at least a part of the non-display area NA of the flexible substrate **110**A, in which the second wire pattern **122**A is configured to electrically connect at least two of the plurality of first wire patterns **121**A.

The wire **120**A (i.e., the plurality of first wire patterns **121**A and at least one second wire pattern **122**A) is formed of one or more conductive materials. It is preferred that the wire **120**A is formed of conductive materials, such as gold (Au), silver (Ag) and aluminum (Al), having excellent flexibility so as to minimize generation of cracks upon bending the flexible substrate **110**A. However, the constituent material of the wire **120**A is not particularly limited, and may be formed with one of various conductive materials used in other components/parts of the display unit **130**A. For instance, the wire **120**A (i.e., the plurality of first wire patterns **121**A and at least one second wire pattern **122**A) may be formed of one of various materials used to manufacture the display unit **130**A, such as molybdenum (Mo), chromium (Cr), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy of silver (Ag) with magnesium (Mg). Also, the wire **120**A (i.e., the first wire patterns **121**A and the second wire pattern **122**A) may be formed in a multi-layer structure including the various conductive materials as described above. For example, the wire **120**A may be formed in a three-layer structure of titanium (Ti), aluminum (Al), and titanium (Ti), but the present invention is not limited thereto. It is sufficient that the first and second wire patterns are formed of conductive material. Accordingly, in the present disclosure, the term "wire pattern" may be referred to as a metal pattern or a conductive pattern.

In the example shown in FIGS. **1**A-**1**D, the wire **120**A includes a plurality of first wire patterns **121**A formed on at least a part of the non-display area NA of the flexible substrate **110**A, a second wire pattern **122**A formed on at least a part of the non-display area NA of the flexible substrate **110**A and electrically connected with the plurality of first wire patterns **121**A, and a third wire pattern **123**A formed on the display area DA of the flexible substrate **110**A and coming in contact with the plurality of first wire patterns **121**A or the second wire pattern **122**A.

In the present disclosure, the third wire pattern **123**A refers to a pattern formed in the wire **120**A at the display area DA of the flexible substrate **110**A. For clearer explanation, the third wire pattern **123**A is illustrated as a separate wire pattern. However, it should be noted that the third wire pattern **123**A can be one of the first wire pattern **121**A having one end electrically connected with the display unit **130**A and the other end electrically connected to another first wire pattern **121**A via the second wire pattern **122**A. Likewise, the third wire pattern **123**A can also be a second wire pattern **122**A having one of its end electrically connected with the display unit **130**A and the other end electrically connected to one of the first wire patterns **121**A. Accordingly, in FIG. **1**B, one end of the third wire pattern **123**A comes in contact with the plurality of first wire patterns **121**A. In some other embodiments, however, the third wire pattern **123**A may come in contact with the second wire pattern **122**A.

The third wire pattern **123**A may be formed of the same material as the plurality of first wire patterns **121**A and/or the second wire pattern **122**A. Also, the third wire pattern **123**A may be formed of the same material as one of the conductive materials used to form the display unit **130**A, and may be formed of a conductive material different from the conductive material used to form the display unit **130**A. In embodiments where the third wire pattern **123**A is not a part of the first wire patterns **121**A or the second wire pattern **122**A, the third wire pattern **123**A can be formed of a material different from the plurality of first wire patterns **121**A and the second wire pattern **122**A.

The plurality of first wire patterns **121**A is formed on the non-display area NA of the flexible substrate **110**A. The plurality of first wire patterns **121**A is discontinuously formed on the flexible substrate **110**A, and is in the form of an island. In other words, each of the first wire patterns **121**A is spaced apart from its adjacent first wire pattern **121**A by a predetermined distance. The plurality of first wire patterns **121**A may be formed at the same time with the same material, and may also be formed at the same time as the third wire pattern **123**A connected with a component in the DA. In some exemplary embodiments, may be formed of the same material as one of the conductive materials used to form the display unit **130**A. As mentioned above, the third wire pattern **123**A may be part of the first wire pattern **121**A.

The second wire pattern **122**A is formed on the first wire patterns **121**A at the non-display area NA of the flexible substrate **110**A, and electrically connected with the first wire patterns **121**A. As shown in FIG. **1**B, some embodiments of the wire **120**A includes multiple second wire patterns **122**A that are separated from each other. Each of the second wire pattern **122**A is formed on some portion of the first wire patterns **121**A being electrically connected via the second wire pattern **122**A so that the portion of each first wire patterns **121**A overlapping with the second wire pattern **122**A is in physical contact with the second wire pattern **122**A. Therefore, the plurality of first wire patterns **121**A and the plurality of second wire patterns **122**A jointly form a wire **120**A. Since each of the plurality of second wire patterns **122**A is electrically connects at least two first wire patterns **121**A, the second wire patterns **122**A may be longer/shorter than the first wire pattern **121**A, depending on the distance between the first wire patterns **121**A. In some embodiments, the second wire pattern **122**A may be formed of the same material as one of the components disposed in the display area.

Generally, the longer the wire, the greater the tensile stress applied to the wire. Accordingly, a wire electrically connecting two points can be formed with multiple conductive patterns in such a way that the conductive patterns are electrically connected with each other to provide electrical channel between two points. In this configuration, the tensile stress is distributed to the conductive patterns forming the wire. Since each of the conductive patterns forming the wire is shorter than the original wire (e.g., single wire extending between the two points), each conductive pattern receives less tensile stress. As a result, the chance of wire being cracked or disconnected is greatly reduced. Even when the distance between the two points increases, additional number of conductive patterns can be used to cover the distance without increasing the chance wire breakage.

FIGS. **1**E and **1**F are cross-sectional views of the flexible display substrates according to various exemplary embodiments of the present invention. A flexible substrate **110**E, a wire **120**E, and a display unit **130**E shown in FIG. **1**E are substantially identical to the flexible substrate **110**A, the wire **120**A, and the display unit **130**A shown in FIG. **1**A, and a flexible substrate **110**F, a wire **120**F, and a display unit **130**F shown in FIG. **1**F are substantially identical to the flexible substrate **110**A, the wire **120**A, and the display unit **130**A, and thus repeated description of the same elements as shown in FIGS. **1**E and **1**F is omitted for brevity.

As shown in FIGS. **1**E and **1**F, lengths of second wire patterns **122**E and **122**F may be greater than those of a plurality of first wire patterns **121**E and **121**F.

Referring to FIG. **1**E, the second wire pattern **122**E may be in the form of an island, and the second wire pattern **122**E in the form of an island may be formed on parts of surfaces of the plurality of first wire patterns **121**E so that parts of surfaces of the plurality of first wire patterns **121**E can come in contact with a part of a surface of the second wire pattern **122**E. As shown, some of the first wire patterns **121**E may be entirely overlapped by the second wire pattern **122**E. In other words, some of the plurality of second wire patterns **122**E may come in contact with two or more first wire patterns **121**E among the plurality of first wire patterns **121**E. For example, one of the second wire patterns **122**E may come in contact with three first wire patterns **121**E, and the other one of the second wire patterns **122**E may come in contact with two first wire patterns **121**E, as shown in FIG. **1**E. Accordingly, the length of the second wire pattern **122**E may be greater than the length of each of the plurality of first wire patterns **121**E.

A material constituting the second wire pattern **122**E may have a higher flexibility than a material constituting the plurality of first wire patterns **121**E. As described above, a greater tensile force is applied to the longer wire. Also, the amount of mechanical stress varies depending on the position of the wire patterns. For instance, wire patterns disposed on the outer side of the curvature receives more tensile stress than the wire patterns disposed in the inner side of the curvature. As such, a greater tensile force is applied to the second wire pattern **122**E having a greater length, compared with the plurality of first wire patterns **121**E. Accordingly, the second wire pattern **122**E can be formed with a material having greater flexibility than the first wire patterns **121**E when the second wire pattern **122**E formed to be longer than the first wire patterns **121**E.

Referring to FIG. **1**F, the second wire pattern **122**F may be in the form of a line, and the second wire pattern **122**F in the form of a line may be formed on parts of surfaces of a plurality of first wire patterns **121**F so that each of the plurality of first wire patterns **121**F comes in contact with a part of a surface of the second wire pattern **122**F. Therefore, the second wire pattern **122**F may electrically connect at least all of the plurality of first wire patterns **121**F on the curved portion of the flexible substrate. In this case, the second wire pattern **122**F has greater length than each of the plurality of first wire patterns **121**F.

