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(54) **CURVED STACK STRUCTURES, MANUFACTURING METHODS THEREOF AND CURVED ELECTRONIC DEVICES**

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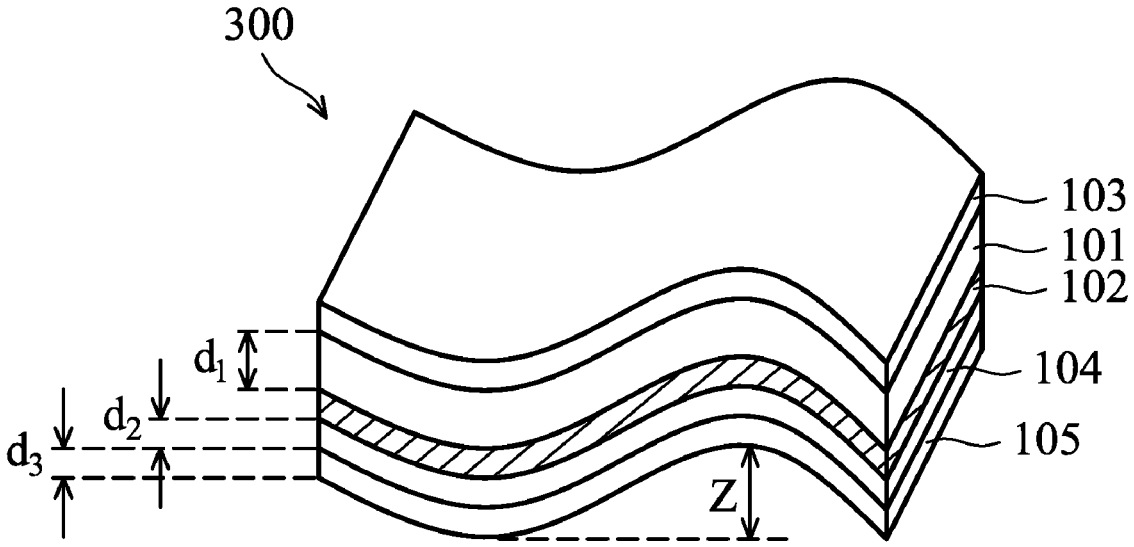
(57) **ABSTRACT**

A curved stack structure is provided. The curved stack structure includes a base having a curved surface. An adhesive layer is disposed on the base, and a substrate is disposed on the adhesive layer, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm. A fabrication method of the curved stack structure and a curved electronic device including the curved stack structure are also provided.



