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(71) Applicant: LG Display Co., Ltd. — 128 Yeoui-daero, Yeongdeungpo-gu, Seoul (Yeouido-dong)

(72) Inventors:

Lee Heon-pil — 245 LG-ro, Wollong-myeon, Paju-si, Gyeonggi-do

Lee Dae-jin — 245 LG-ro, Wollong-myeon, Paju-si, Gyeonggi-do

Kim Dae-hyun — 245 LG-ro, Wollong-myeon, Paju-si, Gyeonggi-do

Kang Ji-yeon — 245 LG-ro, Wollong-myeon, Paju-si, Gyeonggi-do

(74) Agent: Chunmun Patent & Law Firm

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(54) Title of the Invention: FLEXIBLE DISPLAY DEVICE

Representative Drawing: FIG. 8

(57) ABSTRACT

A flexible display device according to an embodiment of the present specification is manufactured by: preparing a flexible substrate including a display area, a non-display area, and a bending area; applying, to the bending area, a protective coating layer having a specific modulus; primarily curing the protective coating layer; bending the flexible substrate including the primarily cured protective coating layer; and secondarily curing the protective coating layer. The device can prevent disconnection of wiring of the flexible substrate and damage to the flexible substrate.

SPECIFICATION

CLAIMS

Claim 1

A method of manufacturing a flexible display device, comprising: preparing a flexible substrate including a display area, a non-display area, and a bending area; applying a protective coating

layer having a specific modulus to the bending area; primarily curing the protective coating layer; bending the flexible substrate including the primarily cured protective coating layer; and secondarily curing the protective coating layer.

Claim 2

The method of manufacturing a flexible display device according to Claim 1, wherein the protective coating layer is made of a resin having a modulus of at least 0.25 GPa or more.

Claim 3

The method of manufacturing a flexible display device according to Claim 1, wherein the illuminance in the primary curing step is 300 mW/cm² or more.

Claim 4

The method of manufacturing a flexible display device according to Claim 1, wherein the light irradiation time in the primary curing step is 2 seconds or more.

Claim 5

The method of manufacturing a flexible display device according to Claim 1, wherein the curing rate of the protective coating layer in the primary curing step is in a range of 70% to 80%.

Claim 6

The method of manufacturing a flexible display device according to Claim 1, wherein the illuminance in the secondary curing step is 300 mW/cm² or more.

Claim 7

The method of manufacturing a flexible display device according to Claim 1, wherein the light irradiation time in the secondary curing step is 1 second or more.

Claim 8

The method of manufacturing a flexible display device according to Claim 1, wherein the curing rate of the protective coating layer in the secondary curing step is 95% or more.

Claim 9

The method of manufacturing a flexible display device according to Claim 1, wherein the curing is carried out with UV light.

Claim 10

A flexible display device comprising: a flexible substrate including a display area, a non-display area, and a bending area; and a protective coating layer formed in the bending area, wherein the protective coating layer is formed through two curing processes and has a higher modulus than a conventional protective coating layer formed through a single curing process.

Claim 11

The flexible display device according to Claim 10, wherein the modulus of the protective coating layer is 0.25 GPa or more, and the modulus of the conventional protective coating layer is 0.156 GPa or less.

Claim 12

The flexible display device according to Claim 10, wherein the protective coating layer has a curing rate in a range of 70% to 80% through a single curing process.

Claim 13

The flexible display device according to Claim 10, wherein the protective coating layer has a curing rate of 95% or more through two curing processes.

Claim 14

The flexible display device according to Claim 10, wherein the thickness of the protective coating layer is in a range of 100 μm to 150 μm .

Claim 15

The flexible display device according to Claim 10, wherein the display area further includes a polarizing layer, and the protective coating layer is formed to overlap one side of the polarizing layer.

Claim 16

A flexible display device comprising: a flexible substrate including a display area, a non-display area, and a bending area; a polarizing layer formed in the display area; and a protective coating layer formed in the bending area, wherein the protective coating layer is made of a resin having a specific modulus capable of implementing a required bending shape while relatively firmly protecting the bending area.

Claim 17

The flexible display device according to Claim 16, wherein the specific-modulus resin has a modulus of at least 0.25 GPa or more.

Claim 18

The flexible display device according to Claim 16, wherein the protective coating layer is formed to overlap one side of the polarizing layer.

Claim 19

The flexible display device according to Claim 16, wherein the thickness of the protective coating layer is in a range of 100 μm to 150 μm .

DESCRIPTION OF THE INVENTION**TECHNICAL FIELD**

[0001] The present specification relates to a flexible display device.

BACKGROUND ART

[0002] Image display devices that implement various types of information on a screen are a core technology of the information and communication era, and are developing in a direction that is thinner, lighter, portable, and yet high in performance. Accordingly, organic light-emitting

display devices, which display images by controlling the amount of light emitted by organic light-emitting elements, are receiving attention. An organic light-emitting element is a self-luminous element that uses a thin light-emitting layer between electrodes, and has the advantage of being able to be made thin.

[0003] A typical organic light-emitting display device has a structure in which a pixel driving circuit and an organic light-emitting element are formed on a substrate, and light emitted from the organic light-emitting element passes through the substrate or a barrier layer to display an image.

[0004] Since an organic light-emitting display device does not have a separate light source device, it is easy to implement it as a flexible display device. In this case, a flexible material such as plastic or metal foil is used as the substrate of the organic light-emitting display device.

[0005] Meanwhile, when an organic light-emitting display device is implemented as a flexible display device, research is being conducted to bend or curve various parts of the display device by utilizing its flexible nature.

[0006] Such research is mainly being conducted for new designs and user interface / user experience (UI/UX), and efforts to reduce the thickness of the flexible display device are also continuously ongoing. In addition, efforts to prevent wiring from cracking in the area where the flexible substrate of the flexible device is bent are also continuously being made.

CONTENT OF THE INVENTION

TECHNICAL PROBLEM

[0007] The present specification addresses, as one problem to be solved, the problem of the wiring of a flexible substrate being disconnected (short-circuited) in a flexible display device.

[0008] Further, the present specification addresses, as another problem to be solved, the problem of breakage or damage of the flexible substrate in a flexible display device.

[0009] Further, the present specification addresses, as another problem to be solved, applying and bending the protective coating layer of the flexible substrate of a flexible display device with a high-modulus resin.

[0010] The problems of the present specification are not limited to the problems mentioned above, and other problems not mentioned will be clearly understood by those skilled in the art from the following description.

MEANS FOR SOLVING THE PROBLEM

[0011] A flexible display device according to an embodiment of the present specification is manufactured by: preparing a flexible substrate including a display area, a non-display area, and a bending area; applying a protective coating layer having a specific modulus to the bending area; primarily curing the protective coating layer; bending the flexible substrate including the primarily cured protective coating layer; and secondarily curing the protective coating layer.

[0012] A flexible display device according to an embodiment of the present specification comprises: a flexible substrate including a display area, a non-display area, and a bending area; a polarizing layer formed in the display area; a protective coating layer formed in the bending area; and the protective coating layer is made of a resin having a specific modulus capable of implementing a required bending shape while relatively firmly protecting the bending area.

[0013] Specific details of other embodiments are included in the detailed description and the drawings.

EFFECTS OF THE INVENTION

[0014] In a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), the high-modulus protective coating layer (384) protects the wiring, thereby having the effect of preventing disconnection caused by external impact.

[0015] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), there is an effect of preventing breakage or damage of the flexible substrate, for example, denting or deformation.