A material constituting the second wire pattern **122**F may have greater flexibility than a material constituting the plurality of first wire patterns **121**F. As described above, as the wire **120**F formed on the bending area at the flexible substrate **110**F increases in length, a greater tensile force is applied to the wire **120**F. As a result, a greater tensile force is applied to the second wire pattern **122**F having a greater length, compared with the plurality of first wire patterns **121**F. Accordingly, in a flexible display substrate **100**F according to still another exemplary embodiment of the present invention, a material constituting the second wire pattern **122**F having a greater length may have greater flexibility than a material constituting the plurality of first patterns.

FIG. **1**G is a top view showing an unbent state of the flexible display substrate according to still another exemplary embodiment of the present invention. Referring to FIG. **1**G, a flexible display substrate **100**G includes a flexible substrate **110**G, a wire **120**G, and a display unit **130**G. The flexible substrate **110**G and the display unit **130**G are substantially identical to the flexible substrate **110**A and the display unit **130**A shown in FIGS. **1**A to **1**D, and thus repeated description of the flexible substrate **110**G and the display unit **130**G is omitted for brevity.

The wire **120**G is formed on the flexible substrate **110**G. A part of the wire **120**G positioned on at least a part of the non-display area NA of the flexible substrate **110**G is formed in an oblique direction. As described above, since it is shown that the entire non-display area NA of the flexible substrate **110**G corresponds to the bending area, a part of the wire **120**G positioned on the non-display area NA of the flexible substrate **110**G is formed in an oblique direction. In this specification, the term "oblique direction" refers to a direction which is neither parallel with a bending direction nor perpendicular to the bending direction. Since the bending direction refers to a horizontal direction of the flexible substrate **110**G as shown in FIG. **1**G, the oblique direction means a direction which is neither parallel with the horizontal direction of the flexible substrate **110**G nor perpendicular to the horizontal direction of the flexible substrate **110**G. For the sake of convenience of description, FIG. **1**G shows that all the wires **120**G formed on the non-display area NA of the flexible substrate **110**G are formed in an oblique direction, but the present invention is not limited thereto. For example, some of the wires **120**G formed on the non-display area NA of the flexible substrate **110**G may be formed in an oblique direction.

When the flexible substrate is bent in a bending direction, the tensile stress is applied to the wires formed on the flexible substrate. In particular, among the wires formed on the flexible substrate, the greatest tensile force is applied to the wires extending in the same direction as the bending direction, thereby causing breaking of the wires. Therefore, in the flexible display substrate **100**G according to another exemplary embodiment of the present invention, the wires **120**G are not formed on the bending area of the flexible substrate **110**G to extend in a bending direction, but at least parts of the wires **120**G may be formed to extend in an oblique direction which is different from the bending direction, thereby reducing the tensile stress applied to the wires **120**G and minimizing breaking of the wires **120**G as well. The wire **120**G is substantially identical to the wire **120**A shown in FIGS. **1**A to **1**D, except that the wire **120**G is formed in an oblique direction, and thus repeated description of the wire **120**G is omitted for brevity.

The wires **120**G formed on the non-display area NA of the flexible substrate **110**G may be formed in various shapes. For example, the plurality of wires **120**G positioned on the non-display area NA of the flexible substrate **110**G may be formed in a trapezoidal wave shape, and also formed in various shapes such as a chopping wave shape, a sawtooth wave shape, a sine wave shape, an omega (Ω) shape, and a lozenge shape. Also, the shape of the wires **120**G may be determined based on the bending direction of the non-display area NA of the flexible substrate **110**G, the width of the non-display area NA, the radius of curvature of the non-display area NA, the widths of the wires **120**G, and the total length of the wires **120**G.

FIG. **1**H is an enlarged diagram of the flexible display substrate according to still another exemplary embodiment of the present invention. FIG. **1**H is a planar enlarged diagram showing a wire **120**H formed on a non-display area NA of a flexible substrate **110**H according to still another exemplary embodiment of the present invention.

The wire **120**H is formed on the flexible substrate **110**H. The wire **120**H includes a plurality of first wire patterns **121**H formed on at least a part of the non-display area NA of the flexible substrate **110**H, and a second wire pattern **122**H formed on at least a part of the non-display area NA of the flexible substrate **110**H and electrically connected with the plurality of first wire patterns **121**H. As shown in FIG. **1**H, when the second wire pattern **122**H is in the form of a plurality of wire patterns, the second wire pattern **122**H may be in the form of an island.

The plurality of first wire patterns **121**H and the second wire pattern **122**H may extend in different directions. For example, the plurality of first wire patterns **121**H may be formed in a bending direction of the flexible substrate **110**H, and the second wire pattern **122**H may be formed in a direction different from the bending direction of the flexible substrate **110**H, as shown in FIG. **1**H. More particularly, since the bending direction is a horizontal direction of the flexible substrate **110**H, the plurality of first wire patterns **121**H may extend in a horizontal direction of the flexible substrate **110**H, and the second wire pattern **122**H may extend in an oblique direction rather than the horizontal direction of the flexible substrate **110**H, as described above. For the sake of convenience of description, FIG. **1**H shows that the second wire pattern **122**H is formed in a chopping wave shape, but the present invention is not limited thereto. In some embodiments, the first wire patterns **121**H may extend in the oblique direction. Also, the wire patterns may be formed in various shapes such as a sawtooth wave shape and a sine wave shape.

In some exemplary embodiments, one wire pattern may include a plurality of portions extending in two different directions. For example, the second wire pattern **122**H may be divided into two parts, each of which extends from one end of one first wire pattern **121**H, in different directions, and the two divided parts of the second wire pattern **122**H may be coupled to one end of one first wire pattern **121**H which is electrically connected with another first wire pattern **121**H by means of the second wire pattern **122**H. In this case, the second wire pattern **122**H may be, for example, formed in various shapes such as a lozenge shape and a circular shape.

In some exemplary embodiments, the second wire pattern **122**H may also be formed in a bending direction, and the plurality of first wire patterns **121**H may be formed in a direction different from the bending direction. In some exemplary embodiments, both the plurality of first wire patterns **121**H and the second wire pattern **122**H may be formed in a direction different from the bending direction. The wire **120**H is substantially identical to the wire **120**A shown in FIGS. **1**A to **1**D except for extension directions of the plurality of first wire patterns **121**H and the second wire pattern **122**H, and thus repeated description of the wire **120**H is omitted for brevity.

FIG. **1**I is a cross-sectional view of a flexible display substrate according to yet another exemplary embodiment of the present invention. Referring to FIG. **1**I, a flexible display substrate **100**I includes a flexible substrate **110**I, a wire **120**I, a separation layer **160**I, and a display unit **130**I. The flexible substrate **110**I and the display unit **130**I are substantially identical to the flexible substrate **110**A and the display unit **130**A shown in FIGS. **1**A to **1**D, and thus repeated description of the flexible substrate **110**I and the display unit **130**I is omitted for brevity.

The wire **120**I is formed on the flexible substrate **110**I. The wire **120**I includes a plurality of first wire patterns **121**I formed on at least a part of a non-display area NA of the flexible substrate **110**I, a second wire pattern **122**I formed on at least a part of the non-display area NA of the flexible substrate **110**I and electrically connected with the plurality of first wire patterns **121**I, and a third wire pattern **123**I formed on a display area DA of the flexible substrate **110**I and coming in contact with the plurality of first wire patterns **121**I or the second wire pattern **122**I. The plurality of first wire patterns **121**I and the third wire pattern **123**I are substantially identical to the plurality of first wire patterns **121**A and the third wire pattern **123**A shown in FIGS. **1**A to **1**D, and thus repeated description of the plurality of first wire patterns **121**I and the third wire pattern **123**I is omitted for brevity.

The separation layer **160**I is formed on the plurality of first wire patterns **121**I and/or the third wire pattern **123**I. The separation layer **160**I may be formed of an insulation material, and also be formed of the same material as one of the insulation materials used to form the display unit **130**I. The separation layer **160**I may include a contact hole configured to open a part of each of the plurality of first wire patterns **121**I and/or the third wire pattern **123**I, and the second wire pattern **122**I may be formed on the separation layer **160**I to come in contact with the plurality of first wire patterns **121**I through the contact hole formed in the separation layer **160**I. The second wire pattern **122**I is substantially identical to the second wire pattern **122**A shown in FIGS. **1**A to **1**D, except that the second wire pattern **122**I comes in contact with the plurality of first wire patterns **121**I through the contact hole formed in the separation layer **160**I, and thus repeated description of the second wire pattern **122**I is omitted for brevity.

