1. (US20190027703) FOLDABLE DISPLAY APPARATUS

Note: Text based on automatic Optical Character Recognition processes. Please use the PDF version for legal matters

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 14/975,689, filed Dec. 18, 2015, which claims priority to, and the benefit of, Korean Patent Application No. 10-2015-0093232, filed on Jun. 30, 2015, in the Korean Intellectual Property Office, the entire content of both of which is incorporated herein by reference.

BACKGROUND

1. Field

One or more exemplary embodiments of the present invention relate to a foldable display apparatus.

2. Description of the Related Art

Flat-panel display apparatuses, such as organic light-emitting display devices, may be flexibly deformed, and thus may be made foldable so that they can be conveniently carried.

SUMMARY

One or more exemplary embodiments of the present invention include a foldable display apparatus.

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

According to one or more exemplary embodiments of the present invention, a foldable display apparatus that is adjustable between a folded configuration and an unfolded configuration includes a flexible display panel that is foldable; a case including a first case that supports a first side of the flexible display panel and a second case that supports a second side of the flexible display panel; a link member connecting the first case to the second case; and a locking unit configured to prevent rotation of the first case and the second case in a folding direction when the foldable display apparatus is in the unfolded configuration.

The locking unit may include a slide cover rotatably coupled to the first case and slidably coupled to the second case; and a locking lever rotatably mounted on the second case and configured to prevent sliding of the slide cover when the locking lever is in a locked position.

The slide cover may slide along a rail groove in the second case when the first case and the second case are rotated to move the foldable display apparatus between the folded configuration and the unfolded configuration. Rotation of the first and second cases may be inhibited when movement of the slide cover along the rail groove is blocked.

A body center of the slide cover may be adjacent the link member when the foldable display apparatus is in the unfolded configuration, and the body center of the slide cover may be moved toward the second case along the rail groove when the foldable display apparatus is moved from the unfolded configuration to the folded configuration.

The second case may define an insertion groove in a surface thereof and on which the slide cover and the locking lever are mounted.

The insertion groove may restrict a sliding range of the slide cover and may restrict a rotating range of the locking lever.

The slide cover and the locking lever may be accommodated in a depth of the insertion groove.

The link member may include a concave-convex type metal sheet.

End surfaces of the concave-convex type metal sheet may be respectively attached to a first end surface of the first case and a second end surface of the second case.

The foldable display apparatus may further include an elastic piece connecting the first case to the second case.

The first case and the second case may each have a stepped surface, and the elastic piece may be attached to the stepped surfaces of the first case and of the second case.

The flexible display panel may be outwardly exposed when the foldable display apparatus is in the folded configuration.

A folded portion of the flexible display panel may be supported by the link member when the foldable display apparatus is in the folded configuration.

The link member may include a concave-convex type metal sheet.

The first case and the second case may each define a coupling groove coupled to the flexible display panel.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a perspective view of a foldable display apparatus according to one or more exemplary embodiments of the present invention;

FIG. 2 is an exploded perspective view of a case included in the foldable display apparatus illustrated in **FIG. 1**;

FIGS. 3A-3B are rear surface perspective views respectively showing an unfolded state and a folded state of the foldable display apparatus of **FIG. 1**;

FIGS. 4A-4D are side views sequentially showing a change in the state of the foldable display apparatus of **FIG. 1** from an unfolded state to a folded state;

FIGS. 5A-5D are rear surface perspective views respectively corresponding to the processes of **FIGS. 4A-4D**; and

FIG. 6 is a cross-sectional view showing a detailed structure of a flexible display panel included in the foldable display apparatus of **FIG. 1**.

DETAILED DESCRIPTION

As the present invention allows for various changes and numerous embodiments, particular embodiments are illustrated in the drawings and described in detail in the written description. Hereinafter, aspects of the present invention and a method for accomplishing them are described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein.

One or more embodiments of the invention are described below in more detail with reference to the accompanying drawings. Unless otherwise noted, like reference numerals denote like elements throughout the attached drawings and the written description, and thus, descriptions thereof will not be repeated. In the drawings, the relative sizes of elements, layers, and regions may be exaggerated for clarity.

It will be understood that, although the terms “first,” “second,” “third,” etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the spirit and scope of the present invention.

The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting of the present invention. As used herein, the singular forms “a” and “an” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

It will be further understood that the terms “comprises,” “comprising,” “includes,” and/or “including” as used herein specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

It will be understood that when an element or layer is referred to as being “on,” “connected to,” or “coupled to” another element or layer, it can be directly on, connected to, or coupled to the other element or layer, or one or more intervening elements or layers may be present. In addition, it will also be understood that when an element or layer is referred to as being “between” two elements or layers, it can be the only element or layer between the two elements or layers, or one or more intervening elements or layers may also be present.

