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(54) **ELECTRONIC COMPONENT MOUNTING DEVICE**

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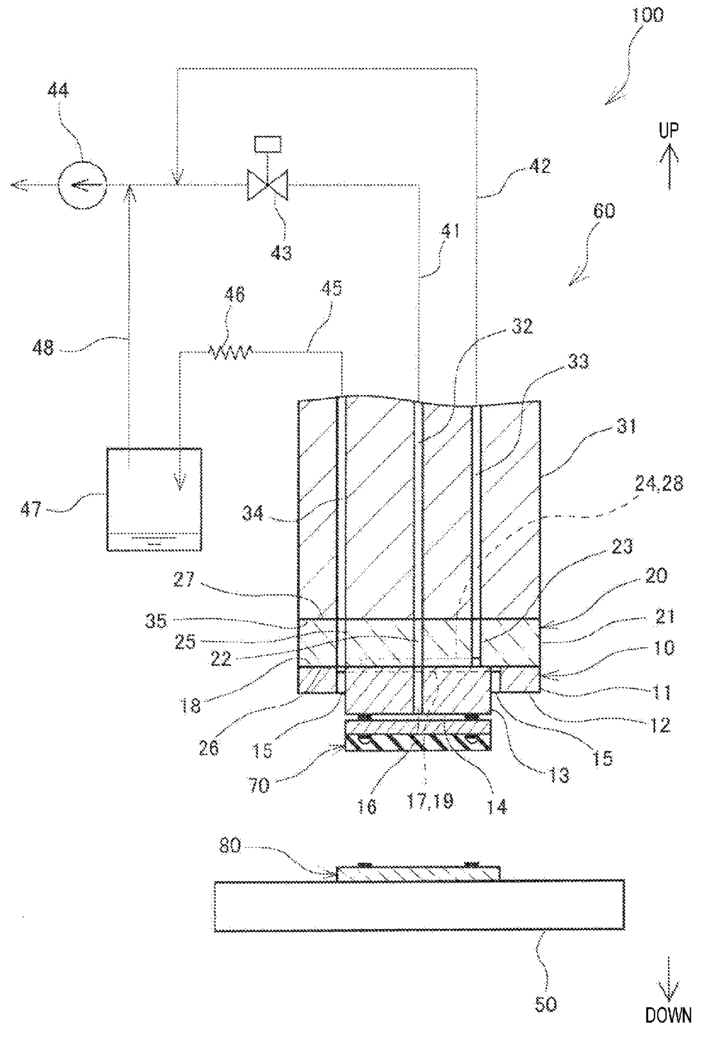
(57) **ABSTRACT**

A flip-chip bonding apparatus (**100**) is provided with: a bonding tool (**10**) that includes a base (**11**), and an island (**13**) that vacuum-sucks, to a surface (**14**) thereof, a semiconductor die (**70**) having protruding electrodes (**72**, **73**) that are disposed on both the surfaces; and a heater (**20**) that heats the semiconductor die (**70**) vacuum-sucked to the island (**13**). The flip-chip bonding apparatus heats the semiconductor die (**70**), bonds the protruding electrodes (**73**) of the semiconductor die (**70**) to protruding electrodes (**82**) of a semiconductor die (**80**), and seals, using a non-conductive film (NCF) (**75**), a gap between the semiconductor die (**70**) and the semiconductor die (**80**). Continuous vacuum suction holes (**15**) are provided in the base (**11**), said continuously vacuum suction holes being at positions adjacent to the outer peripheral surface of the island (**13**).



