processing, wet processing, and/or ultrasonic cleaning processing), together with covalent bonding regions to provide for further processing options, for example, maintaining hermeticity between the carrier and sheet even after dicing the article into smaller pieces for additional device processing. Still further, some surface modification layers provide control of the bonding between the carrier and sheet while, at the same time, reduce outgassing emissions during the harsh conditions in an FPD (for example LTPS) processing environment, including high temperature and/or vacuum processing, for example.

[0013a] In an aspect, there is provided a glass article comprising:

a carrier having a carrier bonding surface;

a sheet having a sheet bonding surface;

a surface modification layer disposed on one of the carrier bonding surface and the sheet bonding surface,

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface energy bonding the sheet to the carrier is of such a character that after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 600°C at a rate of 9.2 °C per minute, held at a temperature of 600°C for 10 minutes, and then cooled at 1 °C per minute to 300 °C, and then removing the article from the chamber and allowing the article to cool to room temperature, the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity, there is no outgassing from the surface modification layer during the temperature cycle, and the sheet may be separated from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces;

wherein said carrier and/or sheet comprises glass; and

wherein the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

[0013b] In another aspect, there is provided a method of making a glass article comprising:

obtaining a carrier having a bonding surface,

obtaining a sheet having a sheet bonding surface,

bonding the sheet to the carrier by disposing the sheet bonding surface on the carrier bonding surface,

controlling the surface energy of the carrier bonding surface and of the sheet bonding surface by providing a surface modification layer disposed on one of the carrier bonding surface and the sheet bonding surface so that a component of the surface energy giving rise to covalent bonding

between the sheet bonding surface and the carrier bonding surface is of such a character that after subjecting the bonded sheet and carrier article to a temperature cycle by heating in an chamber cycled from room temperature to 600°C at a rate of 9.2 °C per minute, held at a temperature of 600°C for 10 minutes, and then cooled at 1 °C per minute to 300 °C, and then removing the article from the chamber and allowing the article to cool to room temperature, the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity, there is no outgassing from the interface between the carrier bonding surface and the sheet bonding surface during the temperature cycle, and the sheet may be separated from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces;

wherein said carrier and/or sheet comprises glass, and

wherein the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

[0014] 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 the description or recognized by practicing the various aspects as exemplified in the written description and the appended drawings. It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the various aspects, and are intended to provide an overview or framework to understanding the nature and character of the disclosure.

[0015] The accompanying drawings are included to provide a further understanding of principles of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s), and together with the description serve to explain, by way of example, principles and operation of the disclosure. It is to be understood that various features disclosed in this specification and in the drawings can be used in any and all combinations. By way of non-limiting example the various features may be combined with one another as set forth in the appended claims

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a schematic side view of an article having carrier bonded to a thin sheet with a surface modification layer therebetween.

[0017] FIG. 2 is an exploded and partially cut-away view of the article in FIG. 1.

[0018] FIG. 3 is a graph of surface hydroxyl concentration on silica as a function of temperature.

[0019] FIG. 4 is a graph of the surface energy of an SC1-cleaned sheet of glass as a function annealing temperature.

[0020] FIG. 5 is a graph of the surface energy of a thin fluoropolymer film deposited on a sheet of glass as a function of the percentage of one of the constituent materials from which the film was made.

[0021] FIG. 6 is a schematic top view of a thin sheet bonded to a carrier by bonding areas.

[0022] FIG. 7 is a schematic side view of a stack of glass sheets

What is Claimed is:

1. A glass article comprising:

a carrier having a carrier bonding surface;

a sheet having a sheet bonding surface;

a surface modification layer disposed on one of the carrier bonding surface and the sheet bonding surface,

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface energy bonding the sheet to the carrier is of such a character that after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 600°C at a rate of 9.2 °C per minute, held at a temperature of 600°C for 10 minutes, and then cooled at 1 °C per minute to 300 °C, and then removing the article from the chamber and allowing the article to cool to room temperature, the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity, there is no outgassing from the surface modification layer during the temperature cycle, and the sheet may be separated from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces;

wherein said carrier and/or sheet comprises glass; and

wherein the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

2. The glass article of claim 1, wherein the heating is performed in Nitrogen.

3. The glass article of claim 1 or 2, wherein the carrier without any surface modification layer has an average surface roughness Ra of ≤ 2 nm.

