Embodiments of this invention disclose a method with which the bonding result is improved.

According to a first aspect of the present invention, there is provided a method for bonding a first contact surface of a first substrate to a second contact surface of a second substrate with the following sequence: arrangement of a substrate stack, formed from the first substrate and the second substrate and aligned on the contact surfaces, between a first heating surface of a first heating system and a second heating surface of a second heating system, whereby the first heating surface is arranged facing a first surface of the first substrate, facing away from the first contact surface, the second heating surface is arranged facing a second surface of the second substrate, facing away from the second contact surface, between the first surface and the first heating surface, there is a separation distance A > 0 μm, and between the second surface and the second heating surface, there is a separation distance B > 0 μm, heating the heating surfaces, wherein the substrates are spaced from the heating surfaces and the substrates are heated by infrared radiation from the heating surfaces, and during the heating approaching the substrate stack to the heating surfaces by reducing the separation distances A and B to 0 μm, forming a bond between the first contact surface and the second contact surface by pressurization of the substrate stack on the surfaces.

According to a second aspect of the present invention, there is provided a device for bonding a first substrate to a second substrate, the device comprising: a first heating system having a first heating surface that provides heat by infrared radiation; a second heating system having a second heating surface that provides heat by infrared radiation; a receiving system for receiving a substrate stack comprised of (i) a first substrate having a first contact surface and a first surface facing away from the first contact surface and (ii) a second substrate having a second contact surface and a second surface facing away from the second contact surface, the first and second substrates aligned on the first and second contact surfaces, wherein the receiving system is arranged between the first heating surface of the first heating system and the second heating surface of the second heating system, the first and second substrates respectively spaced from the first and second heating surfaces by separation distances A and B, the first heating surface faces the first surface of the first substrate, and the second heating surface faces the second surface of

the second substrate, drive means for changing the separation distances A and B; a force actuator for applying pressure to the first and second surfaces of the substrate stack to form a bond between the first contact surface of the first substrate and the second contact surface of the second substrate; and a control system for controlling operation of the first heating system, the second heating system, the drive means, and the force actuator, said control system operable in (i) a heating mode to heat the first and second substrates, wherein the control system controls the drive means to maintain the separation distances A and B such that $A > 0$ μm and $B > 0$ μm, and independently regulate the first and second heating systems in accordance with parameter data to heat the first and second substrates such that a thermal expansion of the first substrate and a thermal expansion of the second substrate are substantially the same during the heating mode, and (ii) a bonding mode to form a permanent bond between the first and second substrates by pressurization of the substrate stack, wherein the control system controls the drive means to approach the substrate stack towards the first and second heating surfaces by reducing the separation distances A and B to 0 μm. and controls the force actuator to apply pressure to the first and second surfaces of the substrate stack to form the bond between the first contact surface of the first substrate and the second contact surface of the second substrate

Also, all combinations that consist of at least two of the features indicated in the specification, the claims and/or the figures fall within the scope of the invention. In the indicated ranges of values, values lying within the above-mentioned limits are also to be disclosed as boundary values and can be claimed in any combination.

Embodiments of this invention heat the substrates of the substrate stack that is aligned at the contact surfaces of the substrates for the, in particular, permanent bonding in the bonding system gently and uniformly from two surfaces to be heated (the sides facing away from the contact surfaces) of the substrate in order to minimize or to completely avoid in particular different deformations of the two substrates.

Embodiments of the invention describe in particular a modularized device as well as a process chain, which makes it possible to implement an alignment system for alignment and for temporary connection of two or more substrates to a substrate stack. In this case, the substrates that are aligned herein are transferred to a bonding system taking into consideration an

CLAIMS

1. A method for bonding a first contact surface (35k) of a first substrate (35) to a second contact surface (36k) of a second substrate (36) with the following sequence:

arranging a substrate stack (14), formed from the first substrate (35) and the second substrate (36) and aligned on the contact surfaces (35k, 36k), between a first heating surface (15) of a first heating system (30) and a second heating surface (19) of a second heating system (26), whereby

a) the first heating surface (15) is arranged facing a first surface (35o) of the first substrate (35), facing away from the first contact surface (35k),

b) the second heating surface (19) is arranged facing a second surface (36o) of the second substrate, facing away from the second contact surface (36k),

c) between the first surface (35o) and the first heating surface (15), there is a separation distance $A > 0$ μm, and

d) between the second surface (36o) and the second heating surface (19), there is a separation distance $B > 0$ μm,

heating the heating surfaces (15, 19), wherein the substrates (35, 36) are spaced from the heating surfaces (15, 19) and the substrates (35, 36) are heated by infrared radiation from the heating surfaces (15, 19), and during the heating approaching the substrate stack (14) to the heating surfaces (15, 19) by reducing the separation distances A and B to 0 μm, and

forming a bond between the first contact surface (35k) and the second contact surface (36k) by pressurization of the substrate stack (14) on the surfaces (35o, 36o).