[0016] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), the thermal strain is low, thereby having the effect of preventing disconnection of the wiring. At high temperatures, because a low-modulus resin has large shrinkage and expansion, thermal deformation occurs and the wiring may be disconnected; however, because a high-modulus resin has small shrinkage and expansion, thermal deformation does not occur and the wiring is not disconnected.

[0017] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), there is an effect of preventing disconnection of the wiring by moving the position of the neutral plane to the area where the wiring is formed. When a high-modulus resin and a low-modulus resin are applied to the same thickness on a flexible substrate having wiring, in the case of the low-modulus resin, which has a low modulus, the neutral plane is located below the position where the wiring is formed, so the wiring of the flexible substrate is subjected to tensile stress, and thus the possibility of disconnection of the wiring becomes high. However, in the case of the high-modulus resin, which has a high modulus, the neutral plane is located above the position of the wiring, so the wiring of the flexible substrate is subjected to compressive stress, and thus the possibility of disconnection of the wiring becomes low.

[0018] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), the high modulus, as compared with the low modulus, allows the thickness of the protective coating layer to be made thin, which is advantageous for constructing a thin flexible display device.

[0019] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), because thermal deformation is small and it is strong against external impact, there is an effect of preventing peeling (delamination) of the protective coating layer.

[0020] Further, in a flexible display device according to another embodiment of the present specification, by using a high-modulus resin as the protective coating layer (384) on the flexible substrate (310), there is an effect of improving productivity by preventing damage to the flexible substrate (310), for example, lifting, denting, and tearing phenomena, as well as disconnection of the wiring.

[0021] The effects of the present specification are not limited to the effects mentioned above, and other effects not mentioned will be clearly understood by those skilled in the art from the following description.

[0022] Because the content of the specification described in the technical problem, the means for solving the problem, and the effects above does not specify the essential features of the claims, the scope of rights of the claims is not limited by the matters described in the content of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 illustrates an exemplary flexible display device that may be included in an electronic device. FIG. 2A and FIG. 2B are cross-sectional views showing the bending structure of a flexible display device according to an embodiment of the present specification. FIG. 3 is a cross-sectional view showing the stacked structure of a flexible display device according to another embodiment of the present specification. FIG. 4 is a view showing applying and curing a protective coating layer with a low-modulus resin on a flexible substrate in a flexible display device according to another embodiment of the present specification. FIG. 5 is a view showing bending a flexible substrate on which a protective coating layer has been applied with a low-modulus resin in a flexible display device according to another embodiment of the present specification. FIG. 6 is a view showing applying and pre-curing a protective coating layer with a high-modulus resin on a flexible substrate in a flexible display device according to another embodiment of the present specification. FIG. 7 is a view showing bending, after pre-curing, a flexible substrate on which a protective coating layer has been applied with a high-modulus resin in a flexible display device according to another embodiment of the present specification. FIG. 8 is a view showing main-curing, after bending, a flexible substrate on which a protective coating layer has been applied with a high-modulus resin in a flexible display device according to another embodiment of the present specification. FIG. 9 is a view showing the curing steps in a flexible display device according to another embodiment of the present specification.

DETAILED DESCRIPTION FOR CARRYING OUT THE INVENTION

[0024] The advantages and features of the present specification, and the methods of achieving them, will become clear with reference to the embodiments described in detail below together with the accompanying drawings.

[0025] However, the present specification is not limited to the embodiments disclosed below, but may be implemented in various different forms; these embodiments are provided merely so that the disclosure of the present invention is complete and to fully inform those of ordinary skill in the art to which the present invention belongs of the scope of the invention, and the present invention is defined only by the scope of the claims.

[0026] The shapes, sizes, ratios, angles, numbers, etc. disclosed in the drawings for describing the embodiments of the present specification are exemplary, so the present specification is not limited to the illustrated matters. Throughout the specification, the same reference numerals refer to the same components.

[0027] In addition, in describing the present invention, where it is determined that a detailed description of a related known technology may unnecessarily obscure the gist of the present invention, the detailed description thereof will be omitted. Where terms such as "include," "have," and "consist of" mentioned in this specification are used, other parts may be added unless

"only" is used. Where a component is expressed in the singular, it includes the plural unless there is a specific explicit statement to the contrary. In interpreting a component, it is to be interpreted as including an error range even if there is no separate explicit description. In the case of a description of a positional relationship, for example, where the positional relationship of two parts is described as "on," "above," "below," "beside," etc., one or more other parts may be located between the two parts unless "immediately" or "directly" is used.

[0028] The reference to an element or layer being "on" another element or layer includes both the case of being directly on the other element and the case of interposing another layer or another element in the middle. Where it is described that a certain component is "connected," "coupled," or "connected to" another component, it should be understood that the component may be directly connected or connected to the other component, but another component may be "interposed" between the respective components, or the respective components may be "connected," "coupled," or "connected" through another component. Although terms such as "first," "second," etc. are used to describe various components, these components are not limited by these terms. These terms are used only to distinguish one component from another. Therefore, the first component mentioned below may be a second component within the technical spirit of the present invention.

[0029] The size and thickness of each component shown in the drawings are illustrated for convenience of description, and the present invention is not necessarily limited to the size and thickness of the illustrated components. Hereinafter, various embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0030] FIG. 1 is a view showing an exemplary flexible display device that may be included in an electronic device.

[0031] A flexible display device refers to a display device to which flexibility has been imparted, and may be used with a meaning similar to a bendable display device, a rollable display device, an unbreakable display device, a foldable display device, and the like.

[0032] The flexible display device (100) includes at least one display area (Active Area, A/A), and an array of pixels is formed in the display area.

[0033] One or more non-display areas (Inactive Area, I/A) may be arranged around the display area. For example, the non-display area may be adjacent to one or more sides of the display area. The non-display area surrounds the rectangular-shaped display area. However, the shape of the display area and the shape/arrangement of the non-display area adjacent to the display area are not limited to the example shown in FIG. 1.

[0034] The display area and the non-display area may have a shape suitable for the design of the electronic device on which the flexible display device (100) is mounted. Exemplary shapes of the display area may be pentagonal, hexagonal, circular, elliptical, and the like, but are not limited thereto. Each pixel within the display area may be associated with a pixel circuit.

[0035] The pixel circuit may include one or more switching transistors and one or more driving transistors on a backplane. Each pixel circuit may be electrically connected to a gate line and a data line to communicate with one or more driving circuits, such as a gate driver and a data driver, located in the non-display area.

[0036] The driving circuit (112) may be implemented as a thin film transistor (TFT) in the non-display area. Such a driving circuit (112) may be referred to as a GIP (Gate-In-Panel). In

addition, some components such as a data driver IC (Integrated Circuit) may be mounted on a printed circuit board. Using a circuit film such as an FPCB (Flexible Printed Circuit Board), COF (Chip On Film), or TCP (Tape-Carrier-Package), it may be coupled to a connection interface arranged in the non-display area, for example, a pad, bump, pin, and the like.

[0037] The flexible display device (100) may include various additional elements for generating various signals or driving the pixels within the display area. Additional elements for driving the pixels may include an inverter circuit, a multiplexer, an electrostatic discharge (ESD) circuit, and the like. The flexible display device (100) may also include additional elements associated with functions other than pixel driving. For example, the flexible display device (100) may include additional elements that provide a touch sensing function, a user authentication function (e.g., fingerprint recognition), a multi-level pressure sensing function, a tactile feedback function, and the like. The additional elements mentioned above may be located in the non-display area and/or in an external circuit connected to the connection interface. The flexible substrate (110) may be made of a material having flexibility so that bending is possible.

