[0007] In embodiments, the disclosure provides a laminate article comprising a glass device substrate work piece reversibly bonded to a reusable carrier, the laminate having a silicon and oxygen depleted and fluorine and carbon enriched glass surface at the interface.

[0008] In embodiments, the disclosure provides a method for bonding and debonding a laminate comprising a glass device substrate work piece and a carrier substrate for the work piece.

[0009] In embodiments, the disclosure provides a method for forming a moderate or intermediate strength bond or adhesion between a carrier and a thin glass device substrate to create a temporary bond, which temporary bond is sufficiently strong to survive, for example, thin film transistors (TFT) processing, but the bond is sufficiently weak to permit timely debonding or separation of the carrier substrate and the glass device substrate after surface processing of the device substrate is completed. The intermediate strength bond or moderate bonding property enables a re-usable carrier function and manufacturing cycle. The moderate bonding property can be, for example, in one or more portions of the area between the carrier substrate and the device substrate work piece, or the entire area between the carrier substrate and the device substrate work piece.

[0009a] In an aspect, there is provided a method of making a device substrate article having a device modified substrate supported on a glass carrier substrate, comprising:

treating at least a portion of the first surface of a glass carrier substrate, to form an interfacial bonding layer having a thickness of about a single atomic layer, wherein the treating comprises contacting the at least a portion of the glass carrier substrate with a plasma comprised of a fluoropolymer polymerizing agent and an etching agent, the treated surface has:

silicon of about 0.1 to about 14 at%;

oxygen of about 1 to about 40 at%;

carbon of about 3 to 60 at%;

fluorine of about 40 to 65 at%; and

a metal to fluorine (M:F) atomic ratio of about 1:1 to about 1: 3, wherein more 50% of the fluorine in the treated surface is present as metal fluorides;

contacting the treated surface with an untreated or a like-treated counterpart device substrate or glass carrier substrate to form a laminate comprised of the device substrate bonded to the glass carrier substrate; and

modifying at least a portion of the non-bonded second surface of the device substrate of the laminate with at least one device surface modification treatment to form the device substrate article.

[0009b] In another aspect, there is provided a laminate glass article, comprising:

a glass device substrate bonded to a glass carrier substrate with a interfacial bonding layer therebetween, the interfacial bonding layer having a thickness of about a single atomic layer and the interfacial bonding layer formed by treating the glass carrier substrate with a plasma selected from:

a fluoropolymer polymerizing agent selected from at least one of CHF_3, C_4F_8, C_3F_6, C_3F_8, and

the reaction products of a fluorinated etching agent selected from at least one of CF_4, C_2F_6 and HF;

wherein the interfacial bond strength between the glass device substrate and the carrier glass substrate is from about 100 to about 1,000 mJ/m^2, the interface between the glass device substrate and the glass carrier has a silicon content of from about 0.1 to about 14 at%; a fluorine content of from about 40 to 65 at%, and a metal to fluorine (M:F) atomic ratio of about 1:1 to 1:3.

Brief Description of the Drawings

[0010] In embodiments of the disclosure:

[0011] Fig. 1 shows a schematic of the disclosed reusable carrier process (100).

[0012] Figs. 2A and 2B show the change in contact angle (Fig. 2A) and surface energy (Fig. 2B) for CF_4 and CHF_3 plasma polymer treated glass surfaces.

[0013] Figs. 3A and 3B show surface concentrations of fluorine (310) and carbon (320) and oxygen (330), (Fig. 3A) as measured by XPS and the concentration of inorganic fluorine atoms (bonded to metal) (340) and the concentration of organic fluorine atoms (in fluoropolymer) (350) (Fig. 3B) as measured by XPS for fluorocarbon plasma treated glass surfaces treated with different mol fractions of CF_4 and CHF_3.

[0014] Fig. 4 shows changes in the glass surface elemental composition in atomic % as measured by XPS with increasing polymer forming plasma treatment times for separate CHF_3 or CF_4 plasma treatments.

[0015] Figs. 5A to 5B show the change in adhesion or bond energy as a function of the anneal temperature (Fig. 5A) and anneal time (Fig. 5B) for selected surface treatments.

