from the first primary surface of the glass layer to a first depth in the glass layer, the region defined by a compressive stress of at least about 100 MPa at the first primary surface of the layer. The glass layer is characterized by: (a) an absence of failure when the layer is held at a bend radius from about 3 mm to about 20 mm for at least 60 minutes at about 25°C and about 50% relative humidity; (b) a puncture resistance of greater than about 1.5 kgf when the second primary surface of the layer is supported by (i) an approximately 25 μm thick pressure-sensitive adhesive having an elastic modulus of less than about 1 GPa and (ii) an approximately 50 μm thick polyethylene terephthalate layer having an elastic modulus of less than about 10 GPa, and the first primary surface of the layer is loaded with a stainless steel pin having a flat bottom with a 200 μm diameter; and (c) a pencil hardness of greater than or equal to 8H.

[0010] In certain examples, the glass article may further include a glass structure having a thickness greater than the thickness of the glass layer and two substantially parallel edge surfaces, the structure comprising the glass layer, wherein the layer is arranged in a central region of the structure between the substantially parallel edge surfaces.

[0011] In some examples, the glass layer comprises an alkali-free or alkali-containing aluminosilicate, borosilicate, boroaluminosilicate, or silicate glass composition. The thickness of the glass layer can also range from about 50 μm to about 100 μm. The thickness can range from 60 μm to about 80 μm, according to some examples.

[0012] In some examples, the bend radius of the glass element or the glass layer can be from about 3 mm to about 20 mm. In other examples, the bend radius can be from about 3 mm to about 10 mm. The bend radius of the glass layer can be from about 1 mm to about 5 mm in some examples. Further, the bend radius can also be from about 5 mm to about 7 mm.

[0012a] In another aspect, there is provided a glass substrate comprising:

a region having a first thickness and a puncture resistance of at least 3 Kg force; and

a region having a second thickness providing the substrate the ability to achieve a bend radius of 5 mm;

wherein the first thickness is ≥ 130 microns and wherein the second thickness is ≥20 microns and ≤ 30 microns.

[0013] According to certain examples, the stack assembly can further comprise a second layer having a low coefficient of friction disposed on the first primary surface of the glass element or layer. According to certain examples, the second layer can be a coating comprising a fluorocarbon material selected from the group consisting of thermoplastics and amorphous fluorocarbons. The second layer can also be a coating comprising one or more of the group consisting of a silicone, a wax, a polyethylene, a hot-end, a parylene, and a diamond-like coating preparation. Further, the second layer can be a coating comprising a material selected from the group consisting of zinc oxide, molybdenum disulfide, tungsten disulfide, hexagonal boron nitride, and aluminum magnesium boride. According to some examples, the second layer can be a coating comprising an additive selected from the group consisting of zinc oxide, molybdenum disulfide, tungsten disulfide, hexagonal boron nitride, and aluminum magnesium boride.

surface of the glass layer. The removing step can also be conducted such that the compressive stress region comprises a maximum flaw size of 2.5 μm or less, or even as low as 0.4 μm or less, at the first primary surface of the glass layer.

[0020a] In another aspect, there is provided a method of etching glass comprising: obtaining a substrate having a first thickness, wherein the first thickness is ≥ 130 microns and wherein the first thickness provides the substrate with a puncture resistance of at least 3 kgf force; and removing a portion of the substrate so as to achieve a second thickness, the second thickness being less than the first, wherein the second thickness provides the substrate the ability to achieve a bend radius of 5 mm and wherein the second thickness is ≥20 microns and ≤ 30 microns, wherein after the removing, the substrate maintains a portion having the first thickness.

[0021] Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the examples as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0022] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary, and are intended to provide an overview or framework to understanding the nature and character of the claims. The accompanying drawings are included to provide a further understanding, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more examples, and together with the description serve to explain principles and operation of the various examples. Directional terms as used herein—for example, up, down, right, left, front, back, top, bottom—are made only with reference to the figures as drawn and are not intended to imply absolute orientation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 is a perspective view of a stack assembly comprising a glass element with a glass layer according to an aspect of this disclosure.

[0024] FIG. 1A is perspective view of the stack assembly depicted in FIG. 1 subjected to bending forces.

[0025] FIG. 1B is a cross-sectional view of the stack assembly depicted in FIG. 1.

[0026] FIG. 1C is a cross-sectional view of a stack assembly comprising a glass element with compressive stress regions formed by an ion exchange process according to a further aspect of this disclosure.

What is claimed is:

1. A glass substrate comprising:

a region having a first thickness and a puncture resistance of at least 3 Kg force; and

a region having a second thickness providing the substrate the ability to achieve a bend radius of 5 mm;

wherein the first thickness is ≥ 130 microns and wherein the second thickness is ≥20 microns and ≤ 30 microns.

2. The glass substrate of claim 1, wherein the second thickness provides the substrate the ability to achieve a bend radius of 2 mm.

3. The glass substrate of claim 1, wherein the second thickness provides the substrate the ability to achieve a bend radius of 1 mm.

4. The glass substrate of any one of claims 1-3, wherein the second thickness is ≤ 25 microns.

5. The glass substrate of any one of claims 1-4, further comprising a length, and wherein the second thickness is continuously provided across the entire length.

6. The glass substrate of any one of claims 1-5, further comprising a protective member disposed so as to cover a portion of the substrate having the second thickness.

7. The glass substrate of any one of claims 1-6, wherein the glass substrate comprises a composition that is an alkali-free, alumino-boro-silicate, glass.

8. The glass substrate of any one of claims 1-7, capable of at least 100 cycles of bending to a 5 mm radius before failure.

9. The glass substrate of any one of claims 1-8, further comprising a Young's modulus of > 50 GPa.

10. The glass substrate of any one of claims 1-9, having a pencil hardness of at least 8H.

11. A display device comprising a body and a cover glass, wherein the cover glass comprises the glass substrate of any one of claims 1-10.

12. A method of etching glass comprising: obtaining a substrate having a first thickness, wherein the first thickness is ≥ 130 microns and wherein the first thickness provides the substrate with a puncture resistance of at least 3 kgf force; and removing a portion of the substrate so as to achieve a second thickness, the second thickness being less than the first, wherein the second thickness provides the substrate the ability to achieve a bend radius of 5 mm and wherein the second thickness is ≥20 microns and ≤ 30 microns, wherein after the removing, the substrate maintains a portion having the first thickness.

13. The method of claim 12, wherein the removing is performed by etching.

14. The method of claim 12, wherein the second thickness provides the substrate the ability to achieve a bend radius of 2 mm.

15. The method of claim 12, wherein the second thickness provides the substrate the ability to achieve a bend radius of 1 mm.

16. The method of claim 12, wherein the second thickness is ≤ 25 microns.

17. The method of claim 12, wherein the substrate comprises a length, and wherein removing provides the second thickness continuously across the entire length.

18. The method of claim 12, further comprising disposing a protective member to cover a portion of the substrate having the second thickness.

19. The method of claim 12, wherein the glass substrate comprises a composition that is an alkali-free, alumino-boro-silicate, glass.

20. The method of claim 12, wherein the substrate comprises an edge, and the method further comprising etching the edge.

21. The method of claim 20, wherein etching the edge is performed simultaneously with the removing.

22. The method of claim 12, wherein the glass substrate comprises a Young's modulus of > 50 GPa.

23. The method of claim 12, wherein the glass substrate comprises a pencil hardness of at least 8H.