[0038] For example, the flexible substrate (110) may be implemented as a thin plastic film made of a polymer such as polyimide, polyethylene naphthalate (PEN), polyethylene terephthalate (PET), and the like, but is not limited thereto. Therefore, the flexible substrate (110) can be bent. For example, the flexible substrate (110) may be bent in the horizontal direction, the vertical direction, or the diagonal direction. Therefore, the flexible substrate (110) may be bent in a combination of vertical, horizontal, and diagonal directions based on the design required for the flexible display device (100), and is not limited to a bending direction.

[0039] The flexible substrate (110) includes a first area, a bending area (Bending Area, B/A) extending from one side of the first area, and a second area extending from one side of the bending area. The first area may be defined as a non-bending area (Non Bending Area, N/A) including the display area (Active Area, A/A), and the second area may be defined as a non-bending area including the non-display area (Inactive Area, I/A) located on the opposite side of the first area with respect to the bending area.

[0040] A portion of the flexible substrate (110) may be bent; for example, as shown in FIG. 1, a lower end portion of the display area may be bent. For example, the flexible substrate (110) may be bent at the bending area (B/A) so that the second area is folded behind the first area.

[0041] Also, FIG. 1 shows the non-display area of the flexible substrate (110) being bent, but a portion of the display area of the flexible substrate (110) may be bent. In this case, an image may be displayed in the bent area of the display area, and the flexible display device (100) may include a substantially flat display area and a curved display area.

[0042] A pad portion (114) or a similar interface is arranged in the non-display area of the second area of the flexible substrate (110). The pad portion (114), for example, as shown in FIG. 1, is arranged in the non-display area that meets the bending area at the lower end portion of the flexible substrate (110). The pad portion (114) is connected to a circuit film such as an FPCB, and may be a contact terminal that connects the circuit film and the wiring (118) to each other.

[0043] A thin film transistor connected to the organic light-emitting element is arranged in the display area. The thin film transistor operates in association with the driving portion (112) located in the non-display area, and controls the amount of driving current provided to the organic light-emitting element.

[0044] The driving portion (112) is arranged in the non-display area of the flexible substrate (110), and provides a driving signal to the thin film transistor. For example, the driving portion (112) may be a gate driving portion that provides a gate signal to the thin film transistor. The driving portion (112) includes various gate driving circuits, and the gate driving circuits may be formed directly on the flexible substrate (110). In this case, the driving portion (112) may be referred to as a GIP (Gate-In-Panel).

[0045] A data driving portion that provides a data signal to the thin film transistor may be mounted on a printed circuit board (PCB) and connected to the flexible substrate (110) through a circuit film such as an FPCB (Flexible Printed Circuit Board), or may be arranged directly on the pad portion (114) of the flexible substrate (110) in a manner such as COF.

[0046] FIG. 2A and FIG. 2B are cross-sectional views showing the bending structure of a flexible display device according to an embodiment of the present specification.

[0047] The flexible substrate (110) includes a first area, a bending area (B/A) extending from one side of the first area, and a second area extending from one side of the bending area. The first area may be defined as a non-bending area (N/A) including the display area (A/A), and the second area may be defined as a non-bending area (N/A) including the non-display area (I/A) located on the opposite side of the first area with respect to the bending area.

[0048] As shown in FIG. 2A and FIG. 2B, a first back plate (120A) is attached to the display area (101) of the flexible substrate (110), and a second back plate (120B) is attached to the non-display area (103). Between the first back plate (120A) attached to the display area (101) of the flexible substrate (110) and the second back plate (120B) attached to the non-display area (103), support members (140A, 140B) are additionally provided, and a portion of the support members (140A, 140B) extends to and is attached up to the bending area (102). A polarizing layer (160) is formed on the display area (101) of the flexible substrate (110), and a cover glass (180) is formed on the polarizing layer (160).

[0049] The back plate includes the first back plate (120A) and the second back plate (120B). The first back plate (120A) is attached to one surface of the display area (101) of the flexible substrate (110) and serves to support the flexible substrate (110), and the second back plate (120B) is attached to one surface of the non-display area of the flexible substrate (110) and serves to support the flexible substrate (110).

[0050] The first back plate (120A) and the second back plate (120B) may not be present in the bending area for easy bending of the flexible substrate (110).

[0051] However, due to the absence of the first back plate (120A) and the second back plate (120B), the flexible substrate (110) in the bending area may be easily broken or deformed by external force. Accordingly, to support the flexible substrate (110) and maintain the curvature of the bending area, the flexible display device (100) may further include a support member or a support structure. The support members (140A, 140B) include a body portion (142A, 142B) and a rounded end portion (144A, 144B) extending from the body portion (142A, 142B).

[0052] One surface of the body portion (142A, 142B) of the support member (140A, 140B) is attached to the first back plate (120A) attached to the display area (101) of the flexible substrate (110), and the other surface is attached to the second back plate (120B) attached to the non-display area (103). In addition, one surface of the end portion (144A, 144B) of the support member (140A, 140B) is attached to the bending area (102) of the flexible substrate (110).

[0053] The support members (140A, 140B) may be formed of a plastic material such as polycarbonate (PC), polyimide (PI), polyethylene naphthalate (PEN), polyethylene terephthalate (PET), and the like, but are not limited thereto.

[0054] The strength of the support members (140A, 140B) made of a plastic material may be controlled by the thickness of the support members (140A, 140B) and/or an additive that increases their strength. The support members (140A, 140B) may be formed in a specific color, for example, black, white, etc., for a function such as a light-blocking effect. In addition, the support members (140A, 140B) may be made of a hard material such as glass, ceramic, or metal, or a combination thereof.

[0055] The size and shape of the end portion of the support members (140A, 140B) may vary depending on the desired minimum bending radius in the bending area. In some embodiments, the thickness of the end portion and the body portion may be substantially the same. In other embodiments, the planar-shaped body portion may be thinner than the end portion.

[0056] The support members (140A, 140B), having a thinner body portion, can support the bending area (102) while reducing an unnecessary increase in the thickness of the flexible display device (100). As shown in FIG. 2A, the thickness of the rounded end portion (144A) and the elongated body portion (142A) of the support member (140A) may be substantially the same. Such a support member (140A) may be formed of a plastic material or a folded thin metal sheet, for example, SUS (stainless steel), but is not limited thereto.

[0057] In this case, the folded edge of the metal sheet may function as the rounded end portion (144A) of the support member (140A). Even when a metal sheet is used to construct the support member (140A), the end portion (144A) may be thicker than the body portion (142A).

[0058] For example, pressure may be applied to a portion of the folded metal sheet so that the body portion becomes thinner than the folded edge. FIG. 2B is another configuration example of the support member. The thickness of the elongated body portion (142B) of the support member (140B) may be thinner than that of the rounded end portion (144B). In this case, if the support member (140B) has a flat bottom, the lower surface of the body portion (142B) is aligned in a straight line with the lowest edge of the end portion (144B). In such an exemplary configuration, the support member (140B) may be formed of the aforementioned plastic material, for example, polycarbonate, etc., or a combination of the aforementioned materials.

[0059] In addition, the adhesive layer (138B) provided on the upper surface of the body portion (142B) may be made thicker than the adhesive layer (138B) provided on the lower surface of the body portion (142B). The adhesive layer (138B) on the lower surface does not include a buffer layer, and the adhesive layer (138B) on the upper surface of the body portion (142B) may include a buffer layer.

[0060] To securely fix the support members (140A, 140B) within the flexible display device (100), an adhesive layer (138A, 138B) may be provided on the surface of the support members (140A, 140B).

