

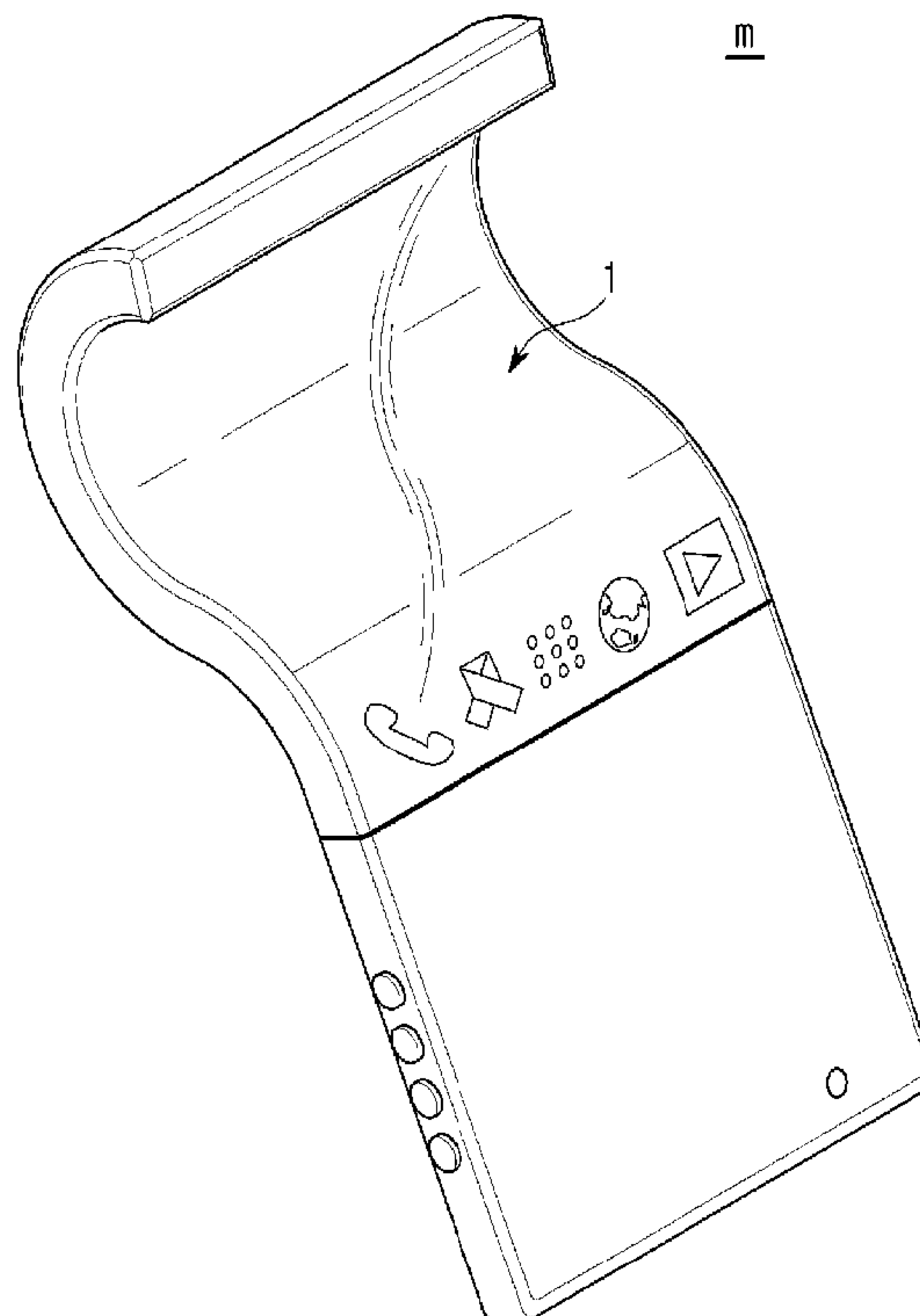


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(54) Title: WINDOW COVER AND DISPLAY APPARATUS HAVING THE SAME AND METHOD OF MANUFACTURING
DISPLAY APPARATUS

[Fig. 1]



(57) Abrégé/Abstract:

Disclosed herein are a display apparatus having an improved structure to satisfy flexibility and durability at the same time and a method of manufacturing the same. The display apparatus includes a display panel to display an image, and a window cover



(57) **Abrégé(suite)/Abstract(continued):**

having a first portion disposed to be integrally bent with the display panel and positioned at an inside of a bending direction and a second portion positioned at an outside of the bending direction and having different stiffness from the first portion.

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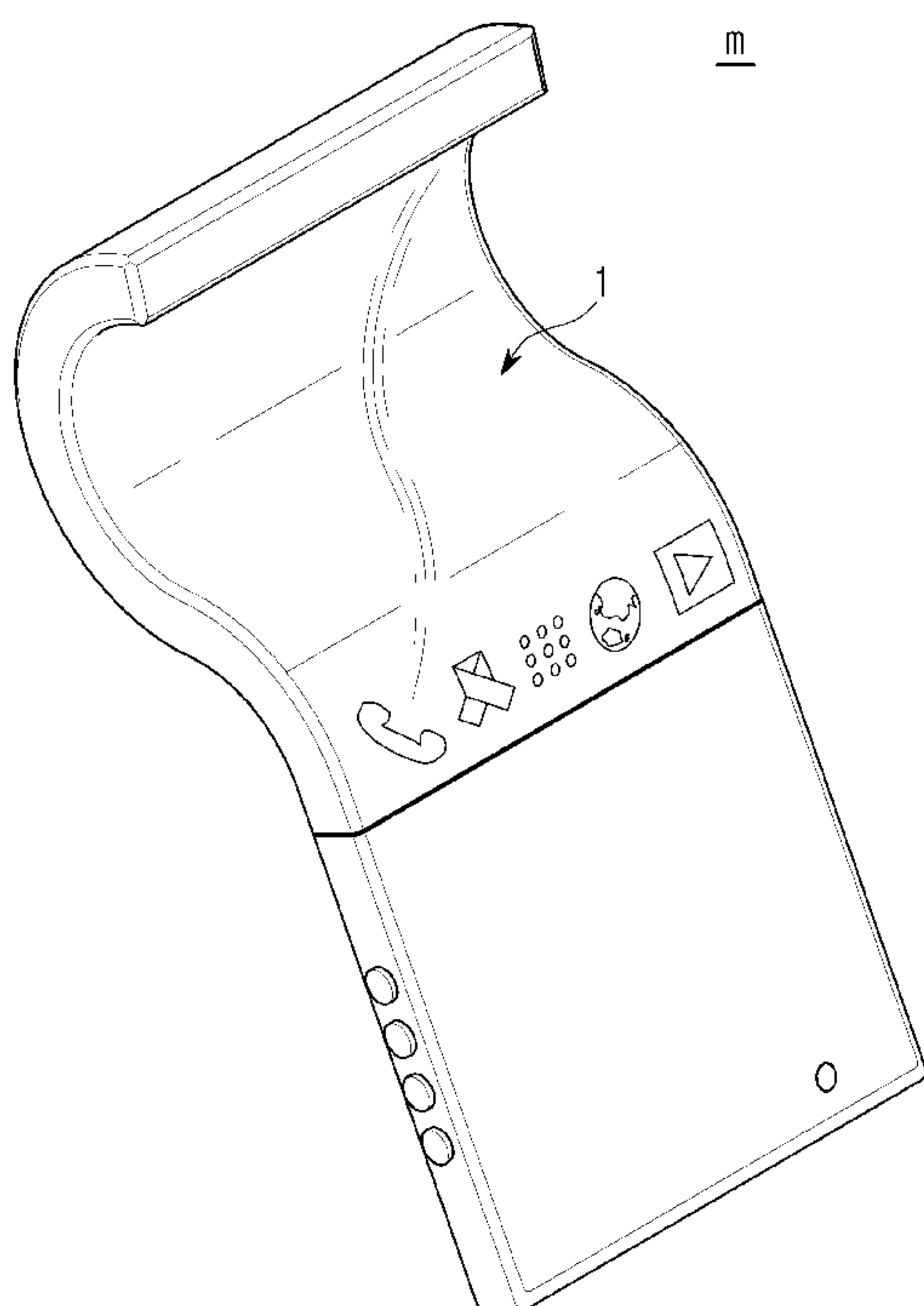
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[Continued on next page]

(54) Title: WINDOW COVER AND DISPLAY APPARATUS HAVING THE SAME AND METHOD OF MANUFACTURING
DISPLAY APPARATUS



(57) Abstract: Disclosed herein are a display apparatus having an improved structure to satisfy flexibility and durability at the same time and a method of manufacturing the same. The display apparatus includes a display panel to display an image, and a window cover having a first portion disposed to be integrally bent with the display panel and positioned at an inside of a bending direction and a second portion positioned at an outside of the bending direction and having different stiffness from the first portion.

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Description

Title of Invention: WINDOW COVER AND DISPLAY APPARATUS HAVING THE SAME AND METHOD OF MANUFACTURING DISPLAY APPARATUS

Technical Field

- [1] The present invention relates to a window cover and a display apparatus having the same and a method of manufacturing the display apparatus, and more particularly, to a window cover having an improved structure to simultaneously satisfy flexibility and durability and a display apparatus having the same and a method of manufacturing the display apparatus.

Background Art

- [2] A display apparatus is an apparatus which displays visual and three-dimensional image information and includes a liquid crystal display (LCD) device, an electroluminescence display (ELD) device, a field emission display (FED) device, a plasma display panel (PDP), a thin film transistor liquid crystal display (TFT-LCD), and the like.
- [3] The display apparatuses have been used in various electronic devices such as a television, a computer monitor, a laptop, a portable terminal, a display unit of a refrigerator, a display unit of a camera, and the like.
- [4] The above display apparatuses perform user interfacing using various input devices such as a keyboard, a mouse, a digitizer, a touch panel, and the like.
- [5] Among these, the touch panel is a device which is installed at a display surface of a display panel to form a touchable display apparatus (referred to as a touch screen) and allows a user to select desired information while viewing an image, thus being simply manipulated, not malfunctioning often, being able to input even without using a separate input device, and having convenience in which a user can promptly and easily manipulate through content displayed on the screen.
- [6] Recently, a foldable display device which reflects a soft electronics trend has been gaining much attention. Particularly, a consumer demand for a foldable display device which simultaneously has flexibility (bendability) and durability has been sharply increasing.

Disclosure of Invention

Technical Problem

- [7] One aspect of the present invention provides a window cover having an improved structure to simultaneously secure flexibility and durability and a display apparatus

having the same.

[8] Another aspect of the present invention provides a window cover having an improved structure to prevent inner parts from being corroded due to gas or moisture and a display apparatus having the same.

[9] Still another aspect of the present invention provides a window cover having an improved structure to manufacture a thin film and a display apparatus having the same.

[10] Yet another aspect of the present invention provides a method of manufacturing a display apparatus which is capable of reducing cracks or curls that may occur in a manufacturing process.

Solution to Problem

[11] According to an aspect of the present invention, a display apparatus includes a display panel to display an image, and a window cover having a first portion disposed to be integrally bent with the display panel and positioned at an inside thereof in a bending direction and a second portion positioned at an outside thereof in the bending direction and having a different stiffness from the first portion.

[12] The stiffness of the first portion may be greater than the stiffness of the second portion.

[13] The thickness of the first portion may be thicker than the thickness of the second portion.

[14] The window cover may be bent such that the first portion has a smaller radius of curvature than the second portion.

[15] The window cover may be bent such that the first portion has the radius of curvature of 5 mm or less.

[16] A ratio of the thickness of the second portion with respect to the thickness of the first portion may be 0.4 or less.

[17] The first portion may have a thickness in a range of 40 mm to 75 mm.

[18] The second portion may have a thickness of 30 mm or less.

[19] Materials of the first portion and the second portion may include an acrylic-based resin.

[20] A Young's modulus of the first portion may be greater than a Young's modulus of the second portion.

[21] The second portion may be formed of a material with a greater tensile strength than the first portion.

[22] The window cover may further include a base layer disposed between the first portion and the second portion.

[23] A material of the base layer may include a plastic.

[24] The material of the base layer may include at least one of polymethyl methacrylate

(PMMA), a polycarbonate (PC), polyethylene terephthalate (PET), polyethylene naphthalate (PEN), and a colorless polyimide (CPI).

[25] The base layer may have a thickness in a range of 150 mm to 190 mm.

[26] At least one among the base layer, the first portion, and the second portion may have a pencil hardness of 9H.

[27] The window cover may further include a blocking layer disposed on the base layer to face at least one of the first portion and the second portion in order to prevent moisture or gas from being introduced into the display apparatus.

[28] A material of the blocking layer may include at least one of silica and alumina.

[29] According to an aspect of the present invention, a flexible display apparatus includes a display panel to display an image, a touch panel disposed adjacent to the display panel to output a touch signal, and a window cover disposed to face the display panel while having the touch panel therebetween and formed of a transparent plastic material, wherein the window cover may include a base layer, a first protective layer disposed on the base layer to be positioned at an inside of the base layer in a bending direction of the display apparatus, and a second protective layer disposed on the base layer to be positioned at an outside of the base layer in a bending direction of the display apparatus and having a different physical property from the first protective layer.

[30] A thickness of the first protective layer may be thicker than a thickness of the second protective layer.

[31] A ratio of the thickness of the second protective layer with respect to the thickness of the first protective layer may be 0.4 or less.

[32] The window cover may be bent such that the first protective layer has a radius of curvature of 5 mm or less.

[33] At least one of the base layer, the first protective layer, and the second protective layer may have a pencil hardness of 9H.

[34] A thickness of the base layer may be thicker than the thickness of at least one of the first protective layer and the second protective layer.

[35] The window cover may further include a blocking layer disposed on the base layer to face at least one of the first protective layer and the second protective layer in order to prevent moisture or gas from being introduced into the display apparatus.

[36] A material of the blocking layer may include at least one of silica and alumina.

[37] The second protective layer may be formed of a material with a greater tensile strength than the first protective layer.

[38] A method of manufacturing the display apparatus according to an aspect of the present invention including a window cover having a base layer includes disposing a first protective layer and a second protective layer to face each other while having the

base layer therebetween, and processing at least one of the first protective layer and the second protective layer such that the first protective layer and the second protective layer have different thicknesses.

[39] The first protective layer and the second protective layer may be respectively disposed on both surfaces of the base layer in the same thicknesses.

[40] At least one of the first protective layer and the second protective layer may be processed by a chemical mechanical polishing (CMP) process.

[41] The method of manufacturing the display apparatus according to an aspect of the present invention may further include disposing a blocking layer on the base layer to face at least one of the first protective layer and the second protective layer before the disposing of the first protective layer and the second protective layer to face each other while having the base layer therebetween.

[42] The blocking layer may be deposited on the base layer.

[43] The window cover according to an aspect of the present invention may be used in a display apparatus having a display panel to display an image, and the window cover may include a first portion disposed to be integrally bent with the display panel and positioned at an inside thereof in a bending direction and a second portion positioned at an outside thereof in the bending direction and having a different stiffness from the first portion.

[44] The stiffness of the first portion may be greater than the stiffness of the second portion.

[45] The thickness of the first portion may be thicker than the thickness of the second portion.

[46] The window cover may be bent such that the first portion has a smaller radius of curvature than the second portion.

Advantageous Effects of Invention

[47] A window cover including a first protective layer and a second protective layer having an asymmetrical structure is applied to a display apparatus, thereby simultaneously securing flexibility and durability.

[48] The window cover is manufactured with a transparent plastic material, thereby implementing a bendable display apparatus.

[49] A blocking layer is formed at the window cover, thereby preventing moisture or gas from permeating into an inner portion of the display apparatus.

[50] A chemical mechanical polishing (CMP) process is used to adjust thicknesses of the first protective layer and the second protective layer of the window cover, thereby reducing cracks or curls that may occur in a process of manufacturing the window cover.

Brief Description of Drawings

- [51] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:
- [52] FIG. 1 is an exemplary view of a display apparatus according to an embodiment of the present invention.
- [53] FIG. 2 is another exemplary view of a display apparatus according to an embodiment of the present invention.
- [54] FIG. 3 is a configuration diagram of a display apparatus according to an embodiment of the present invention.
- [55] FIGS. 4A and 4B are cross-sectional views illustrating a structure in which a direct type backlight unit is applied to a display apparatus according to an embodiment of the present invention.
- [56] FIGS. 5A and 5B are cross-sectional views illustrating a structure in which an edge type backlight unit is applied to a display apparatus according to an embodiment of the present invention.
- [57] FIG. 6 is an exemplary view illustrating a touch panel according to a first embodiment, in the display apparatus according to an embodiment of the present invention.
- [58] FIG. 7 is a cross-sectional view illustrating a first pattern unit provided in the touch panel according to the first embodiment of FIG. 6.
- [59] FIG. 8 is a cross-sectional view illustrating a second pattern unit provided in the touch panel according to the first embodiment of FIG. 6.
- [60] FIG. 9 is a cross-sectional view illustrating a structure in which a touch panel according to a second embodiment is applied to the display apparatus according to an embodiment of the present invention.
- [61] FIG. 10 is a cross-sectional view illustrating a structure in which a touch panel according to a third embodiment is applied to the display apparatus according to an embodiment of the present invention.
- [62] FIG. 11 is a cross-sectional view illustrating a window cover according to a first embodiment, in the display apparatus according to an embodiment of the present invention.
- [63] FIG. 12 is a view illustrating a bent state of the window cover according to the first embodiment, in the display apparatus according to an embodiment of the present invention.
- [64] FIG. 13 is a graph showing flexural characteristics of the window cover according to the first embodiment in accordance with a thickness ratio between a first protective

layer and a second protective layer of the window cover according to the first embodiment, in the display apparatus according to an embodiment of the present invention.

[65] FIG. 14 is a graph showing relations between a thickness of the first protective layer and a radius of curvature and hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11.