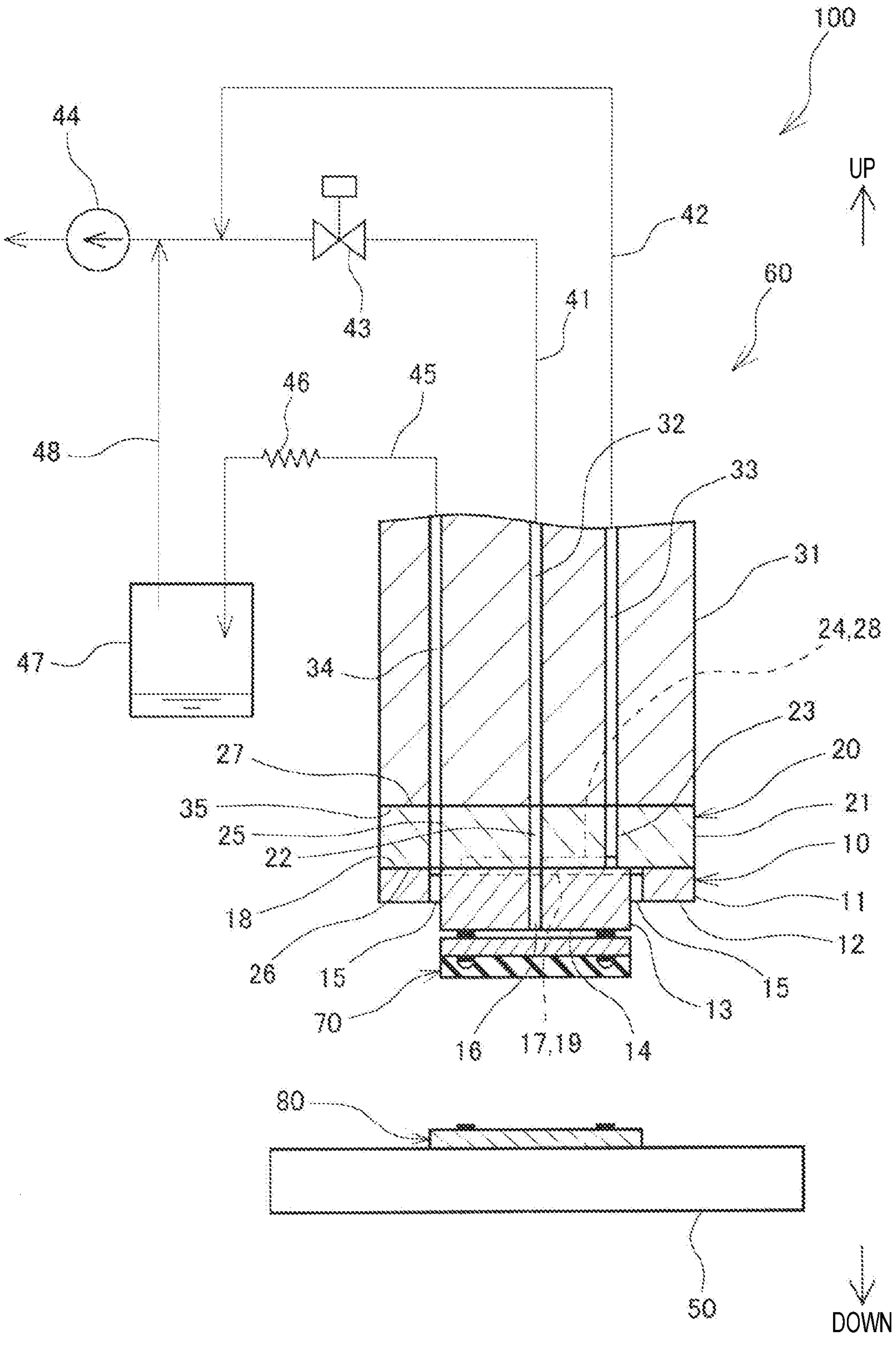

100
44
UP
42
43
60
41
46
45
48
32
33
31
24,28
34
47
23
27
20
35
21
25
10
22
18
11
12
26
15
15
13
70
16
17,19
14
80
50
DOWN