As used herein, the term “substantially,” “about,” and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Further, the use of “may” when describing embodiments of the present invention refers to “one or more embodiments of the present invention.” As used herein, the terms “use,” “using,” and “used” may be considered synonymous with the terms “utilize,” “utilizing,” and “utilized,” respectively. Also, the term “exemplary” is intended to refer to an example or illustration.

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

FIG. 1 is a perspective view of a foldable display apparatus according to one or more exemplary embodiments of the present invention.

The foldable display apparatus includes, as a display, a flexible display panel **100** that is capable of being flexibly bent. The flexible display panel **100** is a structure in which a thin film transistor and a light-emitting device for displaying an image, and an encapsulation layer that covers and protects the thin film transistor and the light-emitting device, are generally stacked on a flexible substrate. Because the flexible substrate is used instead of a rigid glass substrate, the flexible display panel **100** may be moved between a folded or unfolded configuration (e.g., may be freely folded or unfolded) within an allowable flexibility range. Thus, in a folding state (e.g., the folded configuration), the flexible display panel **100** may be folded as shown in **FIGS. 4D and 5D**.

The flexible display panel **100** may be supported by a case **200** that includes first and second cases **210** and **220** such that the flexible display panel **100** may be folded or unfolded. In other words, one end (e.g., a first end) of the flexible display panel **100** is accommodated in, and supported by, a first coupling groove **210** *a* of the first case **210**, and another end (e.g., a second end opposite to the first end) of the flexible display panel **100** is accommodated in, and supported by, a second coupling groove **220** *a* of the second case **220**. Hereinafter, surfaces of the first and second cases **210** and **220**, at the side of the first and second coupling grooves **210** *a* and **220** *a* on which the flexible display panel **100** is mounted are referred to as front surfaces, and surfaces on the opposite side of the first and second coupling grooves **210** *a* and **220** *a* are referred to as rear surfaces.

The first and second cases **210** and **220** are connected to each other via a link member, for example, a ribbed (or concave-convex-type) sheet (e.g., a metal sheet) **300**. In other words, both ends of the concave-convex type metal sheet **300** are attached to surfaces of the first and second cases **210** and **220** that face each other, such that the first and second cases **210** and **220** may be hinged. Accordingly, when the concave-convex type metal sheet **300** is moved between being bent or unbent, the first and second cases **210** and **220** are folded or unfolded.

Elastic pieces **400** are attached on stepped surfaces **212** and **222** (see **FIG. 2**) that are respectively formed on the first and second cases **210** and **220**, and thus the elastic pieces **400** connect the stepped surfaces **212** and **222** to each other. The elastic pieces **400** help the first and second cases **210** and **220** collectively maintain a flat state when the first and second cases **210** and **220** are unfolded. In other words, when being unfolded, the first and second cases **210** and **220** become flat in a straight or substantially straight line (see **FIGS. 4A and 5A**), and, when the first and second cases **210** and **220** are folded, the concave-convex type metal sheet **300** is bent, and thus the first and second cases **210** and **220** are folded to overlap with each other (see **FIGS. 4D and 5D**). The elastic pieces **400** secure (or hold) the first and second cases **210** and **220** such that the flexible display panel **100** may properly maintain a flat state when being unfolded.

When the first and second cases **210** and **220** are in the unfolded configuration, the case **200** should not be accidentally (or unintentionally) folded again in a folding direction. Thus, a slide cover **500** and a locking lever **600**, for example, may be included as locking units for preventing or inhibiting accidental (or unintentional) re-folding.

The slide cover **500** may be rotatably coupled to a rotational shaft **211** formed on the first case **210**, and may also be slidably coupled to a rail groove **221** formed in the second case **220**. Thus, while the first and second cases **210** and **220** are folded or unfolded, the slide cover **500** slides along the rail groove **221** while rotating about the rotational shaft **211**. In other words, the rail groove **221** is provided as a path along which the slide cover **500** may move during a rotating operation for folding or unfolding the first and second cases **210** and **220**, and, when the slide cover **500** does not move (or is hindered from moving) along the rail groove **221**, the first and second cases **210** and **220** enter a locking state in which the first and second cases **210** and **220** cannot rotate.

The locking lever **600** inhibits or stops rotation of the first and second cases **210** and **220**, namely, inhibits or stops re-folding of the first and second cases **210** and **220**, by preventing or inhibiting (e.g., selectively preventing) movement of the slide cover **500**. The locking lever **600** is rotatably mounted on a rear surface of the second case **220**.

FIGS. 3A and 3B respectively illustrate the foldable display apparatus according to one or more embodiments of the present invention in a locked configuration and an unlocked configuration according to movement of the locking lever **600** and the slide cover **500**.