[66] FIG. 15 is a graph showing relations between a thickness of the second protective layer and a radius of curvature and hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11.

[67] FIG. 16 is a graph showing a relation between a thickness of a base layer and the hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11.

[68] FIG. 17 is a cross-sectional view illustrating a window cover according to a second embodiment, in the display apparatus according to an embodiment of the present invention.

[69] FIG. 18 is a flow chart showing a process of manufacturing the window cover of the display apparatus according to an embodiment of the present invention.

[70] FIG. 19 is a view schematically illustrating a manufacturing apparatus for manufacturing the window cover of the display apparatus according to an embodiment of the present invention.

Mode for the Invention

[71] Reference will now be made in detail to embodiments of the disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. Meanwhile, terms such as “front end”, “rear end”, “upper”, “lower”, “upper end” and “lower end” which will be used in the below description are defined based on the drawings, and a shape and a position of each element are not limited by the terms.

[72] FIG. 1 is an exemplary view of a display apparatus according to an embodiment of the present invention, and FIG. 2 is another exemplary view of a display apparatus according to an embodiment of the present invention.

[73] When a person's hand or an object touches a screen, a display apparatus having a touch panel recognizes a touch position and a position change and checks a gesture corresponding to the position change, checks an operation command corresponding to the touch position or an operation command corresponding to the gesture, performs a function corresponding to the checked operation command, and displays an image related to the function performed.

[74] As illustrated in FIGS. 1 and 2, the display apparatus may have flexibility. That is,

the display apparatus may be formed of a foldable material, and include a display unit capable of displaying an image. The display apparatus may be folded along at least one virtual folding line 1a (refer to FIG. 2). In addition, the display apparatus may be bent or curled (refer to FIG. 1.). Thus, the display apparatus having flexibility may be easily stored and carried. Also, since the display apparatus having flexibility may display an image while folded, bent, or curled, various screen configurations are possible.

Moreover, since various design attempts which were difficult to implement in a conventional rigid display apparatus are possible, the display apparatus having flexibility may have excellent usability in many fields.

[75] As illustrated in FIGS. 1 and 2, the display apparatus may be implemented as display units of mobile devices (m,n) such as a smartphone, a tablet, and a laptop.

[76] In addition, the display apparatus may be implemented as a monitor of a television and a PC, and may be implemented as guide display devices in a bus station, a subway station, and a department store. However, an application range of the display apparatus having flexibility is not limited to the above examples.

[77] FIG. 3 is a block diagram of a display apparatus according to an embodiment of the present invention.

[78] As illustrated in FIG. 3, a display apparatus 1 may include a display panel 100. The display panel 100 may display an image such as a character, a figure, a photo, etc.

[79] The display panel 100 may include at least one display panel among a liquid crystal display (LCD) panel, an electroluminescence display (ELD) panel, a field emission display (FED) panel, a plasma display panel (PDP), a thin film transistor liquid crystal display (TFT-LCD), and an organic light-emitting diode (OLED) display panel.

[80] The display apparatus 1 may further include a touch panel 200.

[81] The touch panel 200 may be disposed adjacent to the display panel 100. When touched by a user, the touch panel 200 may output a touch signal. The touch panel 200 will be described in detail below.

[82] The display apparatus 1 may further include a window cover 300.

[83] The window cover 300 may be disposed to face the display panel 100 while having the touch panel 200 therebetween. The window cover 300 may be formed on a surface of the display apparatus 1 to be directly or indirectly touched by the user. When described in different terms, the window cover 300 may be used in the display apparatus 1 having the display panel 100.

[84] The display panel 100, the touch panel 200, and the window cover 300 may have a stacked structure. The display panel 100 may be disposed below the touch panel 200, and the window cover 300 may be disposed above the touch panel 200. In other words, the display panel 100 may be disposed at an upstream side in a direction in which light emitted from a backlight unit 120 (refer to FIGS. 4A and 4B) of the display panel 100

moves. The window cover 300 may be disposed at a lower flow side in the direction in which the light emitted from the backlight unit 120 (refer to FIGS. 4A and 4B) of the display panel 100 moves. The touch panel 200 may be disposed between the display panel 100 and the window cover 300.

[85] The window cover 300 may be integrally bent with the display panel 100 and the touch panel 200. The window cover 300 will be described in detail below.

[86] The display apparatus 1 may further include a first gap portion 410 formed between the display panel 100 and the touch panel 200 and a second gap portion 420 formed between the touch panel 200 and the window cover 300.

[87] The first gap portion 410 may be formed with an air gap, or an optical clear adhesive (OCA) may be formed therein.

[88] The second gap portion 420 may have the optical clear adhesive (OCA) formed therein.

[89] Here, the OCA may be formed from an adhesive composition which includes an adhesive resin such as an acrylic-based resin, a silicon-based resin, a styrene-based resin, a polyester-based resin, a rubber-based resin, or a urethane-based resin solely or in a mixture of two or more thereof.

[90] The display apparatus 1 may further include a drive module 500 to check a position of a touch point based on a touch signal output from the touch panel 200, check an icon displayed at the checked position of the touch point, control the display apparatus 1 to perform a function corresponding to the checked icon, and control the display apparatus 1 such that a result of performing the function is displayed on the display panel 100.

[91] The drive module 500 may also check a gesture performed on the touch panel 200 based on a position change of a touch point, check an operation command corresponding to the checked gesture, and control an operation of the display panel 100.

[92] Furthermore, an image such as a character, a figure, a photo, etc. displayed on the display panel 100 has display position information.

[93] An inner structure of the display apparatus 1 may be different in accordance with a type of a backlight unit for transmitting light to the display panel 100.

[94] FIGS. 4A and 4B are cross-sectional views illustrating a structure in which a direct type backlight unit is applied to a display apparatus according to an embodiment of the present invention. Hereinafter, a liquid crystal display (LCD) device will be exemplarily described.

[95] As illustrated in FIG. 4A, the display apparatus 1 may include the display panel 100, the touch panel 200, and the window cover 300 disposed within an outer bezel 2a for forming an exterior.

[96] The first gap portion 410 formed between the display panel 100 and the touch panel

200 and the second gap portion 420 formed between the touch panel 200 and the window cover 300 may be provided within the outer bezel 2a.

[97] The first gap portion 410 may be formed with an air gap. The second gap portion 420 may include the optical clear adhesive (OCA) provided therein.

[98] The first gap portion 410 between the display panel 100 and the touch panel 200 may be maintained at a predetermined distance by an inner bezel 150.

[99] Specifically, the display panel 100 may include a liquid crystal panel 110, the backlight unit 120, a diffusion plate 130, and an optical sheet 140.

[100] The liquid crystal panel 110 corresponds to an image formation panel which adjusts the transmittance of light passing through a liquid crystal layer to form an image such as a character, a number, a random icon, etc. Since the liquid crystal panel 110 cannot emit light from the liquid crystal itself, an image is shown by adjusting a transmitted amount and color of light emitted from the backlight unit 120.

[101] The backlight unit 120 is disposed at a rear surface of the liquid crystal panel 110 and serves to emit light to the liquid crystal panel 110. The backlight unit 120 is a light source device which emits light at a back surface of the liquid crystal panel 110 and is a direct type LED light source device.

[102] The backlight unit 120 may include a plurality of light sources (not shown) to emit light using power supplied from an optical drive unit (not shown), and the plurality of light sources may include a light-emitting diode (LED) to generate light with high efficiency and low power.

[103] The diffusion plate 130 serves to increase light of the backlight unit 120 and uniformly maintain brightness of a whole surface. The diffusion plate 130 may be positioned between the liquid crystal panel 110 and the backlight unit 120. The diffusion plate 130 is a semitransparent panel which diffuses light emitted from the backlight unit 120 along a surface to allow color and brightness to be uniformly shown throughout a screen, and improves luminance, etc. of light emitted from the backlight unit 120 to supply the light to the display panel 100.

[104] The optical sheet 140 may be disposed between the liquid crystal panel 110 and the diffusion plate 130. The optical sheet 140 serves to protect the display panel 100 from an external impact.

[105] The optical sheet 140 decreases the luminance of red (R) and green (G) and increases the luminance of blue (B) in light incident on the liquid crystal panel 110 in order to improve optical characteristics.

[106] The display panel 100 may further include an electromagnetic wave shielding layer for shielding electromagnetic waves in order to prevent electromagnetic waves incident on the display panel 100 from being emitted to the outside.

[107] The display panel 100 may further include an infrared ray shielding layer for

shielding infrared rays emitted from the display panel 100 in order to prevent infrared rays equal to or higher than a reference level from being emitted to the outside such that signals transmitted using infrared rays such as a remote control are normally transmitted.

[108] The display panel 100 may further include the inner bezel 150 disposed at side edges of the liquid crystal panel 110, the optical sheet 140, and the diffusion plate 130 to fix and cover the liquid crystal panel 110, the optical sheet 140, and the diffusion plate 130.

[109] The inner bezel 150 may be coupled to a frame 2b at which the backlight unit 120 is disposed. Also, the inner bezel 150 may be coupled to the outer bezel 2a. The inner bezel 150 allows the display panel 100 and the touch panel 200 to remain a predetermined interval apart.

[110] Various types of printed circuit boards, input and output devices etc. may be mounted on the frame 2b.

[111] The frame 2b may be formed of a metal with excellent heat dissipation and strength.

[112] The drive module 500 for operating the liquid crystal panel 110, the backlight unit 120, and the touch panel 200 may be disposed in the frame 2b.

[113] As illustrated in FIG. 4B, the display apparatus 1 may include the display panel 100, the touch panel 200, and the window cover 300 disposed within the outer bezel 2a for forming the exterior.

[114] The first gap portion 410 formed between the display panel 100 and the touch panel 200, and the second gap portion 420 formed between the touch panel 200 and the window cover 300 may be provided within the outer bezel 2a.

[115] The optical clear adhesive (OCA) fills the first gap portion 410 and the second gap portion 420.

[116] Since the display panel 100 having the direct type backlight unit 120 is the same as the display panel 100 of FIG. 4A, the description thereof will be omitted.

[117] FIGS. 5A and 5B are cross-sectional views illustrating a structure in which an edge type backlight unit is applied to a display apparatus according to an embodiment of the present invention. Hereinafter, a liquid crystal display (LCD) device will be exemplarily described.

[118] As illustrated in FIG. 5A, the display apparatus 1 may include the display panel 100, the touch panel 200, and the window cover 300 disposed within the outer bezel 2a for forming the exterior.

[119] The first gap portion 410 formed between the display panel 100 and the touch panel 200, and the second gap portion 420 formed between the touch panel 200 and the window cover 300 may be provided within the outer bezel 2a.

[120] The first gap portion 410 may be formed with an air gap. The second gap portion 420

may include the optical clear adhesive (OCA) provided therein.

[121] The first gap portion 410 between the display panel 100 and the touch panel 200 may be maintained at a predetermined distance by the inner bezel 150.

[122] Specifically, the display panel 100 may include the liquid crystal panel 110, the backlight unit 120, and the optical sheet 140.

[123] The liquid crystal panel 110 corresponds to an image formation panel which adjusts the transmittance of light passing through a liquid crystal layer to form an image such as a character, a number, a random icon, etc.

[124] The backlight unit 120 is disposed at a rear surface of the liquid crystal panel 110 and serves to emit light to the liquid crystal panel 110. The backlight unit 120 is a light source device for emitting light from a side surface of the liquid crystal panel 110, and is an edge type LED light source device.

[125] The backlight unit 120 may include a plurality of optical modules 121, a light guide plate 122 disposed between the plurality of optical modules 121, and a reflective sheet 123.

[126] The plurality of optical modules 121 may include a light-emitting diode (LED) to generate light with high efficiency and low power.

[127] The light guide plate 122 serves to guide incident light to the liquid crystal panel 110. The light guide plate 122 may have a transmission material capable of transmitting light. The material of the light guide plate 122 may include a plastic. As an example, the material of the light guide plate 122 may include at least one of polymethyl methacrylate (PMMA) and a polycarbonate (PC). The light guide plate 122 may be formed as a flat type.

[128] The light guide plate 122 has superior transparent, weatherproofing, and tinting characteristics, thus inducing diffusion of light when the light is transmitted.

[129] The reflective sheet 123 is disposed between the light guide plate 122 and the frame 2b, and reflects light provided from the light guide plate 122 to a side surface or a front surface of the light guide plate 122.

[130] The optical sheet 140 may be disposed between the liquid crystal panel 110 and the light guide plate 122. The optical sheet 140 uniformizes the luminance of light output from the light guide plate 122. Also, the optical sheet 140 improves optical characteristics using diffusion or a method of condensing high-luminance light, and then provides the light to the liquid crystal panel 110. Also, the optical sheet 140 decreases the luminance of red (R) and green (G) and increases the luminance of blue (B) to improve the optical characteristics.

[131] The optical sheet 140 is a sheet disposed between the display panel 100 and the backlight unit 120, and may include a prism sheet on which a prism is formed, and a dual brightness enhancement film (DBEF) by a multilayered birefringent coating.

- [132] The display panel 100 may further include the frame 2b. The frame 2b may accommodate the backlight unit 120 and the optical sheet 140.
- [133] The display panel 100 may further include the inner bezel 150. The inner bezel 150 may accommodate the liquid crystal panel 110 and may be coupled to the frame 2b. The inner bezel 150 may be coupled to the outer bezel 2a.
- [134] Various types of printed circuit boards, input and output devices etc. may be mounted on the frame 2b.
- [135] The frame 2b may be formed of a metal with excellent heat dissipation and strength.
- [136] The drive module 500 for operating the liquid crystal panel 110, the backlight unit 120, and the touch panel 200 may be disposed in the frame 2b.
- [137] As illustrated in FIG. 5B, the display apparatus 1 may include the display panel 100, the touch panel 200, and the window cover 300 disposed within the outer bezel 2a for forming the exterior.
- [138] The first gap portion 410 formed between the display panel 100 and the touch panel 200, and the second gap portion 420 formed between the touch panel 200 and the window cover 300 may be provided within the outer bezel 2a.
- [139] The optical clear adhesive (OCA) fills the first gap portion 410 and the second gap portion 420.
- [140] Since the display panel 100 having the edge type backlight unit 120 is the same as the display panel 100 of FIG. 5A, the description thereof will be omitted.
- [141] FIG. 6 is an exemplary view illustrating a touch panel according to a first embodiment, in the display apparatus according to an embodiment of the present invention.
- [142] As illustrated in FIG. 6, the touch panel 200 according to the first embodiment may include a first pattern unit 210, a second pattern unit 220, and an insulation unit 230.
- [143] The first pattern unit 210 may include a plurality of first electrodes. The plurality of first electrodes may be disposed to be spaced apart at regular intervals in a first direction X.
- [144] The first pattern unit 210 receives a signal transmitted from the external drive module 500.
- [145] The second pattern unit 220 may include a plurality of second electrodes. The plurality of second electrodes may be disposed to be spaced apart at regular intervals in a second direction Y.
- [146] The second pattern unit 220 outputs a signal to the external drive module 500.
- [147] One electrode among the plurality of first electrodes and the plurality of second electrodes is a driving electrode to which predetermined voltage is applied, and another electrode among the plurality of first electrodes and the plurality of second electrodes is a sensing electrode which outputs a voltage signal in response to a touch.

- [148] The first direction X and the second direction Y are directions crossing each other.
- [149] The insulation unit 230 may have a transparent material. The insulation unit 230 may be disposed between the first pattern unit 210 and the second pattern unit 220. The insulation unit 230 allows the second pattern unit 220 to be adhered to the first pattern unit 210, and insulates the first pattern unit 210 and the second pattern unit 220.
- [150] The insulation unit 230 may include an adhesive. The adhesive may include at least one of an acrylic-based resin, a silicon-based resin, a styrene-based resin, a polyester-based resin, a rubber-based resin, a urethane-based resin, an isocyanate-based resin, a polyvinyl alcohol-based resin, a gelatin-based resin, and a vinyl polymer-based resin.
- [151] The adhering method may be performed by a method of applying an adhesive on a surface of one of the first pattern unit 210 and the second pattern unit 220, adhering the other one of the first pattern unit 210 and the second pattern unit 220, and drying.
- [152] The applying method is a flexible method which may use, a Mayer bar, an air knife, a gravure, a reverse roll, a kiss-roll, a spray, a blade, a die coater, casting, and spin coating.
- [153] The touch panel 200 may further include a wiring unit 240 to apply a signal of predetermined voltage to the plurality of first electrodes and sense a changed voltage of the signal at the plurality of second electrodes.
- [154] The wiring unit 240 may include a first wiring unit 241 and a second wiring unit 242.
- [155] The first wiring unit 241 is connected to the first pattern unit 210. The first wiring unit 241 serves to receive a voltage signal transmitted from the drive module 500 and transmit the input voltage signal to the first pattern unit 210.
- [156] The second wiring unit 242 is connected to the second pattern unit 220. The second wiring unit 242 serves to receive a sensed voltage signal and transmit the received voltage signal to the drive module 500.
- [157] Each of the first wiring unit 241 and the second wiring unit 242 may include a flexible printed circuit board (FPCB).
- [158] Materials of the first wiring unit 241 and the second wiring unit 242 may include a material with superior electrical conductivity. Specifically, the materials of the first wiring unit 241 and the second wiring unit 242 may include an Ag paste, a material composed of organic Ag, a conductive polymer, carbon black (including CNT), a metal oxide, or a metal. As an example of the metal, Al, AlNd, Mo, MoTi, Cu, CuOx, Cr, etc. may be included.
- [159] A method of forming the first wiring unit 241 and the second wiring unit 242 may include screen printing, gravure printing, or inkjet printing, etc.
- [160] FIG. 7 is a cross-sectional view illustrating a first pattern unit provided in the touch panel according to the first embodiment of FIG. 6, and FIG. 8 is a cross-sectional view illustrating a second pattern unit provided in the touch panel according to the first em-

bodiment of FIG. 6.

