

Method and Device for Prefixing Substrates

This invention relates to a method for prefixing substrates and a corresponding device.

In the publications US6563133B1 and US7332410B2, the bonding of oxide-free substrate pairs at room temperature without external expenditure of force is disclosed. In this case, the substrate surfaces are modified by plasma treatment or ion implantation by the surfaces being treated with a semi-amorphous layer that consists of boron or arsenic ions. After full-surface contact is made under normal pressure, the substrate pairs remain in a light vacuum atmosphere. A binding energy of approximately 400 mJ/m^2 is achieved at room temperature. In order to create a permanent bond, an annealing step also follows at up to 400°C . The substrates are limited to semiconductors such as Si, InGaAs, GaAs, Ge, and SiC.

The publication EP2672509A1 shows a cluster system with a pretreatment unit and a bonding unit. In this case, bonding surfaces are to be produced, which allow a bonding with sufficient bonding force without high vacuum.

The publication US2006/0132544A1 describes the sticking (English: “tacking”) or prefixing of a composite film that has an adhesive layer. Partial areas of the adhesive layer are heated by a laser and thus the sticking is made possible.

The publication US5686226 uses a locally applied resin adhesive for sticking (product) substrates to one another by hardening (polymerization) of the adhesive by means of UV radiation.

In particular, the transport of substrates or substrate stacks causes considerable problems in the state of the art, since the substrates, on the one hand, are not to be damaged and, on the other hand, a possible alignment of the substrates is not to be changed. In addition, the transport is to be carried out in the smallest possible space.

Embodiments of this invention disclose a method and a device with which in particular the transport of the aligned substrates is improved. In addition, the bonding quality is to be enhanced, and less scrap is to be produced. Moreover, the flexibility is to be improved, and the cycle times are to be reduced.

According to a first aspect of the present invention, there is provided a method for prefixing substrates, said method including: pretreating at least one substrate surface of the substrates in at least one surface area, aligning the substrates, contacting the respective substrate surfaces after said aligning, prefixing the substrates on the pretreated surface areas, thereby forming a substrate stack, wherein the prefixing comprising applying heat, in a pulsed manner, at a contact surface, wherein the heat is produced by using one of electric fields, magnetic fields, electromagnetic radiation or lasers, wherein the laser has a wave length that optimally heats at least a material in the substrate stack, and wherein the aligning and the prefixing are carried out in a first module chamber.

According to a second aspect of the present invention, there is provided a device for prefixing substrates with at least one pretreatment system for pretreating at least one substrate surface of the substrates in at least one surface area, an alignment system for aligning the substrates, and a prefixing system downstream from the alignment system for making contact with and prefixing the aligned substrates on the pretreated surface areas, thereby forming a substrate stack, wherein the prefixing system comprises a heating system for applying heat, in a pulsed manner, at a contact surface, wherein the heat is produced by using one of electric fields, magnetic fields, electromagnetic radiation or lasers, wherein the laser has a wavelength that optimally heats at least a material in the substrate stack, and wherein the aligning and the prefixing are carried out in a first module chamber.

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

Embodiments of this invention provide substrates in which at least one substrate surface of the substrates is pretreated, in particular amorphized, in at least one surface area, and to align the substrates and then to make contact and to prefix them on the pretreated surface areas. The alignment and making contact as well as prefixing are done preferably in one and the same vacuum module chamber (prefixing module) that is uninterrupted in particular during alignment and making contact.

According to an advantageous embodiment of the invention, the substrates are then bonded, in particular without interrupting the vacuum in the module chamber. In a preferred high-vacuum environment (in particular $< 10e^{-7}$ mbar, preferably $< 10e^{-8}$ mbar), polished and/or pretreated substrate surfaces bond spontaneously and covalently by making pure contact without additional pressure (or at least only very low pressure), in particular at room temperature. Reference is made to the publication PCT/EP 2014/063303 with respect to the pretreatment.

The method according to embodiment of the invention, the device derived therefrom, and the articles produced therefrom use the effects of the pretreatment in particular to prefix substrate pairs in an adjusting system (alignment system, in particular outside of the bonding chamber), without in this case using high contact forces and/or high temperatures, as were necessary in the case of full-surface permanent bonds. Preferably, the substrates are prefixed or temporarily bonded only at a few points or partial surfaces (surface areas).

Claims

1. A method for prefixing substrates (1, 2), said method comprising:
 - pretreating at least one substrate surface (1o, 2o) of the substrates (1, 2) in at least one surface area,
 - aligning the substrates (1, 2),
 - contacting the respective substrate surfaces (1o, 2o) after said aligning,
 - prefixing the substrates (1, 2) on the pretreated surface areas, thereby forming a substrate stack,
 - wherein the prefixing comprising applying heat, in a pulsed manner, at a contact surface, wherein the heat is produced by using one of electric fields, magnetic fields, electromagnetic radiation or lasers,
 - wherein the laser has a wavelength that optimally heats at least a material in the substrate stack, and
 - wherein the aligning and the prefixing are carried out in a first module chamber.
2. The method according to claim 1, wherein the pretreatment comprises amorphization of the substrates (1, 2).
3. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 1 bar.
4. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 1 mbar.
5. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 10 e^{-5} mbar.
6. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 10 e^{-6} mbar.

7. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 10 e^{-7} mbar.
8. The method according to claim 1 or 2, wherein the alignment and the prefixing are carried out in the first module chamber at a pressure of less than 10 e^{-8} mbar.
9. The method according to one of the preceding claims, wherein the alignment is carried out with an alignment accuracy of less than $100 \text{ }\mu\text{m}$.
10. The method according to claim 9, wherein the alignment is carried out with an alignment accuracy of less than $10 \text{ }\mu\text{m}$.
11. The method according to claim 9, wherein the alignment is carried out with an alignment accuracy of less than $1 \text{ }\mu\text{m}$.
12. The method according to claim 9, wherein the alignment is carried out with an alignment accuracy of less than 100 nm ,
13. The method according to claim 9, wherein the alignment is carried out with an alignment accuracy of less than 10 nm .
14. The method according to one of the preceding claims, wherein the prefixing has a bond strength of between 0.01 J/m^2 and 5 J/m^2 .
15. The method according to claim 14, wherein the prefixing has a bond strength of greater than 0.1 J/m^2 .
16. The method according to claim 14, wherein the prefixing has a bond strength of greater than 0.2 J/m^2 .

17. The method according to claim 14, wherein the prefixing has a bond strength of greater than 0.5 J/m^2 .
18. The method according to claim 14, wherein the prefixing has a bond strength of greater than 1 J/m^2 .
19. The method according to claim 14, wherein the prefixing has a bond strength of greater than 1.5 J/m^2 .
20. The method according to one of the preceding claims, wherein the prefixing is carried out by local energy input.
21. The method according to claim 20, wherein the local energy input is from a side that faces away from the substrate surface (1o, 2o) with which contact is to be made.
22. The method according to one of the preceding claims, wherein at least one of the substrate surfaces (1o, 2o) has a mean roughness index Ra of less than 20 nm.
23. The method according to claim 23, wherein all of the substrate surfaces (1o, 2o) has/have a mean roughness index Ra of less than 20 nm.
24. The method according to claim 23, wherein the substrate surfaces (1o, 2o) has/have a mean roughness index Ra of less than 1 nm.
25. The method according to one of the preceding claims, wherein the substrates are prefixed only at the pretreated surface areas.
26. The method according to one of the preceding claims, wherein the substrates are prefixed by local application of energy.

27. The method according to one of claims 1-26, wherein the substrates are prefixed by local application of force and/or heat.
28. The method according to one of the preceding claims, wherein the wavelength lies in a range of between 1 nm and 1 mm, wherein the diameter of the laser beam is less than 10 mm, wherein the laser output is greater than 10 W.
29. The method according claim 28, wherein the wavelength is between 200 nm and 1 mm
30. The method according to claim 28, wherein the wavelength is between 400 nm and 1 mm.
31. The method according to claim 28, wherein the wavelength is between 600 nm and 1 mm.
32. The method according to claim 28, wherein the wavelength is between 800 nm and 1 mm.
33. The method according to claim 28, wherein the laser is an infrared laser.
34. The method according to claim 28, wherein the diameter of the laser beam is less than 5 mm.
35. The method according to claim 28, wherein the diameter of the laser beam is less than 2 mm.
36. The method according to claim 28, wherein the diameter of the laser beam is less than 1 mm.

37. The method according to claim 28, wherein the laser output is greater than 100 W, even more preferably greater than 1,000 W, and most preferably greater than 0.01 MW.

38. The method according to claim 28, wherein the laser output is greater than 1,000 W.

39. The method according to claim 28, wherein the laser output is greater than 0.01 MW.

40. The method according to one of the preceding claims, wherein for prefixing a laser is used that can be focused as exactly as possible, wherein coherent laser light is bundled by optics, wherein as a result, an intensive and quick heating of the connecting layer that is as locally limited as possible is produced.

41. The method according to claim 40, wherein the optics is located between the product substrate and the carrier substrate, i.e., in the connecting layer.

42. The method according to one of the preceding claims, wherein handling can be done without an accommodating device on one or both holding sides of a substrate stack.

43. The method according to one of the claims 1-41, wherein transporting the substrate stack from a prefixing module to a bond module or other treatment modules, can be done without an accommodating device on one or both holding sides of the substrate stack.

44. A device for prefixing substrates (1, 2) with

- at least one pretreatment system for pretreating at least one substrate surface (1o, 2o) of the substrates (1, 2) in at least one surface area,
- an alignment system for aligning the substrates (1, 2), and

- a prefixing system downstream from the alignment system for making contact with and prefixing the aligned substrates (1, 2) on the pretreated surface areas, thereby forming a substrate stack,

wherein the prefixing system comprises a heating system for applying heat, in a pulsed manner, at a contact surface, wherein the heat is produced by using one of electric fields, magnetic fields, electromagnetic radiation or lasers,

wherein the laser has a wavelength that optimally heats at least a material in the substrate stack, and

wherein the aligning and the prefixing are carried out in a first module chamber.

45. The device according to claim 44, wherein the pretreated surface areas comprise amorphized surface areas (1, 2).

46. The device according to claim 44, wherein the prefixing takes place in a separate prefixing module.