FIG. **2**A is a cross-sectional view showing an unbent state of the flexible organic light emitting display device according to one exemplary embodiment of the present invention. Referring to FIG. **2**A, a flexible organic light emitting display device **200**A includes a flexible substrate **210**A, a wire **220**A, and a display unit **230**A.

The flexible substrate **210**A is a substrate configured to support various elements of the flexible organic light emitting display device **200**A. Here, the flexible substrate **210**A is endowed with flexibility. The flexible substrate **210**A may be referred to as a flexible substrate, a first flexible substrate, or a flexible member. When the flexible substrate **210**A is formed of a plastic, the flexible substrate **210**A may also be referred to as a plastic film or a plastic substrate.

Since a non-display area NA of the flexible substrate **210**A is positioned on a peripheral or edge portion of a display area DA of the flexible substrate **210**A and various circuits are disposed to display an image, the non-display area NA of the flexible substrate **210**A may also be referred to as a peripheral area, a peripheral circuit area, an edge area, or a bezel area.

The non-display area NA of the flexible substrate **210**A includes a bending area. For the sake of convenience of description, FIG. **2**A shows that the entire non-display area NA of the flexible substrate **210**A corresponds to the bending area. However, only a part of the non-display area NA of the flexible substrate **210**A may correspond to the bending area. For the sake of convenience of description, FIG. **2**A shows that the flexible substrate **210**A is in an unbent state. However, the bending area, that is, a non-display area NA of the flexible substrate **210**A may be curved in a bending direction, as shown in FIG. **1**D.

The wire **220**A is formed on the flexible substrate **210**A. The wire **220**A may electrically connect a display unit **230**A, which may be formed on the display area DA of the flexible substrate **210**A, with a drive circuit unit, a gate driver IC, or a data driver IC, which may be formed on the non-display area NA of the flexible substrate **210**A, to send a signal. The wire **220**A may be formed of a conductive material. In particular, the wire **220**A may be formed of a conductive material having excellent flexibility so as to minimize generation of cracks upon bending the flexible substrate **210**A. It is preferred that the wire **220**A is formed of conductive materials, such as gold (Au), silver (Ag) and aluminum (Al), having excellent flexibility so as to minimize generation of cracks upon bending the flexible substrate **210**A. However, the constituent material of the wire **220**A is not particularly limited, and may be formed with one of various conductive materials used in other components/parts of the display unit **230**A. For instance, the wire **220**A (i.e., the plurality of first wire patterns **221**A and at least one second wire pattern **222**A) may be formed of one of various materials used to manufacture the display unit **130**A, such as molybdenum (Mo), chromium (Cr), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy of silver (Ag) with magnesium (Mg). Also, the wire **220**A (i.e., the first wire patterns **221**A and the second wire pattern **222**A) may be formed in a multi-layer structure including the various conductive materials as described above. For example, the wire **220**A may be formed in a three-layer structure of titanium (Ti), aluminum (Al), and titanium (Ti), but the present invention is not limited thereto. It is sufficient that the first and second wire patterns are formed of conductive material.

The wire **220**A includes a plurality of first wire patterns **221**A formed on at least a part of the non-display area NA of the flexible substrate **210**A, a second wire pattern **222**A formed on at least a part of the non-display area NA of the flexible substrate **210**A and electrically connected with the plurality of first wire patterns **221**A, and a third wire pattern **223**A formed on the display area DA of the flexible substrate **210**A and coming in contact with the plurality of first wire patterns **221**A or the second wire pattern **222**A. For the sake of convenience of description, FIG. **2**A shows that the entire non-display area NA of the flexible substrate **210**A corresponds to the bending area. Accordingly, the plurality of first wire patterns **221**A and the second wire pattern **222**A which are formed on the entire non-display area NA of the flexible substrate **210**A will be described hereinafter.

The third wire pattern **223**A refers to a pattern formed on the display area DA of the flexible substrate **210**A in the wire **220**A. Here, one end of the third wire pattern **223**A is electrically connected with the display unit **230**A, and the other end of the third wire pattern **223**A comes in contact with the plurality of first wire patterns **221**A or the second wire pattern **222**A. For the sake of convenience of description, FIG. **2**A shows that the other end of the third wire pattern **223**A comes in contact with the second wire pattern **222**A, but the present invention is not limited thereto. For example, the other end of the third wire pattern **223**A may also come in contact with the first wire pattern **221**A. The third wire pattern **223**A may be formed of a conductive material. In some exemplary embodiments, the third wire pattern **223**A may be formed of the same material as one of the conductive materials used to form the display unit **230**A. Hereinafter, constituent materials of the third wire pattern **223**A will be described later in further detail.

A plurality of first wire patterns **221**A are formed on the non-display area NA of the flexible substrate **210**A. The plurality of first wire patterns **221**A is discontinuously formed on the flexible substrate **210**A, and is in the form of an island. The plurality of first wire patterns **221**A may be formed of the same material at the same time. The first wire patterns **221**A may be formed of a conductive material. In some exemplary embodiments, the first wire patterns **221**A may be formed of the same material as one of the conductive materials used to form the display unit **230**A. Hereinafter, constituent materials of the first wire pattern **221**A will be described later in further detail.

The second wire pattern **222**A is formed on the first wire patterns **221**A at the non-display area NA of the flexible substrate **210**A, and electrically connected with the first wire patterns **221**A. As shown in FIG. **2**A, when the second wire pattern **222**A is in the form of a plurality of wire patterns, the second wire pattern **222**A may be in the form of an island. The second wire pattern **222**A in the form of an island may be formed on parts of surfaces of the plurality of first wire patterns **221**A so that the parts of surfaces of the plurality of first wire patterns **221**A can come in contact with a part of a surface of the second wire pattern **222**A. Therefore, each of the plurality of second wire patterns **222**A may come in contact with two first wire patterns **221**A of the plurality of first wire patterns **221**A. The plurality of second wire patterns **222**A may be formed of the same material at the same time, and may be formed of the same material at the same time as the third wire pattern **223**A coming in contact with the plurality of second wire patterns **222**A. In this case, among the plurality of second wire patterns **222**A, the second wire patterns **222**A coming in contact with the third wire pattern **223**A may be formed integrally with the third wire pattern **223**A. The second wire patterns **222**A may be formed of a conductive material. In some exemplary embodiments, the second wire patterns **222**A may be formed of the same material as one of the conductive materials used to form the display unit **230**A. Hereinafter, constituent materials of the second wire patterns **222**A will be described later in further detail.

In general, as the wires formed on the bending area at the flexible substrate increases in length, a greater tensile force is applied to the wires. Therefore, when a wire for connecting two points is formed in a plurality of wire patterns, the intensity of a tensile force applied to the wires may be reduced, compared with when the wire for connecting two points is formed in one wire pattern. Accordingly, in the flexible organic light emitting display device **200**A according to still one exemplary embodiment of the present invention, the plurality of first wire patterns **221**A and the second wire pattern **222**A configured to electrically connect the plurality of first wire patterns **221**A may be formed on the bending area at the non-display area NA of the flexible substrate **210**A so as to decrease a tensile force applied to the wire **220**A and reduce a risk of breaking the wire **220**A.

The display unit **230**A is disposed on all or part of the display area DA of the flexible substrate **210**A. The display unit **230**A is an element configured to actually display an image, and may also be referred to as an image display unit or a display panel. The display unit **230**A includes an organic light emitting diode **250**A and a thin film transistor **240**A.

A buffer layer **261**A is formed on the flexible substrate **210**A. The buffer layer **261**A may serve to prevent penetration of moisture or impurities through the flexible substrate **210**A and planarize a surface of the flexible substrate **210**A. However, the buffer layer **261**A is not an essentially required configuration, and may be selected according to the kind of the flexible substrate **210**A or the kind of the thin film transistor **240**A used in the flexible organic light emitting display device **200**A. When the buffer layer **261**A is used as shown in FIG. **2**A, the buffer layer **261**A may be formed of a silicon oxide film, a silicon nitride film, or a multilayer film thereof.