[161] As illustrated in FIG. 7, the first pattern unit 210 may include a first film unit 211 and a first electrode unit 212 having a plurality of first electrodes disposed at the first film unit 211.

[162] The first film unit 211 may be formed of a material having bearing power and transparency.

[163] The material of the first film unit 211 may include a plastic film such as polyethylene terephthalate (PET), polycarbonate (PC), polymethyl methacrylate (PMMA), polyethylene naphthalate (PEN), polyether sulfone (PES), a cyclic olefin copolymer (COC), a triacetyl cellulose (TAC) film, a polyvinyl alcohol (PVA) film, a polyimide (PI) film, a polystyrene (PS), and a K-resin containing biaxially oriented PS (BOPS) film.

[164] The plurality of first electrodes of the first electrode unit 212 may include a plurality of first one surface electrodes 212a and a plurality of first back surface electrodes 212b.

[165] The plurality of first one surface electrodes 212a may be disposed in a first direction at one surface of the first film unit 211. The plurality of first back surface electrodes 212b may be disposed in the first direction at a back surface of the first film unit 211.

[166] The plurality of first one surface electrodes 212a and the plurality of first back surface electrodes 212b may be disposed to face each other.

[167] The back surface of the first film unit 211 may face the one surface of the first film unit 211.

[168] The first wiring unit 241 may be connected to at least one of the plurality of first one surface electrodes 212a and the plurality of first back surface electrodes 212b.

[169] The first pattern unit 210 may further include a first connection unit 213 to connect the plurality of first one surface electrodes 212a and the plurality of first back surface electrodes 212b.

[170] The first connection unit 213 may include a first one end connection unit 213a and a first other end connection unit 213b.

[171] The first one end connection unit 213a may be disposed at a first side surface of the first film unit 211 to connect one end of the plurality of first one surface electrodes 212a to one end of the plurality of first back surface electrodes 212b.

[172] The first other end connection unit 213b may be disposed at a second side surface of the first film unit 211 to connect the other end of the plurality of first one surface electrodes 212a to the other end of the plurality of first back surface electrodes 212b.

[173] The first side surface and the second side surface may face each other.

[174] The first wiring unit 241 may be connected to either the first one end connection unit 213a or the first other end connection unit 213b.

- [175] As illustrated in FIG. 8, the second pattern unit 220 may include a second film unit 221 and a second electrode unit 222 having a plurality of second electrodes disposed at the second film unit 221.
- [176] The second film unit 221 may be formed of a material having bearing power and transparency.
- [177] The material of the second film unit 221 may include a plastic film such as polyethylene terephthalate (PET), polycarbonate (PC), polymethyl methacrylate (PMMA), polyethylene naphthalate (PEN), polyether sulfone (PES), a cyclic olefin copolymer (COC), a triacetyl cellulose (TAC) film, a polyvinyl alcohol (PVA) film, a polyimide (PI) film, a polystyrene (PS), and a K-resin containing biaxially oriented PS (BOPS) film.
- [178] The plurality of second electrodes of the second electrode unit 222 may include a plurality of second one surface electrodes 222a and a plurality of second back surface electrodes 222b.
- [179] The plurality of second one surface electrodes 222a may be disposed in a second direction at one surface of the second film unit 221. The plurality of second back surface electrodes 222b may be disposed in the second direction at a back surface of the second film unit 221.
- [180] The plurality of second one surface electrodes 222a and the plurality of second back surface electrodes 222b may be disposed to face each other.
- [181] The back surface of the second film unit 221 may face the one surface of the second film unit 221.
- [182] The second wiring unit 242 may be connected to at least one of the plurality of second one surface electrodes 222a and the plurality of second back surface electrodes 222b.
- [183] The second pattern unit 220 may further include a second connection unit 223 to connect the plurality of second one surface electrodes 222a and the plurality of second back surface electrodes 222b.
- [184] The second connection unit 223 may include a second one end connection unit 223a and a second other end connection unit 223b.
- [185] The second one end connection unit 223a may be disposed at a first side surface of the second film unit 221 to connect one end of the plurality of second one surface electrodes 222a to one end of the plurality of second back surface electrodes 222b.
- [186] The second other end connection unit 223b may be disposed at a second side surface of the second film unit 221 to connect the other end of the plurality of second one surface electrodes 222a to the other end of the plurality of second back surface electrodes 222b.
- [187] The first side surface and the second side surface may face each other.

- [188] The second wiring unit 242 may be connected to either the second one end connection unit 223a or the second other end connection unit 223b.
- [189] The first direction in which the plurality of first electrodes of the first electrode unit 212 are disposed and the second direction in which the plurality of second electrodes of the second electrode unit 222 are disposed are directions crossing each other. That is, the plurality of first electrodes of the first electrode unit 212 and the plurality of second electrodes of the second electrode unit 222 may be disposed to cross each other. However, an arrangement structure of the plurality of first electrodes of the first electrode unit 212 and the plurality of second electrodes of the second electrode unit 222 is not limited to the above example.
- [190] FIG. 9 is a cross-sectional view illustrating a structure in which a touch panel according to a second embodiment is applied to the display apparatus according to an embodiment of the present invention.
- [191] As illustrated in FIG. 9, a touch panel 200a according to the second embodiment may include a film unit 214, a first electrode unit 212, and a second electrode unit 222.
- [192] The film unit 214 may be formed of a material having bearing power and transparency.
- [193] The material of the film unit 214 may include a plastic film such as polyethylene terephthalate (PET), polycarbonate (PC), polymethyl methacrylate (PMMA), polyethylene naphthalate (PEN), polyether sulfone (PES), a cyclic olefin copolymer (COC), a triacetyl cellulose (TAC) film, a polyvinyl alcohol (PVA) film, a polyimide (PI) film, a polystyrene (PS), and a K-resin containing biaxially oriented PS (BOPS) film.
- [194] The first electrode unit 212 may be disposed on the film unit 214. Specifically, the first electrode unit 212 may be disposed on the film unit 214 to be adjacent to the window cover 300.
- [195] The first electrode unit 212 may include a plurality of first electrodes.
- [196] The second electrode unit 222 may be disposed on the film unit 214. Specifically, the second electrode unit 222 may be disposed on the film unit 214 to be adjacent to the display panel 100.
- [197] The second electrode unit 222 may include a plurality of second electrodes.
- [198] The first electrode unit 212 and the second electrode unit 222 may be disposed to face each other while having the film unit 214 therebetween.
- [199] The plurality of first electrodes and the plurality of second electrodes may have a transparent material. Specifically, the plurality of first electrodes and the plurality of second electrodes may include at least one material of indium tin oxide (ITO), a metal material, and a carbon material. As one example, the metal material may include an Ag nanowire (AgNW), a metal mesh, etc. As one example, the carbon material may

include a carbon nanotube (CNT), graphene, etc.

- [200] The window cover 300, the touch panel 200a according to the second embodiment, and the display panel 100 may have a stacked structure. The display panel 100 may be disposed below the touch panel 200a, and the window cover 300 may be disposed above the touch panel 200a. In other words, the display panel 100 may be disposed at an upstream side in a direction in which light emitted from the backlight unit 120 (refer to FIGS. 4A and 4B) of the display panel 100 moves. The window cover 300 may be disposed at a downstream side in the direction in which the light emitted from the backlight unit 120 (refer to FIGS. 4A and 4B) of the display panel 100 moves. The touch panel 200a may be disposed between the display panel 100 and the window cover 300.
- [201] The first gap portion 410 may be formed between the display panel 100 and the touch panel 200a. Specifically, the first gap portion 410 may be formed between the display panel 100 and the second electrode unit 222.
- [202] The second gap portion 420 may be formed between the window cover 300 and the touch panel 200a. Specifically, the second gap portion 420 may be formed between the window cover 300 and the first electrode unit 212.
- [203] At least one of the first gap portion 410 and the second gap portion 420 may be filled with the optical clear adhesive (OCA).
- [204] Here, the OCA may be formed from an adhesive composition which includes an adhesive resin such as an acrylic-based resin, a silicon-based resin, a styrene-based resin, a polyester-based resin, a rubber-based resin, or a urethane-based resin solely or in a mixture of two or more thereof.
- [205] The window cover 300 may be integrally bent with the display panel 100 and the touch panel 200a. The window cover 300 will be described in detail below.
- [206] Since the display panel 100 is the same as that described in FIGS. 4A to 5B, the description thereof will be omitted.
- [207] FIG. 10 is a cross-sectional view illustrating a structure in which a touch panel according to a third embodiment is applied to the display apparatus according to an embodiment of the present invention.
- [208] As illustrated in FIG. 10, a touch panel 200b according to the third embodiment may include the film unit 214, the first electrode unit 212, and the second electrode unit 222.
- [209] The film unit 214 may be disposed adjacent to the display panel 100.
- [210] The film unit 214 may be formed of a material having bearing power and transparency.
- [211] The material of the film unit 214 may include a plastic film such as polyethylene terephthalate (PET), polycarbonate (PC), polymethyl methacrylate (PMMA),

polyethylene naphthalate (PEN), polyether sulfone (PES), a cyclic olefin copolymer (COC), a triacetyl cellulose (TAC) film, a polyvinyl alcohol (PVA) film, a polyimide (PI) film, a polystyrene (PS), and a K-resin containing biaxially oriented PS (BOPS) film.

[212] The first electrode unit 212 may be disposed on the window cover 300. Specifically, the first electrode unit 212 may be disposed on a back surface of the window cover 300.

[213] The first electrode unit 212 may include a plurality of first electrodes.

[214] The second electrode unit 222 may be disposed between the first electrode unit 212 and the film unit 214. In other words, the second electrode unit 222 may be disposed on the film unit 214 so as to face the first electrode unit 212.

[215] The second electrode unit 222 may include a plurality of second electrodes.

[216] The plurality of first electrodes and the plurality of second electrodes may have a transparent material. Specifically, the plurality of first electrodes and the plurality of second electrodes may include at least one material of indium tin oxide (ITO), a metal material, and a carbon material. As one example, the metal material may include an Ag nanowire (AgNW), a metal mesh, etc. As one example, the carbon material may include a carbon nanotube (CNT), graphene, etc.

[217] The window cover 300, the touch panel 200b according to the third embodiment, and the display panel 100 may have a stacked structure. The display panel 100 may be disposed below the touch panel 200b, and the window cover 300 may be disposed above the touch panel 200b. In other words, the display panel 100 may be disposed at an upstream side in a direction in which light emitted from the backlight unit 120 (refer to FIGS. 4A and 4A) of the display panel 100 moves. The window cover 300 may be disposed at a downstream side in the direction in which the light emitted from the backlight unit 120 (refer to FIGS. 4A and 4B) of the display panel 100 moves. The touch panel 200b may be disposed between the display panel 100 and the window cover 300.

[218] The first gap portion 410 may be formed between the display panel 100 and the touch panel 200b. Specifically, the first gap portion 410 may be formed between the display panel 100 and the film unit 214.

[219] The second gap portion 420 may be formed in the touch panel 200b. Specifically, the second gap portion 420 may be formed between the first electrode unit 212 and the second electrode unit 222.

[220] At least one of the first gap portion 410 and the second gap portion 420 may be filled with the optical clear adhesive (OCA).

[221] Here, the OCA may be formed from an adhesive composition which includes an adhesive resin such as an acrylic-based resin, a silicon-based resin, a styrene-based

resin, a polyester-based resin, a rubber-based resin, or a urethane-based resin solely or in a mixture of two or more thereof.

[222] The window cover 300 may be integrally bent with the display panel 100 and the touch panel 200b. The window cover 300 will be described in detail below.

[223] Since the display panel 100 is the same as that described in FIGS. 4A to 5B, the description thereof will be omitted.

[224] FIG. 11 is a cross-sectional view illustrating a window cover according to a first embodiment, in the display apparatus according to an embodiment of the present invention, and FIG. 12 is a view illustrating a bent state of the window cover according to the first embodiment, in the display apparatus according to an embodiment of the present invention. Hereinafter, FIGS. 1 to 10 will be referenced for reference numerals which are not shown. Hereinafter, a first portion of the window cover 300 may be used as a meaning which encompasses a first protective layer 310. Also, a second portion of the window cover 300 may be used as a meaning which encompasses a second protective layer 320. Hereinafter, the bending direction may be used to mean the same as a bending direction F.

[225] As illustrated in FIGS. 11 and 12, the window cover 300 may include a base layer 330, the first protective layer 310, and the second protective layer 320.

[226] The first protective layer 310 may be disposed on the base layer 330.

[227] The second protective layer 320 may be disposed to face the first protective layer 310 while having the base layer 330 therebetween. That is, the base layer 330 may be disposed between the first protective layer 310 and the second protective layer 320.

[228] When described in different terms, the first protective layer 310 may be positioned at an inside thereof in the bending direction F of the display apparatus 1. The second protective layer 320 may be positioned at an outside thereof in the bending direction F. The base layer 330 may be positioned between the first protective layer 310 and the second protective layer 320. Specifically, the first protective layer 310 may be disposed on the base layer 330 to be positioned at an inside of the base layer 330 in the bending direction F of the display apparatus 1. The second protective layer 320 may be disposed on the base layer 330 to be positioned at an outside of the base layer 330 in the bending direction F of the display apparatus 1. The base layer 330 may be disposed between the first protective layer 310 and the second protective layer 320.

[229] The first protective layer 310, the base layer 330, and the second protective layer 320 may have a stacked structure.

[230] The first protective layer 310 may form a surface of the window cover 300 to be pressed by a user. The first protective layer 310 may have scratch resistance to prevent scratches that may occur in the pressing process.

[231] The second protective layer 320 may be disposed on the touch panel 200. The second

protective layer 320 prevents a phenomenon in which the window cover 300 is pressed by a strong external impact.

[232] The first protective layer 310 and the second protective layer 320 may have different physical properties. Specifically, the first protective layer 310 and the second protective layer 320 may have different stiffnesses. Here, stiffness refers to the degree of rigidity of an object.

[233] As one example of the different physical properties, the first protective layer 310 and the second protective layer 320 may have different thicknesses. The thicknesses of the first protective layer 310 and the second protective layer 320 may affect the flexibility or bendability of the window cover 300. The thicknesses of the first protective layer 310 and the second protective layer 320 will be described in detail below.

[234] As another example of the different physical properties, the first protective layer 310 and the second protective layer 320 may be formed of different materials. Specifically, the second protective layer 320 may be formed of a material with a greater tensile strength than the first protective layer 310. As described above, the window cover 300 may be bent such that the first protective layer 310 is positioned at the inside of the base layer 330 in the bending direction F of the display apparatus 1, and the second protective layer 320 is positioned at the outside of the base layer 330 in the bending direction F of the display apparatus 1. Here, a compressive stress may act on the first protective layer 310, and a tensile stress may act on the second protective layer 320. Generally, since the tensile stress is smaller than the compressive stress, the second protective layer 320 positioned at the outside of the base layer 330 in the bending direction F of the display apparatus 1 may be damaged when the window cover 300 is bent. Thus, the second protective layer 320 may be formed of a material with a greater tensile strength than the first protective layer 310 to prevent a phenomenon in which the second protective layer 320 is damaged in a process of bending the window cover 300.

[235] As still another example of the different physical properties, a Young's modulus of the first protective layer 310 may be greater than a Young's modulus of the second protective layer 320. The Young's modulus is proportional to the stiffness of an object. Accordingly, the stiffness of the first protective layer 310 may be greater than the stiffness of the second protective layer 320. As described above, when the window cover 300 is bent such that the first protective layer 310 is positioned at the inside of the base layer 330 in the bending direction F of the display apparatus 1, and the second protective layer 320 is positioned at the outside of the base layer 330 in the bending direction F of the display apparatus 1, the compressive stress may act on the first protective layer 310, and the tensile stress may act on the second protective layer 320. Here, if the stiffness of the second protective layer 320 is greater than the stiffness of

the first protective layer 310, it is difficult for a sufficient tensile stress for bending the display apparatus 1 to act on the second protective layer 320. Thus, it may be difficult to bend the display apparatus 1.

- [236] Preferably, the stiffness of the first protective layer 310 may be greater than the stiffness of the second protective layer 320. Accordingly, the thickness of the first protective layer 310 may be thicker than the thickness of the second protective layer 320. Also, the Young's modulus of the first protective layer 310 may be greater than the Young's modulus of the second protective layer 320. The thicknesses of the first protective layer 310 and the second protective layer 320 will be described in detail below.
- [237] The window cover 300 may be bent such that the first protective layer 310 has a smaller radius of curvature than the second protective layer 320. As illustrated in FIG. 12, a radius of curvature of the first protective layer 310 positioned at the inside of the base layer 330 may be smaller than a radius of curvature of the second protective layer 320 positioned at the outside of the base layer 330. However, it is not limited thereto, and the first protective layer 310 and the second protective layer 320 may have the same radius of curvature.
- [238] The window cover 300 may be bent to have a radius of curvature of 5 mm or less. Specifically, the window cover 300 may be bent such that the first protective layer 310 has the radius of curvature of 5 mm or less.
- [239] The window cover 300 may have a pencil hardness of 9H. That is, at least one of the base layer 330, the first protective layer 310, and the second protective layer 320 may have the pencil hardness of 9H. The window cover 300 may also have a pencil hardness greater than 9H.
- [240] The window cover 300 may be formed of a plastic material. Specifically, the window cover 300 may be formed of a transparent plastic material.
- [241] A material of the base layer 330 may include a plastic. Specifically, the material of the base layer 330 may include at least one of polymethyl methacrylate (PMMA), a polycarbonate (PC), polyethylene terephthalate (PET), polyethylene naphthalate (PEN), and a colorless polyimide (CPI).
- [242] A hard coating may be added to the base layer 330.
- [243] Materials of the first protective layer 310 and the second protective layer 320 may include an acrylic-based resin. Preferably, the first protective layer 310 and the second protective layer 320 may include an organic-inorganic hybrid type acrylic-based resin.
- [244] The first protective layer 310 and the second protective layer 320 may be formed at an upper portion and a lower portion, respectively, of the base layer 330 by various coating methods such as a dipping method, a spray method, a slot die method, a gravure method, etc.