[0061] The adhesive layer (138A, 138B) may include a pressure-sensitive adhesive, a foam-type adhesive, a liquid adhesive, and a light-cured adhesive, or another suitable adhesive material.

[0062] In some embodiments, the adhesive layer (138A, 138B) is formed of a compressible material, or a compressible material may function as a buffer material for the portion adhered by the adhesive layer (138A, 138B). As an example, the constituent material of the adhesive layer

(138A, 138B) may be compressible. The adhesive layer (138A, 138B) may be formed in a multilayer structure, and the multilayer structure may include a buffer layer, for example, polyolefin foam, placed between upper and lower layers of the adhesive material layer, but is not limited thereto. The adhesive layer (138A, 138B) may be located on one or more of the upper and lower surfaces of the body portion of the support members (140A, 140B).

[0063] When the bending area (102) of the flexible display device (100) wraps around the end portion (144A, 144B) of the support members (140A, 140B), the adhesive layer (138A, 138B) may be provided on both the lower surface of the body portion (142A, 142B), for example, the surface facing the rear, and the upper surface, for example, the surface facing the front. Alternatively, the adhesive layer (138A, 138B) may be provided between the end portion (144A, 144B) of the support members (140A, 140B) and the inner surface of the flexible substrate (110).

[0064] FIG. 2A shows that the adhesive layer (138A) is applied to the upper and lower surfaces of the support member (140A). Because the thickness of the support member (140A) is almost the same at the end portion (144A) and the body portion (142A), the adhesive layer (138A) has a substantially uniform thickness on the surface of the support member (140A).

[0065] Also, the adhesive layer (138A) may be thinner or thicker at selected portions of the support member (140A). Various circuits and components in the non-display area, such as a driving IC, a connection interface with a COF, a printed circuit board, and the like, may be provided on the flexible substrate (110). In this way, even components that are not flexible components may be located below the display area.

[0066] By additionally configuring the support members (140A, 140B) in this way, the bending area (103) can be simultaneously supported while supporting the first back plate (120A) of the display area (101) and the second back plate (120B) of the non-display area (103).

[0067] In addition, by extending the end portion (144A, 144B) of the support members (140A, 140B) to the bending area (102), the bending of the flexible substrate (110) can be facilitated.

[0068] In addition, by extending the end portion (144A, 144B) of the support members (140A, 140B) to the bending area (102), breakage or deformation of the flexible substrate (110) due to external impact and the like can be minimized.

[0069] In addition, by extending the end portion (144A, 144B) of the support members (140A, 140B) to the bending area (102), cracking of the flexible substrate (110) or disconnection of the wiring formed in the bending area (102) can be minimized.

[0070] In another configuration example, a protective coating layer may be further provided. On one surface of the display area (101) of the flexible substrate (110), a polarizing layer (160), an adhesive layer (162), and a cover glass (180) are formed.

[0071] Also, a first back plate (120A) for supporting the flexible substrate (110) is attached to the other surface of the flexible substrate (110), and a second back plate (120B) is attached to the other surface of the non-display area (103). A support member (140B) is arranged between the first back plate (120A) and the second back plate (120B) to implement the bending structure of the flexible substrate (110). When the flexible substrate (110) is bent, tensile stress is applied to the outer surface of the flexible substrate (110), and compressive stress is applied to the inner surface. Therefore, the wiring formed in the bending area (102) of the flexible substrate (110) is subjected to tensile stress, which may cause a problem of disconnection of the wiring. This is because the wiring is more vulnerable to tensile stress than to compressive stress.

[0072] By applying a protective coating layer (184) to the bending area (102), the intention is to increase the flexible substrate (110) in the bending area (102) by the thickness of the protective coating layer, thereby moving the position of the neutral plane to the position where the wiring is formed.

[0073] The neutral plane refers to the surface on which neither tensile stress nor compressive stress acts, whereas, when the flexible substrate (110) is bent, the inner surface is subjected to compressive stress and the outer surface is subjected to tensile stress. By applying the protective coating layer to the flexible substrate (110) to increase the thickness, the position of the neutral plane—which is not subjected to the tensile stress of the outer surface and the compressive stress of the inner surface of the flexible substrate (110)—can be moved.

[0074] The neutral plane may vary depending on the properties of the material applied as the protective coating layer, the applied thickness, and the curing method. In FIG. 2A and FIG. 2B, the support member (140A) and the support member (140B) may be a mandrel or a foam tape.

[0075] The thickness of the flexible substrate (110) may have a single thickness in a range of about 20 μm to about 40 μm , and the thickness of the back plates (120A, 120B) may each have a single thickness in a range of about 100 μm to about 150 μm , but is not limited thereto. In addition, the thickness of the support members (140A, 140B, 140C) may each have a single thickness in a range of about 150 μm to about 300 μm , but is not limited thereto.

[0076] The thickness of the adhesive layer may each have a single thickness in a range of about 20 μm to about 100 μm , but is not limited thereto.

[0077] The difference in thickness ranges may be appropriately applied depending on the type, size, use, and the like of the corresponding electronic device included in the display device (100).

[0078] FIG. 3 is a cross-sectional view showing the stacked structure of a flexible display device according to another embodiment of the present specification.

[0079] The flexible substrate (110) includes a first area, a bending area (B/A) extending from one side of the first area, and a second area extending from one side of the bending area. The first area may be defined as a non-bending area (N/A) including the display area (A/A), and the second area may be defined as a non-bending area (N/A) including the non-display area (I/A) located on the opposite side of the first area with respect to the bending area.

[0080] To increase the strength and/or rigidity at a specific portion of the flexible display device (100), one or more back plates (120A, 120B) may be provided at the lower portion, for example, the rear surface, of the flexible substrate (110). The first back plate (120A) is formed on one surface of the display area (101), and the second back plate (120B) may be provided on one surface of the non-display area (103). The back plates (120A, 120B) may not be provided in the bending area where greater flexibility is required. When the flexible substrate (110) has greater elasticity than the back plates (120A, 120B), the back plates (120A, 120B) can suppress the occurrence of cracking or other breakage in the flexible substrate (110).

[0081] As shown in FIG. 3, a first back plate (120A) is attached to the display area (101) of the flexible substrate (110), and a second back plate (120B) is attached to the non-display area (103). Between the first back plate (120A) attached to the display area (101) of the flexible substrate (110) and the second back plate (120B) attached to the non-display area (103), a support member (140C) is additionally provided, and a portion of the support member (140C) extends to and is attached up to the bending area (102).

[0082] On the display area (101) of the flexible substrate (110), an organic light-emitting element layer (154) is formed; an encapsulation layer (150) is formed on the organic light-emitting element layer (154); a polarizing layer (160) is formed on the encapsulation layer (150); and a cover glass (180) is formed on the polarizing layer (160).

[0083] Here, the back plate includes the first back plate (120A) and the second back plate (120B). The first back plate (120A) is attached to one surface of the display area (101) of the flexible substrate (110) and can support the flexible substrate (110), and the second back plate (120B) is attached to one surface of the non-display area of the flexible substrate (110) and can support the flexible substrate (110).

[0084] The support member (140C) includes a body portion (142C) and a rounded end portion (144C) extending from the body portion (142C). One surface of the body portion (142C) of the support member (140C) is attached to the first back plate (120A) attached to the display area (101) of the flexible substrate (110), and the other surface is attached to the second back plate (120B) attached to the non-display area (103).