The silicon oxide film and the silicon nitride film constituting the buffer layer **261**A have poorer flexibility than a metal. Therefore, in the flexible organic light emitting display device according to another exemplary embodiment of the present invention, the buffer layer **261**A may be formed only on the display area DA of the flexible substrate **210**A so as to ensure the flexibility of the non-display area NA of the flexible substrate **210**A. However, when the buffer layer **261**A is formed only on the display area DA of the flexible substrate **210**A and is not formed on the non-display area NA of the flexible substrate **210**A, the elements positioned on an upper portion of the non-display area NA of the flexible substrate **210**A may be susceptible to moisture and oxygen penetrating from a lower portion of the non-display area NA of the flexible substrate **210**A. Therefore, as shown in FIG. **2**C, the buffer layer **261**A formed on the non-display area NA of the flexible substrate **210**A may be smaller in thickness than the buffer layer **261**A formed on the display area DA of the flexible substrate **210**A. In this case, the buffer layer **261**A may be formed on the display area DA and the non-display area NA of the flexible substrate **210**A to have the same thickness, and the buffer layer **261**A having a relatively smaller thickness may then be formed by etching a part of the buffer layer **261**A formed on the non-display area NA of the flexible substrate **210**A.

Also, the silicon oxide film constituting the buffer layer **261**A has poorer flexibility than a metal, but exhibits more excellent flexibility than the silicon nitride film. Therefore, in the flexible organic light emitting display device according to another exemplary embodiment of the present invention, among the materials constituting the buffer layer **261**A, only the silicon oxide film may be formed on the non-display area NA of the flexible substrate **210**A so as to protect the elements positioned on the non-display area NA of the flexible substrate **210**A from moisture and oxygen penetrating from a lower portion of the non-display area NA of the flexible substrate **210**A.

An active layer **241**A is formed on the flexible substrate **210**A. When the buffer layer **261**A is not formed, the active layer **241**A may be directly formed on the flexible substrate **210**A. The active layer **241**A may include a channel region configured to form a channel, a source region, and a drain region. Here, the source region and the drain region come in contact with a source electrode **243**A and a drain electrode **244**A, respectively.

The active layer **241**A may include an oxide semiconductor. As a constituent material of the oxide semiconductor included in the active layer **241**A, a quaternary metal oxide such as an indium tin gallium zinc oxide (InSnGaZnO)-based material, a ternary metal oxide such as an indium gallium zinc oxide (InGaZnO)-based material, an indium tin zinc oxide (InSnZnO)-based material, an indium aluminum zinc oxide (InAlZnO)-based material, a tin gallium zinc oxide (SnGaZnO)-based material, an aluminum gallium zinc oxide (AlGaZnO)-based material, or a tin aluminum zinc oxide (SnAlZnO)-based material, or a binary metal oxide such as an indium zinc oxide (InZnO)-based material, a tin zinc oxide (SnZnO)-based material, an aluminum zinc oxide (AlZnO)-based material, a zinc magnesium oxide (ZnMgO)-based material, a tin magnesium oxide (SnMgO)-based material, an indium magnesium oxide (InMgO)-based material, an indium gallium oxide (InGaO)-based material, an indium oxide (InO)-based material, a tin oxide (SnO)-based material, or a zinc oxide (ZnO)-based material may be used. Composition ratios of elements included in the above-described material of the oxide semiconductor are not particularly limited and may be adjusted to a wide extent. For the sake of convenience of description, the active layer **241**A including the oxide semiconductor has been described in this specification, but the present invention is not limited thereto.

A gate insulation layer **245**A is formed on the active layer **241**A. The gate insulation layer **245**A serves to insulate the active layer **241**A from a gate electrode **242**A. The gate insulation layer **245**A may be formed of a silicon oxide film, a silicon nitride film, or a multilayer film thereof, but the present invention is not limited thereto. For example, the gate insulation layer **245**A may be formed of various materials. The gate insulation layer **245**A may be formed on an entire front surface of the flexible substrate **210**A including the active layer **241**A. However, the gate insulation layer **245**A may be formed only on the active layer **241**A since the gate insulation layer **245**A serves only to insulate the active layer **241**A from the gate electrode **242**A. Also, the gate insulation layer **245**A may be formed on an entire front surface of the flexible substrate **210**A. As shown in FIG. **2**A, the gate insulation layer **245**A may also be formed only on the display area DA of the flexible substrate **210**A. In this case, the gate insulation layer **245**A may be formed to have a contact hole configured to open a part of the active layer **241**A, and the contact hole may serve to open parts of source and drain regions of the active layer **241**A.

The silicon oxide film constituting the gate insulation layer **245**A has poorer flexibility than a metal, but exhibits more excellent flexibility than the silicon nitride film. Therefore, in the flexible organic light emitting display device according to still another exemplary embodiment of the present invention, among the materials constituting the buffer layer **261**A, only the silicon oxide film may be formed on the non-display area NA of the flexible substrate **210**A so as to protect the elements positioned on an upper portion of the non-display area NA of the flexible substrate **210**A from moisture and oxygen penetrating from a lower portion of the non-display area NA of the flexible substrate **210**A.

The gate electrode **242**A is formed on the gate insulation layer **245**A. The gate electrode **242**A overlaps at least a part of the active layer **241**A, particularly, a channel region of the active layer **241**A. The gate electrode **242**A may be formed of at least one selected from the group consisting of molybdenum (Mo), aluminum (Al), chromium (Cr), gold (Au), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy thereof, but the present invention is not limited thereto. For example, the gate electrode **242**A may be formed of various materials. Also, the gate electrode **242**A may be composed of multiple layers formed of at least one selected from the group consisting of molybdenum (Mo), aluminum (Al), chromium (Cr), gold (Au), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy thereof.

An interlayer insulation film **246**A is formed on the gate electrode **242**A. The interlayer insulation film **246**A may be formed of the same material as the gate insulation layer **245**A, and may be formed of a silicon oxide film, silicon nitride film, or a multilayer film thereof, but the present invention is not limited thereto. For example, the interlayer insulation film **246**A may be formed of various materials. The interlayer insulation film **246**A may be formed to have a contact hole configured to open a part of the active layer **241**A, and the contact hole may serve to open parts of source and drain regions of the active layer **241**A. The interlayer insulation film **246**A may be formed only on the display area DA of the flexible substrate **210**A as shown in FIG. **2**A, but may also be formed on both the display area DA and the non-display area NA of the flexible substrate **210**A like the buffer layer **261**A and the gate insulation layer **245**A. Among the materials constituting the interlayer insulation film **246**A, only the material having excellent flexibility, such as a silicon oxide film, may be formed on the non-display area NA of the flexible substrate **210**A.

The source electrode **243**A and the drain electrode **244**A are formed on the interlayer insulation film **246**A. The source electrode **243**A and the drain electrode **244**A may be electrically connected respectively to the source and drain regions of the active layer **241**A through the contact hole formed in the interlayer insulation film **246**A and/or gate insulation layer **245**A. The source electrode **243**A and the drain electrode **244**A may be formed of at least one selected from the group consisting of molybdenum (Mo), aluminum (Al), chromium (Cr), gold (Au), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy thereof, but the present invention is not limited thereto. For example, the source electrode **243**A and the drain electrode **244**A may be formed of various materials. Also, the source electrode **243**A and the drain electrode **244**A may be composed of multiple layers formed of at least one selected from the group consisting of molybdenum (Mo), aluminum (Al), chromium (Cr), gold (Au), titanium (Ti), nickel (Ni), neodymium (Nd), copper (Cu), and an alloy thereof.

A passivation film **262**A is formed on the source electrode **243**A and the drain electrode **244**A. The passivation film **262**A may be formed to have a contact hole configured to expose the source electrode **243**A or the drain electrode **244**A. The passivation film **262**A is a protective layer that may be formed of the same material as the interlayer insulation film **246**A and/or the gate insulation layer **245**A, and may be composed of a single layer or multiple layers formed of at least one selected from the group consisting of a silicon oxide film and a silicon nitride film, but the present invention is not limited thereto. For example, the passivation film **262**A may be formed of various materials. FIG. **2**A shows that the flexible organic light emitting display device **200**A includes the passivation film **262**A, but it is possible to exclude the passivation film **262**A since the passivation film **262**A is not an essentially required configuration. The passivation film **262**A may be formed on both the display area DA and the non-display area NA of the flexible substrate **210**A as shown in FIG. **2**A, and also be formed on the wires **220**A to protect the wires **220**A from the outside.