2. The method according to claim 1, in which the approaching to the heating surfaces (15, 19) is carried out symmetrically with respect to the substrate stack (14), in particular symmetrically to the surfaces (35o, 36o) and/or symmetrically to the contact surfaces (35k, 36k), and/or at the same temperature of the heating surfaces (15, 19).

3. The method according to one of the preceding claims, in which the heating surfaces (15, 19) are in each case larger than the surfaces (35o, 36o) of the substrate stack (14) that in each case face the heating surfaces (15, 19).

4. The method according to one of the preceding claims, in which the first heating surface (15) or the second heating surface (19) is not moved during approaching.

5. The method according to one of the preceding claims, in which the heating systems (30, 26) are controlled during heating and approaching in such a way that at least during the vast majority of the approaching period, the difference between the mean temperature of the first substrate (35) and the mean temperature of the second substrate (36) is smaller than 5°C, in particular smaller than 1°C, preferably smaller than 0.5°C, and still more preferably smaller than 0.1°C.

6. The method according to one of the preceding claims, in which the substrate stack (14) is preheated before the arrangement between the heating surfaces (15, 19), in particular outside a bonding chamber (10) of a bonding system (6) surrounding, in particular vacuumably, the heating systems (30, 26).

7. The method according to one of the preceding claims, in which the arrangement of the substrate stack (14) between the heating surfaces (15, 19) and/or the heating and/or the approaching and/or the formation of the permanent bond is/are carried out in the vacuum.

8. The method according to one of the preceding claims, in which the heating systems (30, 26) during heating and the approaching are controlled in such a way that the radiation energy (17) of the first heating surface (15) striking the first surface (35o) during the approaching is the same as the radiation energy (17) of the second heating surface (19) striking the second surface (36o).

9. A device for bonding a first substrate (35) to a second substrate (36), the device comprising:

a first heating system (30) having a first heating surface (15) that provides heat by infrared radiation;

a second heating system (26) having a second heating surface (19) that provides heat by infrared radiation;

a receiving system (18) for receiving a substrate stack (14) comprised of (i) the first substrate (35) having a first contact surface (35k) and a first surface (35o) facing away from the first contact surface and (ii) the second substrate (36) having a second contact surface (36k) and a second surface (36o) facing away from the second contact surface (36k), the first and second substrates (35, 36) aligned on the first and second contact surfaces (35k, 36k),

wherein

the receiving system (18) is arranged between the first heating surface (15) of the first heating system (30) and the second heating surface (19) of the second heating system (26), the first and second substrates (35, 36) respectively spaced from the first and second heating surfaces (15, 19) by separation distances A and B,

the first heating surface (15) faces the first surface (35o) of the first substrate (35), and

the second heating surface faces the second surface (36o) of the second substrate (36),

drive means for changing the separation distances A and B;

a force actuator (9) for applying pressure to the first and second surfaces (35o, 36o) of the substrate stack to form a bond between the first contact surface of the first substrate (35) and the second contact surface (36k) of the second substrate (36); and

a control system for controlling operation of the first heating system (30), the second heating system (26), the drive means, and the force actuator (9), said control system operable in

(i) a heating mode to heat the first and second substrates (35, 36), wherein the control system controls the drive means to maintain the separation distances A and B such that $A > 0$ μm and $B > 0$ μm, and independently regulate the first and second heating systems (30, 26) in accordance with parameter data to heat the first and second substrates (35, 36) such that a thermal expansion of the first substrate (35) and a thermal expansion of the second substrate (36) are substantially the same during the heating mode,

and

(ii) a bonding mode to form a permanent bond between the first and second substrates (35, 36) by pressurization of the substrate stack, wherein the control system controls the drive means to approach the substrate stack towards the first and second heating surfaces (15, 19) by reducing the separation distances A and B to 0 μm. and controls the force actuator (9) to apply pressure to the first and second surfaces (35o, 36o) of the substrate stack to form the bond between the first contact surface of the first substrate (35) and the second contact surface (36k) of the second substrate (36).

10. The device according to claim 9, whereby the first heating surface (15) and/or the second heating surface (19) are formed by studs (37) with flow channels (32) running between the studs (37) for pressurization, in particular flushing, with a gas.

11. The device according to claim 10, whereby the flow channels (32) are surrounded, in particular enclosed, by an, in particular circular, arm (40) for sealing the flow channels (32) with respect to the first and/or second substrate (35, 36).

12. The device according to claim 11, whereby the arm (40) has an opening (41) for controlled discharge of gas.

13. The device according to claim 9, wherein the control system independently regulates the first and second heating systems (30, 26) in accordance with the parameter data by (i) heating the first heating surface (15) to a different temperature than the second heating surface (19) and/or (ii) maintaining different separation distances A and B.

14. The device according to claim 9, wherein the parameter data is indicative of: type of material of the first and second substrates (35, 36), thermal expansion coefficients of the first and second substrates (35, 36), thickness of the first and second substrates (35, 36); heating temperature of the first and second heating surfaces (15, 19), and/or bonding method.