controlled and rapid cool down of the heater (and thus the bonding tool) before transfer of another workpiece onto the bonding tool to again repeat the cycle.

SUMMARY OF THE INVENTION

[0006] According to an exemplary embodiment of the present invention, a bond head for a thermocompression bonder comprises a tool configured to hold a workpiece to be bonded, a heater configured to heat the workpiece to be bonded, and a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

[0007] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

[0008] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber adapted to move between a first position in contact with the heater and a second position out of contact with the heater the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

[0009] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid during a first operational phase, and a second fluid during a second operational phase, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the

heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

[0010] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, (d) a support structure above the heater, and (e) at least two flexures disposed between the support structure and the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

[0011] According to another exemplary embodiment of the present invention, a bond head for a thermocompression bonder comprises a tool configured to hold a workpiece to be bonded; a heater configured to heat the workpiece to be bonded; and a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

[0012] According to another exemplary embodiment of the present invention, athermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

[0012a] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber adapted to move between a first position in contact with the heater and a second position out of contact with the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater.

[0012b] According to another exemplary embodiment of the present invention, athermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid during a first operational phase, and a second fluid during a second operational phase, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

[0012c] According to another exemplary embodiment of the present invention, a thermocompression bonder comprises a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, (d) a support structure above the heater, and (e) at least two flexures disposed between the support structure and the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater

[0013] Additional exemplary methods are disclosed herein, such as methods of operating any of the bond heads or bonding machines disclosed or claimed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention is best understood from the following detailed description when read in connection with the accompanying drawing. It is emphasized that, according to common practice, the various features of the drawing are not to scale. On the contrary, the dimensions of the various features are arbitrarily deformed or reduced for clarity. Included in the drawing are the following figures:

FIG. 1 is a block diagram side view of elements of a conventional thermocompression bonder;

FIGS. 2A – 2D are block diagram views of bonding structures on a lower substrate, bonding structures on an upper substrate, and a conventional method of bonding the upper substrate to the lower substrate;

CLAIMS

1. A bond head for a thermocompression bonder, the bond head comprising:

a tool configured to hold a workpiece to be bonded;

a heater configured to heat the workpiece to be bonded; and

a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

2. The bond head of claim 1, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

3. The bond head of claim 1 wherein the cooling fluid has a thermal capacity to absorb heat from the heater during contact between the chamber and the heater.

4. The bond head of claim 1 wherein the cooling fluid is selected from the group consisting of water, ethylene glycol and fluorinated liquid.

5. The bond head of claim 1 wherein the cooling fluid is received in the chamber during a first operational phase, and a second fluid is received in the chamber during a second operational phase.

6. The bond head of claim 5 wherein the first operational phase is a cooling phase and the second operational phase is a non-cooling phase.

7. The bond head of claim 5 wherein the second fluid is air.

8. The bond head of claim 1 wherein the cooling fluid includes a corrosive inhibitor.

9. The bond head of claim 1 further comprising at least two flexures disposed between a support structure of the bond head and the heater.

10. The bond head of claim 1 wherein the tool, the heater and the chamber are integrated in a single structure.

11. The bond head of claim 1 wherein the chamber is disposed within a cavity of a

support structure of the bond head above the heater.

12. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

13. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber adapted to move between a first position in contact with the heater and a second position out of contact with the heater the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

14. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid during a first operational phase, and a second fluid during a second operational phase, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

15. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, (d) a support structure above the heater, and (e) at least two flexures disposed between the support structure and the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange

between the heater and the chamber.

16. A bond head for a thermocompression bonder, the bond head comprising:
a tool configured to hold a workpiece to be bonded;
a heater configured to heat the workpiece to be bonded; and
a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

17. The bond head of claim 16 wherein the chamber is in contact with the heater with a variable contact force so as to adjust a heat exchange between the heater and the chamber.

18. The bond head of claim 16 wherein the cooling fluid has a thermal capacity to absorb heat from the heater during contact between the chamber and the heater.

19. The bond head of claim 16 wherein the cooling fluid is selected from the group consisting of water, ethylene glycol and fluorinated liquid.

20. The bond head of claim 16 wherein the cooling fluid is received in the chamber during a first operational phase, and a second fluid is received in the chamber during a second operational phase.

21. The bond head of claim 20 wherein the first operational phase is a cooling phase and the second operational phase is a non-cooling phase.

22. The bond head of claim 20 wherein the second fluid is air.

23. The bond head of claim 16 wherein the cooling fluid includes a corrosive inhibitor.

24. The bond head of claim 16 further comprising at least two flexures disposed between a support structure of the bond head and the heater.

25. The bond head of claim 16 wherein the tool, the heater and the chamber are integrated in a single structure.

26. The bond head of claim 16 wherein the chamber is disposed within a cavity of a

support structure of the bond head above the heater.

27. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

28. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, the chamber adapted to move between a first position in contact with the heater and a second position out of contact with the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater.

29. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, and (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid during a first operational phase, and a second fluid during a second operational phase, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.

30. A thermocompression bonder comprising:

a bond head including (a) a tool configured to hold a workpiece to be bonded, (b) a heater configured to heat the workpiece to be bonded, (c) a chamber proximate the heater, the chamber configured to receive a cooling fluid for cooling the heater, (d) a support structure above the heater, and (e) at least two flexures disposed between the support structure and the heater, the chamber being positioned on a side of the heater, the tool being positioned on an opposite side of the heater, wherein the chamber is moveable relative to the heater to be in and out of contact with the heater.