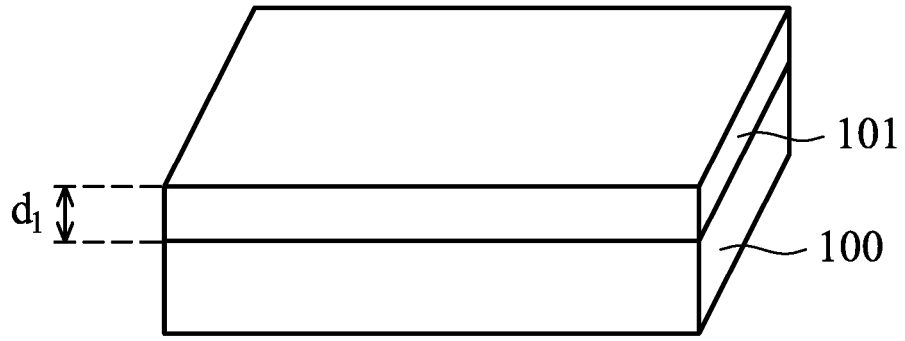


FIG. 1A

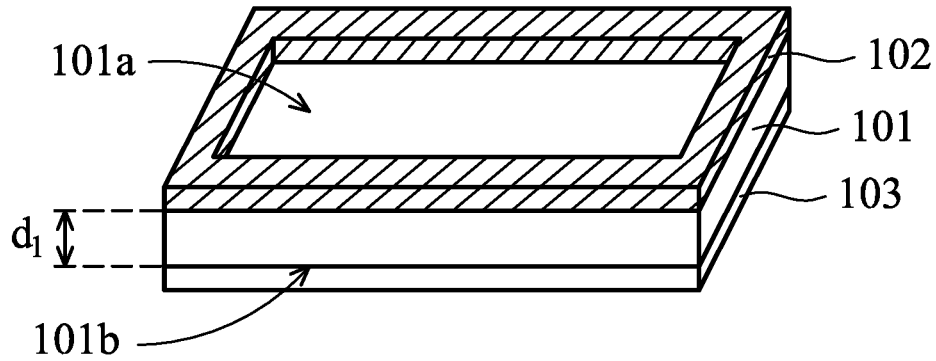


FIG. 1B

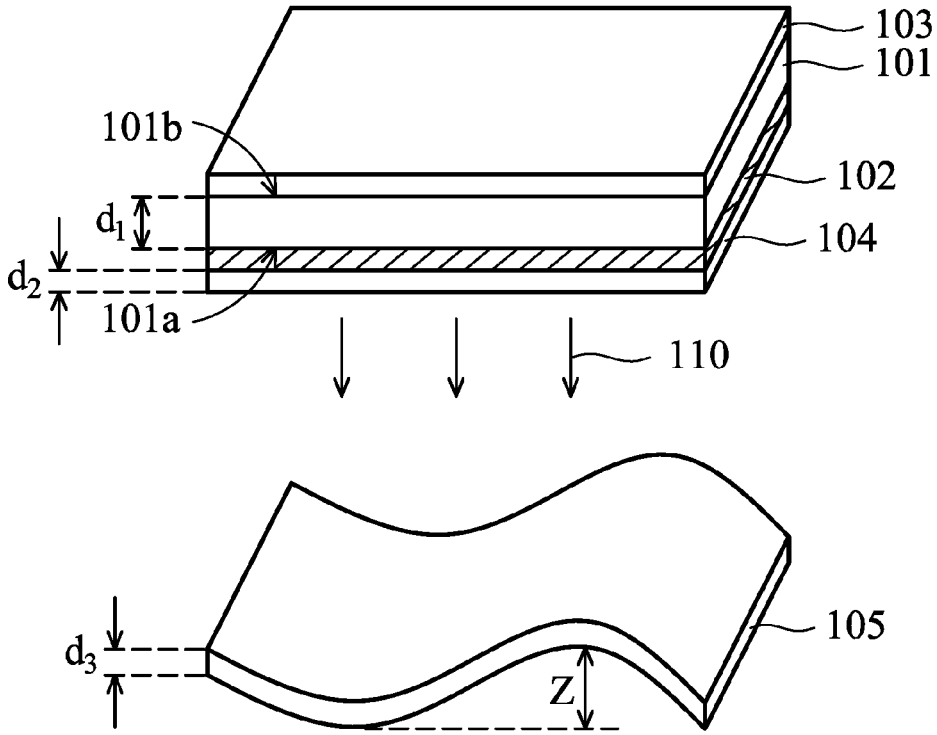

103
101
101b
102
d_1
104
d_2
101a
110
d_3
105
Z

FIG. 1C

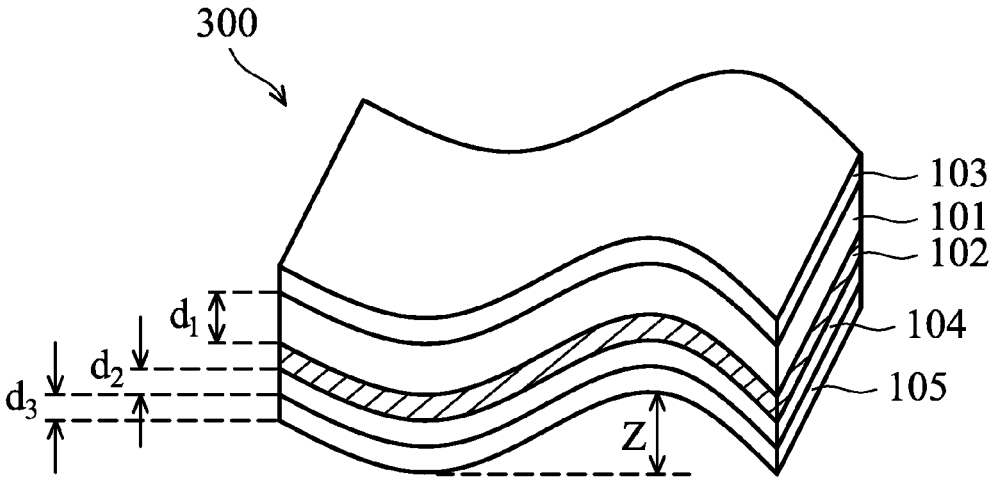

300
103
101
102
d_1
104
d_2
d_3
105
Z

FIG. 1D

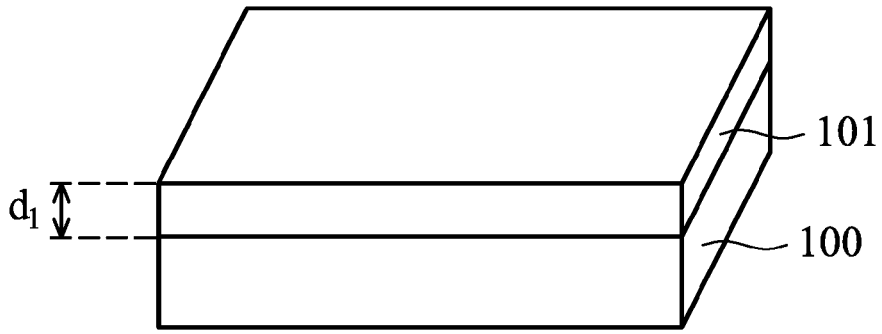


FIG. 2A

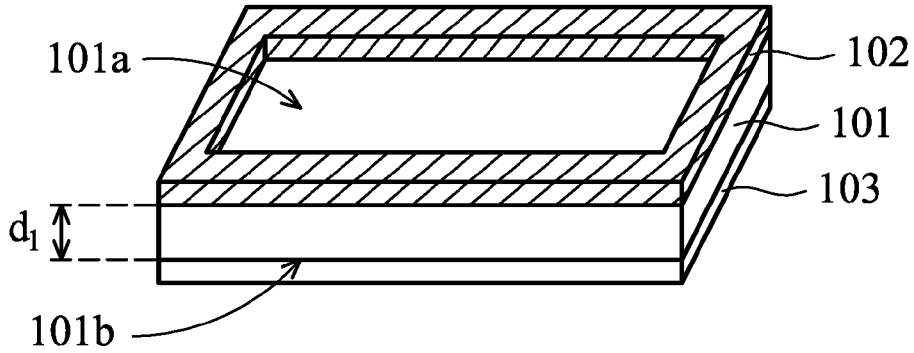


FIG. 2B

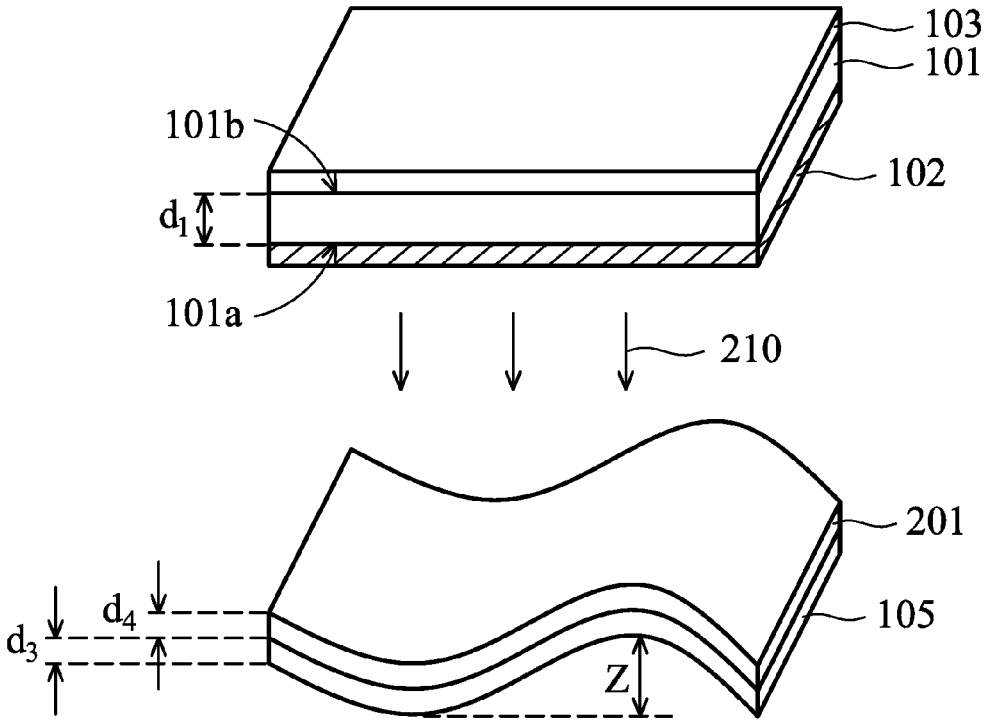

103
101
101b
102
d_1
101a
210
201
105
d_4
d_3
Z

FIG. 2C

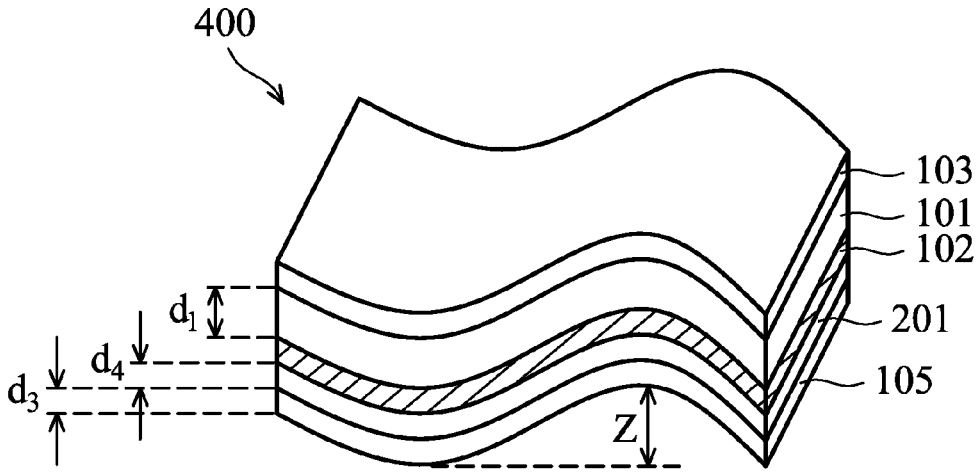

400
103
101
102
d_1
201
d_4
105
d_3
Z

FIG. 2D

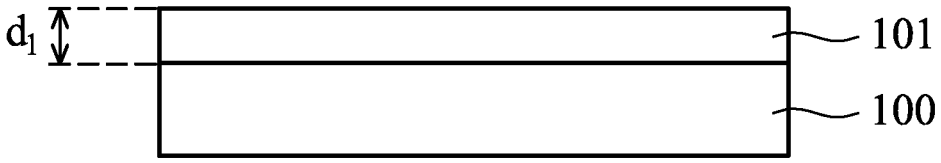


FIG. 3A

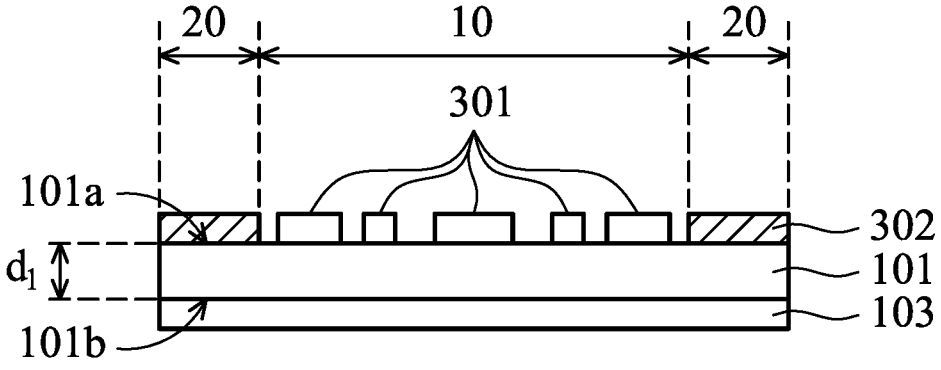


FIG. 3B

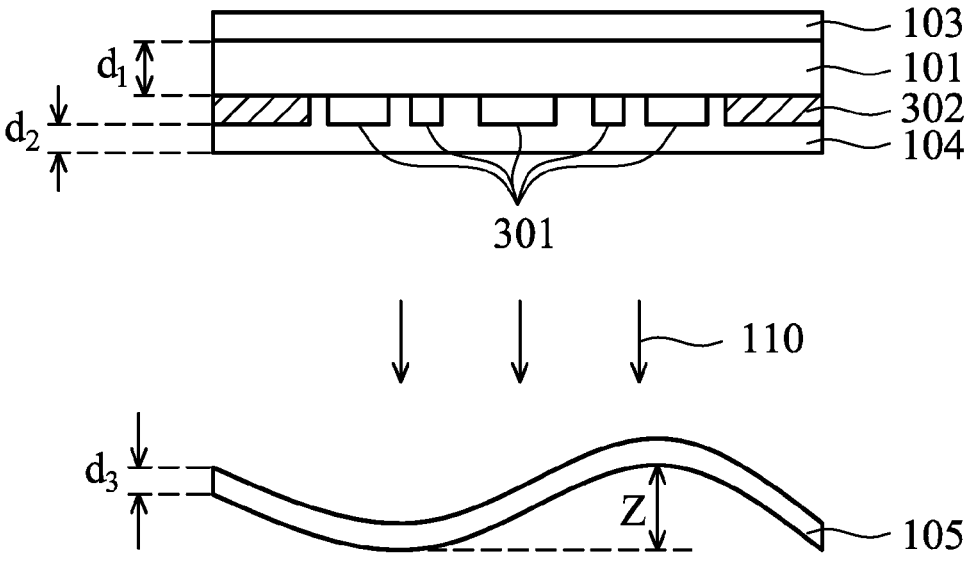

103
101
302
104
d_1
d_2
301
110
d_3
Z
105

FIG. 3C

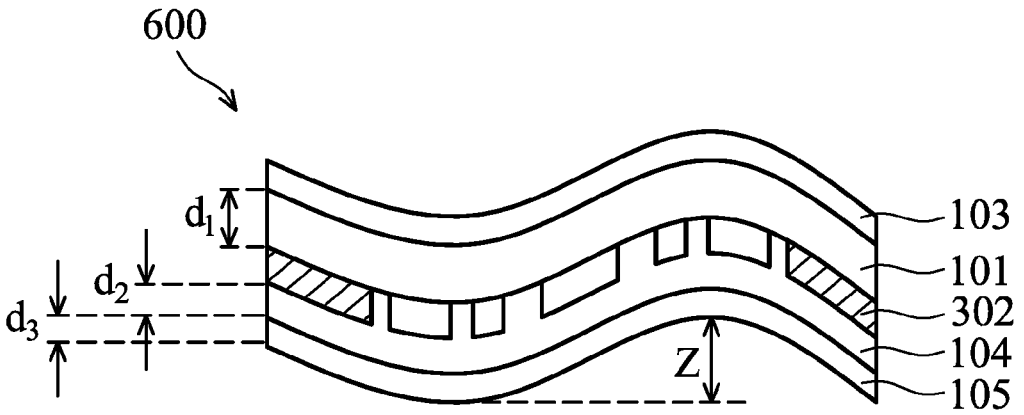

600
d_1
d_2
d_3
103
101
302
104
Z
105

FIG. 3D

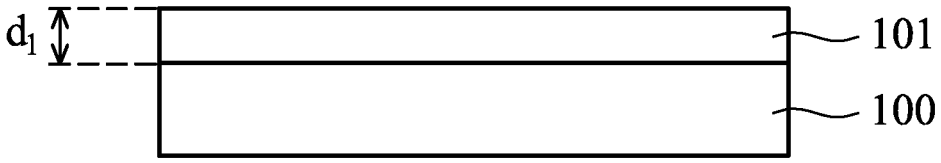


FIG. 4A

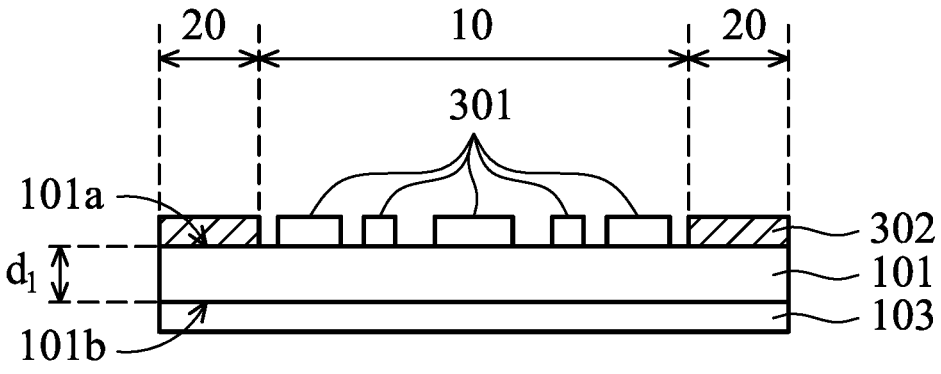


FIG. 4B

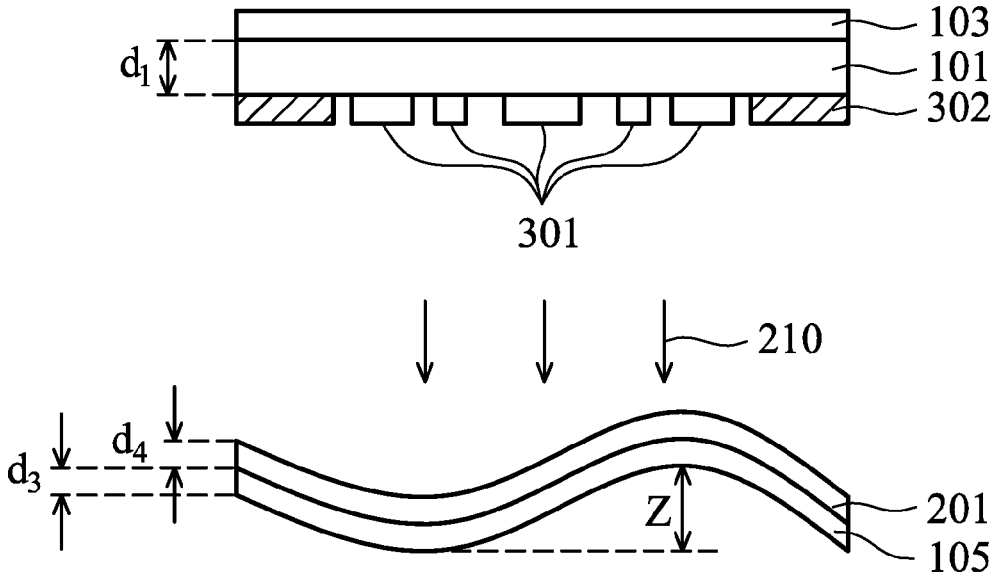

103
101
302
d_1
301
210
d_3
d_4
Z
201
105

FIG. 4C

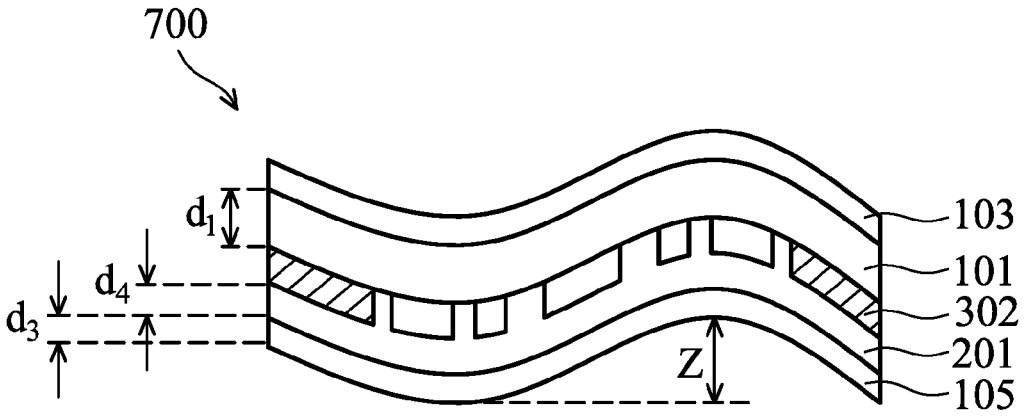

700
d_1
d_4
d_3
103
101
302
Z
201
105

FIG. 4D

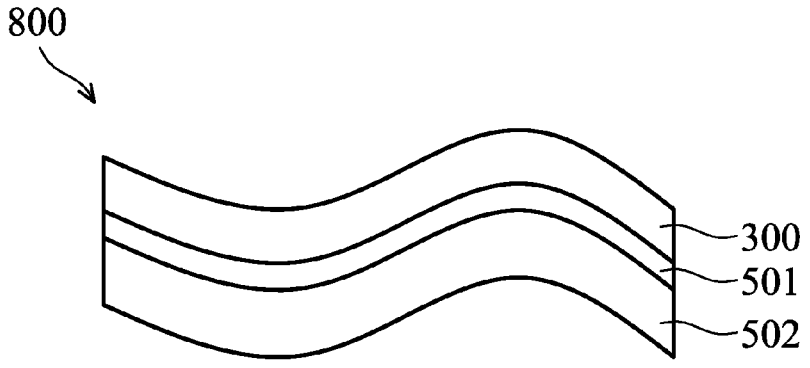


FIG. 5A

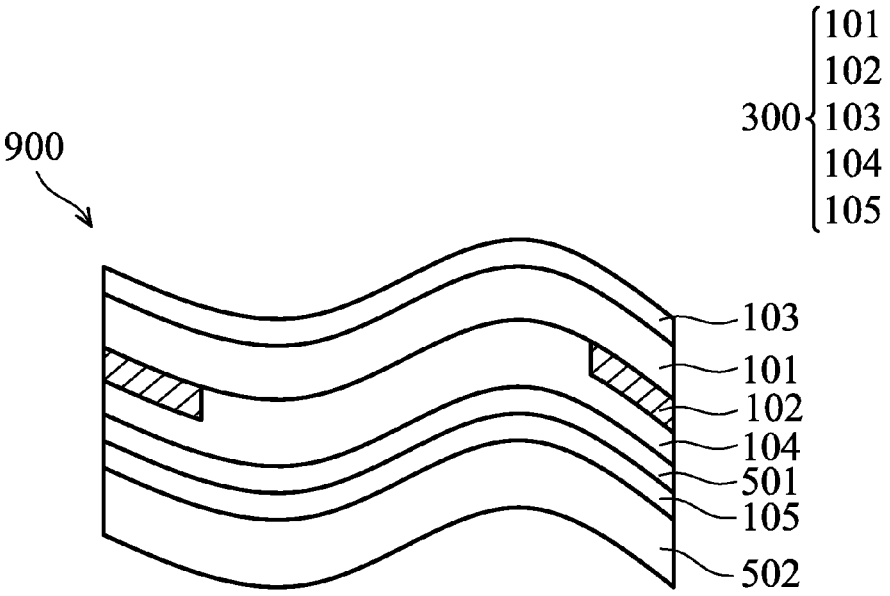


FIG. 5B

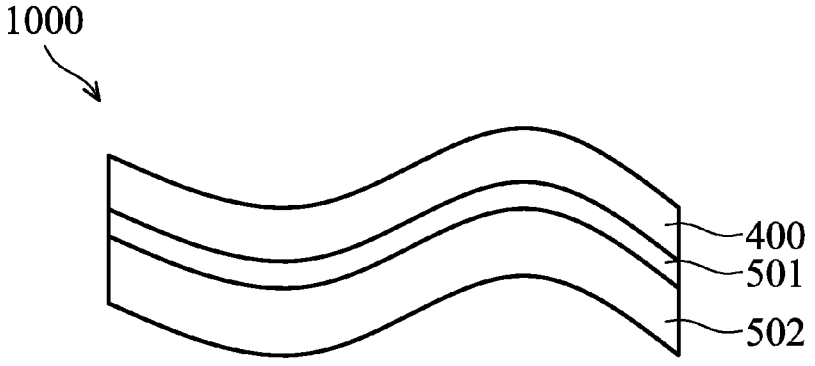


FIG. 6

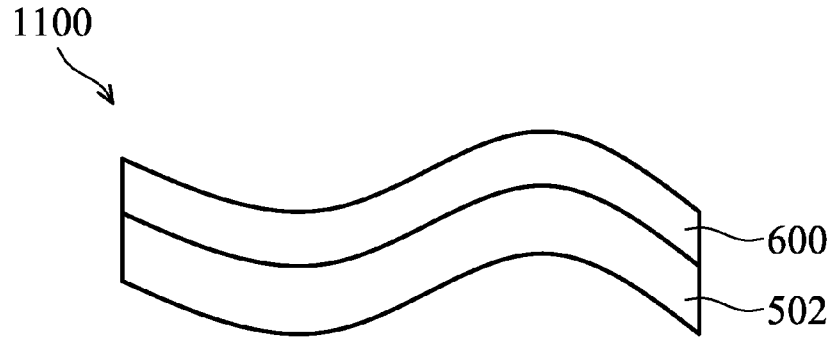


FIG. 7A

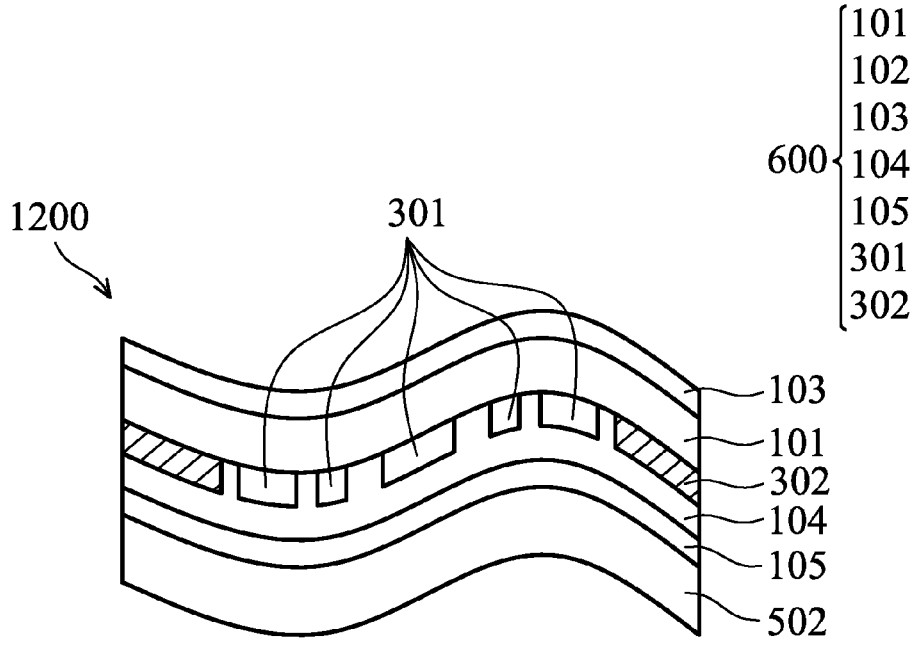


FIG. 7B

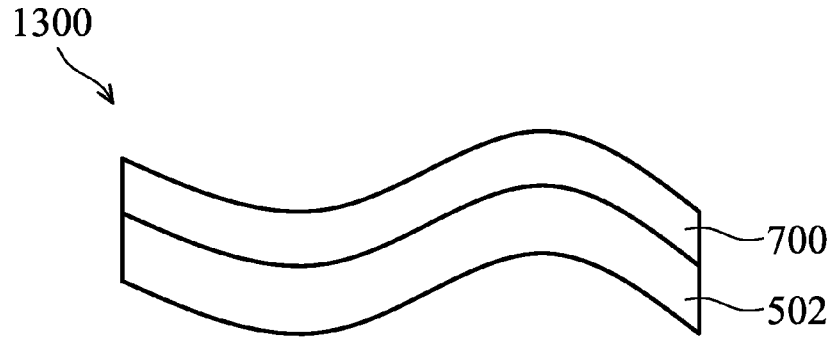


FIG. 8