- [245] The first protective layer 310 and the second protective layer 320 may have high hardness.
- [246] FIG. 13 is a graph showing flexural characteristics of the window cover according to the first embodiment in accordance with a thickness ratio between a first protective layer and a second protective layer of the window cover according to the first embodiment, in the display apparatus according to an embodiment of the present invention. Hereinafter, FIGS. 11 and 12 will be referenced for reference numerals which are not shown.
- [247] As illustrated in FIG. 13, a ratio of the thickness of the second protective layer 320 with respect to the thickness of the first protective layer 310 may be 0.4 or less. Specifically, when the ratio of the thickness of the second protective layer 320 with respect to the thickness of the first protective layer 310 is 0.4, the radius of curvature of the window cover 300 is 5 mm. Also, when the ratio of the thickness of the second protective layer 320 with respect to the thickness of the first protective layer 310 is less than 0.4, the radius of curvature of the window cover 300 is less than 5 mm. When the thicknesses of the first protective layer 310 and the second protective layer 320 are the same, i.e. when a ratio between the thickness of the first protective layer 310 and the thickness of the second protective layer 320 is 1, the radius of curvature of the window cover 300 is 7 mm. In other words, when the first protective layer 310 and the second protective layer 320 have a symmetrical structure in terms of the thickness with respect to the base layer 330, it is difficult to obtain a desired radius of curvature (5 mm or less) of the window cover 300.
- [248] FIG. 14 is a graph showing relations between a thickness of the first protective layer and a radius of curvature and hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11, and FIG. 15 is a graph showing relations between a thickness of the second protective layer and a radius of curvature and hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11. FIG. 16 is a graph showing a relation between a thickness of a base layer and the hardness of the window cover according to the first embodiment, in the window cover according to the first embodiment of FIG. 11. Hereinafter, FIGS. 11 and 12 will be referenced for reference numerals which are not shown.
- [249] As illustrated in FIGS. 14 to 16, the base layer 330, the first protective layer 310, and the second protective layer 320 may have predetermined thicknesses.
- [250] The thicknesses of the first protective layer 310 and the second protective layer 320 may be different from each other. Specifically, the thickness of the first protective layer 310 may be thicker than the thickness of the second protective layer 320.
- [251] The thickness of the base layer 330 may be thicker than the thickness of at least one

of the first protective layer 310 and the second protective layer 320.

- [252] As illustrated in FIG. 14, the first protective layer 310 may have a thickness in a range of 40 mm to 75 mm. Specifically, when the first protective layer 310 has the thickness in the range of 40 mm to 75 mm, desired values of the pencil hardness and the radius of curvature of the first protective layer 310 may be simultaneously satisfied. A desired value of the pencil hardness of the first protective layer 310 is 9H or greater. The desired value of the radius of curvature of the first protective layer 310 is 5 mm or less.
- [253] As illustrated in FIG. 15, the second protective layer 320 may have a thickness of 30 mm or less. Specifically, when the second protective layer 320 has the thickness of 30 mm or less, desired values of the pencil hardness and the radius of curvature of the second protective layer 320 may be simultaneously satisfied. A desired value of the pencil hardness of the second protective layer 320 is 9H or greater. The desired value of the radius of curvature of the second protective layer 320 is 5 mm or less.
- [254] As illustrated in FIG. 16, the base layer 330 may have a thickness in a range of 150 mm to 190 mm. Specifically, when the base layer 330 has the thickness in the range of 150 mm to 190 mm, a desired value of the pencil hardness of the base layer 330 may be satisfied. A desired value of the pencil hardness of the base layer 330 is 9H or greater. Specifically, when the base layer 330 has a colorless polyimide (CPI) material, the base layer 330 is able to satisfy the desired value of the pencil hardness if the thickness of the base layer 330 is in the range of 150 mm to 190 mm. When the base layer 330 has a polyethylene terephthalate (PET) material, a decrease in the pencil hardness may occur if the thickness of the base layer 330 is less than 190 mm, and the window cover 300 may be damaged due to repetitive bending if the thickness of the base layer 330 exceeds 190 mm.
- [255] FIG. 17 is a cross-sectional view illustrating a window cover according to a second embodiment, in the display apparatus according to an embodiment of the present invention. Hereinafter, FIGS. 11 and 12 will be referenced for reference numerals which are not shown. Also, overlapping descriptions with FIGS. 11 to 16 will be omitted.
- [256] As illustrated in FIG. 17, the window cover 300 may further include a blocking layer 340. That is, the window cover 300 may include the base layer 330, the first protective layer 310, the second protective layer 320, and the blocking layer 340.
- [257] The blocking layer 340 may be disposed on the base layer 330 to face at least one of the first protective layer 310 and the second protective layer 320. The blocking layer 340 serves to prevent moisture or gas from being introduced into the display apparatus 1. In other words, the blocking layer 340 blocks the moisture or gas introduced through the window cover 300, thereby preventing a decrease in durability of at least one of the

plurality of first electrodes and the plurality of second electrodes provided in the touch panels 200, 200a, and 200b.

[258] A material of the blocking layer 340 may include at least one of silica and alumina.

[259] The blocking layer 340 may be deposited on the base layer 330. As one example, the blocking layer 340 may be formed on the base layer 330 using a sputter deposition method.

[260] In a case of the window cover 300 with the blocking layer 340 disposed on the base layer 330, a moisture permeation rate was measured to be about 40 times lower than in a case of the window cover 300 without the blocking layer 340 disposed on the base layer 330. Specifically, in the case of the window cover 300 with the blocking layer 340 disposed on the base layer 330, a moisture permeation rate of 0.14 g/day·m² was measured. In the case of the window cover 300 without the blocking layer 340 disposed on the base layer 330, a moisture permeation rate of 6 g/day·m² was measured.

[261] In addition, it was confirmed that the window cover 300 with the blocking layer 340 disposed on the base layer 330 and the window cover 300 without the blocking layer 340 disposed on the base layer 330 have the same pencil hardness.

[262] FIG. 18 is a flow chart showing a process of manufacturing the window cover of the display apparatus according to an embodiment of the present invention, and FIG. 19 is a view schematically illustrating a manufacturing apparatus for manufacturing the window cover of the display apparatus according to an embodiment of the present invention. Hereinafter, FIGS. 11, 12, and 17 will be referenced for reference numerals which are not shown. Hereinafter, processing may be used as a meaning encompassing slimming.

[263] As illustrated in FIGS. 18 and 19, a method of manufacturing the display apparatus 1 including the window cover 300 having the base layer 330 may include forming the first protective layer 310 and the second protective layer 320 to face each other while having the base layer 330 therebetween (S2), and processing at least one of the first protective layer 310 and the second protective layer 320 such that the first protective layer 310 and the second protective layer 320 have different thicknesses (S3).

[264] The first protective layer 310 and the second protective layer 320 may be respectively disposed on both surfaces of the base layer 330 in the same thicknesses.

[265] The first protective layer 310 or the second protective layer 320 may be processed by a chemical mechanical polishing (CMP) process. As described above, the first protective layer 310 and the second protective layer 320 may have different thicknesses. When the second protective layer 320 having a relatively thinner thickness is disposed at one surface of the base layer 330 and the first protective layer 310 having relatively thicker thickness is disposed at the other surface of the base layer

330, crack or curls may occur at the window cover 300. That is, the window cover 300 may curl toward the first protective layer 310 having the relatively thicker thickness. Thus, the CMP process may be used to prevent cracks or curls caused by an asymmetrical structure of the thicknesses of the first protective layer 310 and the second protective layer 320.

[266] A process in which the first protective layer 310 or the second protective layer 320 is slimmed by the CMP process is as follows.

[267] A CMP apparatus may include a rotary plate 610, a polishing pad 620 coupled to an upper portion of the rotary plate 610, a carrier 630 rotating while facing the polishing pad 620, and a slurry feed pipe 640 for feeding a slurry 650. The polishing pad 620 may integrally rotate with the rotary plate 610. The slurry 650 may include an abrasive.

[268] The window cover 300 may be mounted on the carrier 630. Specifically, the window cover 300 may be mounted on the carrier 630 such that the second protective layer 320 to be slimmed faces the polishing pad 620. Here, since the first protective layer 310 and the second protective layer 320 of the window cover 300 have the same thicknesses, cracks or curls that are caused by the asymmetrical structure of the thicknesses of the first protective layer 310 and the second protective layer 320 may be prevented. The second protective layer 320 of the window cover 300 may be slimmed in a rotation process of the carrier 630 and the polishing pad 620.

[269] The method of manufacturing the display apparatus 1 including the window cover 300 having the base layer 330 may further include disposing the blocking layer 340 on the base layer 330 to face at least one of the first protective layer 310 and the second protective layer 320 (S1). The blocking layer 340 may be disposed on the base layer 330 before the first protective layer 310 and the second protective layer 320 are disposed on the base layer 330. When blocking layers 340 are respectively disposed at both surfaces of the base layer 330, the first protective layer 310 and the second protective layer 320 may be respectively disposed on the blocking layers 340. When the blocking layer 340 is disposed at one surface of the base layer 330, one of the first protective layer 310 and the second protective layer 320 may be disposed on the blocking layer 340, and the other one of the first protective layer 310 and the second protective layer 320 may be disposed on the base layer 330.

[270] The blocking layer 340 may be deposited on the base layer 330.

[271] Although a few exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these exemplary embodiments without departing from the principles and spirit of the exemplary embodiments, the scope of which is defined in the claims and their equivalents.

Claims

- [Claim 1] A display apparatus comprising:
a display panel configured to display an image; and
a window cover disposed to be integrally bent with the display panel and having a first portion positioned at an inside thereof in a bending direction and a second portion positioned at an outside thereof in the bending direction and having a different stiffness from the first portion.
- [Claim 2] The display apparatus according to claim 1, wherein the stiffness of the first portion is greater than the stiffness of the second portion.
- [Claim 3] The display apparatus according to claim 1, wherein a thickness of the first portion is thicker than a thickness of the second portion.
- [Claim 4] The display apparatus according to claim 1, wherein the window cover is bent such that the first portion has a smaller radius of curvature than the second portion.
- [Claim 5] The display apparatus according to claim 4, wherein the window cover is bent such that the first portion has a radius of curvature of 5 mm or less.
- [Claim 6] The display apparatus according to claim 3, wherein a ratio of the thickness of the second portion with respect to the thickness of the first portion is 0.4 or less.
- [Claim 7] The display apparatus according to claim 3, wherein the first portion has a thickness in a range of 40 mm to 75 mm.
- [Claim 8] The display apparatus according to claim 3, wherein the second portion has a thickness of 30 mm or less.
- [Claim 9] The display apparatus according to claim 1, wherein the materials of the first portion and the second portion comprise an acrylic-based resin.
- [Claim 10] The display apparatus according to claim 1, wherein a Young's modulus of the first portion is greater than a Young's modulus of the second portion.
- [Claim 11] The display apparatus according to claim 1, wherein the second portion is formed of a material with a greater tensile strength than the first portion.
- [Claim 12] The display apparatus according to claim 1, wherein the window cover further comprises a base layer disposed between the first portion and the second portion.
- [Claim 13] The display apparatus according to claim 12, wherein a material of the base layer comprises a plastic.

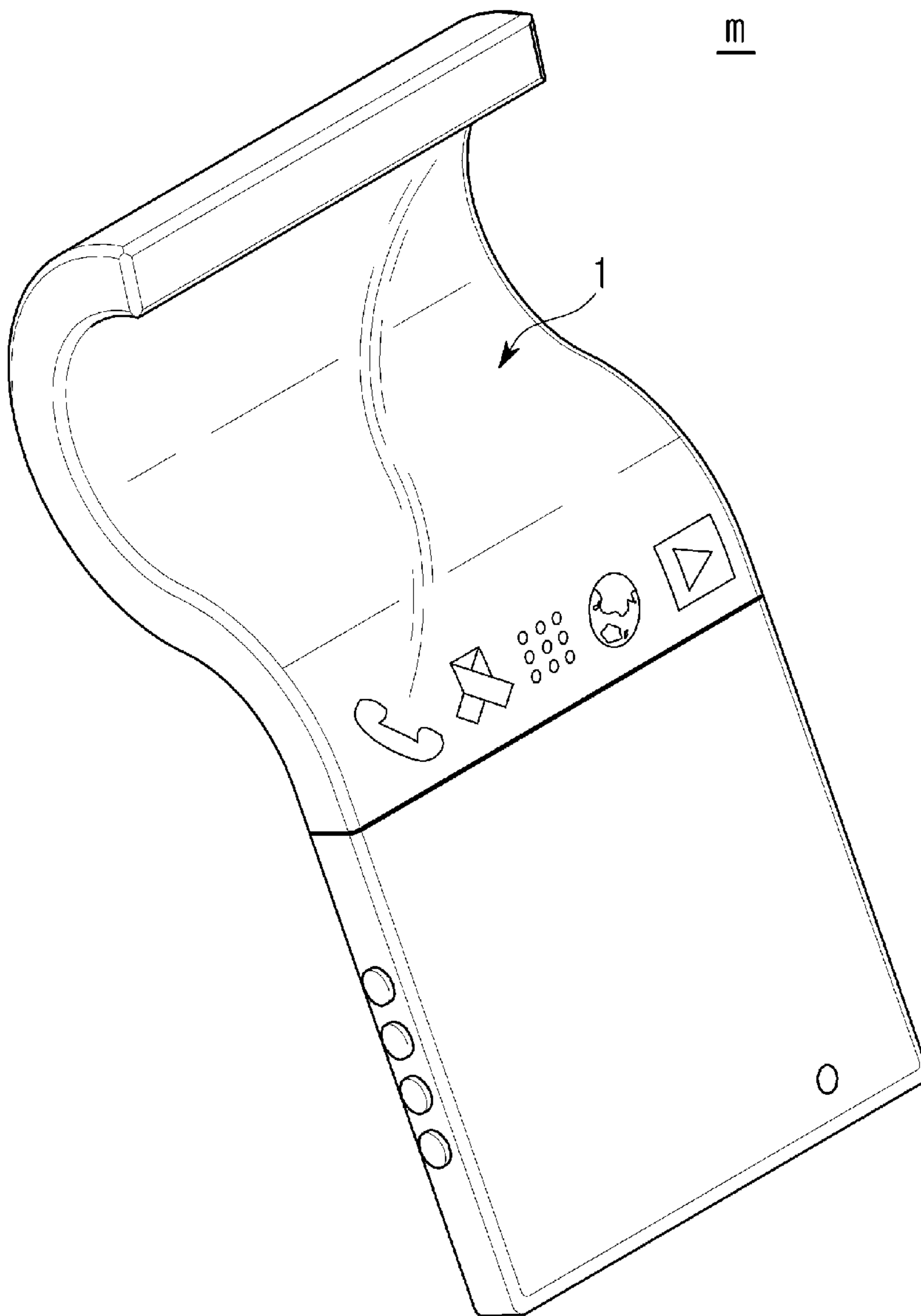
- [Claim 14] The display apparatus according to claim 13, wherein the material of the base layer comprises at least one of polymethyl methacrylate (PMMA), a polycarbonate (PC), polyethylene terephthalate (PET), polyethylene naphthalate (PEN), and a colorless polyimide (CPI).
- [Claim 15] The display apparatus according to claim 12, wherein the base layer has a thickness in a range of 150 mm to 190 mm.
- [Claim 16] The display apparatus according to claim 12, wherein at least one among the base layer, the first portion, and the second portion has a pencil hardness of 9H.
- [Claim 17] The display apparatus according to claim 12, wherein the window cover further comprises a blocking layer disposed on the base layer to face at least one of the first portion and the second portion in order to prevent moisture or gas from being introduced into the display apparatus.
- [Claim 18] The display apparatus according to claim 17, wherein a material of the blocking layer comprises at least one of silica and alumina.
- [Claim 19] A flexible display apparatus, the display apparatus comprising:
a display panel configured to display an image;
a touch panel disposed adjacent to the display panel to output a touch signal; and
a window cover disposed to face the display panel while having the touch panel therebetween and formed of a transparent plastic material, wherein the window cover comprises:
a base layer;
a first protective layer disposed on the base layer to be positioned at an inside of the base layer in a bending direction of the display apparatus;
and
a second protective layer disposed on the base layer to be positioned at an outside of the base layer in the bending direction of the display apparatus and having a different physical property from the first protective layer.
- [Claim 20] The display apparatus according to claim 19, wherein a thickness of the first protective layer is thicker than a thickness of the second protective layer.
- [Claim 21] The display apparatus according to claim 19, wherein a ratio of a thickness of the second protective layer with respect to a thickness of the first protective layer is 0.4 or less.
- [Claim 22] The display apparatus according to claim 19, wherein the window

cover is bent such that the first protective layer has a radius of curvature of 5 mm or less.