[0085] In addition, one surface of the end portion (144C) of the support member (140C) is attached to the bending area (102) of the flexible substrate (110). Therefore, by additionally configuring the support member (140C), the first back plate (120A) of the display area (101) and the second back plate (120B) of the non-display area (103) can be supported, and the bending area (103) can be supported. In addition, breakage or deformation of the flexible substrate (110) due to external impact and the like can be minimized. In addition, cracking of the flexible substrate (110) or disconnection of the wiring formed in the bending area (102) can be minimized. In addition, the flexible substrate (110) can be supported and the bending shape can be maintained.

[0086] The bending area (102) may be bent outward from the display area (101) with a bending angle and a bending radius about a bending axis.

[0087] During the manufacturing process, some parts of the flexible display device (100) may be exposed to external light. The materials used to manufacture the components, or the components themselves, may be exposed to light during the manufacture of the flexible display device (100). As a result, they undergo an undesired state change (e.g., a threshold voltage shift in the TFT). Some parts of the flexible display device (100) are excessively exposed to external light compared to other parts. And this may cause display non-uniformity (e.g., Mura, shadow defects, etc.). To minimize this problem, the flexible substrate (110) and/or the back plate may include one or more materials capable of reducing the amount of external light.

[0088] In FIG. 3, the organic light-emitting display device (OLED) layer (154) is arranged on the flexible substrate (110). The organic light-emitting element layer (154) includes a plurality of organic light-emitting elements. The organic light-emitting elements are controlled by a pixel circuit and a driving circuit implemented on the flexible substrate (110), and by another external driving circuit connected to a connection interface on the flexible substrate (110). The organic light-emitting element layer (154) includes an organic light-emitting material layer that emits light of a specific color (e.g., red, green, blue). In some embodiments, the organic light-emitting material layer may have a stacked structure capable of emitting white light, for example, a combination of light of various colors. The encapsulation layer (150) is provided to protect the organic light-emitting element (154) layer from external air and moisture.

[0089] The encapsulation layer (150) may include multiple layers of materials to reduce the penetration of air and moisture. In some embodiments, the encapsulation layer (150) may be provided in a thin film shape, for example, as a barrier film.

[0090] The flexible display device (100) may include a polarizing layer (160) to control display characteristics (e.g., external light reflection, color accuracy, luminance, etc.). And a cover glass (180) may be used on the polarizing layer (160) to protect the flexible display device (100).

[0091] An electrode for sensing a user's touch input may be formed on one surface of the cover glass (180) and/or inside at least one surface of the polarizing layer (160).

[0092] If necessary, a separate layer (hereinafter referred to as a touch sensor layer (170)) on which a touch sensing electrode and/or other components associated with touch input sensing are configured may be provided within the flexible display device (100). The touch sensor layer (170) may include one or more deformable dielectric materials. One or more electrodes may interface with the touch sensor layer (170) or be located near the touch sensor layer (170), and may read a signal that measures the electrical change on the electrode. This measurement is analyzed so that the amount of pressure input to the flexible display device (100) is evaluated at various levels.

[0093] In some embodiments, the touch sensing electrode may be utilized to confirm the position of a user input and to evaluate the pressure of the user input.

[0094] The confirmation of the touch input position and the measurement of the touch pressure may be performed by measuring the change in capacitance of the touch sensing electrode on one surface of the touch sensor layer (170). The touch sensing electrode and/or other electrodes may be used to measure a signal representing the pressure on the flexible display device (100) due to the touch input. Such signals are obtained from the touch sensing electrode simultaneously with the touch signal or at a different timing. Various other components, for example, the polarizing layer (160), the touch sensor layer (170), and the like, may not be present in the bending area.

[0095] FIG. 4 is a view showing applying and curing a protective coating layer with a low-modulus resin on a flexible substrate in a flexible display device according to another embodiment of the present specification.

[0096] Referring to FIG. 4, in the flexible display device (200), the flexible substrate (210) is defined by a display area (201), a non-display area (203), and a bending area (202). A semiconductor layer and an organic light-emitting element layer are formed in the display area (201), and an encapsulation layer is formed on the organic light-emitting element layer to prevent the penetration of moisture and the like. And on the encapsulation layer, a polarizing layer (260) and an adhesive layer (262) are formed, and a cover glass (280) is formed on the adhesive layer (262). On the other surfaces of the display area (201) and the non-display area (203), back plates (220A, 220B) for supporting the flexible substrate (210) are respectively formed. A circuit board (288) is formed on one surface of the non-display area (203) of the flexible substrate (210), and the circuit board (288) may be composed of at least one of a COF, TCP, FPCB, and PCB.

[0097] And wiring is formed in the bending area (202) of the flexible substrate (210), and a protective coating layer (284) is applied to protect the wiring. After applying the protective coating layer (284), a curing process is performed and then a bending process is performed.

[0098] The material used as the protective coating layer (284) requires sufficient flexibility so that bending is easy after the curing process. It must have properties soft enough to be applied to the flexible substrate (210) and easily bent together with the flexible substrate (210) during bending in order for bending to be possible.

[0099] If the protective coating layer (284) is composed of a rigid material, bending becomes difficult, and it may also become a cause of disconnection of the wiring formed in the bending area (202). In an embodiment of the present specification, a curable resin having a modulus of 0.156 GPa or less is applied as the protective coating layer (284) to the flexible substrate (210) on which the wiring is formed.

[0100] The modulus refers to the elastic modulus that a material has. In the present specification, a modulus in a range lower than 0.156 GPa is defined as a low modulus, and a resin having a low modulus is defined as a low-modulus resin. And as shown in FIG. 4, the protective coating layer (284) is cured using a curing device (290).

[0101] Although there are thermal curing and photo-curing processes as the curing process, in this embodiment, a UV photo-curing process is performed. At this time, the UV curing conditions require a certain temperature (°C), time (S), illuminance (mW/cm²), energy (mJ/cm²), and the like.

[0102] In the case where the protective coating layer (284) is a low-modulus resin having 0.156 GPa, curing is performed at a temperature of 10°C to 45°C, an illuminance of 500 mW/cm², for a time of 4 seconds. At this time, the total energy amount is 2000 mJ/cm². The curing conditions may differ depending on the modulus of the protective coating layer, temperature, illuminance, light irradiation time, and the like.

[0103] In an embodiment of the present specification, the curing process for the protective coating layer (284) is performed once.

[0104] First, by applying the protective coating layer (284) with a low-modulus resin to the bending area (202) of the flexible substrate (210) on which the wiring is formed, the thickness of the flexible substrate (210) and the protective coating layer (284) in the bending area (202) is increased, so that the position of the neutral plane—on which tensile stress and compressive stress do not act during bending—is changed to the position where the wiring is formed, thereby minimizing disconnection of the wiring.

[0105] FIG. 5 is a view showing bending a flexible substrate on which a protective coating layer has been applied with a low-modulus resin in a flexible display device according to another embodiment of the present specification.

[0106] As shown in FIG. 5, after performing the curing process in FIG. 4, the flexible substrate (210) is bent to implement the bending structure.

[0107] In a flexible display device, it is important to prevent damage in the bending area of the flexible substrate, for example, denting, denting deformation, and deformation.

[0108] And, in a flexible display device, it is important to prevent disconnection of the wiring formed in the bending area of the flexible substrate.

[0109] And, in a flexible display device according to an embodiment of the present specification, a support member (mandrel or foam tape) is configured on the inner side of the bending area of the flexible substrate, that is, on the inner surface where the flexible substrate is bent, to support

the bending area, thereby preventing damage to the flexible substrate and also improving the problem of disconnection of the wiring.

