

adsorption or separation of the electronic component or the air-permeable sheet can be each controlled independently as necessary. Also, since the air-permeable sheet is adsorbed by the second suction hole provided on the tapered side surface, an end portion of the individual piece-like air-permeable sheet is prevented from sagging, and the
5 air-permeable sheet can be reliably adsorbed to the bonding distal end portion during the bonding process. Therefore, the electronic component can be satisfactorily bonded on the substrate with the adhesive material therebetween.

[Advantageous Effects of Invention]

[0008]

10 According to the present invention, an electronic component can be satisfactorily bonded to a substrate with an adhesive material therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

15 Fig. 1 is a view illustrating a bonding apparatus according to a first embodiment of the present invention.

Fig. 2 is a plan view of a bonding tool of Fig. 1.

Fig. 3 is a cross-sectional view taken along line III-III of Fig. 2.

Fig. 4 is a view illustrating a bonding method according to the present
20 embodiment.

Fig. 5 is a plan view of a sheet placement stage of Fig. 4.

Fig. 6 is a view illustrating the bonding method according to the first embodiment.

Fig. 7 is a view illustrating the bonding method according to the first
25 embodiment.

sheet 130 is preferably small in order to adsorb an electronic component such as the semiconductor die 100 and is preferably, for example, in a range of 1 to 2 (s/100 cc/ in²).

[0027]

Also, the porous sheet 130 is made of a material softer than a semiconductor material of the semiconductor die 100 or a material of a bonding surface 44 to be bonded. The porous sheet 130 may be, for example, a nonwoven fabric.

[0028]

The porous sheet 130 may be, for example, a polytetrafluoroethylene (PTFE) resin or polyimide, but the material is not limited thereto, and other porous materials may also be used. For example, when a polytetrafluoroethylene resin is used for the porous sheet 130, the polytetrafluoroethylene resin may be PTFE nanofibers. PTFE nanofibers having a pore diameter of about 1 to 2 μm, a thickness of about 56 μm, and a Gurley value of 1.2 (s/100 cc/ in²) may be used. PTFE nanofibers can be made to have a small Gurley value (that is, improved air permeability) despite being thick, and have heat resistance in a manufacturing process in which heating to, for example, 230°C or higher is applied because there is almost no heat shrinkage even when they are heated to about 260°C. Therefore, it is effective when PTFE nanofibers be used for the porous sheet 130 of the present embodiment.

[0029]

The bonding control unit 30 controls necessary processing for bonding by the bonding apparatus 10. The bonding control unit 30 performs position control of the bonding tool 40 including XYZ axis driving, θ axis driving (rotation around the Z axis), and tilt driving (inclination direction) of the bonding tool 40, ON or OFF control of an air vacuum function and/or an air blow function, load control when the semiconductor die 100 is mounted on substrate 110, heat supply control of the bonding tool 40 or the

placement stage according to the present embodiment. The bonding method according to the present embodiment can be performed by the bonding apparatus 10 illustrated in Fig. 1. A semiconductor device (see Fig. 8) in which the semiconductor die 100 is mounted on the substrate 110 with an adhesive material 114 therebetween can be manufactured by the bonding method of the present embodiment.

[0044]

Hereinafter, the bonding method will be described according to the flowchart of Fig. 10 while referring to each of Figs. 4 to 9.

[0045]

First, a plurality of semiconductor dies 100 divided into individual pieces are prepared on the wafer stage 12 (S10). Specifically, the wafer 120 consisting of a plurality of semiconductor dies 100 affixed to a film is prepared on the wafer stage 12 as illustrated in Fig. 1. The wafer 120 is disposed on the wafer stage 12 such that each of the plurality of semiconductor dies 100 has the first main surface 102a facing upward and the second main surface 102b facing the wafer stage 12.

[0046]

Next, the semiconductor die 100 is transferred to the intermediate stage 14 (S11). For example, the plurality of semiconductor dies 100 on the wafer stage 12 may be transferred to the intermediate stage 14 one at a time by a cooperative operation of the suction tool and the pickup unit (none of which is illustrated).

[0047]

On the other hand, the porous sheet 130 is supplied to the sheet placement portion 60 of the sheet placement stage 17, the bonding tool 40 is moved above the sheet placement stage 17, and the porous sheet 130 is adsorbed to the bonding surface 44 (S12). Specifically, as illustrated in Fig. 4, the bonding distal end portion 42 is fitted to the sheet

XY plan view.

[0052]

The tapered side surface 66 is provided corresponding to the tapered side surface 46 of the bonding distal end portion 42 and is provided on each side of the bottom surface 64. In the example illustrated in Fig. 5, the tapered side surface 66a is provided on any one of the sides of the bottom surface 64, the tapered side surface 66b is provided adjacent to the tapered side surface 66a, the tapered side surface 66c is provided adjacent to the tapered side surface 66b, and the tapered side surface 66d is provided adjacent to the tapered side surface 66c. In other words, the tapered side surfaces 66a and 66c are provided on respective sides of the bottom surface 64 facing each other, while the tapered side surfaces 66b and 66d are provided on respective sides of the bottom surface 64 facing each other. As illustrated in Fig. 4, an angle θ_2 formed by each of the tapered side surfaces 66a to 66d and a periphery 68 (or the bottom surface 64) of the sheet placement stage 17 is $\theta_2 > 90$ degrees (for example, $\theta_2 \geq 135$ degrees). The inclination angle θ_2 of each of the tapered side surfaces 66a to 66d may be substantially the same as the inclination angle θ_1 of each of the tapered side surfaces 46a to 46d of the bonding distal end portion 42.

