The semiconductor chip 12 placed on the chip preheat stage 28 is then preheated to a predetermined temperature (e.g. a third temperature) in a step 250. The predetermined temperature is for example 200°C. The preheating of the semiconductor chip 12 is performed gradually by displacing the semiconductor chip 12 across a series of heaters 34 towards a bond tool location. More specifically, the semiconductor chip 12 is attached to a preheat buffer stage, also known as a turret, which is rotated for displacing the semiconductor chip 12 across the series of heaters 34. The heaters 34 are preferably convection heaters. Temperature of each heater 34 is preferably preset to provide incremental heating of the semiconductor chip 12 as it progresses from one to another of the heaters 34 along the series. Heating of the semiconductor chip 12 by the heaters may be effected by at least one of conduction, convection or radiation. Further preferably, the temperature of each heater 34 can be kept constant or can be varied as required.

The gradual preheating of the semiconductor chip 12, which can also be referred to as controlled preheating, of the semiconductor chip 12 reduces or eliminates thermal shock to the semiconductor chip 12. It will be understood by a person skilled in the art that preheating profile of the semiconductor chip 12 can be adjusted as required by altering any one or more of the temperatures of the radiation heaters 34. It will also be understood by a person skilled in the art that preheating profile of the semiconductor chip 12 can be adjusted as required by altering speed of displacement of the preheat stage and/or spacing between the semiconductor chip 12 and the radiation heaters 34. Control of the speed of the chip preheat stage 28 and control of the preheating of the semiconductor chip 12 can be either manually or software controlled.

As previously mentioned, the chip preheat stage 28 is displaced towards the bond tool location during the step 250. At the bond tool location, the semiconductor chip 12 is picked up by a bond tool 36 in a step 260. The semiconductor chip 12 is preferably held or secured to the bond tool 36 by vacuum or suction. Alternatively, the semiconductor chip 12 is held or secured to the bond tool 36 by mechanical means, for example by a gripper (not shown).

Preferably, the bond tool 36 is preheated and maintained at a predetermined elevated temperature prior to pick up of the semiconductor chip 12 in the step 260. The predetermined temperature is preferably sufficiently high enough to melt the solder

The flux transfer process 400 can also be substituted with use of a no-flow underfill. The no-flow underfill can be transferred or dispensed onto the surface of the substrate 22 via methods known to a person skilled in the art. For example, the no-flow underfill may be directly dispensed onto the substrate 22 by use of a needle (not shown).

In a step 340, the substrate 22 comprising flux 56 on the surface thereof is transferred from the flux stage 54 onto a substrate preheat stage 66 (also known as a substrate preheat plate or holder) by a substrate pickup tool 72. Preferably, the substrate preheat stage 66 is preheated and maintained at a predetermined elevated temperature, for example 150°C. It will be understood by a person skilled in the art that the predetermined elevated temperature of the substrate preheat stage 66 can be predetermined and varied as required using techniques known in the art.

In a step 350, the substrate 22 on the substrate preheat stage 66 is heated to a transition temperature (e.g. a fourth temperature). The transition temperature of the substrate 22 can be selected, and is further variable, as required. Control of heating of the substrate 22 on the substrate preheat stage 66 can be either manually or software controlled.

The transfer of flux 54 occurring in the step 330 may alternatively be performed after the substrate 22 has been transferred onto the substrate preheat stage 66 and heated to the transition temperature.

In a step 360, the substrate 22 is transferred from the substrate preheat stage 66 to a bond stage 70 (also known as a bond plate or holder) using a substrate transfer tool 72. The substrate pickup tools 52 and 68 and the substrate transfer tool 72 may be the same tool. The substrate 22 is preferably held or secured onto the bond stage 70 by use of a vacuum or suction. Alternatively, the substrate is held or secured onto the bond stage 70 by alternative mechanical means or mechanism. Preferably, the vacuum or suction is applied at specific or predetermined positions on the substrate 22 held onto the bond stage 70. More preferably, the specific positions do not correspond to bond pad 64 locations on the substrate 22. This is to prevent deformation or warping of the substrate 22 when the substrate 22 is heated.

of the semiconductor chip 12. Preferably, the heating of the substrate 22 to the transition temperature (e.g. the fourth temperature) in the step 350 reduces time required for the further heating of the substrate 22 to the substrate processing temperature in the step 370. The temperature of the bond stage 70 is preferably maintained at the predetermined elevated temperature, for example 200°C.