[0110] And, in a flexible display device according to an embodiment of the present specification, a low-modulus resin having a modulus of 0.156 GPa or less is applied as the protective coating layer (284) to the bending area of the flexible substrate, thereby improving the problem of disconnection of the wiring when the flexible substrate is bent.

[0111] And, in a flexible display device according to an embodiment of the present specification, it was recognized that even if the support member supports the bending area of the flexible substrate, the bending area of the flexible substrate is subjected to external impact, or is damaged during the bending process, for example, dented and deformed.

[0112] And, in a flexible display device according to an embodiment of the present specification, it was recognized that even if a low-modulus resin is applied as the protective coating layer to the bending area of the flexible substrate, although bending was possible in the bending area, because the applied protective coating layer and the flexible substrate are a flexible substrate or soft, if a user carelessly drops the flexible display device, or if external impact is applied to the bending area (302) of the flexible substrate (310), the bending area (302) of the flexible substrate (310) is broken or damaged, for example, there is a problem that denting and deformation occur.

[0113] And, in general, even if a resin having a modulus of 0.156 GPa or more is applied as the protective coating layer, because the high modulus gives it a more rigid property than a low-modulus resin due to the nature of the material, there was a problem that it was difficult to actually apply it as a protective coating layer because bending was difficult.

[0114] Therefore, the inventors of the present specification recognized the problems mentioned above and continuously conducted various experiments to apply a resin having a specific modulus as the protective coating layer to the bending area of the flexible substrate, so that bending is possible while securing rigidity after bending to prevent breakage of the flexible substrate.

[0115] Through various experiments, instead of a typical low-modulus resin, a resin having a specific modulus was configured as the protective coating layer, thereby inventing a new flexible display device that facilitates bending while being able to firmly maintain the bending area after bending.

[0116] This will be described with reference to FIG. 6 to FIG. 9.

[0117] FIG. 6 is a view showing applying and pre-curing a protective coating layer with a high-modulus resin on a flexible substrate in a flexible display device according to another embodiment of the present specification.

[0118] Referring to FIG. 6, in the flexible display device (300), the flexible substrate (310) is defined by a display area (301), a non-display area (303), and a bending area (302). A semiconductor layer and an organic light-emitting element layer are formed in the display area (301), and an encapsulation layer is formed on the organic light-emitting element layer to prevent the penetration of moisture and the like. And on the encapsulation layer, a polarizing layer (360) and an adhesive layer (362) are formed, and a cover glass (380) is formed on the adhesive layer (362).

[0119] On the other surfaces of the display area (301) and the non-display area (303), back plates (320A, 320B) for supporting the flexible substrate (310) are respectively formed. And a circuit board (388) is formed on one surface of the non-display area (303) of the flexible substrate (310), and the circuit board (388) may be composed of at least one of a COF, TCP, FPCB, and PCB. And wiring is formed in the bending area (302) of the flexible substrate (310), and a resin having a specific modulus is applied as the protective coating layer (384) to protect the wiring.

[0120] In the present specification, a modulus in a range greater than 0.156 GPa is defined as a high modulus, and a resin having a high modulus is defined as a high-modulus resin.

[0121] In an embodiment of the present specification, a high-modulus resin having a modulus of 0.25 GPa is applied as the protective coating layer (384) to the flexible substrate (310). Here, although a high-modulus resin having a modulus of 0.25 GPa was given as an example, a resin having a modulus in a range of 0.25 GPa to 2.0 GPa is included as a high-modulus resin. Preferably, a resin selected from those having a modulus of 0.25 GPa to 1.3 GPa may be used as the protective coating layer. The protective coating layer (384) is applied in a range of 100 μm to 150 μm .

[0122] The protective coating layer (384) is applied so that one side of the polarizing layer (360) formed in the display area (301) of the flexible substrate (310) overlaps, that is, so as to cover the end of the polarizing layer (360), and is applied so that one side of the circuit board (388) formed in the non-display area (303) overlaps, that is, so as to cover the end of the circuit board (388). This is for the purpose of preventing delamination of the protective coating layer (384). The application range of the protective coating layer (384) is not limited thereto.

[0123] The degree to which the protective coating layer (384) overlaps or covers the polarizing layer (360) may be applied differently depending on the size, use, use environment, and the like of the flexible substrate (310) or the display device to which it is applied.

[0124] For example, in the case where the delamination phenomenon of the protective coating layer (384) may occur relatively frequently for a relatively large flexible substrate (310), the degree of overlap or covering is implemented to be large, and in the case where the delamination phenomenon of the protective coating layer (384) occurs relatively little for a relatively small flexible substrate (310), the degree of overlap or covering may be implemented to be small. In order to use a high-modulus resin as the protective coating layer (384), it is very important to apply the protective coating layer (384) to the flexible substrate (310) and bend it without disconnection of the wiring or breakage or damage of the flexible substrate (310).

[0125] Therefore, in an embodiment of the present specification, to solve this, a two-step curing process is performed in which a protective coating layer (388) made of a specific high-modulus resin is applied, pre-curing is performed before bending the flexible substrate (310), and main-curing is performed after bending is performed. That is, in the two-step curing process, the protective coating layer (388) is applied to the flexible substrate (310), a pre-curing process, which is the primary curing process, is performed, a bending process is performed after the pre-curing process, and a main-curing process, which is the secondary curing process, is performed. Because a high-modulus resin having a modulus of 0.25 GPa is used as the protective coating layer (384), the bending and curing conditions are very important. To describe the curing process, the pre-curing process of the protective coating layer (384) is performed using a curing device (390).

[0126] The pre-curing process performs a UV photo-curing process. At this time, the curing conditions require a temperature ($^{\circ}\text{C}$), light irradiation time (seconds), illuminance (mW/cm^2), energy (mJ/cm^2), and the like.

[0127] For example, in the case where the protective coating layer (384) is a high-modulus resin having a modulus of 0.25 GPa, the pre-curing process is performed using the curing device (390) at a temperature of 10°C to 45°C , an illuminance of $500 \text{ mW}/\text{cm}^2$, for a time of 4 seconds. At this time, the total pre-curing energy amount is $1500 \text{ mJ}/\text{cm}^2$. Alternatively, the pre-curing process may be performed at a temperature of 10°C to 45°C , an illuminance of $400 \text{ mW}/\text{cm}^2$, for a time of 5 seconds. At the same temperature, the total energy amount can be provided by multiplying the illuminance and time.

[0128] And, if the total energy amount required for pre-curing is set to $1000 \text{ mJ}/\text{cm}^2$ to $2500 \text{ mJ}/\text{cm}^2$, pre-curing can be performed for a time of 2.5 seconds to 6.3 seconds at an illuminance of $400 \text{ mW}/\text{cm}^2$, and pre-curing can be performed for a time of 2 seconds to 5 seconds at an illuminance of $500 \text{ mW}/\text{cm}^2$.

[0129] The range of illuminance is not limited thereto, and may be determined depending on the resin between $100 \text{ mW}/\text{cm}^2$ and $1000 \text{ mW}/\text{cm}^2$. The range of time is also not limited, and may be determined depending on the resin between 1 second and 100 seconds. The pre-curing conditions may be made different depending on the modulus of the protective coating layer, temperature, illuminance, time, and the like. Through the pre-curing process, the curing rate of the protective coating layer (384) can be advanced to 60 to 85%. Preferably, the curing rate of the protective coating layer (384) can be advanced to 70 to 80%.

[0130] The curing device (390) irradiates UV light. FIG. 7 is a view showing bending, after pre-curing, a flexible substrate on which a protective coating layer has been applied with a high-modulus resin in a flexible display device according to another embodiment of the present specification.