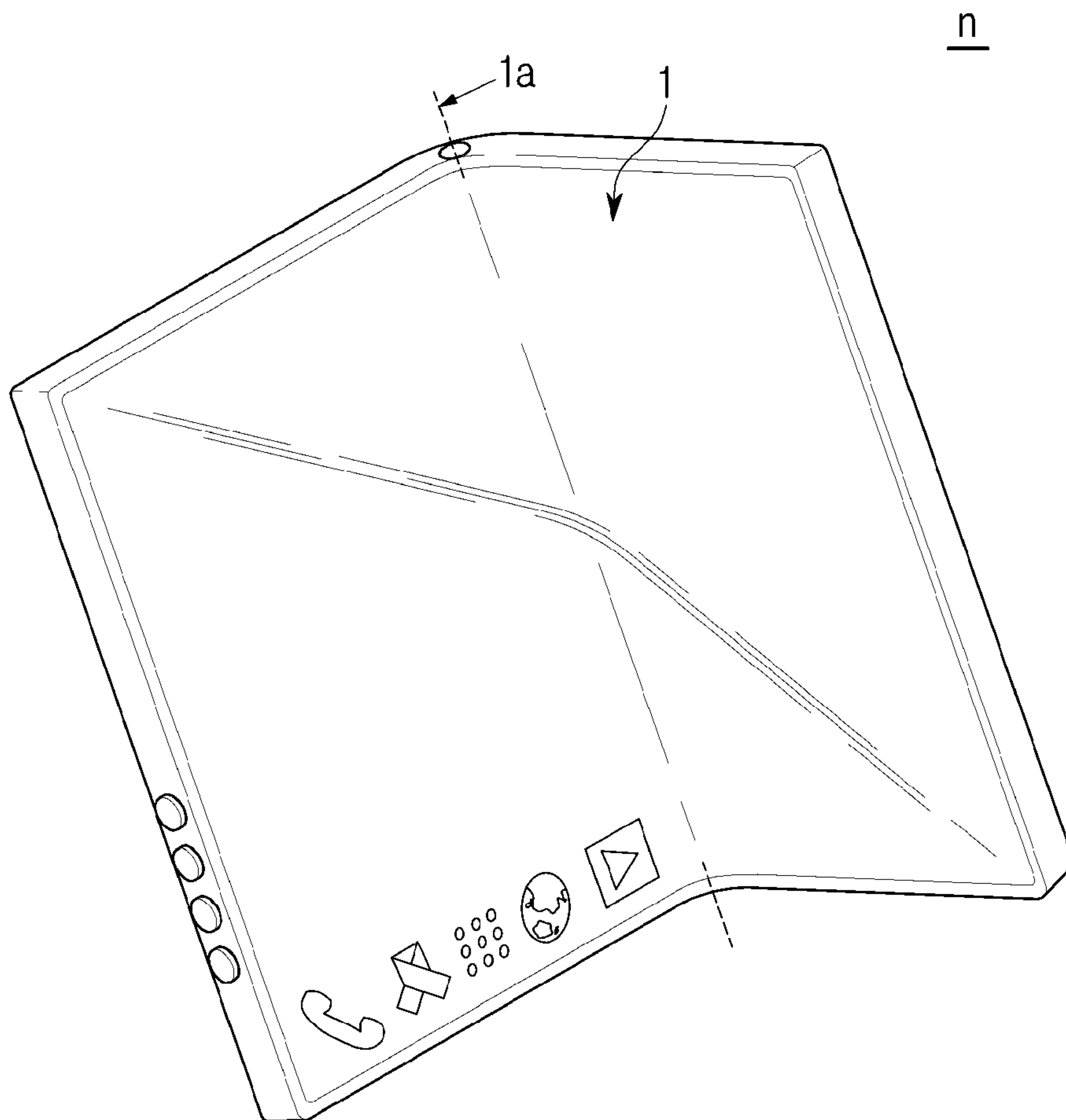
- [Claim 23] The display apparatus according to claim 19, wherein at least one of the base layer, the first protective layer, and the second protective layer has a pencil hardness of 9H.
- [Claim 24] The display apparatus according to claim 19, wherein a thickness of the base layer is thicker than the thickness of at least one of the first protective layer and the second protective layer.
- [Claim 25] The display apparatus according to claim 19, wherein the window cover further comprises a blocking layer disposed on the base layer to face at least one of the first protective layer and the second protective layer in order to prevent moisture or gas from being introduced into the display apparatus.
- [Claim 26] The display apparatus according to claim 25, wherein a material of the blocking layer comprises at least one of silica and alumina.
- [Claim 27] The display apparatus according to claim 19, wherein the second protective layer is formed of a material with a greater tensile strength than the first protective layer.
- [Claim 28] A method of manufacturing a display apparatus including a window cover having a base layer, the method comprising:
disposing a first protective layer and a second protective layer to face each other while having the base layer therebetween; and
processing at least one of the first protective layer and the second protective layer such that the first protective layer and the second protective layer have different thicknesses.
- [Claim 29] The method according to claim 28, wherein the first protective layer and the second protective layer are respectively disposed on both surfaces of the base layer in the same thicknesses.
- [Claim 30] The method according to claim 28, wherein at least one of the first protective layer and the second protective layer is processed by a chemical mechanical polishing (CMP) process.
- [Claim 31] The method according to claim 28, further comprising disposing a blocking layer on the base layer to face at least one of the first protective layer and the second protective layer, before the disposing of the first protective layer and the second protective layer to face each other while having the base layer therebetween.
- [Claim 32] The display apparatus according to claim 31, wherein the blocking layer is deposited on the base layer.

- [Claim 33] A window cover that may be used in a display apparatus having a display panel to display an image, the window cover comprising: a first portion disposed to be integrally bent with the display panel and positioned at an inside thereof in a bending direction; and a second portion positioned at an outside thereof in the bending direction and having a different stiffness from the first portion.
- [Claim 34] The window cover according to claim 33, wherein the stiffness of the first portion is greater than the stiffness of the second portion.
- [Claim 35] The window cover according to claim 33, wherein a thickness of the first portion is thicker than a thickness of the second portion.
- [Claim 36] The window cover according to claim 33, wherein the window cover is bent such that the first portion has a smaller radius of curvature than the second portion.

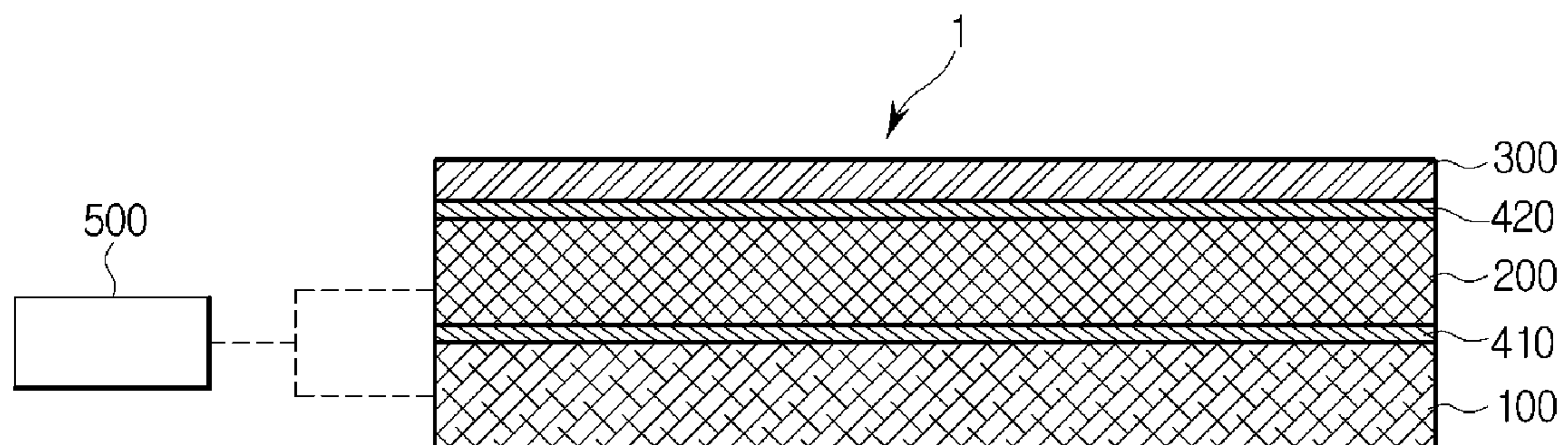
[Fig. 1]



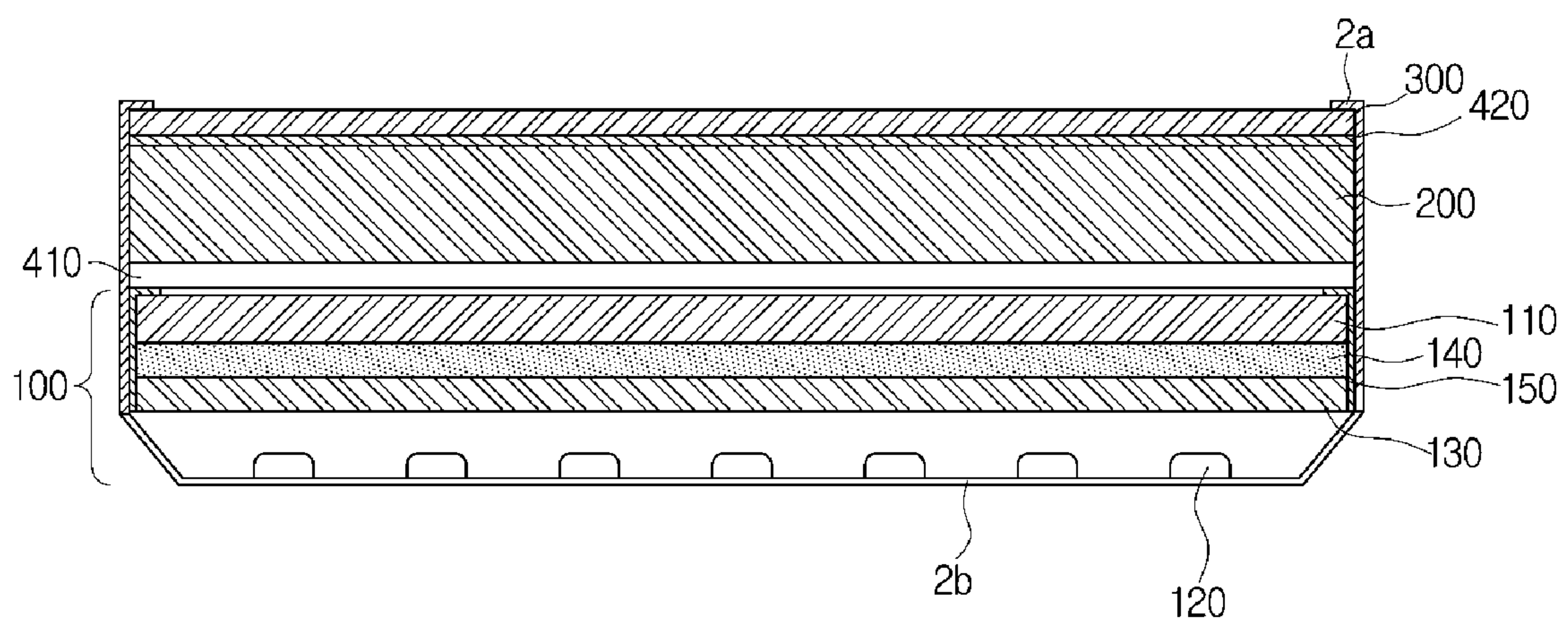
[Fig. 2]



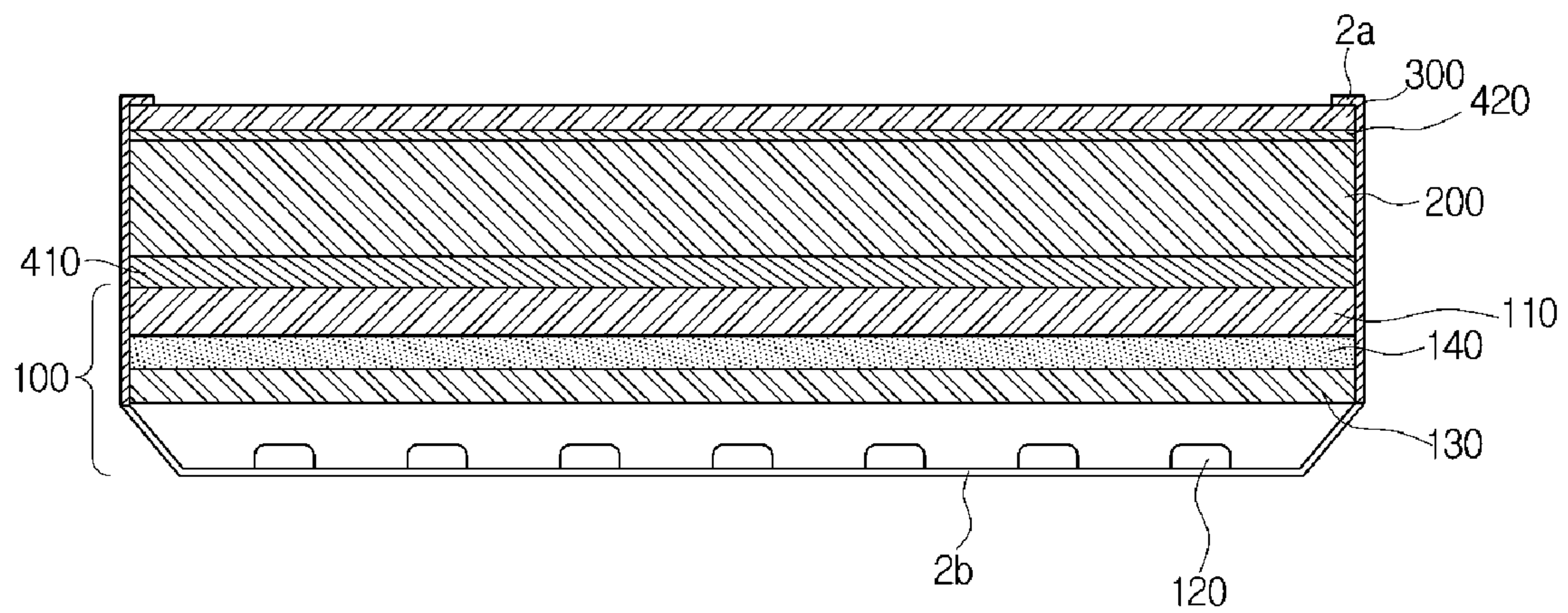
[Fig. 3]



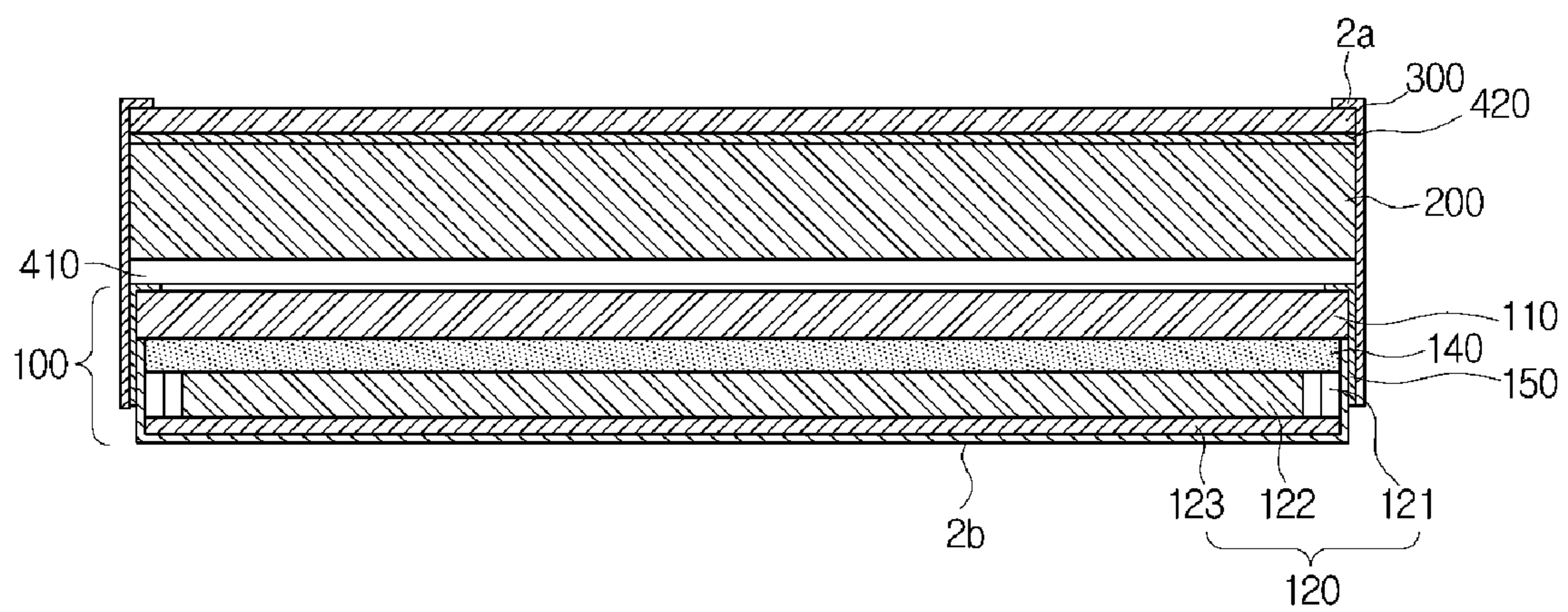
[Fig. 4a]