An overcoat layer **264**A may be formed on the source electrode **243**A and the drain electrode **244**A. The overcoat layer **264**A may also be referred to as a planarization film. When the passivation film **262**A is formed, the overcoat layer **264**A may be formed on the passivation film **262**A. The overcoat layer **264**A serves to planarize an upper surface of the flexible substrate **210**A. Also, the overcoat layer **264**A may be formed to have a contact hole configured to expose the source electrode **243**A or the drain electrode **244**A. The overcoat layer **264**A may be formed of at least one material selected from the group consisting of an acrylic resin, an epoxy resin, a phenolic resin, a polyamide-based resin, a polyimide-based resin, an unsaturated polyester-based resin, a polyphenylene-based resin, a polyphenylene-sulfide-based resin, and benzocyclobutene, but the present invention is not limited thereto. For example, the overcoat layer **264**A may be formed of various materials.

The thin film transistor **240**A includes the active layer **241**A, the gate insulation layer **245**A, the gate electrode **242**A, the interlayer insulation film **246**A, the source electrode **243**A, and the drain electrode **244**A, all of which are formed as described above. The thin film transistor **240**A may be formed on every pixel or sub-pixel region of the display area DA of the flexible substrate **210**A, and each pixel or sub-pixel region may be independently driven. A configuration of the thin film transistor **240**A is not limited to the exemplary embodiments as described above, and may be widely modified and changed into the known configurations which may be readily practiced by those skilled in the related art.

The thin film transistor **240**A may be formed on the flexible substrate **210**A to allow an organic light emitting layer **254**A of the organic light emitting diode **250**A to emit light. In general, a switching thin film transistor and a driving thin film transistor are used to allow the organic light emitting layer **254**A to emit light using image information of an input data signal according to a scan signal.

The switching thin film transistor serves to send a data signal from a data wire to a gate electrode of the driving thin film transistor when a scan signal is applied from a gate wire. The driving thin film transistor serves to send an electric current, which is transmitted through a power wire by the data signal received from the switching thin film transistor, to an anode, and control light emission of the organic light emitting layer of the corresponding pixels or sub-pixels by the electric current transmitted to the anode.

The flexible organic light emitting display device **200**A may further include a thin film transistor for compensation circuits, which is designed to prevent abnormal driving of the flexible organic light emitting display device **200**A.

In this specification, among various thin film transistors that may be included in the flexible organic light emitting display device **200**A, only the driving thin film transistor **240**A is shown for the sake of convenience of description.

Structures of the thin film transistor may be classified into an inverted-staggered structure and a coplanar structure according to positions of the elements constituting the thin film transistor. The thin film transistor having an inverted-staggered structure refers to a thin film transistor having a structure in which a gate electrode is positioned opposite to a source electrode and a drain electrode based on an active layer, and the thin film transistor having a coplanar structure refers to a thin film transistor having a structure in which a gate electrode is positioned on the same plane as a source electrode and a drain electrode based on an active layer. In this specification, the thin film transistor **240**A having a coplanar structure is shown for the sake of convenience of description, but the present invention is not limited thereto. For example, the thin film transistor having an inverted-staggered structure may also be used herein.

The organic light emitting diode **250**A including an anode **251**A, the organic light emitting layer **254**A, and a cathode **255**A is formed on the flexible substrate **210**A. The organic light emitting diode **250**A is driven to form an image on a principle that holes provided in the anode **251**A and electrons provided in the cathode **255**A are combined at the organic light emitting layer **254**A to emit light.

The flexible organic light emitting display device **200**A is an independent drive display device which is driven per each sub-pixel region of the display area DA. Therefore, the thin film transistor **240**A and the organic light emitting diode **250**A as described above may be disposed on each sub-pixel region of the display area DA to allow the thin film transistor **240**A disposed on each sub-pixel region to independently drive the organic light emitting diode **250**A.

The anode **251**A is formed on the overcoat layer **264**A. The anode **251**A may also be referred to as a positive pole, a pixel electrode, or a first electrode. The anode **251**A may be formed separately on each sub-pixel region of the display area DA. The anode **251**A may be connected to the source electrode **243**A of the thin film transistor **240**A via the contact hole formed in the overcoat layer **264**A. In this specification, under the assumption that the thin film transistor **240**A is an N-type thin film transistor, it is described that the anode **251**A is connected to the source electrode **243**A. However, when the thin film transistor **240**A is a P-type thin film transistor, the anode **251**A may also be connected to the drain electrode **244**A. The anode **251**A may come in direct contact with the organic light emitting layer **254**A, or may be in contact and electrically connected to the organic light emitting layer **254**A with a conductive material positioned therebetween.

The anode **251**A is formed of a conductive material having a high work function since the anode **251**A should provide holes. The anode **251**A may include a transparent conductive layer **253**A having a high work function, and the transparent conductive layer **253**A may be formed of a transparent conductive oxide (TCO), for example, indium tin oxide (ITO), indium zinc oxide (IZO), indium tin zinc oxide (ITZO), zinc oxide, or tin oxide.

As shown in FIG. **2**C, when the flexible organic light emitting display device **200**A is an organic light emitting display device with a top emission mode, the anode **251**A includes a reflective layer **252**A formed under the transparent conductive layer **253**A. The organic light emitting layer **254**A emits light in all directions. However, in the case of the organic light emitting display device with a top emission mode, light emitted from the organic light emitting layer **254**A should be radiated from an upper portion of the organic light emitting display device. However, when the anode **251**A is composed only of the transparent conductive layer **253**A as described above, the light emitted from the organic light emitting layer **254**A toward the anode **251**A is reflected upward on the other elements positioned below the anode **251**A, but may be lost as the light radiates downward to the flexible substrate **210**A. In this case, optical efficiency of the organic light emitting display device may be lowered. Therefore, the anode **251**A may include a separate low-resistive reflective layer **252**A so as to radiate the light emitted from the organic light emitting layer **254**A toward the anode **251**A from an upper portion of the organic light emitting display device. The reflective layer **252**A may be formed of a conductive layer having excellent reflexibility, for example, silver (Ag), nickel (Ni), gold (Au), platinum (Pt), aluminum (Al), copper (Cu), or molybdenum/aluminum neodymium (Mo/AlNd).

In this specification, it is defined that the anode **251**A includes the transparent conductive layer **253**A and the reflective layer **252**A, but it may also be defined that the anode **251**A is composed only of the transparent conductive layer **253**A and the reflective layer **252**A has a separate configuration. In this specification, it is also described that the anode **251**A is composed of a reflective metal layer and a transparent conductive material having a high work function. However, the anode **251**A itself may be formed of a conductive material having a high work function and exhibiting excellent reflexibility. Although not shown in FIG. **2**A, when the flexible organic light emitting display device **200**A is an organic light emitting display device with a bottom emission mode, the anode **251**A may be formed of only a transparent conductive material having a high work function, or may also be formed of the transparent conductive material having a high work function together with a semi-transmissive metal layer positioned under the transparent conductive material so as to embody microcavities.

Among the transparent conductive layer **253**A and the reflective layer **252**A, both of which constitute the anode **251**A, the transparent conductive layer **253**A may be electrically connected to the source electrode **243**A. Referring to FIG. **2**A, the reflective layer **252**A is formed on the overcoat layer **264**A, and a contact hole is formed in the overcoat layer **264**A to electrically connect the transparent conductive layer **253**A with the drain electrode **244**A. For the sake of convenience of description, FIG. **2**A shows that the transparent conductive layer **253**A is electrically connected to the source electrode **243**A. However, the reflective layer **252**A may be electrically connected to the source electrode **243**A via the contact hole formed in the overcoat layer **264**A, and the transparent conductive layer **253**A may be formed on the reflective layer **252**A to be electrically connected to the source electrode **243**A through the reflective layer **252**A.

A bank layer **265**A is formed on the anode **251**A and the overcoat layer **264**A. The bank layer **265**A serves to distinguish adjacent sub-pixel regions from each other so that the bank layer **265**A can be disposed between the adjacent sub-pixel regions. Also, the bank layer **265**A may be formed to open a part of the anode **251**A. The bank layer **265**A may be formed of an organic insulation material, for example, one material selected from the group consisting of polyimide, photoacryl, and benzocyclobutene (BCB). The bank layer **265**A may be formed in a tapered shape. When the bank layer **265**A is formed in a tapered shape, the bank layer **265**A may be formed using a positive-type photoresist. The bank layer **265**A may be formed with a predetermined thickness so as to distinguish the adjacent sub-pixel regions from each other.