CURVED STACK STRUCTURES, MANUFACTURING METHODS THEREOF AND CURVED ELECTRONIC DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims priority of U.S. Provisional Patent Application Ser. No. 62/394,269, filed on Sep. 14, 2016 and China Patent Application No. 201611024496.1, filed on Nov. 21, 2016, the entirety of which is incorporated by reference herein.

BACKGROUND

Field of the Invention

[0002] The disclosure relates to curved stack structures, and in particular to curved stack structures having thinner glass, manufacturing methods thereof, and curved electronic devices including the curved stack structures are applied.

Description of the Related Art

[0003] Curved structures have been widely used in household appliances, communication devices, and electronic information devices. Currently, curved structures can be combined with a touch panel and a display panel to use as a touch display device, the touch display device allows users to directly select images shown on the panel using a finger or a touch pen. Therefore, touch display device can provide an efficient operation system, gradually replacing physical keyboards as the input interface of choice in various electronic products.

[0004] Methods for fabricating a curved glass having a decoration layer in a conventional curved structure generally include a printing process after a bending process. However, in the processes of printing after bending, since the curved glass has a complex appearance, the subsequent printing process (and other processing) is hard to perform. Therefore, conventional curved structures have the problem of having a lower quality of appearance uniformity. Thus, conventional curved structures still have a bottleneck to break through.

BRIEF SUMMARY

[0005] In some embodiments of the disclosure, a curved stack structure is provided. The curved stack structure includes a base having a curved surface and an adhesive layer disposed on the base. The curved stack structure also includes a substrate disposed on the adhesive layer, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

[0006] In some embodiments of the disclosure, a method for fabricating a curved stack structure is provided. The method provides a base having a curved surface and fabricating an adhesive layer on the base. The method also provides a substrate and attaches the substrate to the adhesive layer, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

[0007] In some embodiments of the disclosure, a curved electronic device is provided. The curved electronic device includes a curved stack structure. The curved stack structure includes a base having a curved surface and an adhesive layer disposed on the base. The curved stack structure also includes a substrate disposed on the adhesive layer. The curved electronic device also includes a display panel disposed at a side of the curved stack structure, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

[0008] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The disclosure can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0010] FIGS. **1**A-**1**D shows perspective views of various stages of a method of fabricating a curved stack structure according to some embodiments of the disclosure.

