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 following aspects:

[0018] According to a first aspect, there is provided an article, comprising:

a carrier with a carrier bonding surface;

a sheet with at least one via therein, the sheet further comprising a sheet bonding surface;

a surface modification layer;

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface modification layer is of such a character that at least one of:

(i) after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 500°C at a rate of 9.2 °C per minute, held at a temperature of 500°C for 10 minutes, and then cooled at furnace rate 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, 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 when separation is performed at room temperature; and

(ii) after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 400°C at a rate of 9.2 °C per minute, held at a temperature of 400°C for 10 minutes, and then cooled at furnace rate 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 according to test #2, 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 when separation is performed at room temperature.

[0019] According to a second aspect, there is provided an article, comprising:

a carrier with a carrier bonding surface;

a sheet with at least one via therein, the sheet further comprising a sheet bonding surface;

a surface modification layer;

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface modification layer is of such a character that after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 400°C at a rate of 9.2 °C per minute, held at a temperature of 400°C for 10 minutes, and then cooled at furnace rate 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 according to test #2, 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 when separation is performed at room temperature.

[0020] According to a third aspect, there is provided the article of the first aspect ~~1~~ or the second aspect ~~2~~, the sheet comprises silicon, quartz, sapphire, ceramic, or glass.

[0021] According to a fourth aspect, there is provided the article of the first aspect ~~1~~, the sheet thickness is ≤ 200 microns.

[0022] According to a fifth aspect, there is provided an article, comprising:

a carrier with a carrier bonding surface;

a wafer sheet comprising a thickness ≤ 200 microns, the sheet further comprising a sheet bonding surface, the sheet comprising silicon, quartz, or sapphire;

a surface modification layer;

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface modification layer is of such a character that at least one of:

(i) after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 500°C at a rate of 9.2 °C per minute, held at a temperature of 500°C for 10 minutes, and then cooled at furnace rate 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, 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 when separation is performed at room temperature; and

(ii) after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 400°C at a rate of 9.2 °C per minute, held at a temperature of 400°C for 10 minutes, and then cooled at furnace rate 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 according to test #2, 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 when separation is performed at room temperature.

[0023] According to a sixth aspect, there is provided an article, comprising:

a carrier with a carrier bonding surface;

a wafer sheet comprising a thickness ≤ 200 microns, the sheet further comprising a sheet bonding surface, the sheet comprising silicon, quartz, or sapphire;

a surface modification layer;

the carrier bonding surface being bonded with the sheet bonding surface with the surface modification layer therebetween, wherein the surface modification layer is of such a character that after subjecting the article to a temperature cycle by heating in an chamber cycled from room temperature to 400°C at a rate of 9.2 °C per minute, held at a temperature of 400°C for 10 minutes, and then cooled at furnace rate 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 according to test #2, 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 when separation is performed at room temperature.

[0024] According to a seventh aspect, there is provided the article of fifth aspect ~~5~~ or sixth aspect ~~6~~, the sheet further comprising at least one via therein.

[0025] According to an eighth aspect, there is provided the article of any one of the first to fourth and seventh aspects ~~1-4, 7~~, the at least one via has a diameter of ≤ 150 microns.

[0026] According to a ninth aspect, there is provided the article of any one of the first to fourth, seventh and eighth aspects ~~1-4, 7, 8~~, the at least one via comprises electrically conductive material therein.

[0027] According to a tenth aspect, there is provided the article of any one of the first to ninth aspects ~~1-9~~, the sheet comprising a device surface opposite the sheet bonding surface, the device surface comprising an array of devices selected from the group consisting of: integrated circuits; MEMS; CPU; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

[0028] According to an eleventh aspect, there is provided the article of any one of aspects 1-9, the sheet comprising a device surface opposite the sheet bonding surface, the device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; interconnection routings; interconnect lines; insulating oxide layers; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

[0029] According to a twelfth aspect, there is provided the article of any one of the first ot eleventh aspects ~~1-11~~, wherein the heating is performed in Nitrogen.

[0030] According to a thirteenth aspect, there is provided the article of any one of the first, third to fifth and seventh to twelfth aspects ~~1, 3-5, 7-12~~, wherein there is no outgassing from the surface modification layer during the heating, wherein outgassing from the surface modification layer is defined as at least one of:

(a) wherein the change in surface energy of the cover is ≥ 15 mJ/m^2 at a test-limit temperature of 600°C according to outgassing test #1; and

(b) wherein the change in % bubble area is ≥ 5 at a test limit temperature of 600°C according to outgassing test #2.

[0031] According to a fourteenth aspect, there is provided the article of any one of the first to thirteenth aspects ~~1-13~~, the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

[0032] According to a fifteenth aspect, there is provided the article of any one of the first to fourteenth aspects ~~1-14~~, thickness of the surface modification layer is from 0.1 to 100 nm.

[0033] According to a sixteenth aspect, there is provided the article of any one of the first to fifteenth aspects ~~1-15~~, the carrier comprises glass.

[0034] According to a seventeenth aspect, there is provided the article of any one of the first to sixteenth aspects ~~1-16~~, wherein the bonding surface of at least one of the carrier and the sheet comprises an area of ≥ 100 square cm.

[0035] According to an eighteenth aspect, there is provided a method of making an interposer, comprising:

obtaining a carrier with a carrier bonding surface;

obtaining a sheet with at least one via therein, the sheet further comprising a sheet bonding surface, wherein at least one of the carrier bonding surface and the sheet bonding surface comprises a surface modification layer thereon;

bonding the carrier to the sheet with the bonding surfaces and the surface modification layer to form an article;

subjecting the article to front-end-of-line (FEOL) processing, wherein after FEOL processing the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity;

removing the sheet from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces.