4. The glass article of any one of claims 1-3, wherein the carrier has a thickness of 200 microns to 3 mm.

5. The glass article of any one of claims 1-4, wherein the sheet without any surface modification layer has an average surface roughness Ra of ≤ 2 nm.

6. The glass article of any one of claims 1-5, wherein the sheet has a thickness of ≤ 300 microns.

7. The glass article of any one of claims 1-6, wherein the surface modification layer has a thickness of from 0.1 to 100 nm.

8. The glass article of claim 1, wherein when the surface modification layer comprises a plasma polymerized fluoropolymer, the surface modification layer is one of: plasma polymerized polytetrafluroethylene; and a plasma polymerized fluoropolymer surface modification layer deposited from a CF4-C4F8 mixture having $\leq 40\%$ C4F8.

9. The glass article of claim 1, wherein when the surface modification layer comprises an aromatic silane, the surface modification layer is one of: phenyltriethoxysilane; diphenyldiethoxysilane; and 4-pentafluorophenyltriethoxysilane.

10. The glass article of claim 1, wherein when the surface modification layer comprises an aromatic silane, the surface modification layer contains chlorophenyl, or fluorophenyl, silyl groups.

11. A method of making a glass article comprising:

obtaining a carrier having a bonding surface,

obtaining a sheet having a sheet bonding surface,

bonding the sheet to the carrier by disposing the sheet bonding surface on the carrier bonding surface,

controlling the surface energy of the carrier bonding surface and of the sheet bonding surface by providing a surface modification layer disposed on one of the carrier bonding surface and the sheet bonding surface so that a component of the surface energy giving rise to covalent bonding between the sheet bonding surface and the carrier bonding surface is of such a character that after subjecting the bonded sheet and carrier article to a temperature cycle by heating in an chamber cycled from room temperature to 600°C at a rate of 9.2 °C per minute, held at a temperature of 600°C for 10 minutes, and then cooled at 1 °C per minute to 300 °C, and then removing the article from the chamber and allowing the article to cool to room temperature, the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity, there is no outgassing from the interface between the carrier bonding surface and the sheet bonding surface during the temperature cycle, and the sheet may be separated from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces;

wherein said carrier and/or sheet comprises glass, and

wherein the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

12. The method of claim 11, wherein the heating is performed in Nitrogen.

13. The method of claim 11 or 12, wherein the carrier without any surface modification layer has an average surface roughness Ra of ≤ 2 nm.

14. The method of any one of claims 11-13, wherein the carrier has a thickness of 200 microns to 3 mm.

15. The method of any one of claims 11-14, wherein the sheet without any surface modification layer has an average surface roughness Ra of ≤ 2 nm.

16. The method of any one of claims 11-15, wherein the sheet has a thickness of ≤ 300 microns.

17. The method of any one of claims 11-16, wherein the surface modification layer has a thickness of from 0.1 to 100 nm.

18. The method of claim 11, wherein when the surface modification layer comprises a plasma polymerized fluoropolymer, the surface modification layer is one of: plasma polymerized polytetrafluroethylene; and a plasma polymerized fluoropolymer surface modification layer deposited from a CF4-C4F8 mixture having $\leq 40\%$ C4F8.

19. The method of claim 11, wherein when the surface modification layer comprises an aromatic silane, the surface modification layer is one of: phenyltriethoxysilane; diphenyldiethoxysilane; and 4-pentafluorophenyltriethoxysilane.

20. The method of claim 11, wherein when the surface modification layer comprises an aromatic silane, the surface modification layer contains chlorophenyl, or fluorophenyl, silyl groups.