[0131] As shown in FIG. 7, after the pre-curing process, the flexible substrate (310) is bent to implement the bending. At this time, because the protective coating layer (388) has a curing rate of 70% to 80%, the bending process is possible despite being a high-modulus resin.

[0132] FIG. 8 is a view showing main-curing, after bending, a flexible substrate on which a protective coating layer has been applied with a high-modulus resin in a flexible display device according to another embodiment of the present specification.

[0133] As shown in FIG. 8, after the bending process, a main-curing process, which is the secondary curing process, is performed.

[0134] Using a curing device (395), the main-curing process is performed at a temperature of 10°C to 45°C , an illuminance of $500 \text{ mW}/\text{cm}^2$, for a time of 1 second. At this time, the total main-curing energy amount is $500 \text{ mJ}/\text{cm}^2$.

[0135] If the total energy amount required for main-curing is set to $500 \text{ mJ}/\text{cm}^2$ to $1500 \text{ mJ}/\text{cm}^2$, main-curing can be performed at an illuminance of $500 \text{ mW}/\text{cm}^2$ for a time of 1 second to 3 seconds, and main-curing can be performed at an illuminance of $400 \text{ mW}/\text{cm}^2$ for a time of 1.3 seconds to 3.8 seconds.

[0136] The main-curing process may be performed at a temperature of 10°C to 45°C with different illuminances and times. At the same temperature, the total energy amount can be

provided by multiplying the illuminance and time. The main-curing conditions may be made different depending on the modulus of the protective coating layer, temperature, illuminance, time, and the like.

[0137] Through the main-curing process, the curing rate of the protective coating layer (384) can be advanced to 95% or more, and preferably, the curing rate can be advanced to 99%. The curing device (395) irradiates UV light. Here, the curing device (395) may be the same as the curing device (390) used in the pre-curing process, or may be a different curing device.

[0138] And, in the flexible display device according to this embodiment, the flexible substrate on which the protective coating layer is composed of a high-modulus resin is more effective in the case where the support member is a foam tape that is not directly attached to the bending area of the flexible substrate.

[0139] And, the modulus of the main-cured protective coating layer (384) can be measured by utilizing equipment called a rheometer.

[0140] In this way, when a high-modulus resin is used as the protective coating layer (384), the following effects are obtained.

[0141] A flexible display device according to another embodiment of the present specification, by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), has the effect of preventing disconnection caused by external impact because the high-modulus protective coating layer (384) protects the wiring.

[0142] And, a flexible display device according to another embodiment of the present specification, by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), has the effect of preventing breakage or damage of the flexible substrate, for example, denting or deformation.

[0143] And, a flexible display device according to another embodiment of the present specification, by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), has the effect of preventing disconnection of the wiring because the thermal strain is low. At high temperatures, because a low-modulus resin has large shrinkage and expansion, thermal deformation occurs and the wiring may be disconnected; however, because a high-modulus resin has small shrinkage and expansion, thermal deformation does not occur and the wiring is not disconnected.

[0144] And, a flexible display device according to another embodiment of the present specification, by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), has the effect of preventing disconnection of the wiring by moving the position of the neutral plane to the area where the wiring is formed. When a high-modulus resin and a low-modulus resin are applied to the same thickness on a flexible substrate having wiring, in the case of the low-modulus resin, which has a low modulus, the neutral plane is located below the position where the wiring is formed, so the wiring of the flexible substrate is subjected to tensile stress, and thus the possibility of disconnection of the wiring becomes high.

[0145] However, in the case of the high-modulus resin, which has a high modulus, the neutral plane is located above the position of the wiring, so the wiring of the flexible substrate is subjected to compressive stress, and thus the possibility of disconnection of the wiring becomes low. And, a flexible display device according to another embodiment of the present specification,

by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), the high modulus, as compared with the low modulus, allows the thickness of the protective coating layer to be made thin, which is advantageous for constructing a thin flexible display device.

[0146] And, a flexible display device according to another embodiment of the present specification, by using a high-modulus resin having a modulus of 0.25 GPa or more as the protective coating layer (384) on the flexible substrate (310), because thermal deformation is small and it is strong against external impact, has the effect of preventing delamination of the protective coating layer.

[0147] FIG. 9 is a view showing the curing steps in a flexible display device according to another embodiment of the present specification.

[0148] First, as shown in FIG. 9, a protective coating layer having a high modulus is formed on a flexible substrate including a display area, a non-display area, and a bending area (S410). Wiring is formed in the bending area. The protective coating layer includes a high-modulus resin having a modulus of at least 0.25 GPa or more. An encapsulation layer and a polarizing layer are formed on one surface of the display area, and a back plate is formed on the rear surface.

[0149] Next, the protective coating layer formed on the flexible substrate is primarily cured (S420).

[0150] The primary curing process is performed using a curing device, and is performed at a temperature of 10°C to 45°C, an illuminance of 500 mW/cm², for a time of 4 seconds. Here, the primary curing process means the pre-curing process. At this time, the total primary curing energy amount is 1500 mJ/cm². Through the primary curing, the protective coating layer has a curing rate of 70% to 80%.

[0151] Next, the flexible substrate including the primarily cured protective coating layer is bent (S430).

[0152] Next, the protective coating layer of the bent flexible substrate is secondarily cured (S440).

[0153] The secondary curing process is performed using a curing device, and is performed at a temperature of 10°C to 45°C, an illuminance of 500 mW/cm², for a time of 1 second. At this time, the total secondary curing energy amount is 500 mJ/cm². Through the secondary curing, the protective coating layer has a curing rate of 95% or more.

[0154] As a result, by applying a protective coating layer having a high modulus to a flexible substrate including a display area, a non-display area, and a bending area, and through the primary curing step, the bending step, and the secondary curing step, a flexible display device is implemented that protects the wiring formed in the bending area and prevents disconnection.

[0155] A flexible display device according to an embodiment of the present specification may be described as follows.

[0156] A method of manufacturing a flexible display device according to an embodiment of the present specification comprises: preparing a flexible substrate including a display area, a non-display area, and a bending area; applying a protective coating layer having a specific modulus to the bending area; primarily curing the protective coating layer; bending the flexible substrate

including the primarily cured protective coating layer; and secondarily curing the protective coating layer.

[0157] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the protective coating layer is made of a resin having a modulus of at least 0.25 GPa or more.

[0158] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the primary curing step is performed at an illuminance of 300 mW/cm² or more.

[0159] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the primary curing step is performed at a light irradiation time of 2 seconds or more.

[0160] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, in the primary curing step, the curing rate of the protective coating layer is in a range of 70% to 80%.

[0161] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the secondary curing step is performed at an illuminance of 300 mW/cm² or more.

[0162] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the secondary curing step is performed at a light irradiation time of 1 second or more.

[0163] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, in the secondary curing step, the curing rate of the protective coating layer is 95% or more.

[0164] And, in the method of manufacturing a flexible display device according to an embodiment of the present specification, the curing is performed with UV light.

[0165] And, in a flexible display device according to an embodiment of the present specification: a flexible substrate including a display area, a non-display area, and a bending area; a protective coating layer formed in the bending area; and the protective coating layer is formed through two curing processes and is made to have a higher modulus than a conventional protective coating layer formed through a single curing process.

[0166] And, in a flexible display device according to an embodiment of the present specification, the modulus of the protective coating layer is 0.25 GPa or more, and the modulus of the conventional protective coating layer is 0.156 GPa or less.