As a method of displaying an image, the flexible organic light emitting display device **200**A uses a method of forming an organic light emitting layer that autonomously emits red, green, and blue lights on every sub-pixel region, and a method of forming an organic light emitting layer emitting a white light on all sub-pixel regions and simultaneously applying color filters. In the case of the organic light emitting display device manufactured using the organic light emitting layer autonomously emitting the red, green, and blue lights from each of the sub-pixel regions, an organic light emitting layer emitting one of red, green, and blue lights may be formed on the anode formed on each of a red sub-pixel region, a green sub-pixel region, and a blue sub-pixel region, all of which are opened by the bank layer. Also, the organic light emitting layers formed on the red sub-pixel region, the green sub-pixel region, and the blue sub-pixel region may be separated. In the case of the organic light emitting display device manufactured using the white organic light emitting layer and the color filter, a white organic light emitting layer may be formed on the anode formed on each of the red sub-pixel region, the green sub-pixel region, and the blue sub-pixel region, all of which are opened by the bank layer. The organic light emitting layers formed on the red sub-pixel region, the green sub-pixel region, and the blue sub-pixel region may be connected to or separated from each other. For the sake of convenience of description, the flexible organic light emitting display device **200**A manufactured using the organic light emitting layer **254**A autonomously emitting the red, green, and blue lights from each of the sub-pixel regions is shown in FIG. **2**A. It is also shown that the organic light emitting layers **254**A of the respective sub-pixel regions are not connected to each other, but the present invention is not limited thereto.

The cathode **255**A is formed on the organic light emitting layer **254**A. The cathode **255**A may also be referred to as a negative pole, a common electrode, or a second electrode. The cathode **255**A may be connected to a separate voltage wire **220**A to apply the same level of voltage to all the sub-pixel regions of the display area DA.

Since the cathode **255**A should provide electrons, the cathode **255**A is formed of a material having high electric conductivity and a low work function, that is, a material for cathodes. Specific materials constituting the cathode **255**A may be differently selected according to an emission mode of the organic light emitting display device. As shown in FIG. **2**A, when the flexible organic light emitting display device **200**A is an organic light emitting display device with a top emission mode, the cathode **255**A may be formed of a metallic material having a very small thickness and a low work function. For example, when the cathode **255**A is formed of a metallic material having a low work function, a metallic material such as silver (Ag), titanium (Ti), aluminum (Al), molybdenum (Mo), or an alloy of silver (Ag) with magnesium (Mg) may be formed into a thin film having a thickness of several hundreds of Å or less, for example, 200 Å or less so as to form the cathode **255**A. In this case, the cathode **255**A becomes a substantially semi-transmissive layer and then is used as a substantially transparent cathode. Although a material constituting the cathode **255**A is a metal which is opaque and has a high reflection coefficient, the cathode **255**A has such a thickness that the cathode **255**A can become transparent at a certain point of time as the cathode **255**A gets thinner to a thickness equal to or less than a predetermined thickness (for example, 200 Å). The cathode **255**A having such a thickness may be referred to as a substantially transparent cathode. Also, carbon nanotube and graphene coming into the spotlight as new materials may also be used as the material for cathodes.

As a sealing member covering the organic light emitting diode **250**A, an encapsulation unit **270**A is formed on the organic light emitting diode **250**A including the cathode **255**A. The encapsulation unit **270**A may serve to protect internal elements, such as a thin film transistor **240**A and an organic light emitting diode **250**A, of the flexible organic light emitting display device **200**A from moisture, air, and impact provided from the outside. The encapsulation unit **270**A may be formed on a display area DA of the flexible organic light emitting display device **200**A to protect the internal elements of the flexible organic light emitting display device **200**A.

The encapsulation unit **270**A may have various configurations according to a method of sealing the internal elements, such as a thin film transistor **240**A and an organic light emitting diode **250**A, of the flexible organic light emitting display device **200**A. For example, the method of sealing the flexible organic light emitting display device **200**A includes methods such as metal can encapsulation, glass can encapsulation, thin film encapsulation (TFE), and face sealing.

A pad portion **266**A is formed on the flexible substrate **210**A. The pad portion **266**A may be formed on the display area DA of the flexible substrate **210**A. For the sake of convenience of description, FIG. **2**A shows that the pad portion **266**A is formed on the gate insulation layer **245**A in the display area DA of the flexible substrate **210**A, but the present invention is not limited thereto. For example, the pad portion **266**A may be formed on the flexible substrate **210**A or the buffer layer **261**A.

The pad portion **266**A shown in FIG. **2**A is configured to connect the gate wire **220**A with a gate driver IC configured to apply a gate signal to the gate wire **220**A, and is formed on the same plane as the gate electrode **242**A and made of the same material as the gate electrode **242**A. When the pad portion **266**A is configured to connect the data wire **220**A with the data driver IC configured to apply the data signal to the data wire **220**A, the pad portion **266**A may be formed on the same plane as the source electrode **243**A and the drain electrode **244**A and made of the same material as that of the source electrode **243**A and the drain electrode **244**A.

The wires **220**A may electrically connect the pad portion **266**A formed on the display area DA of the flexible substrate **210**A with a drive circuit unit, a gate driver IC, or a data driver IC to send a signal. A plurality of first wire patterns **221**A may be formed of the same material as one of the gate electrode **242**A, the source electrode **243**A, the drain electrode **244**A, and the reflective layer **252**A, and the second wire pattern **222**A may be formed of the same material as the other one of the source electrode **243**A, the drain electrode **244**A, the reflective layer **252**A and the cathode **255**A, which is different from the material of the first wire pattern **221**A. Here, a case in which the second wire pattern **222**A is formed of the same material as "the other one" of the source electrode **243**A, the drain electrode **244**A, the reflective layer **252**A, and the cathode **255**A encompasses that the second wire pattern **222**A is formed of the same material as an element different from another element of the display unit **230**A formed of the same material as the plurality of first wire patterns **221**A. Since the second wire pattern **222**A is formed on the plurality of first wire patterns **221**A in the non-display area NA of the flexible substrate **210**A, the plurality of first wire patterns **221**A is first formed, and the second wire pattern **222**A is then formed according to the sequence of manufacturing processes. Therefore, since the element of the display unit **230**A formed of the same material as the second wire pattern **222**A is formed on the element of the display unit **230**A formed of the same material as the plurality of first wire patterns **221**A, the element of the display unit **230**A formed of the same material as the second wire pattern **222**A is formed on the element of the display unit **230**A formed of the same material as the plurality of first wire patterns **221**A according to the sequence of manufacturing processes.

FIG. **2**A shows that the plurality of first wire patterns **221**A are formed of the same material as the gate electrode **242**A, and the second wire pattern **222**A is formed of the same material as the source electrode **243**A and the drain electrode **244**A, but the present invention is not limited thereto. For example, the second wire pattern **222**A may be formed of the same material as the reflective layer **252**A or the cathode **255**A having a configuration different from the configuration of the display unit **230**A formed of the same material as the first wire pattern **221**A.

The first wire pattern **221**A may be formed of a metal which is not etched upon etching an inorganic film. In the manufacture of the flexible organic light emitting display device **200**A, the first wire pattern **221**A formed of the same material as the gate electrode **242**A may be formed on the flexible substrate **210**A, the interlayer insulation film **246**A may be formed on a front surface of the flexible substrate **210**A, and the interlayer insulation film **246**A formed on the first wire pattern **221**A in which it is unnecessary to dispose the interlayer insulation film **246**A may be etched. In general, since the interlayer insulation film **246**A includes an inorganic film, an etchant is used to etch the inorganic film upon etching the interlayer insulation film **246**A. In this case, when the first wire pattern **221**A is etched by an etchant for etching an inorganic film, the first wire pattern **221**A may be damaged. In this regard, the first wire pattern **221**A may be formed of a metal which is not etched upon etching an inorganic film.

The third wire pattern **223**A may come in contact with the second wire pattern **222**A, and may be formed integrally with the second wire pattern **222**A. Therefore, the third wire pattern **223**A may be formed of the same material as the second wire pattern **222**A.

FIG. **2**A shows that the flexible organic light emitting display device **200**A is an organic light emitting display device with a top emission mode. However, when the flexible organic light emitting display device **200**A is an organic light emitting display device with a bottom emission mode, the plurality of first wire patterns **221**A may be formed of the same material as one of the gate electrode **242**A, the source electrode **243**A, the drain electrode **244**A, and the semi-transmissive metal layer, and the second wire pattern **222**A may be formed of the same material as the other one of the source electrode **243**A, the drain electrode **244**A, the semi-transmissive metal layer, and the cathode **255**A, which is different from the material of the plurality of first wire patterns **221**A.