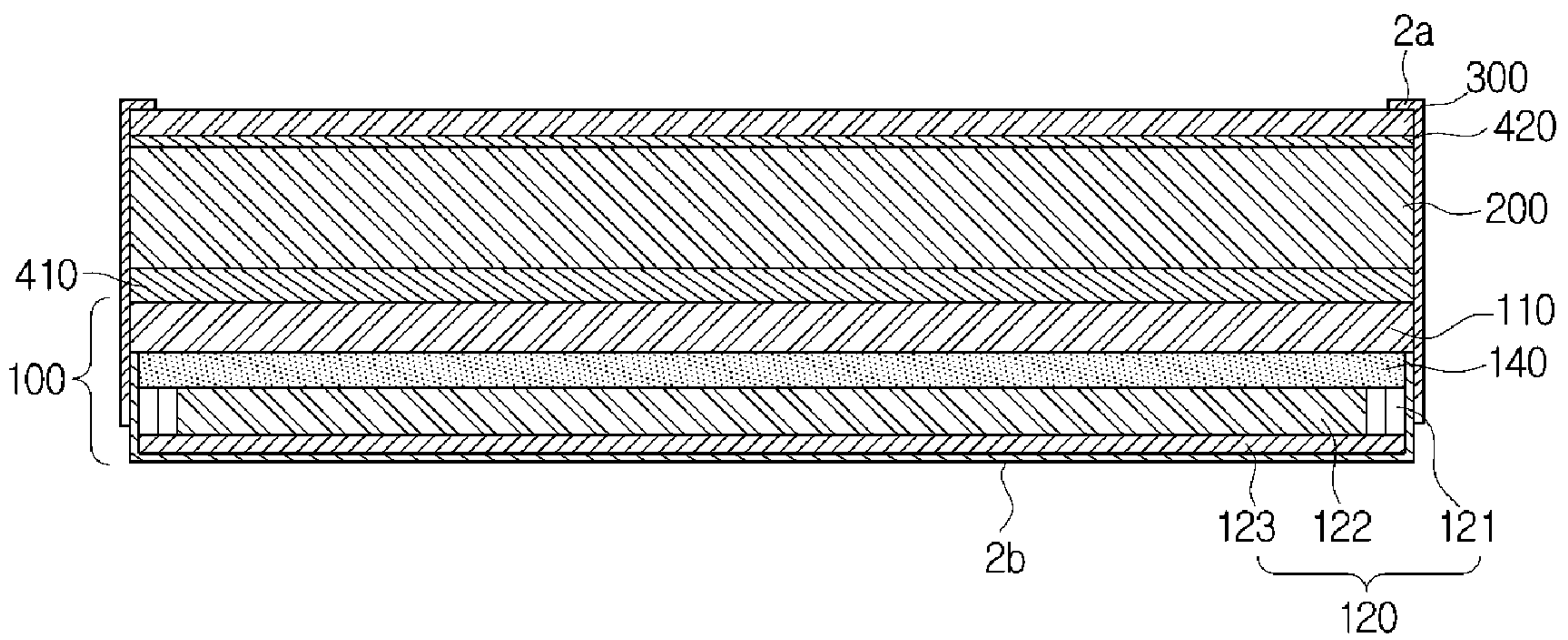
[Fig. 4b]



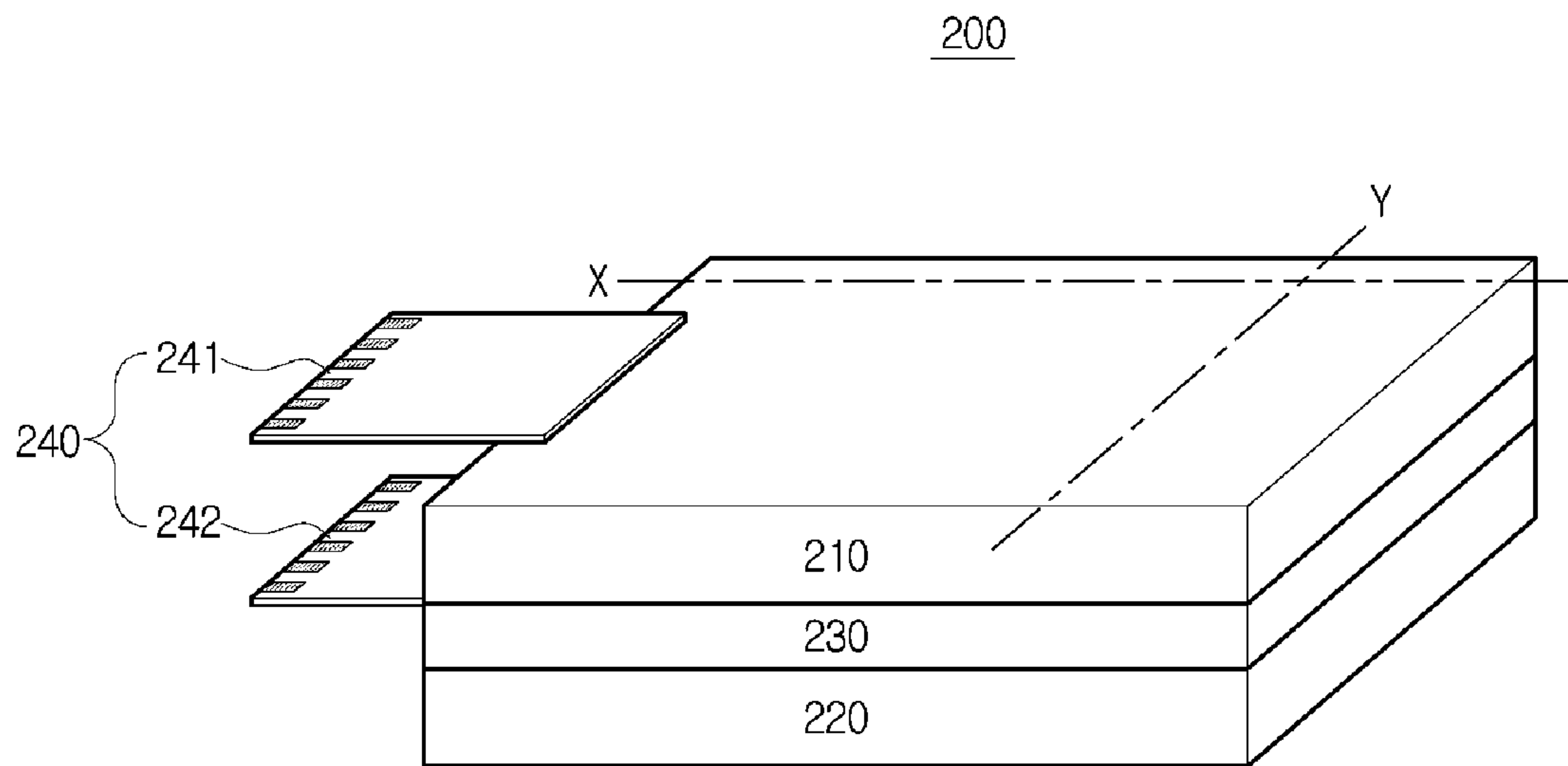
[Fig. 5a]



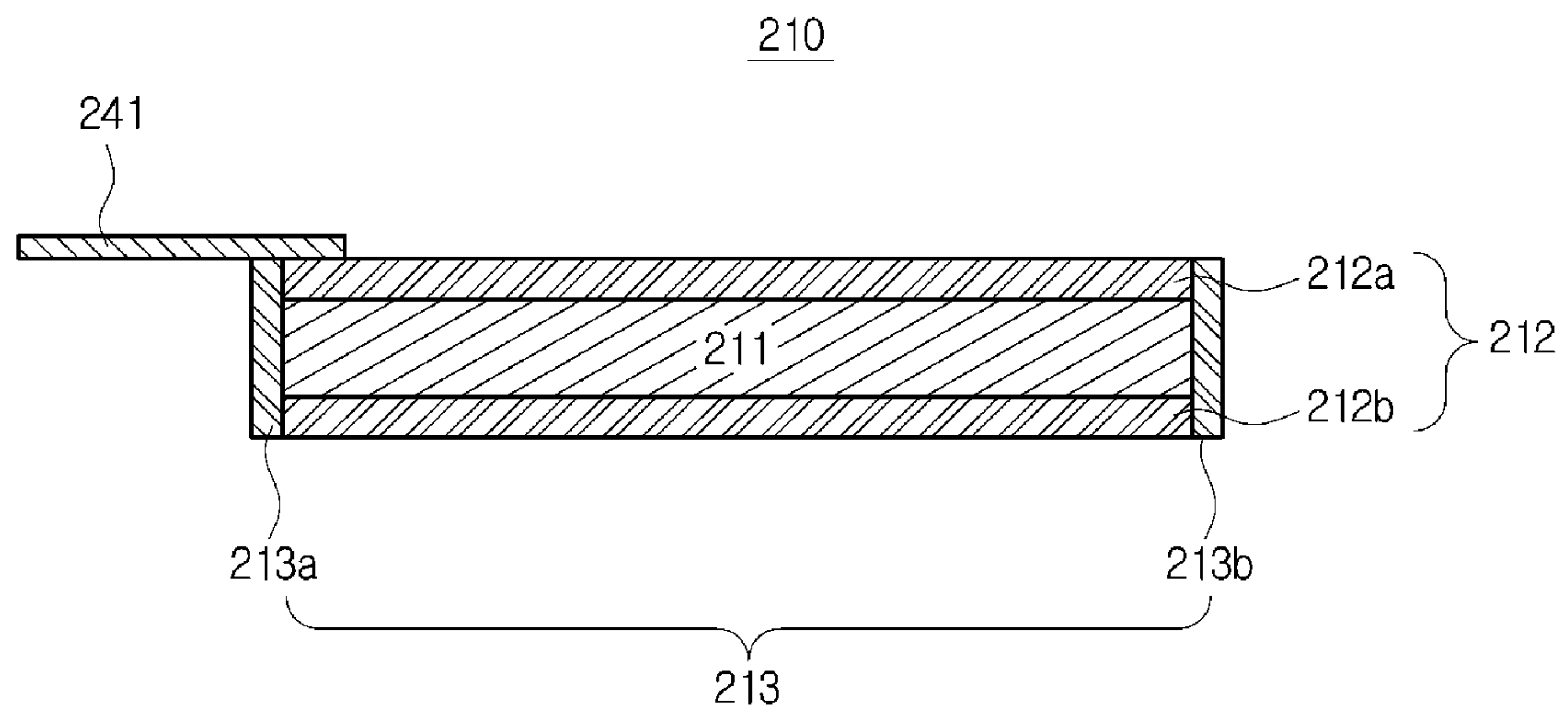
[Fig. 5b]



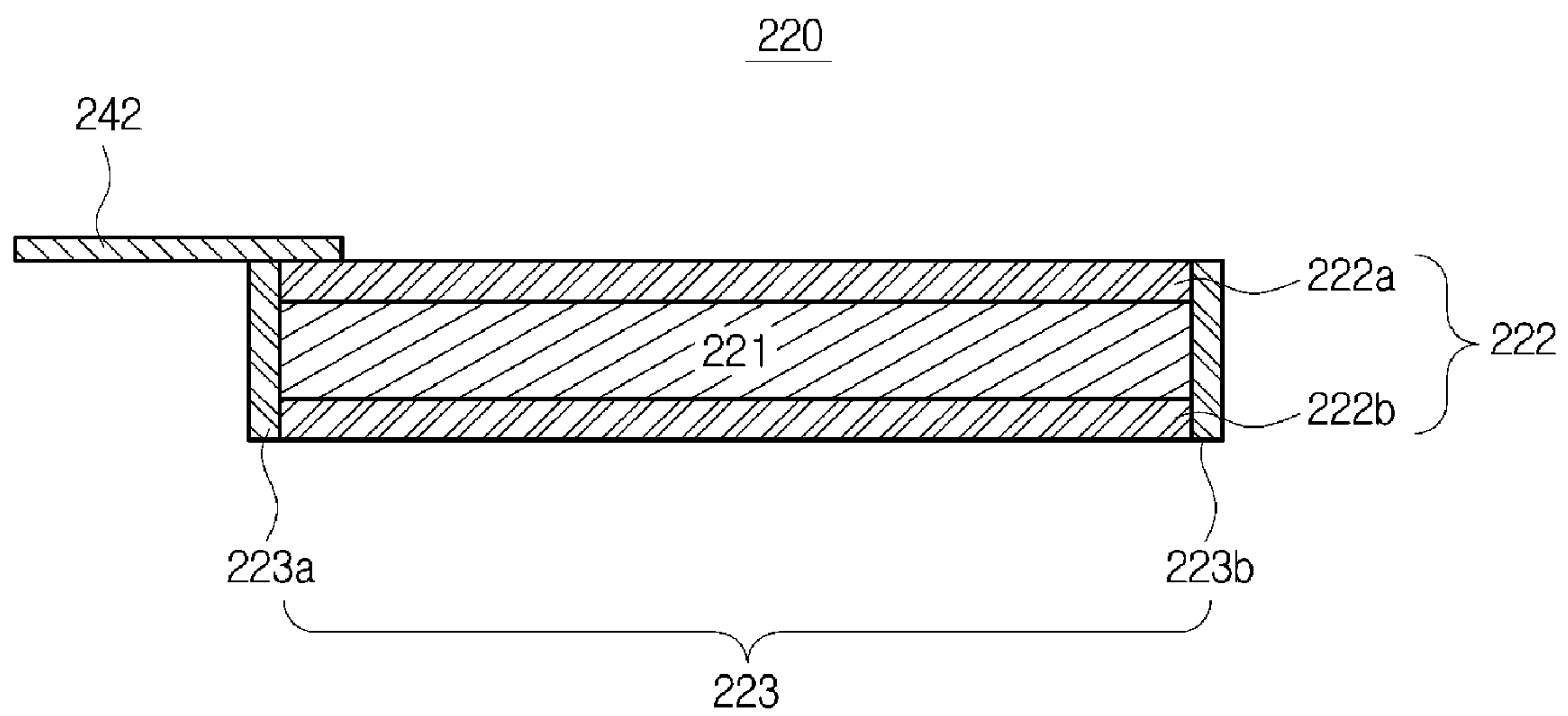
[Fig. 6]



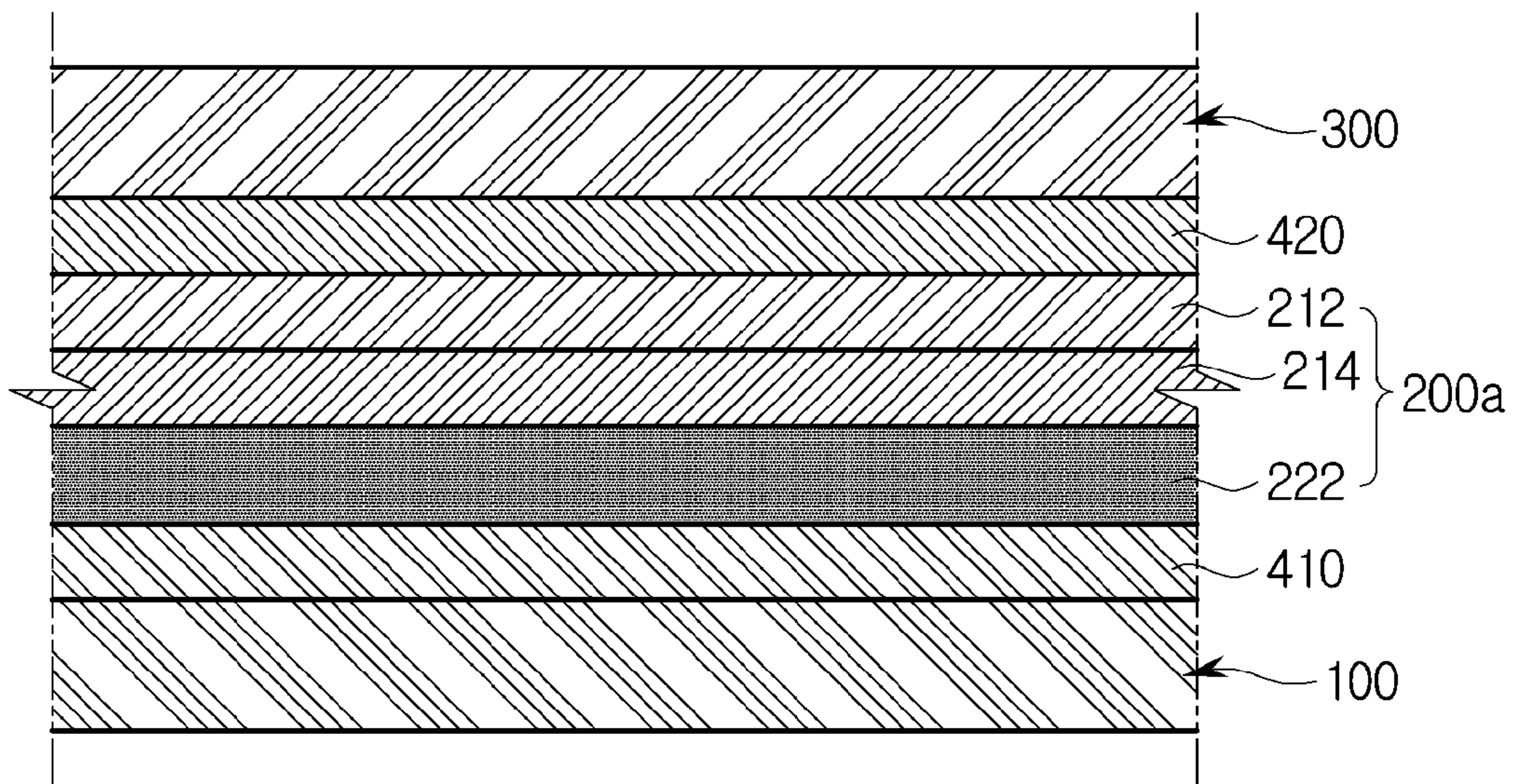
[Fig. 7]



