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. 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., in 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 210a 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 220a 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 210a and 220a 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 210a and 220a 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 connected to a rotational shaft 211 formed on the first case 210, and may also be slidably connected 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 rotate. 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 blocked. However, in a state (or configuration) as shown in FIG. 3A, because the locking lever 600 is rotated to be substantially perpendicular to the slide cover 500, the slide cover 500 is unable to move, and thus 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 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 outward (see FIGS. 4A 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 Group 4, 12, 13, and 14, and 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 includes an insulating layer 121 g that is formed on the source and drain region doped with N-type or P-type impurities at a high concentration. The insulating layer 121 g may include an oxide semiconductor. For example, the oxide semiconductor may include an oxide of a material selected from the group consisting of Group 4, 12, 13, and 14, and metal elements, such as zinc (Zn), indium (In), gallium (Ga), stannum (Sn), cadmium (Cd), germanium (Ge), hafnium (Hf), and/or a combination thereof.

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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.