In some exemplary embodiments, a separation layer may be formed between the plurality of first wire patterns **221**A and the second wire pattern **222**A. The separation layer may be formed of an insulation material, and may also be formed of the same material as one of the insulation material used to form the display unit **230**A. For example, when the plurality of first wire patterns **221**A is formed of the same material as the gate electrode **242**A, and the second wire pattern **222**A is formed of the same material as the source electrode **243**A and the drain electrode **244**A, as shown in FIG. **2**A, the separation layer may be formed of an insulation material formed between the gate electrode **242**A and the source electrode **243**A and drain electrode **244**A in the display unit **230**A, and may also be formed of the same material as one of the gate insulation layer **245**A and the interlayer insulation film **246**A. When the separation layer is formed, the separation layer may include a contact hole configured to open a part of the first wire pattern **221**A, and the second wire pattern **222**A may be formed on the separation layer to come in contact with the plurality of first wire patterns **221**A through the contact hole formed in the separation layer.

FIG. **2**B is a cross-sectional view showing an unbent state of the flexible organic light emitting display device according to another exemplary embodiment of the present invention. Referring to FIG. **2**B, a flexible organic light emitting display device **200**B includes a flexible substrate **210**B, a wire **220**B, and a display unit **230**B. The flexible substrate **210**B and the display unit **230**B are substantially identical to the flexible substrate **210**A and the display unit **230**A shown in FIG. **2**A, and thus repeated description of the flexible substrate **210**B and the display unit **230**B is omitted for brevity.

A plurality of first wire patterns **221**B may be formed of the same material as one of a gate electrode **242**B, a source electrode **243**B, a drain electrode **244**B, and a reflective layer **252**B, and a second wire pattern **222**B may be formed of the same material as the other one of the source electrode **243**B, the drain electrode **244**B, the reflective layer **252**B, and the cathode **255**B, which is different from the material of the plurality of first wire patterns **221**B. FIG. **2**B shows that the plurality of first wire patterns **221**B are formed of the same material as the source electrode **243**B and the drain electrode **244**B, and the second wire pattern **222**B is formed of the same material as the reflective layer **252**B, but the present invention is not limited thereto. For example, the second wire pattern **222**B may be formed of the same material as the cathode **255**B. In some exemplary embodiments, the plurality of first wire patterns **221**B may also be formed of the same material as the reflective layer **252**B, and the second wire pattern **222**B may be formed of the same material as the cathode **255**B. The third wire pattern **223**B may come in contact with the second wire pattern **222**B, and may be formed integrally with the second wire pattern **222**B. Therefore, the third wire pattern **223**B may be formed of the same material as the second wire pattern **222**B. The wire **220**B is substantially identical to the wire **220**A shown in

FIG. **2**A except for the constituent materials of the wire **220**B, and thus repeated description of the wire **220**B is omitted for brevity.

FIG. **2**C is a cross-sectional view showing an unbent state of the flexible organic light emitting display device according to still another exemplary embodiment of the present invention. Referring to FIG. **2**C, a flexible organic light emitting display device **200**C includes a flexible substrate **210**C, a wire **220**C, a display unit **230**C, and an organic film **269**C. The flexible substrate **210**C, the wire **220**C, and the display unit **230**C are substantially identical to the flexible substrate **210**A, the wire **220**A, and the display unit **230**A shown in FIG. **2**A, and thus repeated description of the flexible substrate **210**C, the wire **220**C, and the display unit **230**C is omitted for brevity.

The organic film **269**C may be formed on the wire **220**C. When the flexible substrate **210**C is bent, a tensile force is applied to the wire **220**C formed on the flexible substrate **210**C. Accordingly, in the flexible organic light emitting display device **200**C according to still another exemplary embodiment of the present invention, the organic film **269**C is formed on the wire **220**C of the flexible substrate **210**C. When the flexible substrate **210**C on which the organic film **269**C is further formed is bent, a tensile force from the flexible substrate **210**C, and a compressive force from the organic film **269**C are simultaneously applied to the wire **220**C formed on the flexible substrate **210**C so that the tensile force and the compressive force can be offset, and the stress applied to the wire **220**C may be minimized to be protected from impact according to bending of the flexible organic light emitting display device **200**C. Here, to offset the tensile force and the compressive force applied to the wire **220**C, the organic film **269**C may have the same thickness as the flexible substrate **210**C, or the organic film **269**C may have a greater thickness than the flexible substrate **210**C.

As shown in FIG. **2**C, the organic film **269**C may be formed around the boundary between the display area DA and the non-display area NA of the flexible substrate **210**C, that is, formed only at an area in which the flexible substrate **210**C is bent, but the present invention is not limited thereto. For example, the organic film **269**C may be formed on the entire non-display area NA of the flexible substrate **210**C.

FIG. **2**D is an enlarged diagram of an area X shown in FIG. **2**A according to another exemplary embodiment of the present invention. Referring to FIG. **2**D, a crack prevention layer **280**D may be disposed on top and bottom surfaces of a wire **220**D. More particularly, the crack prevention layer **280**D may be disposed between the wire **220**D and a substrate or an insulation layer formed under the wire **220**D in the non-display area NA of the flexible substrate **210**D, or between the wire **220**D and the insulation layer formed under the wire **220**D in the non-display area NA of the flexible substrate **210**D. For the sake of convenience of description, FIG. **2**D shows that a buffer layer **261**D is formed as an insulation layer between the wire **220**D and the flexible substrate **210**D, and a passivation film **262**D is formed on a top surface of the wire **220**D, but the present invention is not limited thereto. For example, various insulation layers may be formed on the wire **220**D. FIG. **2**D shows that the prevention layers **280**D are disposed on both the top and bottom surfaces of the wire **220**D, but the present invention is not limited thereto. For example, the crack prevention layer **280**D may also be formed on one of the top and bottom surfaces of the wire **220**D.

The crack prevention layer **280**D may include a crack preventing material **281**D such as a porous material or nanoparticles. The crack prevention layer **280**D may have an interlayer structure in which the porous material or nanoparticles are dispersed in a packing layer made of an insulation material. Here, when the crack prevention layer **280**D is formed with an interlayer structure including a porous material, the crack prevention layer **280**D may be formed with an interlayer structure including a silica gel. On the other hand, when the crack prevention layer **280**D is formed with an interlayer structure in which nanoparticles are dispersed, the crack prevention layer **280**D may be formed with an interlayer structure including various nanoparticles such as silver (Ag). FIG. **2**D shows that the crack prevention layer **280**D is formed with an interlayer structure in which the porous material or nanoparticles are dispersed in the packing layer made of the insulation material. However, the crack prevention layer **280**D may include only the nanoparticles, and may be formed with a structure in which the nanoparticles are dispersed between the wire **220**D and the insulation layer.

When a non-display area of the flexible organic light emitting display device is bent, more cracks are caused at the other elements formed on upper and lower portion of the wire formed of the insulation material, compared with the wire formed of a metal. As a result, the wires may be cracked. Accordingly, in a flexible organic light emitting display device **200**D according to still another exemplary embodiment of the present invention, the crack prevention layer **280**D including the porous material or nanoparticles may be disposed on the top surface and/or the bottom surface of the wire **220**D to allow the crack prevention layer **280**D to absorb stress transferred from an upper or lower portion of the crack prevention layer **280**D. Also, when the elements positioned on or under the crack prevention layer **280**D are cracked, a crack direction is changed to different directions other than a direction perpendicular to the wire **220**D to prevent the wire **220**D from being cracked by cracks caused at the other elements.

FIG. **3** is a flowchart illustrating a method of manufacturing a flexible organic light emitting display device according to one exemplary embodiment of the present invention.

First, a flexible substrate including a display area and a non-display area is prepared (S**30**). Preparation of the flexible substrate is substantially identical to preparation of the flexible substrate shown in FIGS. **1**A to **2**D, and thus repeated description of the preparation of the flexible substrate is omitted for brevity.

Next, a display unit including an organic light emitting diode and a thin film transistor is formed on a display area of the flexible substrate (S**31**). Formation of the display unit is substantially identical to formation of the display unit shown in FIGS. **1**A to **2**D, and thus repeated description of the formation of the display unit is omitted for brevity.