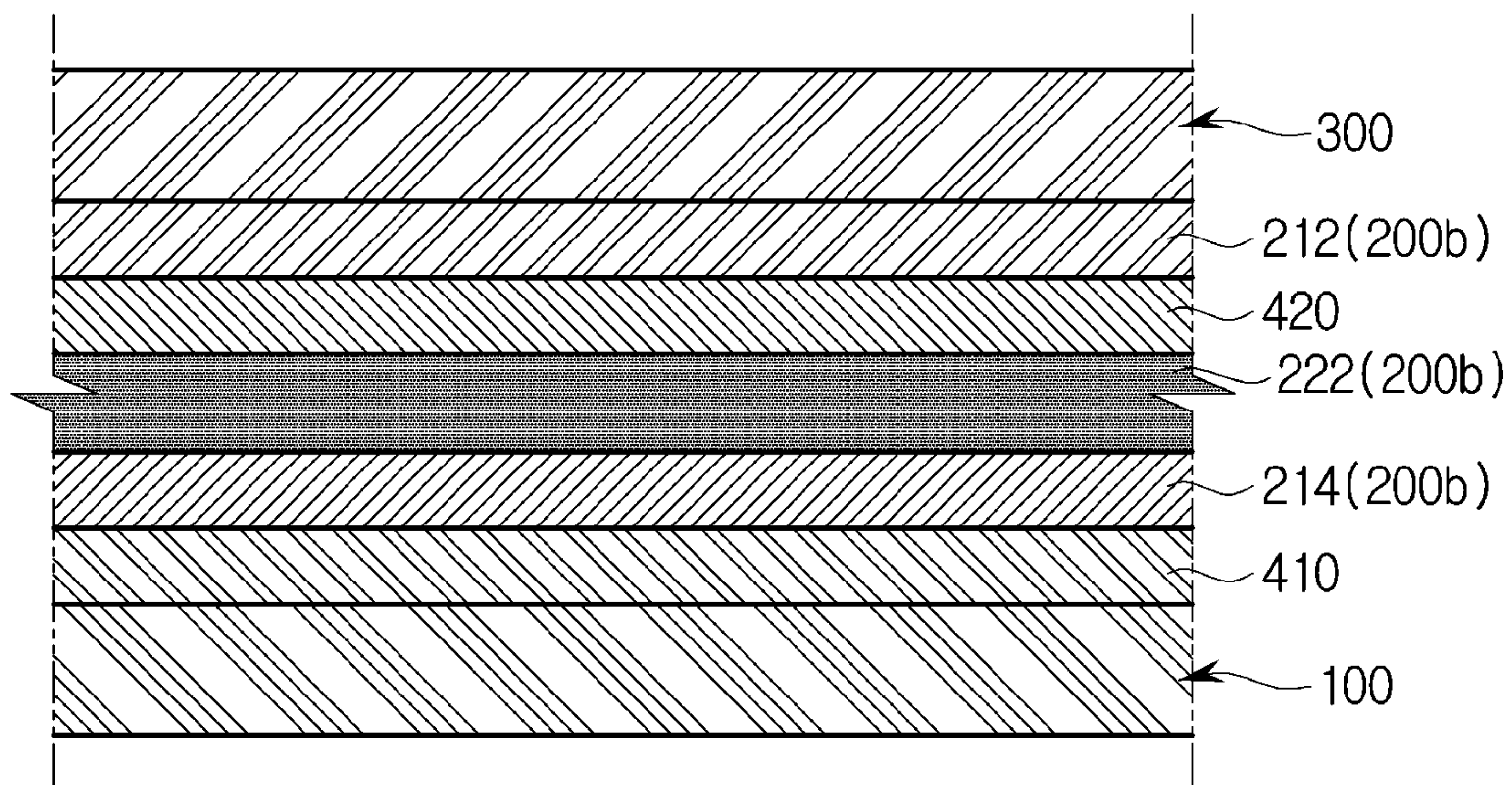
[Fig. 8]



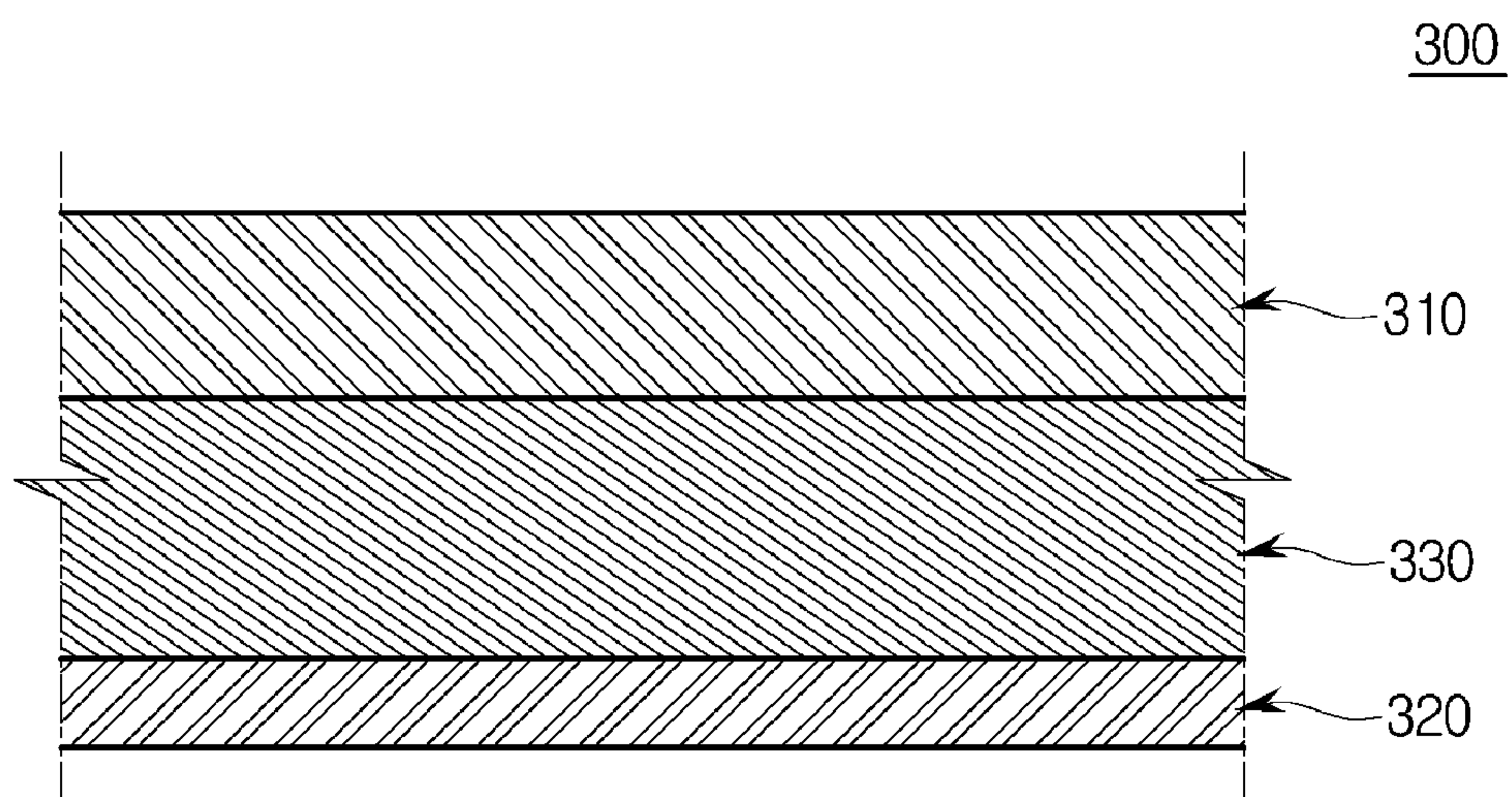
[Fig. 9]



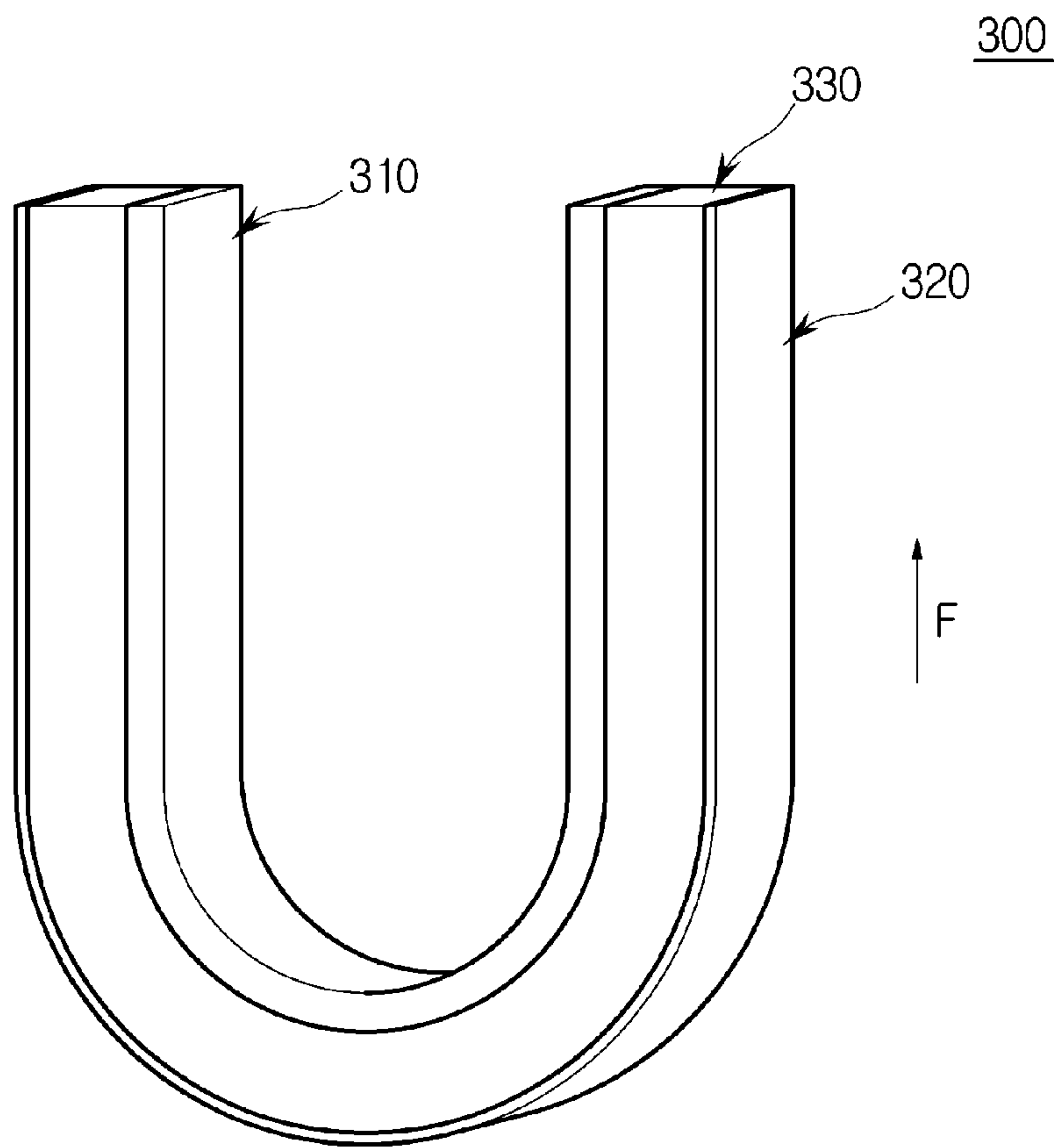
[Fig. 10]



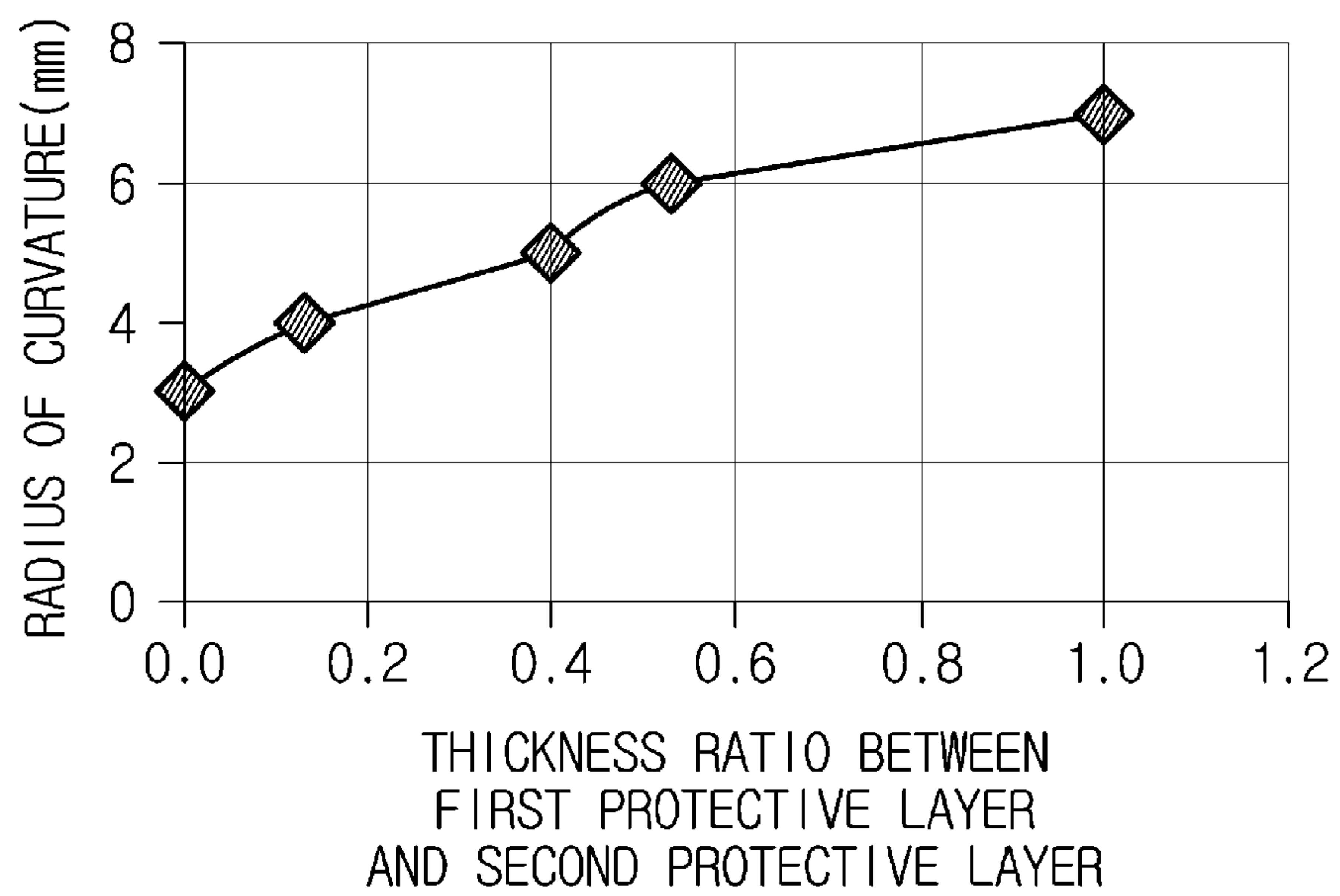
[Fig. 11]



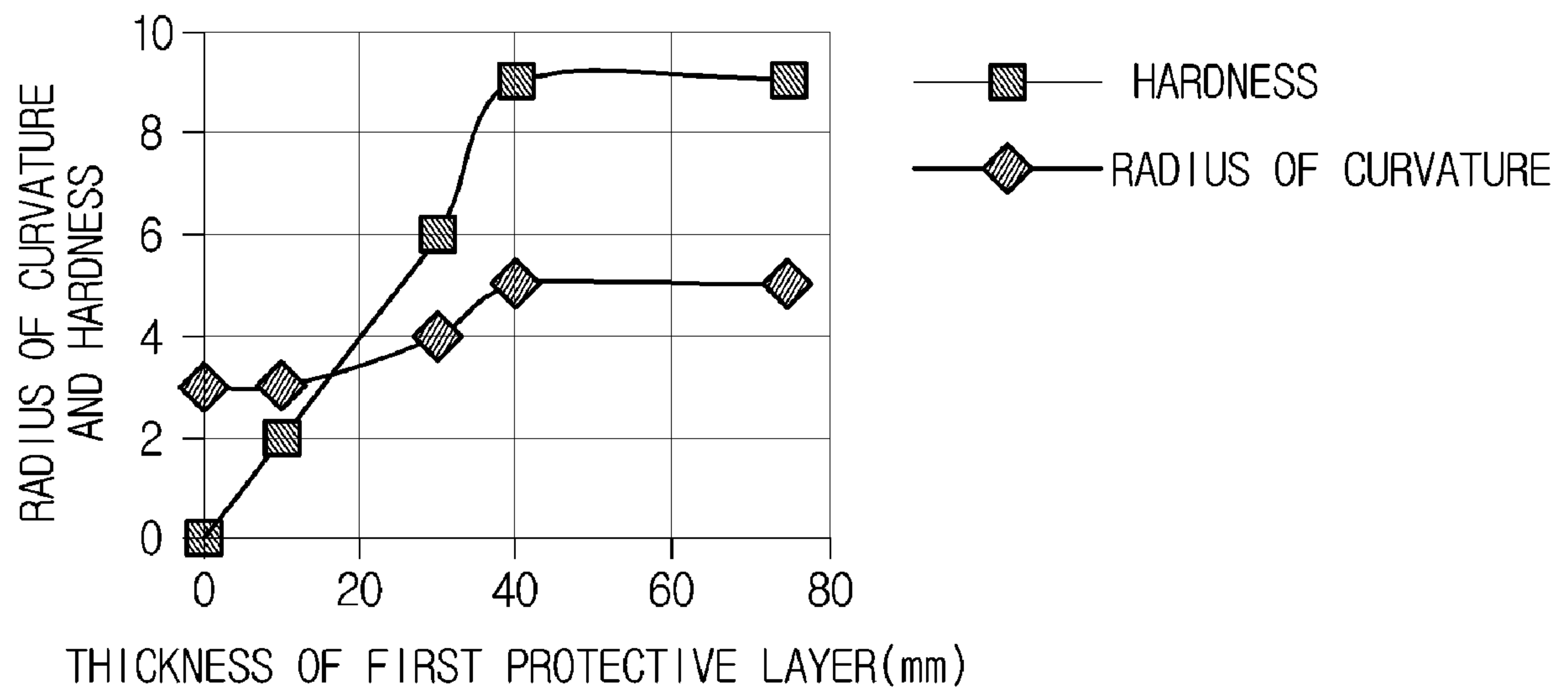
[Fig. 12]