[0036] According to a ninteenth aspect, there is provided the method of the eighteenth aspect ~~18~~, the sheet comprises silicon, quartz, sapphire, ceramic, or glass.

[0037] According to a twentieth aspect, there is provided the method of the eighteenth aspect ~~18~~, the sheet thickness is ≤ 200 microns.

[0038] According to a twenty first aspect, there is provided a method of processing a silicon wafer sheet, comprising:

obtaining a carrier with a carrier bonding surface;

obtaining a wafer sheet with a thickness ≤ 200 microns, the sheet comprising silicon, quartz, or sapphire, the sheet further comprising a sheet bonding surface, wherein at least one of the carrier bonding surface and the sheet bonding surface comprises a surface modification layer thereon;

bonding the carrier to the sheet with the bonding surfaces and the surface modification layer to form an article;

subjecting the article to front-end-of-line (FEOL) processing, wherein after FEOL processing the carrier and sheet do not separate from one another if one is held and the other subjected to the force of gravity;

removing the sheet from the carrier without breaking the thinner one of the carrier and the sheet into two or more pieces.

[0039] According to a twenty second aspect, there is provided the method of the twenty-first aspect ~~21~~, the sheet further comprising at least one via therein.

[0040] According to a twenty third aspect, there is provided the method of any one of the eighteenth to twenty-second aspects ~~18-22~~, wherein the FEOL processing comprises at least one of:

(i) processing-chamber temperatures of from 500°C to 700°C; and

(ii) at least one of: DRIE (dry reactive ion etch); PVD; CVD TiN; PECVD SiO2; Electrolytic Cu Plating; Cu Annealing; Metrology; Cu CMP; Cu (H2O2 + H2SO4) + Ti (DHF) Wet Etch; Sputter Adhesion Layer; Sputter Seed Layer; Lithography (Photoresist, expose, strip, etch Cu).

[0041] According to a twenty fourth aspect, there is provided the method of any one of the eighteenth to twenty-second aspects ~~18-22~~, wherein the FEOL processing comprises at least one of: DRIE (dry reactive ion etch); PVD; CVD TiN; PECVD SiO2; Electrolytic Cu Plating; Cu Annealing; Metrology; Cu CMP; Cu (H2O2 + H2SO4) + Ti (DHF) Wet Etch; Sputter Adhesion Layer; Sputter Seed Layer; Lithography (Photoresist, expose, strip, etch Cu).

[0042] According to a twenty fifth aspect, there is provided the method of any one of the eighteenth to twentieth and twenty-second to twenty-fourth aspects ~~18-20, 22-24~~, the at least one via has a diameter of ≤ 150 microns.

[0043] According to a twenty sixth aspect, there is provided the method of any one of the eighteenth to twentieth and twenty-second to twenty-fifth aspects ~~18-20, 22-25~~, the at least one via comprises electrically conductive material therein.

[0044] According to a twenty seventh aspect, there is provided the method of any one of the eighteenth to twenty-sixth aspects ~~18 26~~, the sheet comprising a device surface opposite the sheet bonding surface, the device surface comprising at least one of:

(i) an array of devices selected from the group consisting of: integrated circuits; MEMS; CPU; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride; and

(ii) at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; interconnection routings; interconnect lines; insulating oxide layers; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

[0045] According to a twenty eighth aspect, there is provided the method of any one of the eighteenth to twenty-sixth aspects ~~18-26~~, the sheet comprising a device surface opposite the sheet bonding surface, the device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; interconnection routings; interconnect lines; insulating oxide layers; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

[0046] According to a twenty ninth aspect, there is provided the method of any one of the eighteenth to twenty-eighth aspects ~~18-28~~, wherein the heating is performed in Nitrogen.

[0047] According to a thirtieth aspect, there is provided the method of any one of the eighteenth to twenty-ninth aspects ~~18-29~~, wherein there is no outgassing from the surface modification layer during the heating, wherein outgassing from the surface modification layer is defined as at least one of:

(a) wherein the change in surface energy of the cover is $\geq$ 15 mJ/m^2 at a test-limit temperature of 600°C according to outgassing test #1; and

(b) wherein the change in % bubble area is $\geq$ 5 at a test limit temperature of 600°C according to outgassing test #2.

[0048] According to a thirty first aspect, there is provided the method of any one of the eighteenth to thirtieth aspects ~~18-30~~, the surface modification layer comprises one of:

a) a plasma polymerized fluoropolymer; and

b) an aromatic silane.

[0049] According to a thirty second aspect, there is provided the method of any one of the eighteenth to thirty-first aspects ~~18-31~~, thickness of the surface modification layer is from 0.1 to 100 nm.

[0050] According to a thirty third aspect, there is provided the method of any one of the eighteenth to thirty-second aspects ~~18-32~~, the carrier comprises glass.

[0051] According to a thirty fourth aspect, there is provided the method of any one of the eighteenth to thirty-third aspects ~~18-33~~, wherein the bonding surface of at least one of the carrier and the sheet comprises an area of $\geq$ 100 square cm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] FIG. 1 is FIG. 1 is a schematic side view of an article having carrier bonded to a thin sheet with a surface modification layer therebetween.

[0053] FIG. 2 is an exploded and partially cut-away view of the article in FIG. 1.