In a step 380, a thickness or height of the substrate 22 is measured and recorded by a substrate thickness measurement tool 74 or apparatus. The substrate thickness measurement tool 74 preferably determines the thickness or height of the substrate 22 with reference to a datum defined by the bond stage 70. Further preferably, the substrate thickness measurement tool 74 measures thickness of the substrate 22 excluding the bond pads 64 and flux 56. Preferably, the substrate thickness measurement tool 74 further measures at least one of thickness of flux 56 on the substrate 22 and height of bond pads 64, also known as contact pads, formed on the substrate 22.

The bond stage 70 is then positioned below the second vision lens 38 in a step 390. Preferably, the second vision lens 38 facilitates at least one of x, y translational and θ angular alignment of the substrate 22 relative to the semiconductor chip 12. More specifically, the second vision lens 38 facilitates x, y translational and θ angular alignment of the bond pads 64 formed on the substrate 22 relative to the bump structures 16 formed on the semiconductor chip 12. The second vision lens can alternatively be referred to as a look-up/look-down camera for facilitating at least one of x, y translational and θ angular alignment of the substrate 22 relative to the semiconductor chip 12. It will however be appreciated by a person skilled in the art that the x, y translational and θ angular alignment of the bond pads 64 formed on the substrate 22 relative to the bump structures 16 formed on the semiconductor chip 12 can be effected by a third vision lens (not shown) or other alignment means known in the art.

The processing of the semiconductor chip 12 in the step 1 10 and the processing of the substrate 22 in the step 120 prepares the semiconductor chip 12 and the substrate 22 for bonding therebetween in a step 130. Preferably, the bonding between the semiconductor chip 12 and the substrate 22 in the step 130 occurs via an exemplary

Claims

1. A method for device packaging, the method comprising:

heating a semiconductor device to a first temperature, the semiconductor device comprising a plurality of bump structures, each of the plurality of bump structures comprising a solder portion, the first temperature being at least the melting temperature of the solder portion of each of the plurality of bump structures to bring the solder portion to a molten state;

heating a substrate to a second temperature, the substrate comprising a plurality of contact pads; and

spatially aligning the plurality of bump structures with the plurality of contact pads,

wherein the semiconductor device is disposed at a distance from the substrate during the heating of the semiconductor device to the first temperature, at least one of the semiconductor device and the substrate being displaced towards the other thereof subsequent the heating of the semiconductor device for abutting each of the plurality of bump structures with a corresponding one of the plurality of contact pads; and

wherein heating the semiconductor device to the first temperature comprises gradually heating the semiconductor device to a third temperature, the third temperature being lower than the melting temperature of the solder portion of each of the plurality of bump structures.

2. The method as in claim 1, wherein ~~heating the substrate comprising~~:

~~heating the substrate to a second temperature,~~ the second temperature ~~being~~ is lower than the first temperature.

3. The method as in claim 2, the second temperature being lower than the melting temperature of the solder portion of each of the plurality of bump structures

4. The method as in claim 2, further comprising:

displacing at least one of the semiconductor device and the substrate towards the other thereof for abutting each of the plurality of bump structures with a corresponding one of the plurality of contact pads to thereby obtain a semiconductor device package therefrom.

5. The method as in claim 4, heating the semiconductor device to the first temperature comprising:

~~heating the semiconductor device to a third temperature, the third temperature being lower the melting temperature of the solder portion of each of the plurality of bump structures; and~~

gripping the semiconductor device with a gripper ~~tool~~, the gripper ~~tool~~ for heating the semiconductor device to the first temperature.

6. The method as in claim 5, heating the semiconductor device to a third temperature comprising:

displacing the semiconductor device across a plurality of heating elements, the heating elements being operated for generating a heat profile thereacross, the heat profile being controlled for gradual heating of the semiconductor device to the third temperature.

7. The method as in claim 6, heating the semiconductor device to a third temperature further comprising:

disposing the semiconductor device on a plate, the plate being displaceable for displacing the semiconductor device across the plurality of heating elements.

8. The method as in claim 7, heating the semiconductor device to a third temperature further comprising:

displacing the semiconductor device in one of rotationally and linearly for disposing the semiconductor device on the plate in a required orientation; and

determining height of the semiconductor device with reference to a datum defined by the plate.

9. The method as in claim 4, heating the substrate to a second temperature comprising:

disposing the substrate on a first holder, the first holder for heating the substrate to a fourth temperature, the fourth temperature being lower the second temperature; and

disposing the substrate on a second holder subsequent the substrate reaching the fourth temperature, the second holder for heating the substrate to the second temperature.

10. The method as in claim 9, further comprising:

depositing fluxing agent onto the plurality of contact pads when the substrate is disposed on the first holder, the second temperature being lower than the activation temperature of the fluxing agent.

11. The method as in claim 9, further comprising:

depositing at least one underfill material onto the plurality of contact pads when the substrate is disposed on the first holder, the second temperature being lower the curing temperature of underfill material.