Referring to **FIG. 3A**, the locking lever **600** may rotate in a direction indicated by arrow A on the second case **220**, and the slide cover **500** may slide in a direction indicated by arrow B. However, when the locking lever **600** has been rotated to be substantially perpendicular to the slide cover **500** as illustrated in **FIG. 3A**, the slide cover **500** may not move. In other words, if the locking lever **600** is not utilized, the slide cover **500** may move along the rail groove **221** because a path of movement of the slide cover **500** is not blocked. However, in a state (or configuration) as shown in **FIG. 3A**, because the locking lever **600** blocks the moving path of the slide cover **500**, the slide cover **500** is unable to move. When the first and second cases **210** and **220** rotate in a folding direction, the slide cover **500** naturally moves along the rail groove **221**. However, when the slide cover **500** is unable to move, the first and second cases **210** and **220** are unable to rotate. In other words, the first and second cases **210** and **220** are locked such that the first and second cases **210** and **220** may not be folded again from an unfolded state when the slide cover **500** is unable to move.

However, when the locking lever **600** is released from a locking position by being at least slightly rotated, as shown in **FIG. 3B**, the slide cover **500** is able to move along the rail groove **221** while also pushing (or further rotating) the locking lever **600**, and thus the first and second cases **210** and **220** are able to be folded in a direction indicated by arrow C. An insertion groove **223** may be formed in the rear surface of the second case **220**. The slide cover **500** and the locking lever **600** are inserted (or accommodated) in the insertion groove **223**, and thus do not protrude outward from a surface adjacent to the slide cover **500** and the locking lever **600**. As illustrated in **FIGS. 3A and 3B**, the insertion groove **223** restricts a sliding range of the slide cover **500**, and restricts a rotating range of the locking lever **600** to the area of the insertion groove **223**.

During folding, the first and second cases **210** and **220** are folded in a direction such that the flexible display panel **100** is exposed outwardly (see **FIGS. 4D and 5D**). During folding, a folded portion of the flexible display panel **100** is supported by the link member, for example, the concave-convex type metal sheet **300**. Because the folded portion is stably supported according to a curvature of the concave-convex type metal sheet **300** even when an external force is applied to the folded portion, the folded portion is neither easily wrinkled nor deformed.

Folding and unfolding operations are described in more detail below. Turning now to an internal structure of the flexible display panel **100**, the flexible display panel **100** may have, for example, a structure as shown in **FIG. 6**. In other words, a thin film transistor **121** and an organic light-emitting device **122** are included in the flexible display panel **100**, and the organic light-emitting device **122** includes an emission layer **122** *b* that is vulnerable to, particularly, contact with gas. In more detail, an active layer **121** *f* is formed on a buffer layer **121** *a* that is adjacent to a flexible substrate **123**, and the active layer **121** *f* has source and drain regions doped with N-type or P-type impurities at a high concentration. The active layer **121** *f* may include an oxide semiconductor. For example, the oxide semiconductor may include an oxide of a material selected from the group consisting of Groups 4, 12, 13, and 14 metal elements, such as zinc (Zn), indium (In), gallium (Ga), stannum (Sn), cadmium (Cd), germanium (Ge), hafnium (Hf), and/or a combination thereof. For example, the active layer **121** *f* may include G-I-Z-O [(In2O3a(Ga2O3b(ZnO)c], wherein a, b, and c are integers that respectively satisfy a≥0, b≥0, and c>0. A gate insulating layer **121** *b* is formed on the active layer **121** *f*, and a gate electrode **121** *g* is formed on the gate insulating layer **121** *b*. A source electrode **121** *h* and a drain electrode **121** *i* are formed on the gate electrode **121** *g*. An interlayer insulating layer **121** *c* is included between the gate electrode **121** *g* and each of the source electrode **121** *h* and the drain electrode **121** *i*, and a passivation layer **121** *d* is interposed between an anode **122** *a* of the organic light-emitting device **122** and each of the source electrode **121** *h* and the drain electrode **121** *i*.

The organic light-emitting device **122** includes an insulative planarization layer **121** *e* (e.g., a pixel defining layer), which may include acryl, for example, on the anode **122** *a*, and also includes an aperture **122** *d* that is formed in the insulative planarization layer **121** *e*.

The organic light-emitting device **122** displays an image (e.g., predetermined image information) by emitting red, green, and blue light as current flows therethrough. The organic light-emitting device **122** includes the anode **122** *a*, which is connected to the drain electrode **121** *i* of the thin film transistor **121**, and to which a positive power voltage is applied, includes a cathode **122** *c*, which is formed to cover the entire pixel, and to which a negative power voltage is applied, and also includes the emission layer **122** *b*, which is disposed between the anode **122** *a* and the cathode **122** *c* to emit light.

A hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL) and an electron injection layer (EIL), for example, may be stacked adjacent to the emission layer **122** *b*.

For reference, the emission layer **122** *b* may be formed in each pixel to form a single unit pixel that includes pixels that emit red, green, and blue light beams. The emission layers **122** *b* formed in the pixels may be spaced apart from one another. Alternatively, an emission layer may be commonly formed over the entire pixel region, regardless of locations of the pixels. In this case, the emission layer **122** *b* may be formed by stacking a light-emitting substance that is configured to emit a red light, a light-emitting substance that is configured to emit a green light, and a light-emitting substance that is configured to emit a blue light on one another, or by mixing a light-emitting substance that is configured to emit a red light, a light-emitting substance that is configured to emit a green light, and a light-emitting substance that is configured to emit a blue light. Any combination of other various colors that is capable of emitting white light may be utilized in addition to, or as an alternative to, a combination of red, green, and blue colors. The flexible display panel **100** may further include a color converting layer or a color filter that converts the white light into a light of a corresponding color.

In other embodiments, a thin film encapsulation layer, in which an organic layer and an inorganic layer are alternately stacked on one another, may be additionally formed on the cathode **122** *c*.

Because the flexible display panel **100** is flexibly deformable, the flexible display panel **100** may be used while being folded or unfolded according to folding and unfolding operations of the case **200**.

A foldable display apparatus as described above may be used as shown in **FIGS. 4A-4D** and **FIGS. 5A-5D**. **FIGS. 4A-4D** are side views sequentially showing a change in the state of the foldable display apparatus from an unfolded state/configuration to a folded state/configuration. **FIGS. 5A-5D** are rear surface perspective views respectively corresponding to the processes of **FIGS. 4A-4D**.

First, when the foldable display apparatus is in an unfolded configuration where the foldable display apparatus is flat or substantially flat, the first case **210** and the second case **220** are unfolded to form a straight or substantially straight line, as shown in **FIGS. 4A and 5A**.

At this time, the locking lever **600** is in a state of blocking the slide cover **500** from moving along the rail groove **221**. In other words, because the locking lever **600** blocks a moving path of the slide cover **500**, the slide cover **500** is unable to move, and, as described above, the first and second cases **210** and **220** are also unable to move or rotate. Thus, the unfolded state in which the first and second cases **210** and **220** are unfolded to form a straight line is maintained. Accordingly, a user is able to view a plane image via the flexible display panel **100** that is unfolded to be flat.

When the foldable display apparatus is stored or carried, for example, the locking lever **600** may be released, and the case **200** may be folded. To fold the case **200**, when the locking lever **600** is slightly rotated, as shown in **FIGS. 4B and 5B**, the slide cover **500** is able to move along the rail groove **221** while pushing or further rotating the locking lever **600**, and thus the first and second cases **210** and **220** are folded in a folding direction.

The first and second cases **210** and **220** may be folded past an angle of 90 degrees, as shown in **FIGS. 4C and 5C**, and may be folded to overlap with each other, as shown in **FIGS. 4D and 5D**. In this case, the flexible display panel **100** is outwardly exposed. Thus, even when the flexible display panel **100** is folded, a user may view an image displayed on the flexible display panel **100**. Because the folded portion of the flexible display panel **100** is stably supported by the concave-convex type metal sheet **300**, the folded portion is neither easily wrinkled nor deformed by an external force.

In the unfolded configuration, as shown in **FIGS. 4A and 5A**, a center CL of the body of the slide cover **500** is located at an area adjacent the concave-

convex type metal sheet **300**. However, in the folded configuration, as shown in **FIGS. 4D and 5D**, the center CL of the body of the slide cover **500** is moved to be at an area adjacent the second case **220**.

On the other hand, when display apparatus is moved from the folded configuration to the unfolded configuration, the above-described process during folding is conducted in reverse order. When the unfolding has been completed, the locking lever **600** is rotated, as shown in **FIGS. 4A and 5A**, to prevent or inhibit the slide cover **500** from moving, and thus the unfolding state is stably maintained. Thus, a flat state of the display apparatus may be maintained (e.g., firmly maintained), and a stable plane image may be displayed.

Therefore, when the foldable display apparatus according to one or more exemplary embodiments of the present invention is folded, the foldable display apparatus may stably support a folded portion of a flexible display panel without wrinkling or breaking, and thus damage to the flexible display panel may be prevented, or the likelihood thereof may be reduced. When the foldable display apparatus is unfolded, the flexible display panel may be firmly maintained in a flat state, and thus a stable plane image may be displayed.

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

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