[0011] FIGS. **2**A-**2**D shows perspective views of various stages of a method of fabricating a curved stack structure according to some other embodiments of the disclosure.

[0012] FIGS. **3**A-**3**D shows perspective views of various stages of a method of fabricating a curved touch panel according to some embodiments of the disclosure.

[0013] FIGS. **4**A-**4**D shows perspective views of various stages of a method of fabricating a curved touch panel according to some other embodiments of the disclosure.

[0014] FIG. **5**A shows a cross section of a curved electronic device according to some embodiments of the disclosure.

[0015] FIG. **5**B shows a cross section of a curved electronic device according to some other embodiments of the disclosure.

[0016] FIG. **6** shows a cross section of a curved electronic device according to some other embodiments of the disclosure.

[0017] FIG. **7**A shows a cross section of a curved electronic device according to some other embodiments of the disclosure.

[0018] FIG. **7**B shows a cross section of a curved electronic device according to some other embodiments of the disclosure.

[0019] FIG. **8** shows a cross section of a curved electronic device according to some other embodiments of the disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The following description is about a curved stack structure, fabricating methods thereof and curved electronic devices including the curved stack structures are applied according to embodiments of the disclosure. However, it should be appreciated that the embodiments of the disclosure provide lots of suitable concepts of the invention and can be performed in a wide variety of specific backgrounds. The specific embodiments of the disclosure are used to explain the fabrication by specific methods and use of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims. Moreover, the same or similar elements in the drawings and the description are labeled with the same reference numbers.

[0021] In the embodiments of the disclosure, a structure (a layer, an element, a substrate) located on another structure (a layer, an element, a substrate) can mean that two structures

are adjacent to each other and directly connected with each other. It can also mean that the lower surface of one structure is adjacent to and directly connected with the upper surface of another structure, or it can also mean that two structures are adjacent to each other and not directly connected with each other. It can also mean that at least one interposed structure (an interposed layer, an interposed element, an interposed substrate, an interposed spacer) between two structures, and the lower surface of a structure is adjacent to or directly connected with the upper surface of the interposed structure, and the upper surface of another structure is adjacent to or directly connected with the lower surface of the interposed structure. The interposed structure can be made of a single layer or multiple layers of a physical structure or a non-physical structure, but the disclosure is not limited thereto.

[0022] The thickness of a structure described in the embodiments of the disclosure indicates a value for the average thickness of the structure after deleting outliers. The outliers can be the thickness of an edge, an obvious micro-trench, or an obvious micro-raised area. After deleting the outliers, most values of the thickness are within a range of plus or minus three standard deviations.

[0023] FIGS. **1**A-**1**D shows perspective views of various stages of a method of fabricating a curved stack structure **300** according to some embodiments of the disclosure. Referring to FIG. **1**A, a carrier **100** is provided, and a substrate **101** having a smaller thickness is attached to the carrier **100** having a greater thickness by a glass on glass (GOG) process or a roll to roll (R2R) process. The stack of the carrier **100** and the substrate **101** can undergo subsequent processes to avoid lack of rigidity and stiffness. Lack of rigidity and stiffness may cause difficulty in subsequent processes. In the embodiment, the carrier **100** may be alkali-free glass or alkali-containing glass. The substrate **101** may be alkali-free glass, alkali-containing glass or chemical-strengthening glass, and the thickness d_1 of the substrate **101** is greater than or equal to 0.01 mm and less than or equal to 0.4 mm. Thus, the substrate **101** can be called thin glass or ultra-thin glass. Since the thickness d_1 of the substrate **101** is less than or equal to 0.4 mm, the substrate **101** has bendability, flexibility or the ability to be foldable. In some embodiments, the thickness d_1 of the substrate **101** is greater than or equal to 0.03 mm and less than or equal to 0.4 mm. In some embodiments, the thickness d_1 of the substrate **101** is greater than or equal to 0.04 mm and less than or equal to 0.2 mm. In the embodiment, the carrier **100** is used for carrying the substrate **101**, and the carrier **100** may be temporarily removed or permanently removed during or after subsequent processes. In some other embodiments, if the carrier **100** is used as a part of resulting stack structure, the carrier **100** may not be removed.

[0024] In some other embodiments, the material of the substrate **101** may be replaced by another non-glass material formed as single, mixed or stacked polymer material (polyimide (PI), plastic or rubber), metal or ceramic material, and transparent material is preferred, but the disclosure is not limited thereto. The material of the carrier **100** may be replaced by another non-glass material formed as single, mixed or stacked polymer material (polyimide, polymethylmethacrylate (PMMA), polycarbonate (PC), plastic or rubber), metal, ceramic material or composite material, and material that has similar material characteristics as the material of the substrate **101** is preferred, but the disclosure is not limited thereto. The glass on glass process used on the carrier **100** and the substrate **101** may be vacuum adsorption, electrostatic adsorption, gluing, or another process of physical or chemical bonding, but the disclosure is not limited thereto.

[0025] In some embodiments, when there is a requirement for the substrate **101** to be strengthened and the substrate **101** is glass that is capable of being chemically strengthened, the substrate **101** may be soaked in a chemical solution such as potassium nitrate to perform ion exchange and form a chemical-strengthening layer (not shown) on the surface of the substrate **101** before the substrate **101** and the carrier **100** are attached together. Then, the strengthened substrate **101** is attached to the carrier **100**.

[0026] Referring to FIG. **1**B, the substrate **101** has a first surface **101***a* and a second surface **101***b* opposite to the first surface **101***a*. The first surface **101***a* is a non-viewing surface facing away from a viewer after the substrate **101** is modularized. The second surface **101***b* is a viewing surface facing a viewer after the substrate **101** is modularized. In the embodiment, the second surface **101***b* of the substrate **101** is attached to the carrier **100**. In the embodiment, a light-shielding layer **102** is disposed on a peripheral area of the first surface **101***a* of the substrate **101** by screen printing, inkjet printing or transfer printing, but the disclosure is not limited thereto. In the embodiment, the light-shielding layer **102** comprises a single layer, multiple layers or in a composite way of using photo-curable ink, thermal-curable ink, or another light-shielding material, but the disclosure is not limited thereto. The color of the light-shielding layer **102** comprises any color that does not make light transmission easy, such as white, black, grey, red, green, blue, gold, silver, another suitable color, or a combination thereof, but the disclosure is not limited thereto. The light-shielding layer **102** is used to decorate the color of an exterior frame of the curved stack structure **300** shown in FIG. **1**D.

[0027] Then, the carrier **100** is removed, and a functional layer **103** is disposed on the second surface **101***b* of the substrate **101** by a deposition process (for example, a physical vapor deposition process, a chemical vapor deposition process or another suitable process), a printing process or a spraying process, but the disclosure is not limited thereto. In the embodiment, the light-shielding layer **102** and the functional layer **103** are disposed on opposite sides of the substrate **101**. The substrate **101** is located between the light-shielding layer **102** and the functional layer **103**. In some other embodiments, the carrier **100** may be removed or be kept, and the functional layer **103** is disposed on the light-shielding layer **102**. Namely, the functional layer **103** is also on the first surface **101***a* of the substrate **101**, and the light-shielding layer **102** is located between the substrate **101** and the functional layer **103**. In some embodiments, the functional layer **103** may include an anti-scratch layer, an anti-glare layer, an anti-reflection layer, an anti-smudge layer, or a combination thereof, but the disclosure is not limited thereto. After the functional layer **103** is formed, the carrier **100** may be removed, and the substrate **101** and the related light-shielding layer **102** and the functional layer **103** are cut to the desired shape by a laser, a wheel, or another suitable cutting method, but the disclosure is not limited thereto. The profile of the substrate **101** after cutting may be a rectangle or a non-rectangular type such as a circle, oval, triangle, hexagon, octagon or another irregular shape, but the disclosure is not limited thereto. Since the light-shielding

layer **102** is designed by the cutting pattern and the path of cutting may be located at an edge near the outer side of the light-shielding layer **102**, the light-shielding layer **102** would still cover the peripheral area of the substrate **101**. The peripheral area is located outside and adjacent to a light-transmitting area in the substrate **101**.

[0028] Referring to FIG. **1**C, an adhesive layer **104** is attached on the first surface **101***a* of the substrate **101**. The adhesive layer **104** is in contact with the substrate **101** in the light-transmitting area and the light-shielding layer **102** in the peripheral area. The light-shielding layer **102** is located between the substrate **101** and the adhesive layer **104**. The adhesive layer **104** has a thickness d_2. In the embodiment, the thickness d_2 of the adhesive layer **104** may be between 50 μm and 1000 μm. In some other embodiments, the thickness d_2 may be between 100 μm and 800 μm. In the embodiment, the area of the adhesive layer **104** may be greater than or equal to the area of the substrate **101**, and the boundary profile of the substrate **101** may be located within the boundary profile of the adhesive layer **104**. In some other embodiments, the area of the adhesive layer **104** may be less than or equal to the area of the substrate **101**, and the boundary profile of the adhesive layer **104** may be located within the boundary profile of the substrate **101**. In the embodiment, the material of the adhesive layer **104** may include optical clear adhesive (OCA), optical clear resin (OCR) or another suitable transparent and adhesive material, but the disclosure is not limited thereto.

