the surfaces does not occur, or any bonding of the surfaces that does occur may be so weak that the bond cannot survive processing with the equipment.

SUMMARY

[0005] The following presents a simplified summary of the disclosure in order to provide a basic understanding of some example aspects described in the detailed description. The present disclosure provides a surface modification layer including a plasma polymerized material. The plasma polymerized material planarizes at least one of the carrier bonding surface and the sheet bonding surface having an otherwise moderate surface roughness (surface roughness as described herein refers to root mean square surface roughness, Rq). By reducing the surface roughness with the plasma polymerized material, van der Waals bonding forces may be high enough to permit an initial bond of the sheet to the carrier that will survive processing with the equipment. At the same time, the plasma polymerized material inhibits, for example prevents or reduces, covalent bond formation between the sheet and the carrier that would otherwise prevent separation of the sheet from the carrier following processing.

[0006] In the disclosure, there is provided an article includes a carrier including a carrier bonding surface, a sheet including a sheet bonding surface, and a surface modification layer disposed on at least one of the carrier bonding surface and the sheet bonding surface. The surface modification layer includes a plasma polymerized material. The plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface. The carrier bonding surface and the sheet bonding surface are bonded with the surface modification layer so that the carrier is temporarily bonded with the sheet.

[0006a] In an aspect, there is provided an article comprising:

a carrier comprising a carrier bonding surface;

a sheet comprising a sheet bonding surface; and

a surface modification layer disposed on at least one of the carrier bonding surface and the sheet bonding surface, wherein the surface modification layer comprises a plasma polymerized material, wherein the plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface, and wherein the carrier bonding surface and the sheet bonding surface are bonded with the surface modification layer so that the carrier is temporarily bonded to the sheet.

[0007] In one example, the at least one of the planarized carrier bonding surface and the planarized sheet bonding surface has a surface roughness Rq less than about 0.8 nm.

[0008] In a further example, the at least one of the carrier bonding surface and the sheet bonding surface has a surface roughness Rq within a range of about 0.8 nm to about 5.0 nm.

[0009] In another example, the at least one of the carrier bonding surface and the sheet bonding surface has a surface roughness Rq greater than about 2.0 nm.

[0010] In yet another example, the surface modification layer has at least one of an elastic modulus and a plasticity so that at least one of a portion of the carrier bonding surface and a portion of the sheet bonding surface may penetrate into the surface

modification layer. For example, the elastic modulus is within a range of from about 0.6 GPa to about 20 GPa.

[0011] In still another example, at least one of the carrier and the sheet includes glass.

[0012] In still another example, the carrier has a thickness within a range of from about 200 microns to about 3 mm.

[0013] In still another example, the sheet has a thickness less than or equal to about 300 microns.

[0014] In still another example, the surface modification layer has a thickness within a range from about 0.1 nm to about 100 nm.

[0015] The first aspect may be provided alone or in combination with one or any combination of the examples discussed above.

[0016] In the disclosure, there is also provided an article includes a carrier including a carrier bonding surface, a sheet including a sheet bonding surface, and at least one of a carrier surface modification layer disposed on the carrier bonding surface and a sheet surface modification layer disposed on the sheet bonding surface. The at least one of the carrier surface modification layer and the sheet surface modification layer includes a plasma polymerized material. The plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface. The carrier bonding surface and the sheet bonding surface are bonded with at least one of the carrier surface modification layer and the sheet surface modification layer so that the carrier is temporarily bonded with the sheet.

[00016a] In another aspect, there is provided an article comprising:

a carrier comprising a carrier bonding surface;

a sheet comprising a sheet bonding surface; and

at least one of a carrier surface modification layer disposed on the carrier bonding surface and a sheet surface modification layer disposed on the sheet bonding surface, wherein the at least one of the carrier surface modification layer and the sheet surface modification layer comprises a plasma polymerized material, wherein the plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface, and wherein the carrier bonding surface and the sheet bonding surface are bonded with the at least one of the carrier surface modification layer and the sheet surface modification layer so that the carrier is temporarily bonded with the sheet.

[0017] In one example, with respect to the at least one of the carrier surface modification layer and the sheet surface modification layer, the article includes only the carrier surface modification layer. At least a portion of the sheet bonding surface penetrates into the carrier surface modification layer.

[0018] In another example, with respect to the at least one of the carrier surface modification layer and the sheet surface modification layer, the article includes only the sheet surface modification layer. At least a portion of the carrier bonding surface penetrates into the sheet surface modification layer.

[0019] In yet another example, with respect to the at least one of the carrier surface modification layer and the sheet surface modification layer, the article includes both the carrier surface modification layer and the sheet surface modification layer. At least one of (i) a portion of the sheet bonding surface penetrates into the carrier surface

modification layer and (ii) a portion of the carrier bonding surface penetrates into the sheet surface modification layer.

[0020] In still another example, the at least one of the planarized carrier bonding surface and the planarized sheet bonding surface has a surface roughness Rq less than about 0.8 nm.

[0021] In still another example, the at least one of the carrier bonding surface and the sheet bonding surface has a surface roughness Rq within a range of about 0.8 nm to about 5.0 nm.

[0022] The second aspect may be provided alone or in combination with one or any combination of the examples discussed above.

[0023] In the disclosure, there is also provided a method of making an article includes depositing a surface modification layer on at least one of a carrier bonding surface of a carrier and a sheet bonding surface of a sheet. The surface modification layer includes a plasma polymerized material. The plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface. The method includes bonding at least one of the carrier bonding surface and the sheet bonding surface with the surface modification layer so that the carrier is temporarily bonded with the sheet.

[0023a] In another aspect, there is provided a method of making an article comprising:

depositing a surface modification layer on at least one of a carrier bonding surface of a carrier and a sheet bonding surface of a sheet, wherein the surface modification layer comprises a plasma polymerized material, and wherein the depositing of the plasma polymerized material planarizes the at least one of the carrier bonding surface and the sheet bonding surface; and

bonding the carrier bonding surface and the sheet bonding surface with the surface modification layer so that the carrier is temporarily bonded with the sheet.

[0024] In one example, the at least one of the planarized carrier bonding surface and the planarized sheet bonding surface has a surface roughness Rq less than about 0.8 nm.

[0025] In another example, the at least one of the carrier bonding surface and the sheet bonding surface has a surface roughness Rq within a range of about 0.8 nm to about 5.0 nm.

[0026] In yet another example, the method further includes at least one of an elastic modulus and a plasticity of the surface modification layer that allow penetration of at least one of a portion of the carrier bonding surface and a portion of the sheet bonding surface into the surface modification layer.

[0027] The third aspect may be provided alone or in combination with one or any combination of the examples discussed above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The above and other features, aspects and advantages of the present invention are better understood when the following detailed description of the invention is read with reference to the accompanying drawings, in which:

[0029] **FIG. 1** illustrates an example article in an unassembled (e.g. unbonded) state;