What is Claimed is:

1. A method of making a device substrate article having a device modified substrate supported on a glass carrier substrate, comprising:

treating at least a portion of the first surface of a glass carrier substrate, to form an interfacial bonding layer having a thickness of about a single atomic layer, wherein the treating comprises contacting the at least a portion of the glass carrier substrate with a plasma comprised of a fluoropolymer polymerizing agent and an etching agent, the treated surface has:

silicon of about 0.1 to about 14 at%;

oxygen of about 1 to about 40 at%;

carbon of about 3 to 60 at%;

fluorine of about 40 to 65 at%; and

a metal to fluorine (M:F) atomic ratio of about 1:1 to about 1: 3, wherein more 50% of the fluorine in the treated surface is present as metal fluorides;

contacting the treated surface with an untreated or a like-treated counterpart device substrate or glass carrier substrate to form a laminate comprised of the device substrate bonded to the glass carrier substrate; and

modifying at least a portion of the non-bonded second surface of the device substrate of the laminate with at least one device surface modification treatment to form the device substrate article.

2. The method of claim 1 further comprising heating the laminate in at least one device surface modification treatment at from about 200 to about 700 °C, for 1 second to 1200 minutes; and separating the device substrate article having the device modified second surface from the glass carrier substrate of the laminate

3. The method of claim 2 wherein separating comprises at least one of:

peeling the device substrate article from the glass carrier substrate, peeling the glass carrier substrate from the device substrate, or both; and

contacting at least one of the device substrate or the glass carrier substrate with a suction device, a gripper device, a knife edge, or a combination thereof.

4. The method of claim 2 or claim 3 further comprising cleaning the separated glass carrier substrate for repeated reuse in the method.

5. The method of claim 1 wherein:

the fluoropolymer polymerizing agent comprises at least one of CHF_3, C_4F_8, C_3F_6, C_3F_8; and

the etching agent comprises at least one of CF_4, C_2F_6, NF_3, SF_6, HF, or a combination thereof.

6. The method of any one of claims 1-5 wherein the laminate has an interfacial bond with an adhesive strength of from about 100 to about 2,000 mJ/m^2 between the device substrate and the glass carrier substrate, when the device substrate is glass.

7. The method of any one of claims 1-6 wherein modifying with at least one device surface modification treatment is at least one of: etching, coating, printing, plating, vapor deposition, sputtering, or combinations thereof.

8. The method of any one of claims 1-7 wherein the device substrate is glass and has a thickness of from about 10 to about 500 microns, the carrier glass substrate has a thickness of about 200 microns to 3 mm.

9. The method of claim 8, wherein the device substrate includes a plurality of holes therein.

10. The method of any one of claims 1-9 wherein the device substrate has a device modified semiconductor substrate supported on the glass carrier.

11 The method of claim 10 wherein the device substrate is selected from a silicon (Si), a gallium arsenide (GaAs), or a combination thereof.

12. A laminate glass article, comprising:

a glass device substrate bonded to a glass carrier substrate with a interfacial bonding layer therebetween, the interfacial bonding layer having a thickness of about a single atomic layer and the interfacial bonding layer formed by treating the glass carrier substrate with a plasma selected from:

a fluoropolymer polymerizing agent selected from at least one of CHF_3, C_4F_8, C_3F_6, C_3F_8, and

the reaction products of a fluorinated etching agent selected from at least one of CF_4, C_2F_6 and HF; ,

wherein the interfacial bond strength between the glass device substrate and the carrier glass substrate is from about 100 to about 1,000 mJ/m^2, the interface between the glass device

substrate and the glass carrier has a silicon content of from about 0.1 to about 14 at%; a fluorine content of from about 40 to 65 at%, and a metal to fluorine (M:F) atomic ratio of about 1:1 to 1: 3.

13. The article of claim 12 further comprising the non-bonded second surface of the glass device substrate in the laminate article has at least one device modified surface area.

14. The article of claim 2 or claim 13 wherein the glass device substrate has a plurality of holes therein.

15. The article of any one of claims 12-14 wherein the glass device substrate has a thickness of from about 20 to about 500 microns, the carrier glass substrate has a thickness of about 200 microns to about 3 mm.