[0029] Then, a base (or spine) **105** is provided. The area of the base **105** may be greater than or equal to the area of the adhesive layer **104**, and the boundary profile of the adhesive layer **104** may be located within the boundary profile of the base **105**. The base **105** at least has a curved surface. The curved surface may be formed in a single or multiple staggered way of convex part, convex point, concave part or concave point. The exterior of the curved surface may be seen as a υ shape, ω shape, Ω shape, ν shape, σ shape or o shape in a cross section. There is a height difference Z. There is a highest point in the partial area such as a ridge point or a top point and a lowest point in the partial area such as a saddle point or a concave point, and there is a single vertical distance between a tangent plane of the highest point in the partial area and a tangent plane of the lowest point in the partial area. This distance is called the height difference or the surface height difference. The distance is the largest value of the height difference in the partial area and is disposed in a partial area of the curved surface, and may be greater than or equal to 2 cm and less than or equal to 20 cm. In some embodiments, the height difference Z may be greater than or equal to 4 cm and less than or equal to 18 cm. In some embodiments, the height difference Z may be greater than or equal to 5 cm and less than or equal to 16 cm. The base **105** has a thickness d_3. The thickness d_3 is greater than or equal to the thickness d_2. The thickness d_3 is greater than the thickness d_1. In some embodiments, the thickness d_3 is greater than or equal to 1 mm and less than or equal to 10 mm. The thickness d_3 is greater than the thickness d_1. In some embodiments, the thickness d_3 is greater than or equal to 1 mm and less than or equal to 5 mm. In some embodiments, the thickness d_3 is greater than or equal to 1 mm and less than or equal to 3 mm. The profile of the base **105** may be a rectangle or another non-rectangular shape such as a circle, oval, triangle, hexagon or another irregular shape, but the disclosure is not limited thereto. In some embodiments, the material of the base **105** may include glass, polymethylmethacrylate (PMMA), polycarbonate (PC) or another suitable material, but the disclosure is not limited thereto.

[0030] Then, a stack structure formed by the functional layer **103**, the substrate **101**, the light-shielding layer **102** and the adhesive layer **104** is conformably attached to curved surface of the base **105** using a laminating process **110** to finish the curved stack structure **300** shown in FIG. **1**D. As shown in FIG. **1**D, the substrate **101** is disposed between the functional layer **103** and the base **105**. In some other embodiments, the laminating process **110** may also be replaced by vacuum adsorption, electrostatic adsorption or another attaching process. In some embodiments, the shape of the curved stack structure **300** is similar to the shape of the curved surface of the base **105**. The curved stack structure **300** may include a plurality of continuous or discontinuous concave surfaces and convex surfaces, but the disclosure is not limited thereto.

[0031] In some embodiments, the edges of all layers of the curved stack structure **300** are adjusted so that they are aligned with one another. In a cross section, when the radius (R) of curvature of the substrate **101** of the curved stack structure **300** in an area is longer than the radius (R) of curvature of the adhesive layer **104** in the area, and the radius (R) of curvature of the adhesive layer **104** in the area is longer than the radius (R) of curvature of the base **105** in the area, the length of the substrate **101** along the direction of the cross section in the area is greater than 100.1% of the length of the adhesive layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is greater than 100.1% of the length of the base **105** along the direction of the cross section in the area. In some embodiments, the length of the substrate **101** along the direction of the cross section in the area is 100%-100.2% of the length of the adhesive layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is 100%-100.2% of the length of the base **105** along the direction of the cross section in the area. In some other embodiments, the length of the substrate **101** along the direction of the cross section in the area is 100%-101% of the length of the adhesive layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is 100%-101% of the length of the base **105** along the direction of the cross section in the area.

[0032] In some other embodiments, the edges of all layers of the curved stack structure **300** are adjusted so that they are aligned with one another. In a cross section, when the radius (R) of curvature of the base **105** of the curved stack structure **300** in an area is longer than the radius (R) of curvature of the adhesive layer **104** in the area, and the radius (R) of curvature of the adhesive layer **104** in the area is longer than the radius (R) of curvature of the substrate **101** in the area, the length of the base **105** along the direction of the cross section in the area is greater than 100.1% of the length of the adhesive layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is greater than 100.1% of the length of the substrate **101** along the direction of the cross section in the area. In some embodiments, the length of the base **105** along the direction of the cross section in the area is 100%-100.2% of the length of the adhesive

layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is 100%-100.2% of the length of the substrate **101** along the direction of the cross section in the area. In some other embodiments, the length of the base **105** along the direction of the cross section in the area is 100%-101% of the length of the adhesive layer **104** along the direction of the cross section in the area, and the length of the adhesive layer **104** along the direction of the cross section in the area is 100%-101% of the length of the substrate **101** along the direction of the cross section in the area.

[0033] In the embodiment, the above-mentioned printing process, deposition process, cutting process and the process of the adhesive layer **104** attached to the light-shielding layer **102** and the substrate **100** are all plane processes, which can be completed in a two-dimensional plane. The above-mentioned laminating process **110** is a curved surface process, which can be completed in three-dimensional (3D) space.

[0034] In the curved stack structure **300** finished in the above-mentioned laminating process **110**, the light-shielding layer **102** is disposed on the surface (i.e. first surface **101***a*) of the substrate **101** close to the base **105** on the peripheral area. Namely, the light-shielding layer **102** is located between the substrate **101** and the adhesive layer **104**. The functional layer **103** is disposed on the surface (i.e. the second surface **101***b*) of the substrate **101** away from the base **105**. Namely, the functional layer **103** is located on the viewing surface.

[0035] Since the substrate **101** is an ultra-thin glass having a thickness d_1 less than or equal to 0.4 mm, the substrate **101** has flexibility. Under the condition that the substrate **101** has flexibility, the substrate **101** can be conformably attached to the curved surface of the base **105** without using a heating process for 3D forming to finish the curved stack structure **300**, but the disclosure is not limited thereto. The heating process can also be used. In addition, since the curved stack structure **300** is finished without performing a heating process for 3D forming on the substrate **101**, the substrate **101** of the curved stack structure **300** can overcome restrictions in equipments for processing curved surface objects (then the height difference Z can be greater than 5 cm), and the substrate **101** can obtain a more uniform surface processing effect. Moreover, since the curved stack structure **300** is finished without a heating process for 3D forming being performed on the substrate **101**, the chosen processing material (such as ink) processing on the substrate **101** of the curved stack structure **300** is less restricted by the temperature, and the light-shielding layer **102** on the substrate **101** can have a better shielding effect.

[0036] Moreover, since the curved stack structure **300** is a glued laminated structure which laminates the substrate **101**, the adhesive layer **104** and the base **105** together, and the materials of the substrate **101** and the base **105** are glass, the glued laminated structure can be called laminated safety glass (LSG). Therefore, the curved stack structure **300** has better structural strength and can pass a hit impact test (HIT). The curved stack structure **300** can be used as a component in aerospace transportation, cars, boats, or another form of transportation.

[0037] Referring to FIGS. **2**A-**2**D, they show perspective views of various stages of a method of fabricating a curved stack structure **400** according to some other embodiments of the disclosure. Elements in FIGS. **2**A-**2**D that are the same as those in FIGS. **1**A-**1**D are labeled with the same reference numbers as in FIGS. **1**A-**1**D and are not described again for brevity.

[0038] The method for fabricating the curved stack structure **400** shown in FIGS. **2**A-**2**D is similar to that of the method for fabricating the curved stack structure **300** shown in FIGS. **1**A-**1**D. The difference between the curved stack structure **400** and the curved stack structure **300** is in the embodiment of FIG. **2**C, an adhesive layer **201** is conformably disposed on the curved surface of the base **105**, and the adhesive layer **201** has a thickness d_4. Then, an entire structure of the functional layer **103**, the substrate **101** and the light-shielding layer **102** is conformably attached to the adhesive layer **201** by a laminating process **210** to finish the curved stack structure **400** shown in FIG. **2**D. In some embodiments, the laminating process **210** is performed in a vacuum chamber under high temperature and high pressure. In the embodiment, the material of the adhesive layer **201** may include polyvinylbutyral (PVB) or another suitable transparent and adhesive material, and the thickness d_4 is between 100 μm and 800 μm. In some other embodiments, the thickness d_4 is between 50 μm and 1000 μm.