In some exemplary embodiments, the forming of the display unit may include forming a wire electrically connected with the display unit on the display area and a non-display area of the flexible substrate. Since the wire is formed of the same material as one of the conductive materials used to form the display unit, the wire may be formed together with a process of forming a display unit. In some exemplary embodiments, the wires positioned on at least a part of the non-display area of the flexible substrate may include a plurality of discontinuously formed first wire patterns, and a second wire pattern formed on the plurality of first wire patterns and electrically connected with the plurality of first wire patterns. In some exemplary embodiments, the wire formed on at least a part of the non-display area of the flexible substrate may include a portion formed in at least one shape selected from the group consisting of a chopping wave shape, a sawtooth wave shape, a square wave shape, a sine wave shape, an omega (Ω) shape, a trapezoidal wave shape, and a lozenge shape, and may also include a wire portion formed in an oblique direction. Formation of the wire is substantially identical to formation of the wire shown in FIGS. **1**A to **2**D, and thus repeated description of the formation of the wire is omitted for brevity.

Subsequently, at least a part of the non-display area of the flexible substrate is crooked in a bending direction (S**32**).

The foregoing description of the specific embodiments will so fully reveal the general nature of the invention that others can, by applying knowledge within the skill of the art, readily modify and/or adapt for various applications such specific embodiments, without undue experimentation, without departing from the general concept of the present invention. Therefore, such adaptations and modifications are intended to be within the meaning and range of equivalents of the disclosed embodiments, based on the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and not of limitation, such that the terminology or phraseology of the present specification is to be interpreted by the skilled artisan in light of the teachings and guidance.

The breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. A flexible display substrate comprising:

a flexible substrate having;

a display area, and

a non-display area adjacent to the display area and including a curved portion that is bent: and

a wire extending from the display area over the curved portion, the wire having a plurality of first wire patterns and at least one second wire pattern in the non-display area: and

wherein each of the plurality of first wire patterns is spaced apart from an adjacent first wire pattern, wherein the second wire pattern electrically connects at least two of the plurality of first wire patterns.

2. The flexible display substrate of claim **1**, wherein the second wire pattern partially overlaps with the at least two of the plurality of first wire patterns.

3. The flexible display substrate of claim **2**, wherein each of the at least two of the plurality of first wire patterns overlaps with the second wire pattern and is in physical contact with the second wire pattern.

4. The flexible display substrate of claim **3**, further comprising additional second wire patterns, wherein each of the additional second wire patterns electrically connects the first wire patterns.

5. The flexible display substrate of claim **4**, wherein the second wire pattern and the additional second wire patterns have different lengths.

6. The flexible display substrate of claim **1**, wherein the second wire pattern covers at least one of the plurality of first wire patterns entirely.

7. The flexible display substrate of claim **1**, wherein the second wire pattern is in physical contact with all of the plurality of first wire patterns.

8. The flexible display substrate of claim **1**, wherein the second wire pattern has greater flexibility than the plurality of first wire patterns.

9. The flexible display substrate of claim **2**, wherein two adjacent first wire patterns are spaced apart by a predetermined distance, and the second wire pattern has a length longer the predetermined distance.

10. The flexible display substrate of claim **2**, further comprising an insulation layer formed between and formed on each of the plurality of first wire patterns, wherein the second wire pattern is disposed on the insulation layer.

11. The flexible display substrate of claim **2**, wherein at least a portion of the wire in the curved portion extends in a direction that is not parallel to a bending direction of the curved portion.

12. The flexible display substrate of claim **2**, wherein the second wire pattern comprises a plurality of portions, at least one of the plurality of portions extending in a direction that is not parallel to a bending direction of the curved portion.

13. The flexible display substrate of claim **1**, further comprising a third wire pattern on the display area of the flexible substrate, wherein the third wire pattern is electrically connected to the plurality of first wire patterns.

14. The flexible display substrate of claim **1**, further comprising a thin film transistor (TFT) on the display area of the flexible substrate to operate a light emitting element based on a signal transmitted via the wire.

15. A flexible display device, comprising:

a flexible substrate including:

a display area that is substantially flat along a plane, and

a non-display area including a bending area adjacent to the display area and bending away from the plane;

a wire extending from the display area over the bending area of the flexible substrate; and

a crack prevention layer disposed on at least one of top and bottom surfaces of the wire and including at least one of a porous material and nanoparticles,

wherein the wire includes a first layer of wire segments and a second layer of wire segments electrically connecting the first layer of wire segments, at least part of the second layer formed on the first layer, and wherein at least one of the first layer of wire segments and the second layer of wire segments are in the form of an island in the bending area so as to reduce or prevent cracks on the wire upon the bending the flexible substrate at the bending area.

16. The flexible display device of claim **15**, further comprising:

a passivation layer formed above the wire at an opposite side of the flexible substrate; and

wherein the crack prevention layer is disposed between the passivation layer and the wire.

17. The flexible display device of claim **15**, further comprises a display unit having an anode, a cathode, an organic light emitting diode between the anode and the cathode, and a plurality of thin-film-transistors (TFT), each TFT having a source electrode, a drain electrode and a gate electrode, wherein the first layer or the second layer is formed of the same material as at least one of the anode, the cathode, the source electrode, the drain electrode and the gate electrode.

18. The flexible display device of claim **17**, wherein the wire is connected to at least one of the anode, the cathode, the source electrode, the drain electrode and the gate electrode.

19. The flexible display device of claim **15**, further comprising a separation layer interposed between the first layer of wire segments and the second layer of wire segments, the separation layer having a plurality of contact holes, wherein the first layer is in physically contact with the second layer through the plurality of contact holes.

20. The flexible display device of claim **19**, further comprises:

a buffer layer interposed between the wire and the flexible substrate; and

a crack prevention layer interposed between the buffer layer and the wire.

21. The flexible display device of claim **19**, further comprises:

a passivation film disposed on the wire; and

a crack prevention layer interposed between the passivation film and the wire.

22. The flexible display device of claim **15**, further comprising a third layer of wire segment on the display area, wherein the third layer of wire segment is electrically connected the first layer of wire segments.

23. The flexible display device of claim **17**, wherein the plurality of thin film transistor (TFT) on the display area to operate the organic light emitting diode based on a signal transmitted via the wire.

24. A method fabrication a flexible display device, comprising:

forming a plurality of first wire segments that extend from a display area of a flexible substrate over at least a bending area of a non-display area of the flexible substrate;

forming a second wire segment bridging the first wire segments in the bending area of the non-display area of the flexible substrate;

forming a display unit on the display area of a flat area adjacent to the bending area, the display unit having an anode, a cathode, an organic light emitting diode between the anode and the cathode, and a plurality of thin-film-transistors (TFT), each TFT having a source electrode, a drain electrode and a gate electrode, wherein the first wire segments or the second wire segment are formed of the same material as any one of the anode, the cathode, the source electrode, the drain electrod and the gate electrode; and

bending the flexible substrate at the bending area away from a plane along which the flat area of the flexible substrate extends,

wherein the first wire segments and the second wire segment are in the form of an island so as to reduce or prevent cracks on the wire upon the bending the flexible substrate at the bending area.

25. The method of claim **24**, wherein forming the plurality of first wire segments comprises etching a layer of metal on the flexible substrate.

26. The method of fabricating the flexible display device of claim **24**, further comprising forming a third wire segment on the display area electrically connected to the plurality of first wire segments.

27. The method of fabricating the flexible display device of claim **24**, wherein the plurality of thin-film-transistors (TFT) are to operate the organic light emitting diode based on a signal transmitted via the plurality of first wire segments and the second wire segment.

* * * * *

专利名称(译)	柔性显示基板，柔性有机发光显示装置及其制造方法		
公开(公告)号	US9659966	公开(公告)日	2017-05-23
申请号	US14/106173	申请日	2013-12-13
[标]申请(专利权)人(译)	乐金显示有限公司		
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IPC分类号	H01L51/05 H01L27/32 B82Y30/00 H01L51/56 H01L27/12 H01L51/50 H01L51/00 B82Y10/00 H01L51/52		
CPC分类号	H01L27/1218 H01L27/124 H01L27/3276 H01L51/0097 H01L51/5246 H01L51/5253 H01L2251/5338 Y02E10/549		
优先权	1020130012032 2013-02-01 KR		
其他公开文献	US20140217397A1		
外部链接	Espacenet USPTO		

摘要(译)

提供一种柔性显示基板，柔性有机发光显示装置及其制造方法。柔性显示基板包括柔性基板和导线，柔性基板包括显示区域和从显示区域延伸的非显示区域，导线形成在柔性基板上。柔性基板的非显示区域的至少一部分在弯曲方向上形成为弯曲形状，并且位于柔性基板的非显示区域的至少一部分上的导线包括多个第一导线图案和第二导线图案形成在多个第一导线图案上并与多个第一导线图案电连接。