12. The method as in claim 9, further comprising:

determining height of the device carrier with reference to a datum defined by the second holder subsequent the heating of the substrate to the second temperature.

13. The method as in claim 4, spatially aligning the plurality of bump structures with the plurality of contact pads comprising:

defining a first coordinate system on the semiconductor device and a plurality of reference axes intersecting and configuratively corresponding with the plurality of bump structures;

defining a second coordinate system on the substrate and a plurality of reference vertices coinciding and configuratively corresponding with the plurality of contact pads of the substrate; and

aligning the first coordinate system with the second coordinate system for substantially coinciding each of the plurality of reference axes with a corresponding one of the plurality of reference vertices to thereby spatially align the plurality of bump structures with the plurality of contact pads.

14. A system for packaging a device, the system comprising:

means for heating a semiconductor device to a first temperature, the semiconductor device comprising a plurality of bump structures, each of the plurality of bump structures comprising a solder portion, the first temperature being at least a melting temperature of the solder portion of each of the plurality of bump structures to bring the solder portion to a molten state;

means for heating a substrate to a second temperature, the substrate having a plurality of contact pads; ~~and~~

means for spatially aligning the plurality of bump structures with the plurality of contact pads; and

a plurality of heating elements, the plurality of heating elements operable for generating a heat profile thereacross, the heat profile being controllable for gradual heating of the semiconductor device to a third temperature, the third temperature being lower than the melting temperature of the solder portion of each of the plurality of the bump structures,

wherein the semiconductor device is disposed at a distance from the substrate during the heating of the semiconductor device to the first temperature, at least one of the semiconductor device and the carrier device being displaced towards the other thereof subsequent the heating of the semiconductor device to the first temperature for abutting each of the plurality of bump structures with a corresponding one of the plurality of contact pads.

15. The system as in claim 14, wherein the second temperature is lower than the first temperature.

16. The system as in claim 15, wherein the second temperature is lower than the melting temperature of the solder portion of each of the plurality of bump structures.

17. The system as in claim 15, further comprising:

means for displacing at least one of the semiconductor device and the device carrier towards the other thereof for abutting each of the plurality of bump structures with a corresponding one of the plurality of contact pads to thereby obtain a semiconductor device package therefrom.

18. The system as in claim 17, further comprising:

a gripper ~~tool~~ for gripping the semiconductor device, the gripper ~~tool~~ for heating the semiconductor device to the first temperature.

~~19. The system as in claim 18, further comprising:~~

~~a plurality of heating elements, the plurality of heating elements operable for generating a heat profile thereacross, the heat profile being controllable for gradual heating of the semiconductor device to a third temperature, the third temperature being lower than the melting temperature of the solder portion of each of the plurality of bond structures.~~

~~20~~19. The system as in claim 1~~8~~9, further comprising:

a plate for disposing the semiconductor device across the plurality of heating elements.

2~~0~~1. The system as in claim 19~~20~~, further comprising:

means for displacing the semiconductor device one of rotationally and linearly for disposing the semiconductor device on the plate in a predetermined orientation; and

means for determining height of the semiconductor device with reference to a datum defined by the plate.

2~~1~~2. The system as in claim 17, further comprising:

a first holder for heating the substrate to a fourth temperature, the fourth temperature being lower the second temperature;

a second holder for heating the substrate to the second temperature; and

means for disposing the substrate onto the second holder subsequent the substrate reaching the fourth temperature.

2~~2~~3. The system as in claim 2~~1~~2, further comprising:

means for depositing fluxing agent onto the plurality of the contact pads when the substrate is disposed on the first holder, the second temperature being lower than an activation temperature of the fluxing agent.

234. The system as in claim 223, wherein the fourth temperature is lower the activation temperature of the fluxing agent.

245. The system as in claim 212, further comprising:

means for depositing an underfill material on onto the plurality of the contact pads when the substrate is disposed on the first holder, the second temperature being lower a curing temperature of the underfill material.

256. The system as in claim 212, further comprising:

means for determining height of the device carrier with reference to a datum defined by the second holder subsequent the heating of the device carrier to the second temperature.

267. The system as in claim 14, the means for spatially aligning the plurality of bump structures with the plurality of contact pads comprising:

means for defining a first coordinate system on the semiconductor device and a plurality of reference axes intersecting and configuratively corresponding with the plurality of bump structures;

means for defining a second coordinate system on the substrate and a plurality of reference vertices coinciding and configuratively corresponding with the plurality of contact pads of the substrate; and

means for aligning the first coordinate system with the second coordinate system for substantially coinciding each of the plurality of reference axes with a corresponding one of the plurality of reference vertices to thereby spatially align the plurality of bump structures with the plurality of contact pads.