[0039] In the embodiment, the high temperature of the laminating process **210** makes the polyvinylbutyral become adhesive, and the substrate **101**, the adhesive layer **201** and the base **105** can have a better bonding force to be bonded together. The polyvinylbutyral is highly light-transmitting, and a highly light-transmitting laminated safety glass is thereby obtained. The curved stack structure **400** would have better structural strength and optical performance, and it can pass a hit impact test and meet the requirements of optical transparency.

[0040] Referring to FIGS. **3**A-**3**D, they show perspective views of various stages of a method for fabricating a curved touch panel **600** according to some embodiments of the disclosure. Elements in FIGS. **3**A-**3**D that are the same as those in FIGS. **1**A-**1**D are labeled with the same reference numbers as in FIGS. **1**A-**1**D and are not described again for brevity.

[0041] The method for fabricating the curved touch panel **600** shown in FIGS. **3**A-**3**D is similar to that of the method of fabricating the curved stack structure **300** shown in FIGS. **1**A-**1**D. The difference between the curved stack structure **600** and the curved stack structure **300** is in the embodiment of FIG. **3**B, a patterned touch-sensing electrode layer **301** and black matrix layer **302** are disposed on the first surface **101***a* of the substrate **101** by a deposition process (for example, a physical vapor deposition process, a chemical vapor deposition process or another suitable process) and a photolithography process. The touch-sensing electrode layer **301** is located in a touch area **10**, and the touch area **10** corresponds to the light-transmitting area of the substrate **101**. The black matrix layer **302** is located in peripheral area **20** near the touch-sensing electrode layer **301**. Then, the functional layer **103** is disposed on the second surface **101***b* of the substrate **101** by a deposition process (for example, a physical vapor deposition process, a chemical vapor deposition process or another suitable process). After the functional layer **103** is formed, the substrate **101** is cut to the desired shape by a laser, a wheel, or another suitable cutting method. In some embodiments, the material of the touch-sensing electrode layer **301** may include transparent conductive material such as indium tin oxide (ITO), indium zinc

oxide (IZO), fluorine doped tin oxide (FTO), aluminum doped zinc oxide (AZO), gallium doped zinc oxide (GZO) or another suitable transparent conductive material. In some embodiments, the material of the touch-sensing electrode layer **301** may be metal, another transparent conductive material or another non-transparent conductive material, such as metal mesh, carbon nano-tube (CNT), silver nano-wire or grapheme. In some embodiments, the material of the black matrix layer **302** may be metal, organic material or ink, such as Cr or black resin. In some embodiments, the black matrix layer **302** can be any color that does not easily transmit light and has a certain thickness to decrease the transmittance, and conductive lines (not shown) connected to the touch-sensing electrode layer **301** in the peripheral area **20** can be shielded. In some other embodiments, the touch-sensing electrode layer **301** may be disposed between the substrate **101** and the functional layer **103**.

[0042] Referring to FIG. **3**C, the adhesive layer **104** is attached to the touch-sensing electrode layer **301**, the black matrix layer **302** and the first surface **101***a* of the substrate **100**, and the adhesive layer **104** has a thickness d_2. Then, the base **105** is provided. The base **105** has a curved surface, and the height difference Z of the curved surface can be greater than 5 cm, but the disclosure is not limited thereto. The base **105** has a thickness d_3. Then, an entire structure of the functional layer **103**, the substrate **101**, the touch-sensing electrode layer **301**, the black matrix layer **302** and the adhesive layer **104** is conformably attached to the base **105** using a laminating process **110** to finish the curved touch panel **600** shown in FIG. **3**D. In the embodiment, the material of the adhesive layer **104** may include optical clear adhesive (OCA), optical clear resin (OCR) or another suitable transparent and adhesive material, and the thickness d_2 is between 100 μm and 800 μm. In some embodiments, the material of the base **105** may include glass, polymethylmethacrylate (PMMA), polycarbonate (PC) or another suitable material. The height difference Z is between 5 cm and 16 cm, and the thickness d_3 is between 1 mm and 3 mm. In some other embodiments, the height difference Z may be between 2 cm and 20 cm, and the thickness d_2 may be between 50 μm and 1000 μm, and the thickness d_3 is between 1 mm and 10 mm.

[0043] In the embodiment, the above-mentioned printing process, deposition process, cutting process and the process of the adhesive layer **104** attached to the touch-sensing electrode layer **301**, the black matrix layer **302** and the substrate **100** are all plane processes completed in a two-dimensional plane. The above-mentioned laminating process **110** is a curved surface process completed in three-dimensional (3D) space.

[0044] In the curved touch panel **600**, the touch-sensing electrode layer **301** and the black matrix layer **302** are disposed on the surface (i.e. first surface **101***a*) of the substrate **101** close to the base **105**. Namely, the touch-sensing electrode layer **301** and the black matrix layer **302** are located between the substrate **101** and the adhesive layer **104** and between the substrate **101** and the base **105**. The functional layer **103** is disposed on the surface (i.e. the second surface **101***b*) of the substrate **101** away from the base **105**. Namely, the functional layer **103** is located on the viewing surface.

[0045] Since the touch-sensing electrode layer **301** is disposed on the substrate **101** of the curved touch panel **600**, the curved touch panel **600** is a one-glass touch panel, or a so-called window integrated sensor (WIS). The curved touch panel **600** can have the advantages of a one-glass touch panel (such as a lighter and thinner structure) and the advantages of the above-mentioned curved stack structure **300** of FIG. **1**D.

[0046] Referring to FIGS. **4**A-**4**D, they show perspective views of various stages of a method for fabricating a curved touch panel **700** according to some other embodiments of the disclosure. Elements in FIGS. **4**A-**4**D that are the same as those in FIGS. **3**A-**3**D are labeled with the same reference numbers as in FIGS. **3**A-**3**D and are not described again for brevity.

[0047] The method for fabricating the curved touch panel **700** shown in FIGS. **4**A-**4**D is similar to that of the method for fabricating the curved touch panel **600** shown in FIGS. **3**A-**3**D. The difference between the curved stack structure **700** and the curved stack structure **600** is in the embodiment of FIG. **4**C, the adhesive layer **201** is conformably disposed on the curved surface of the base **105**, and the adhesive layer **201** has a thickness d_4. Then, the entire structure of the functional layer **103**, the substrate **101**, the touch-sensing electrode layer **301** and the black matrix layer **302** is attached to the adhesive layer **201** using a laminating process **110** to finish the curved touch panel **700** shown in FIG. **4**D. In some embodiments, the laminating process **110** is performed in a vacuum chamber under high temperature and high pressure. In the embodiment, the material of the adhesive layer **201** may include polyvinylbutyral (PVB) or another suitable transparent and adhesive material, and the thickness d_4 is between 100 μm and 800 μm.

[0048] Referring to FIG. **5**A, it shows a cross section of a curved electronic device **800** according to some embodiments of the disclosure. The curved electronic device **800** includes the curved stack structure **300** and a display panel **502** conformably disposed under the substrate **101** (not shown in FIG. **5**A) of the curved stack structure **300**. In the embodiment, the display panel **502** is located on the base **105** of the curved stack structure **300** shown in FIG. **1**D. Namely, the base **105** of the curved stack structure **300** shown in FIG. **1**D is located between the display panel **502** and the substrate **101** of the curved stack structure **300** shown in FIG. **1**D. The display panel **502** is located on the base **105** and over the first surface **101***a*, and the curved stack structure **300** is located between the viewer and the display panel **502**. In some embodiments, the display panel **502** may be a liquid-crystal display (LCD), a light-emitting diode display, an organic light-emitting diode (OLED) display, an electrophoresis display, an electrowetting display or another self-luminous or non-self-luminous display. It is not necessary for the self-luminous display to have a backlight module, and a backlight module is required to be disposed on the backside of the display panel **502** (opposite side to the curved stack structure **300**). The material of the substrate of the display panel **502** may be glass, quartz, plastic, rubber, metal foil or another inorganic or organic polymer material, but the disclosure is not limited thereto. The above-mentioned curved electronic device **800** may be a mobile phone, digital camera, personal digital assistant (PDA), laptop, desktop computer, television, car display, or portable DVD player.

[0049] In the embodiment, the curved electronic device **800** further includes a touch structure **501** disposed between the base **105** (not shown in FIG. **5**A) of the curved stack structure **300** and the display panel **502**. In some other

embodiments, the curved stack structure **300** is disposed between the touch structure **501** and the display panel **502**. In some other embodiments, the display panel **502** is disposed between the curved stack structure **300** and the touch structure **501**. In some other embodiments, the curved electronic device **800** may not include the touch structure **501**.

[0050] Referring to FIG. **5**B, it shows a cross section of a curved electronic device **900** according to some other embodiments of the disclosure. Elements in FIG. **5**B that are the same as those in FIG. **5**A are labeled with the same reference numbers as in FIG. **5**A and are not described again for brevity.