[0167] And, in a flexible display device according to an embodiment of the present specification, the protective coating layer has a curing rate in a range of 70% to 80% through a single curing process.

[0168] And, in a flexible display device according to an embodiment of the present specification, the protective coating layer has a curing rate of 95% or more through two curing processes.

[0169] And, in a flexible display device according to an embodiment of the present specification, the thickness of the protective coating layer is in a range of 100 μm to 150 μm.

[0170] And, in a flexible display device according to an embodiment of the present specification, the display area further includes a polarizing layer, and the protective coating layer is formed to overlap one side of the polarizing layer.

[0171] And, in a flexible display device according to an embodiment of the present specification: a flexible substrate including a display area, a non-display area, and a bending area; a polarizing layer formed in the display area; a protective coating layer formed in the bending area; and the protective coating layer is made of a resin having a specific modulus capable of implementing a required bending shape while relatively firmly protecting the bending area.

[0172] And, in a flexible display device according to an embodiment of the present specification, the specific-modulus resin has a modulus of at least 0.25 GPa or more.

[0173] And, in a flexible display device according to an embodiment of the present specification, the protective coating layer is formed to overlap one side of the polarizing layer.

[0174] And, in a flexible display device according to an embodiment of the present specification, the thickness of the protective coating layer is in a range of 100 μm to 150 μm .

DESCRIPTION OF REFERENCE NUMERALS

[0175] 100, 200, 300: Flexible display device; 110, 210, 310: Flexible substrate; 101, 201, 301: Display area (Active Area); 102, 202, 302: Bending area (Bending Area); 103, 203, 303: Non-display area (Non Active Area); 120, 220, 320: Back plate; 140, 240: Support member; 160, 260, 360: Polarizing layer; 170: Touch sensor layer; 180, 280, 380: Cover glass; 184, 284, 384: Protective coating layer

DRAWINGS

FIG. 1

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170 : 터치 센서층

180, 280, 380 : 커버글라스

184, 284, 384 : 보호 코팅층

도면

도면1

100

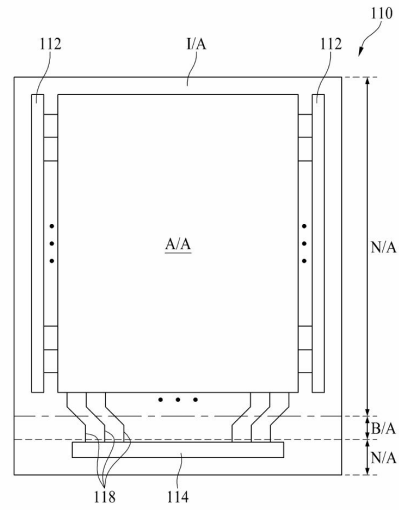
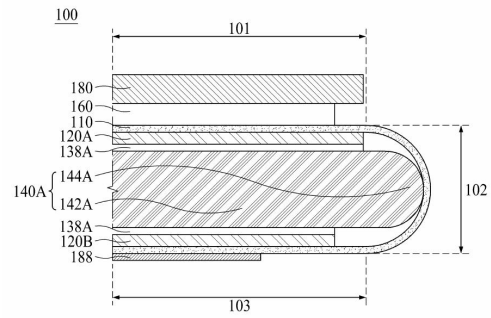


FIG. 2A and FIG. 2B

도면2a



도면2b

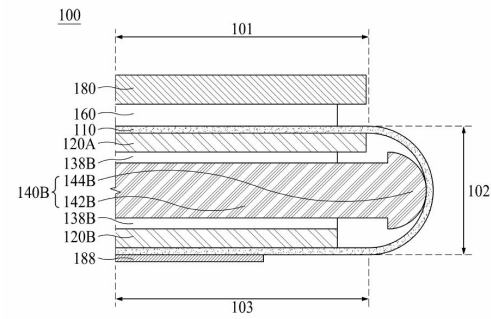
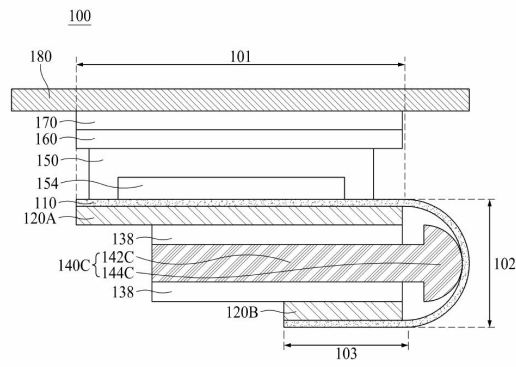


FIG. 3 and FIG. 4

도면3



도면4

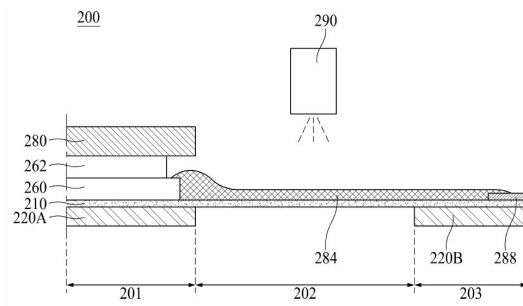
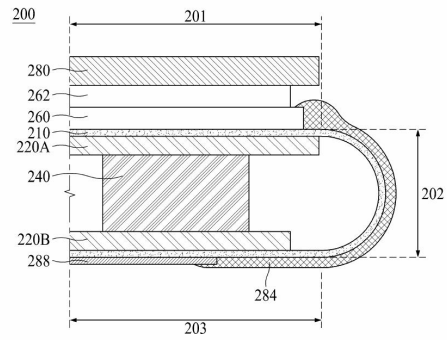


FIG. 5 and FIG. 6

도면5



도면6

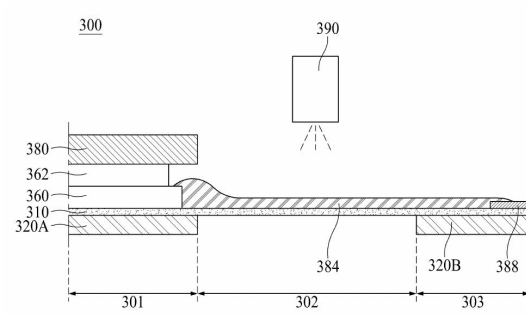
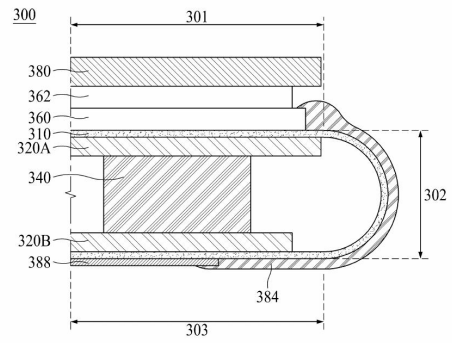


FIG. 7 and FIG. 8

도면7



도면8

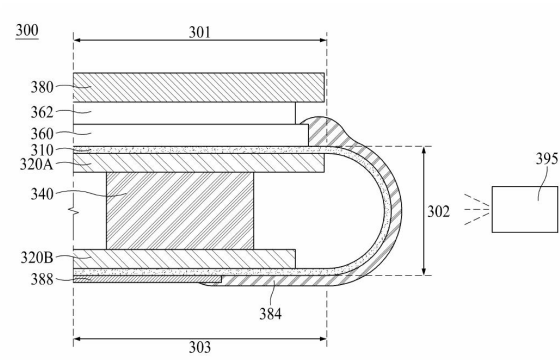


FIG. 9

도면9