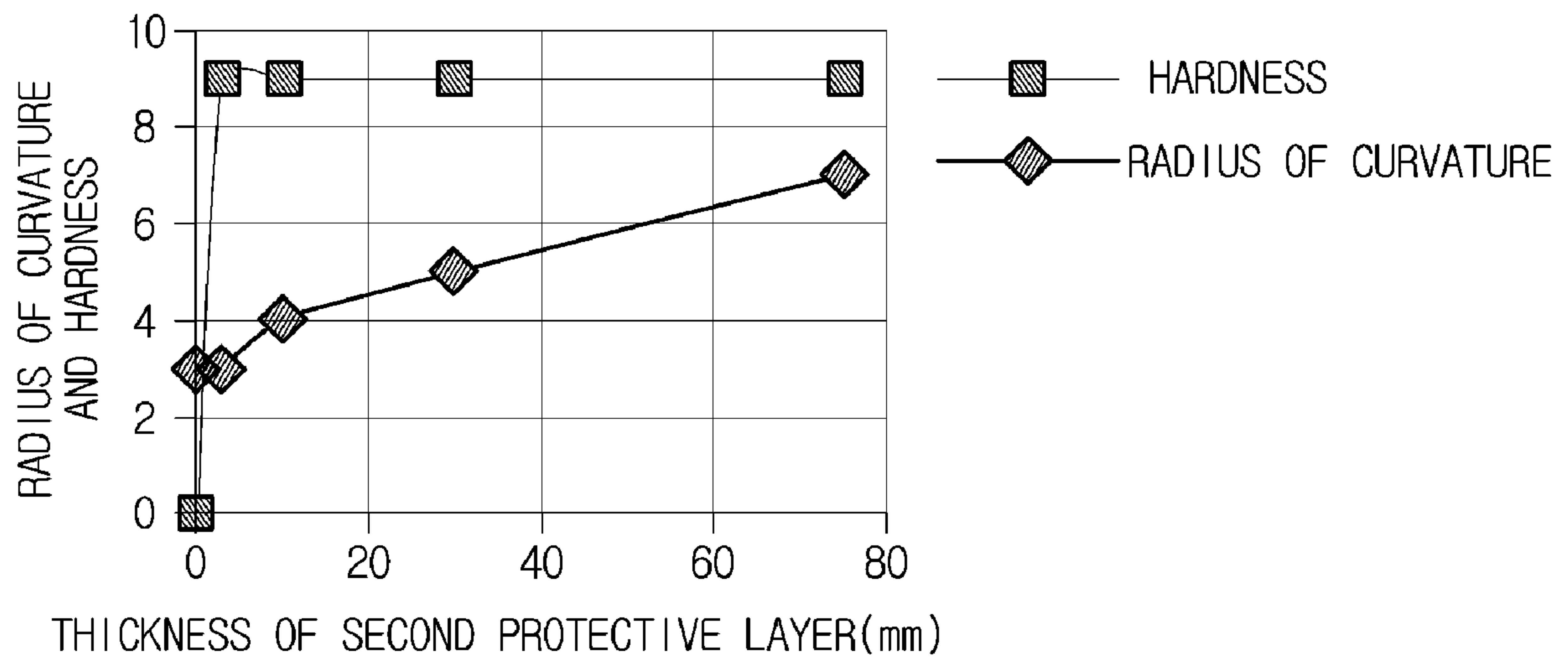
[Fig. 13]



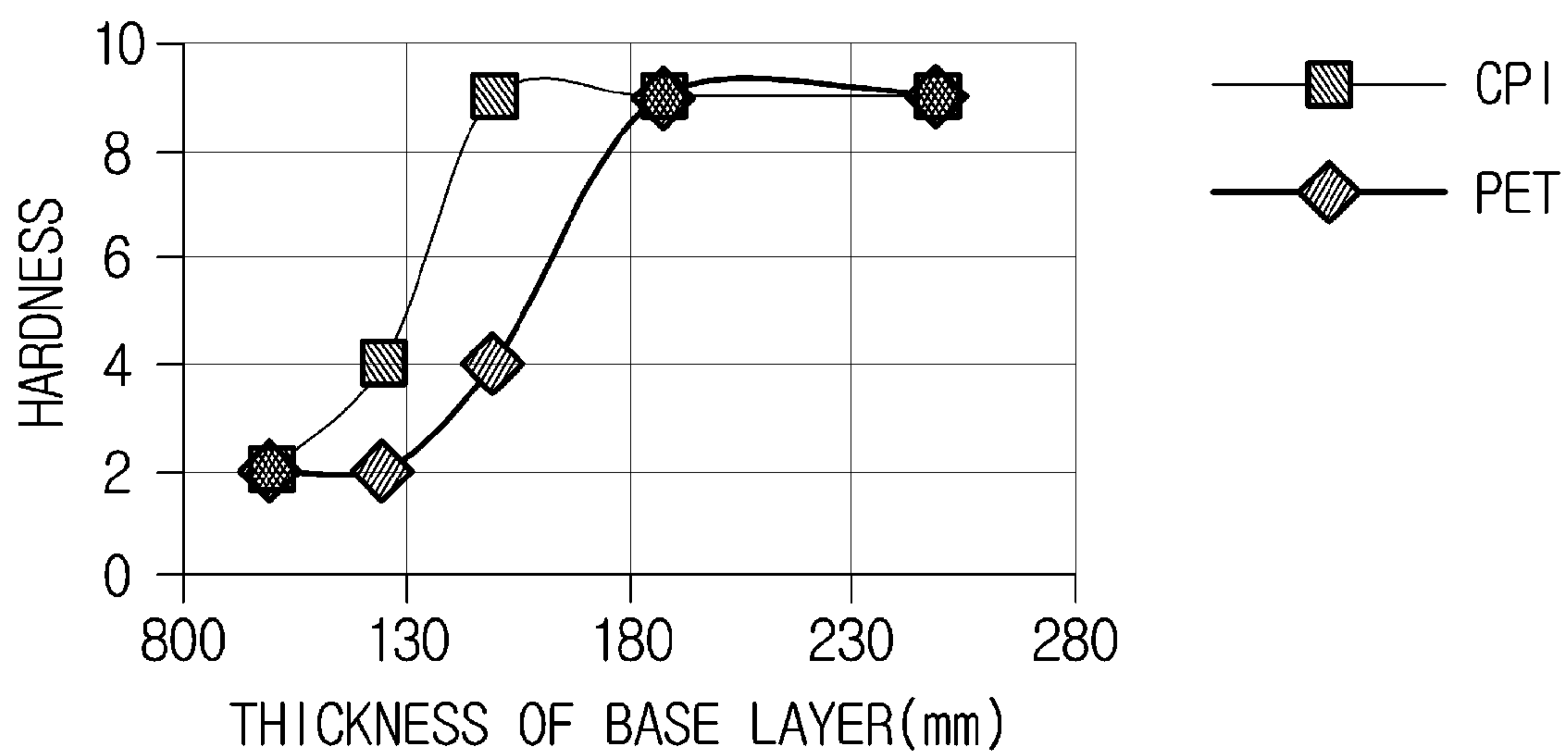
[Fig. 14]



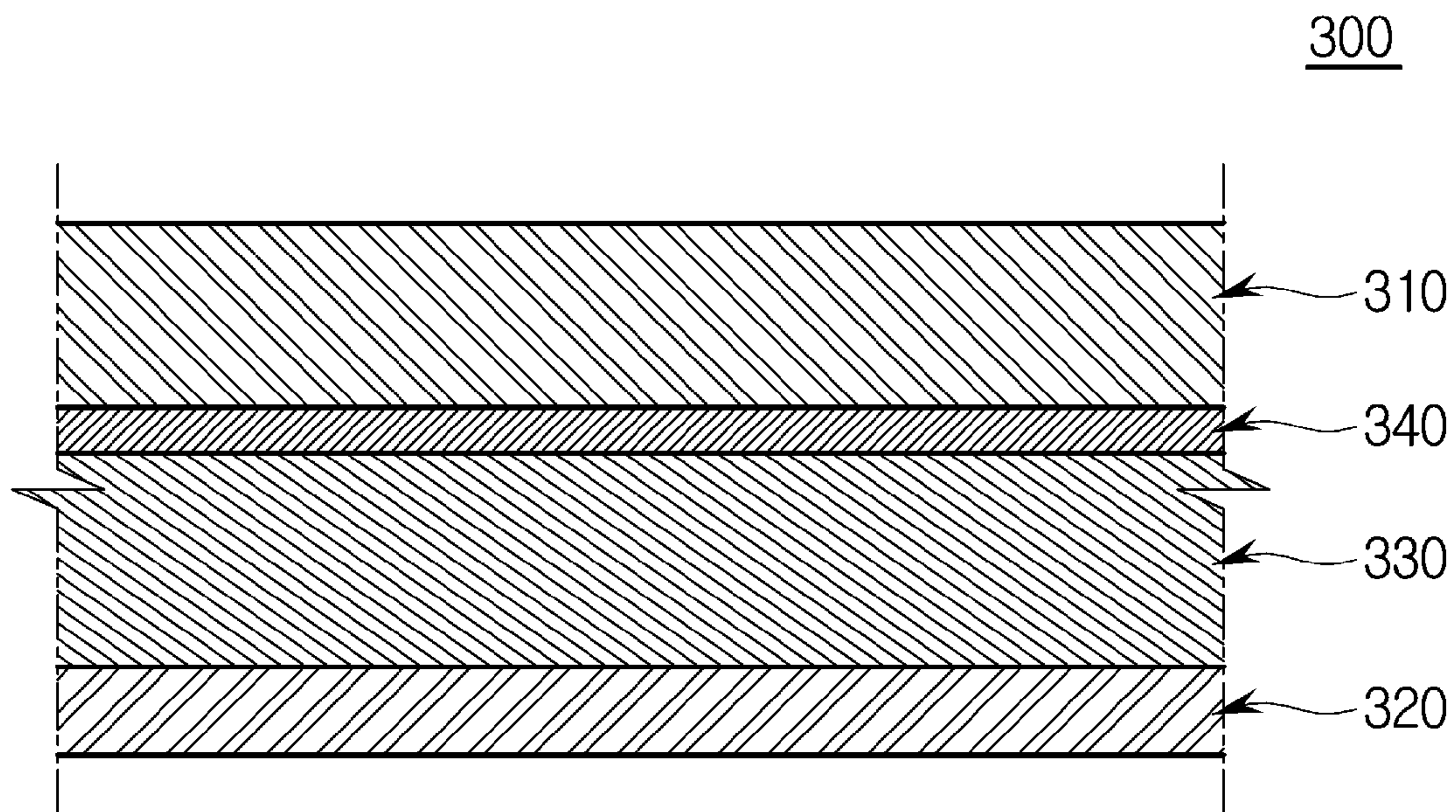
[Fig. 15]



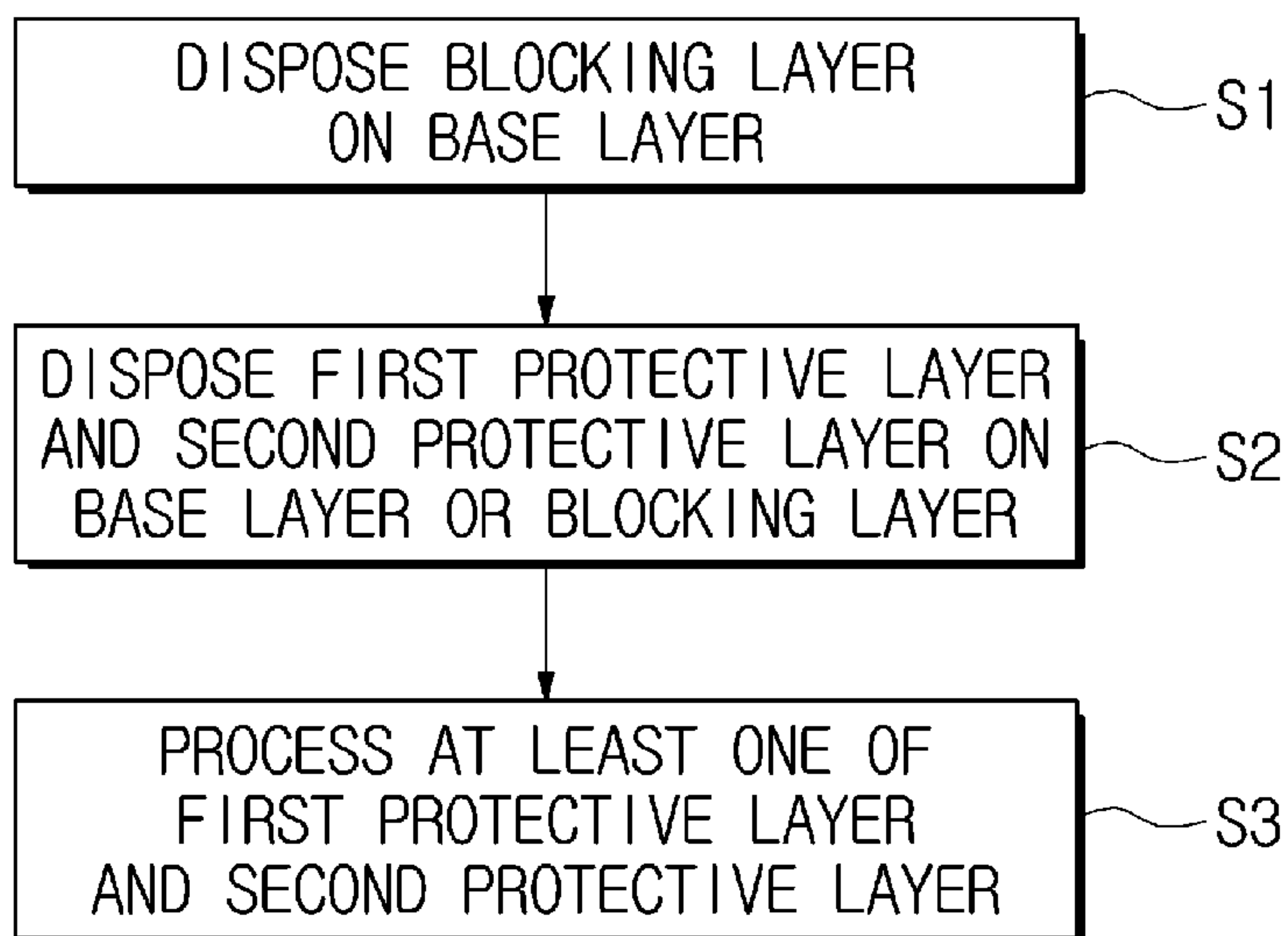
[Fig. 16]



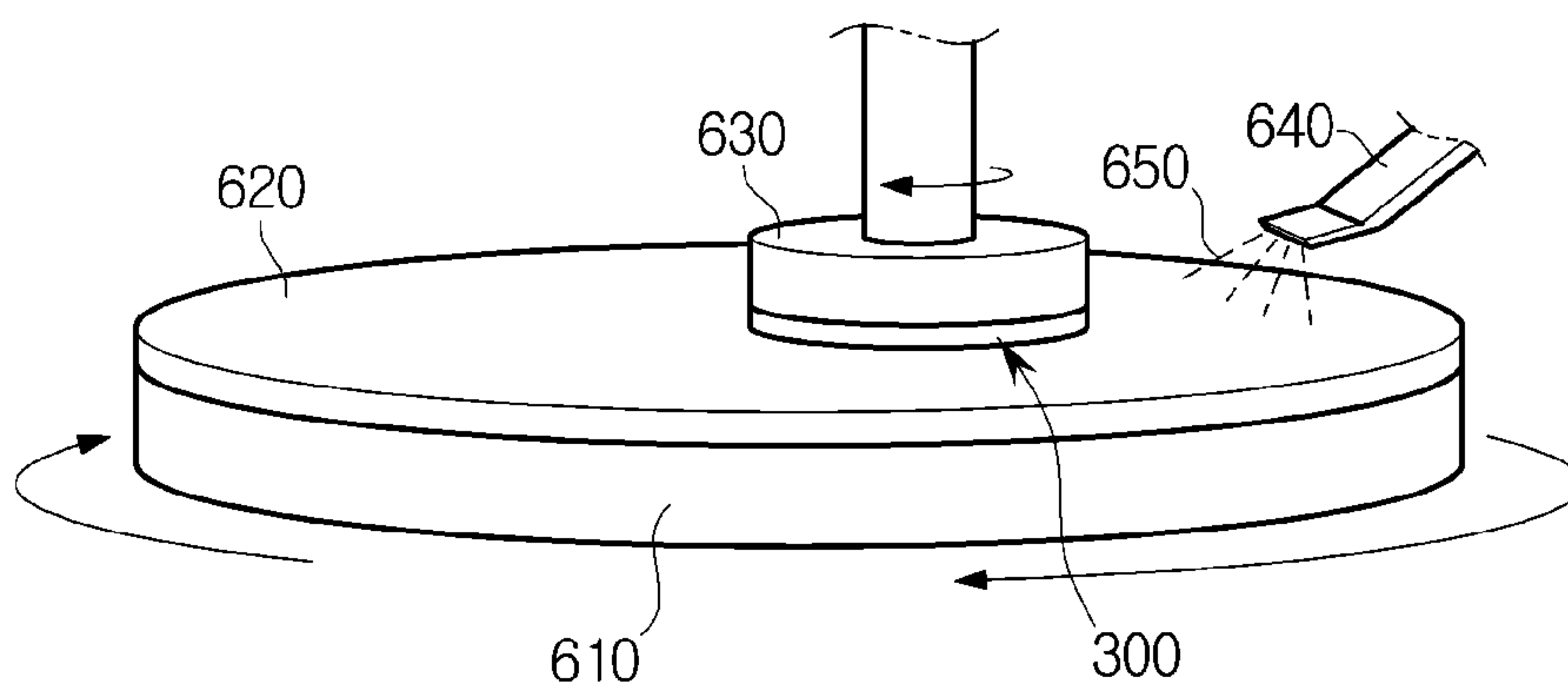
[Fig. 17]



[Fig. 18]



[Fig. 19]



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