[0051] The curved electronic device **900** shown in FIG. **5**B is similar to that of the curved electronic device **800** shown in FIG. **5**A. The difference between the curved electronic device **900** and the curved electronic device **800** is in the embodiment of FIG. **5**B, the base **105** of the curved stack structure **300** is disposed between the touch structure **501** and the display panel **502**. The touch structure **501** can be adjacent to the substrate of the display panel **502** or adjacent to the base **105** of the curved stack structure **300**. In some other embodiments, the curved electronic device **900** may not include the touch structure **501**. In some other embodiments, the substrate of the display panel **502** has a touch structure **501** thereon, and the touch structure **501** is one of the elements that are disposed on the substrate of the display panel **502**.

[0052] In some other embodiments, the stack order of the curved electronic device **900** is the functional layer **103**→the touch structure **501**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the base **105**→the display panel **502**. In some other embodiments, the stack order of the curved electronic device **900** is the touch structure **501**→the functional layer **103**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the base **105**→the display panel **502**. In some other embodiments, the stack order of the curved electronic device **900** is the display panel **502**→the functional layer **103**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the touch structure **501**→the base **105**. In some other embodiments, the stack order of the curved electronic device **900** is the display panel **502**→the functional layer **103**→the touch structure **501**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the base **105**. In some other embodiments, the stack order of the curved electronic device **900** is the display panel **502**→the touch structure→the functional layer **103**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the base **105**. In some other embodiments, the stack order of the curved electronic device **900** is the touch structure **501**→the display panel **502**→the functional layer **103**→the substrate **101**→the light-shielding layer **102**→the adhesive layer **104**→the base **105**.

[0053] Referring to FIG. **6**, it shows a cross section of a curved electronic device **1000** according to some other embodiments of the disclosure. Elements in FIG. **6** that are the same as those in FIG. **5**A are labeled with the same reference numbers as in FIG. **5**A and are not described again for brevity.

[0054] The curved electronic device **1000** shown in FIG. **6** is similar to that of the curved electronic device **800** shown in FIG. **5**A. The difference between the curved electronic device **1000** and the curved electronic device **800** is in the embodiment of FIG. **6**, the curved stack structure **300** is replaced by the curved stack structure **400**.

[0055] Referring to FIG. **7**, it shows a cross section of a curved electronic device **1100** according to some embodiments of the disclosure. The curved electronic device **1100** includes the curved touch panel **600** and the display panel **502** conformably disposed under the substrate **101** (not shown in FIG. **7**A) of the curved surface of the curved touch panel **600**. As shown in FIG. **3**D, in addition to the curved touch panel **600** including all structures of the curved stack structure **300**, the curved touch panel **600** further includes the touch-sensing electrode layer **301** located on the surface of the substrate **101** near the base **105**. In the embodiment, the display panel **502** is located under the base **105** (not shown in FIG. **7**A) of the curved touch panel **600**. The display panel **502** is disposed on the base **105** and over the first surface **101***a*.

[0056] Referring to FIG. **7**B, it shows a cross section of a curved electronic device **1200** according to some other embodiments of the disclosure. Elements in FIG. **7**B that are the same as those in FIG. **7**A are labeled with the same reference numbers as in FIG. **7**A and are not described again for brevity.

[0057] The curved electronic device **1200** shown in FIG. **7**B is similar to that of the curved electronic device **1100** shown in FIG. **7**A. The difference between the curved electronic device **1200** and the curved electronic device **1100** is in the embodiment of FIG. **7**B, the base **105** of the curved touch panel **600** is disposed between the adhesive layer **104** and the display panel **502**.

[0058] Referring to FIG. **8**, it shows a cross section of a curved electronic device **1300** according to some other embodiments of the disclosure. Elements in FIG. **8** that are the same as those in FIG. **7**A are labeled with the same reference numbers as in FIG. **7**A and are not described again for brevity.

[0059] The curved electronic device **1300** shown in FIG. **8** is similar to that of the curved electronic device **1100** shown in FIG. **7**A. The difference between the curved electronic **1300** and the curved electronic device **1100** is in the embodiment of FIG. **8**, the curved touch panel **600** is replaced by the curved touch panel **700**.

[0060] According to some embodiments of the disclosure, since the thickness of the substrate of the curved stack structure is less than or equal to 0.4 mm, the substrate **101** has flexibility. Provided that the substrate **101** has flexibility, the substrate can be conformably attached to the curved surface of the base without using a heating process for 3D forming to finish the curved stack structure.

[0061] Since the curved stack structure can be finished without performing a heating process for 3D forming on the substrate, the processes performed on the substrate are all plane processes. Compared to conventional processes of printing after bending, the substrate of the curved stack structure can overcome restrictions in equipments for processing objects having a curved surface (such as the vertical height of the curved surface needing to be less than 5 cm), and the substrate can also obtain a more uniform surface processing effect. In addition, since the curved stack structure is finished without performing a heating process for 3D forming on the substrate, the chosen processing material (such as ink) of the processing on the substrate of the curved stack structure is less restricted by the temperature compared

to conventional processes of printing after bending, and the light-shielding layer on the substrate can have a better shielding effect.

[0062] Moreover, since the curved stack structure is a glued laminated structure which laminates the substrate, the adhesive layer and the base together, and the glued laminated structure can also be called laminated safety glass (LSG). In some embodiments, the substrate, the adhesive layer and the base can have a better bonding force to be bonded together by the laminating process under high temperature. Therefore, the curved stack structure has a better structural strength and can pass the hit impact test (HIT).

[0063] While the disclosure has been described by way of example and in terms of the embodiments, it is to be understood that the disclosure is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A curved stack structure, comprising:
- a base having a curved surface;
- an adhesive layer disposed on the base; and
- a substrate disposed on the adhesive layer, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

2. The curved stack structure of claim **1**, wherein a height difference of the curved surface is greater than or equal to 2 cm and less than or equal to 20 cm.

3. The curved stack structure of claim **2**, wherein the height difference of the curved surface is greater than or equal to 4 cm and less than or equal to 18 cm.

4. The curved stack structure of claim **3**, wherein the height difference of the curved surface is greater than or equal to 5 cm and less than or equal to 16 cm.

5. The curved stack structure of claim **1**, wherein the substrate has a chemical-strengthening layer.

6. The curved stack structure of claim **1**, further comprising:
- a light-shielding layer disposed between the adhesive layer and the substrate and correspondingly disposed on a peripheral area of the substrate; and
- a functional layer, wherein the substrate is disposed between the functional layer and the light-shielding layer.

7. The curved stack structure of claim **1**, wherein in a first cross section, the substrate has a first length, the adhesive layer has a second length, and the base has a third length, and wherein the first length is 100%-101% of the second length, and the second length is 100%-101% of the third length.

8. The curved stack structure of claim **1**, wherein in a first cross section, the substrate has a first length, the adhesive layer has a second length, and the base has a third length, and wherein the third length is 100%-101% of the second length, and the second length is 100%-101% of the first length.

9. A method for fabricating a curved stack structure, comprising:
- providing a base having a curved surface;
- fabricating an adhesive layer disposed on the base; and
- providing a substrate and attaching the substrate to the adhesive layer, wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

10. The method of claim **9**, wherein the height difference of the curved surface is greater than or equal to 2 cm and less than or equal to 20 cm.

11. The method of claim **10**, wherein the height difference of the curved surface is greater than or equal to 4 cm and less than or equal to 18 cm.

12. The method of claim **11**, wherein the height difference of the curved surface is greater than or equal to 5 cm and less than or equal to 16 cm.

13. The method of claim **9**, further comprising performing a laminating process to closely laminate the base, the adhesive layer and the substrate together, and the laminating process is performed in a vacuum chamber under high temperature and high pressure.

14. The method of claim **9**, further comprising:
- fabricating a light-shielding layer between the adhesive layer and the substrate, and the light-shielding layer is correspondingly disposed on a peripheral area of the substrate; and
- fabricating a functional layer, wherein the substrate is disposed between the functional layer and the light-shielding layer.

15. A curved electronic device, comprising:
- a curved stack structure, comprising:
  - a base having a curved surface;
  - an adhesive layer disposed on the base; and
  - a substrate disposed over the adhesive layer; and
- a display panel disposed at a side of the curved stack structure,
- wherein the substrate has a first thickness that is greater than or equal to 0.01 mm and less than or equal to 0.4 mm.

16. The curved electronic device of claim **15**, further comprising a touch structure disposed between the curved stack structure and the display panel.

17. The curved electronic device of claim **15**, further comprising a touch-sensing electrode layer disposed between the substrate and the base.

18. The curved electronic device of claim **15**, further comprising a touch-sensing electrode layer disposed between the adhesive layer and the substrate.

19. The curved electronic device of claim **15**, wherein the base is located between the display panel and the substrate.

20. The curved electronic device of claim **15**, wherein the height difference of the curved surface is greater than or equal to 2 cm and less than or equal to 20 cm.

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