[0053]

Referring to the flowchart of Fig. 10 again, next, the semiconductor die 100 is thermo-compression bonded to the substrate 110 with an adhesive material 112 therebetween using the bonding tool 40 (S13).

[0054]

Specifically, first, in a state in which the porous sheet 130 is adsorbed to the bonding distal end portion 42, the bonding tool 40 is moved above the intermediate stage 14, and the semiconductor die 100 on the intermediate stage 14 is adsorbed to the

bonding distal end portion 42. In this case, since the porous sheet 130 is adsorbed to the pair of tapered side surfaces 46a and 46c facing each other, the porous sheet 130 can remain and be stably adsorbed to the bonding distal end portion 42.

[0060]

5 Thereafter, the bonding tool 40 is moved above the sheet placement stage 17, and the porous sheet 130 is separated from the bonding surface 44 onto the sheet placement portion 60 (S15). Specifically, as illustrated in Fig. 9, all the suction operations of the first suction holes 50 and the second suction holes 52 and 54 are caused to be in OFF states. In this way, the porous sheet 130 can be separated from the
10 bonding distal end portion 42. Thereafter, the used porous sheet 130 disposed on the sheet placement portion 60 is collected into the sheet collection hole 62 by causing a suction operation of the sheet collection hole 62 to be in an ON state (VAC: ON).

[0061]

 Further, in the bonding method described above, instead of causing the suction
15 operation to be in the OFF state, an exhaust operation may be controlled such that it is in an ON state to cause vacuum breakage by air blowing or the like. According to this, the semiconductor die 100 or the porous sheet 130 can be reliably separated from the bonding tool 40.

[0062]

20 As described above, the bonding apparatus according to the present embodiment is a bonding apparatus in which an electronic component is thermo-compression bonded to a substrate or other electronic components with an adhesive material therebetween, and includes a bonding tool having a bonding distal end portion which includes a bonding surface having first suction holes that adsorb the electronic component with an
25 individual piece-like porous sheet sandwiched therebetween, and a tapered side surface

packaged may be bonded to the substrate. Alternatively, the electronic component may be either an active element or a passive element or may be other components.

[0082]

(Second embodiment)

5 In the first embodiment, a semiconductor die is bonded to the substrate 110 with a porous sheet having air permeability sandwiched between the bonding tool and the semiconductor die, but the present embodiment is different from the first embodiment in that air-permeable pores are formed in a sheet having no air permeability to give the sheet air permeability. Hereinafter, differences from the first embodiment will be
10 mainly described.

[0083]

Fig. 11 is a view illustrating a bonding apparatus according to a second embodiment of the present invention. A bonding apparatus 10A of the present embodiment illustrated in Fig. 11 includes a perforating mechanism 70. The perforating
15 mechanism 70 forms air-permeable pores in a sheet 140 for preventing creeping-up that is held by a bonding distal end portion 42. The sheet 140 is a resin sheet having no air permeability, for example, such as polypropylene, polyester, vinyl chloride, or polyimide, but the material can be used without being limited thereto.

[0084]

20 The perforating mechanism 70 is provided in a range in which a bonding head 18 is movable in X and Y directions. The perforating mechanism 70 includes a plurality of needle members 70a for forming air-permeable pores in the sheet 140 corresponding to the first suction holes 50 illustrated in Fig. 3. The needle members 70a moves up and down in a Z direction using a drive mechanism (not illustrated) together with the
25 perforating mechanism 70 and penetrate through the sheet 140 held by a bonding tool 40

that is stopped immediately above the perforating mechanism 70, thereby forming air-permeable pores in the sheet 140.

[0085]

Here, second suction holes 52 formed at the bonding distal end portion 42 are
5 provided to suppress wrinkling or sagging of the sheet 140 held by the bonding tool 40.
Therefore, a semiconductor die 100 can be adsorbed and held by the bonding tool 40
without forming the air-permeable pores at portions corresponding to the second suction
holes 52 and 54 of the sheet 140 using the perforating mechanism 70. Further, as long
as the wrinkling and sagging of the sheet 140 can be suppressed, the air-permeable pores
10 corresponding to the second suction holes 52 may be formed as a matter of course.

[0086]

Also, the perforating mechanism 70 may be configured to be fixed and disposed
to the bonding apparatus 10A without having a drive mechanism. In this configuration,
the bonding tool 40 moves up and down with respect to the perforating mechanism 70 to
15 form the air-permeable pores in the sheet 140.

[0087]

Further, each of the air-permeable pores need not be formed in the sheet 140
corresponding to one first suction hole 50, and one or a plurality of air-permeable pores
may be formed corresponding to the first suction hole 50. In this configuration, a hole
20 having a diameter larger than a diameter of the needle member 70a may be formed in the
bonding distal end portion 42, and air-permeable pores corresponding to the hole may be
formed in the sheet 140. Also, a groove communicating with the bonding distal end
portion 42 may be formed and the needle member 70a may be formed into a hollow
shape corresponding to the groove, and thereby an open hole having a shape
25 corresponding to the groove and the hollow shape may be formed in the sheet 140.