700 °C. At such high temperatures, the materials used are mechanically heavily stressed. In the presence of high temperature differentials, mechanical strain is determined by, above all, thermal stresses. The thermal stresses are dependent on the thermal expansion coefficient and temperature differential. If materials cannot expand freely together because they are welded together along a bond interface, a difference in the thermal expansion coefficients in the presence of a temperature differential results in correspondingly high thermal stress. Because the choice of material is quite often determined by other boundary conditions, thermal stresses can only be avoided when the temperature differentials within the process steps are as small as possible.

It should be mentioned that the material combinations with which the bonding process should offer the greatest advantage (as an integration of materials with different lattice parameters and/or different thermal expansion coefficients should follow) are least compatible with a heat-treatment process because it is mostly here that the greatest differences with regard to thermal expansion occur.

Embodiments of the present invention disclose a device and a method for bonding with which the bonding process can be carried out more efficiently and qualitatively more valuably.

According to an aspect, there is provided a method for producing a direct bond between a bonding side of a first substrate and a bonding side of a second substrate in a workspace, wherein the method comprises: a) modifying the bonding sides of the first and second substrates in a plasma chamber and/or a bonding/plasma chamber, the modifying comprising: (i) changing a stoichiometry of oxide layers respectively formed on the bonding sides of the first and second substrates; (ii) introducing one or more of the following reducing gases into the plasma chamber and/or the bonding/plasma chamber: hydrogen, nitrogen oxides, carbon monoxide, and methane; and (iii) mixing the one or more reducing gases with one or more of the following inert gases: xenon, argon, helium, nitrogen, and carbon dioxide; b) bringing the modified bonding sides of the first and second substrates into contact with each other; c) applying force to the first and second substrates to close nano-gaps between the modified bonding sides that are in contact with each other; and d) subsequently bonding the modified bonding side of the first substrate with the modified bonding side of the second substrate in a bonding chamber and/or the bonding/plasma chamber.

The scope of the invention includes all combinations of at least two features given in the description, the claims, and/or the figures. With the given value ranges, values that lie inside of the boundaries mentioned should also be revealed as limits and should be claimable in any combination.

CLAIMS

1. A method for producing a direct bond between a bonding side of a first substrate and a bonding side of a second substrate in a workspace, wherein the method comprises:

a) modifying the bonding sides of the first and second substrates in a plasma chamber and/or a bonding/plasma chamber, the modifying comprising:

(i) changing a stoichiometry of oxide layers respectively formed on the bonding sides of the first and second substrates;

(ii) introducing one or more of the following reducing gases into the plasma chamber and/or the bonding/plasma chamber: hydrogen, nitrogen oxides, carbon monoxide, and methane; and

(iii) mixing the one or more reducing gases with one or more of the following inert gases: xenon, argon, helium, nitrogen, and carbon dioxide;

b) bringing the modified bonding sides of the first and second substrates into contact with each other;

c) applying force to the first and second substrates to close nano-gaps between the modified bonding sides that are in contact with each other; and

d) subsequently bonding the modified bonding side of the first substrate with the modified bonding side of the second substrate in a bonding chamber and/or the bonding/plasma chamber.

2. The method according to claim 1, wherein the step of modifying the bonding sides of the first and second substrates includes:

a) altering the oxide layer on at least one of the bonding sides of the first and second substrates, and/or

b) at least partially removing part of the oxide layer from at least one of the bonding sides of the first and second substrates.

3. The method according to claim 1, wherein said method further comprises:

applying an ion energy of less than 1000eV between an upper electrode and a lower electrode of the plasma chamber and/or the bonding/plasma chamber to expose the first and second substrate to the ion energy.

4. The method according to claim 3, wherein an AC voltage with a frequency greater than a frequency of an AC voltage applied to the lower electrode is supplied to the upper electrode.

5. The method according to claim 1, wherein the step of modifying the bonding sides of the first and second substrates includes completely removing a part of the oxide layer from at least one of the bonding sides of the first and second substrates.

6. The method according to claim 1, wherein the step of modifying the bonding sides of the first and second substrates includes:

a) altering the oxide layer on at least one of the bonding sides of the first and second substrates; and

b) completely removing a part of the oxide layer from at least one of the bonding sides of the first and second substrates.

7. The method according to claim 1, wherein the changing of the stoichiometry of the oxide layer on the bonding sides of the first and second substrates comprises, prior to the bonding, subsequently removing oxygenated products formed within the plasma chamber or the bonding/plasma chamber as a result of the changing of the stoichiometry from the plasma chamber or the bonding/plasma chamber, respectively.

8. The method according to claim 1, wherein applying the force comprises deforming the modified bonding sides in contact with each other to create a layer between the modified bonding sides that serves to close the nano-gaps between the modified bonding sides.