FIG. 1

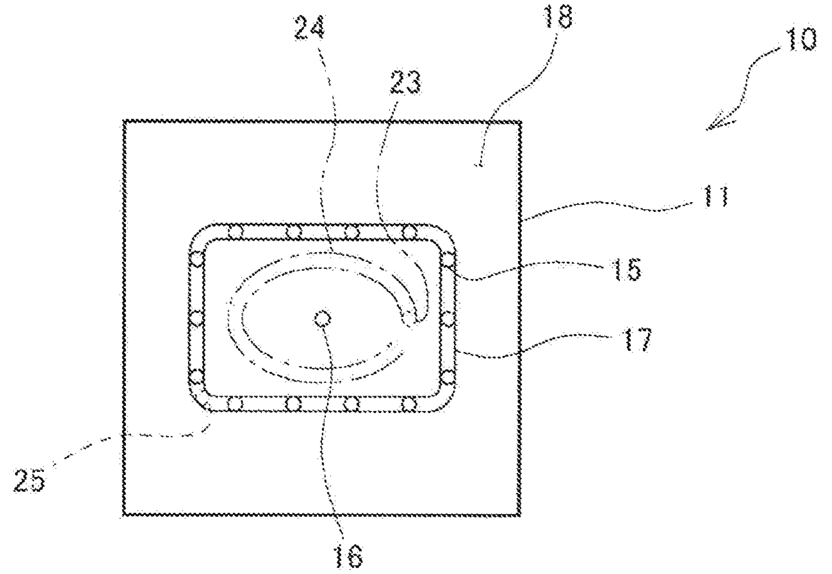


FIG. 2A

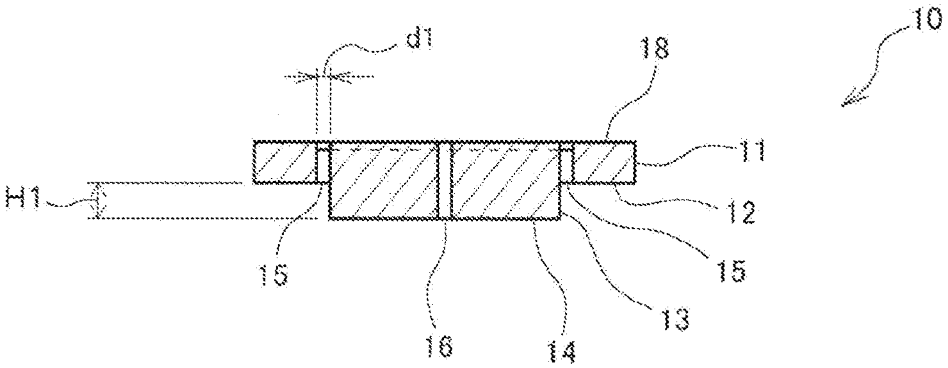


FIG. 2B

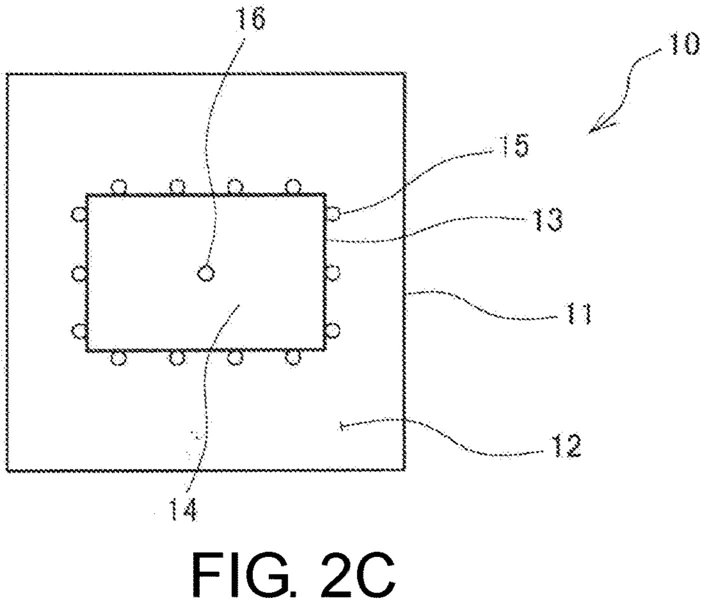


FIG. 2C

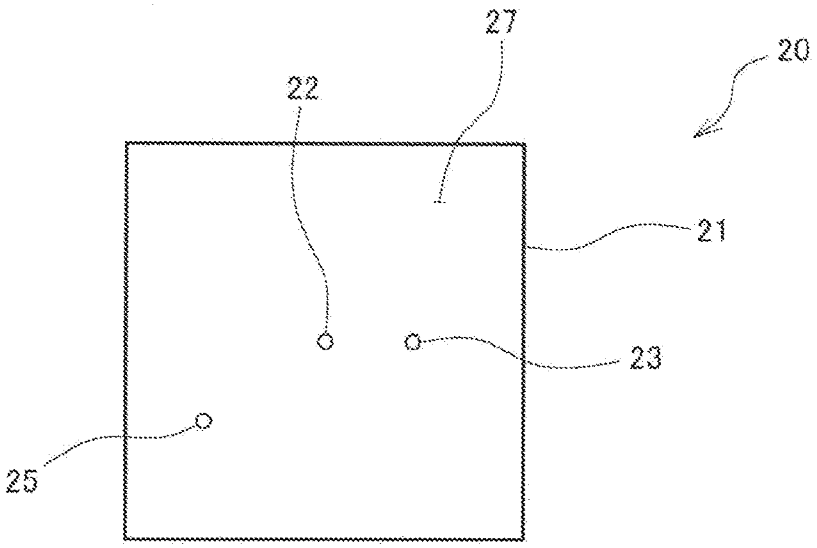


FIG. 3A

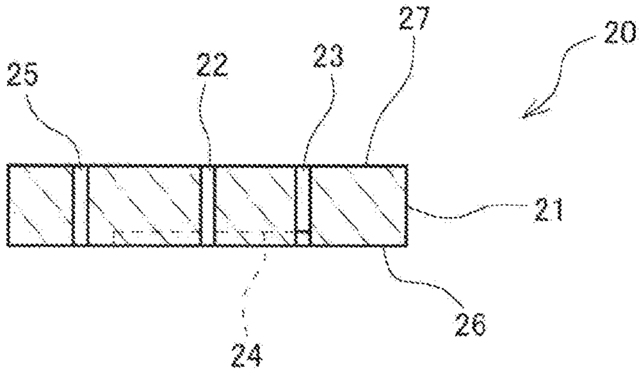


FIG. 3B

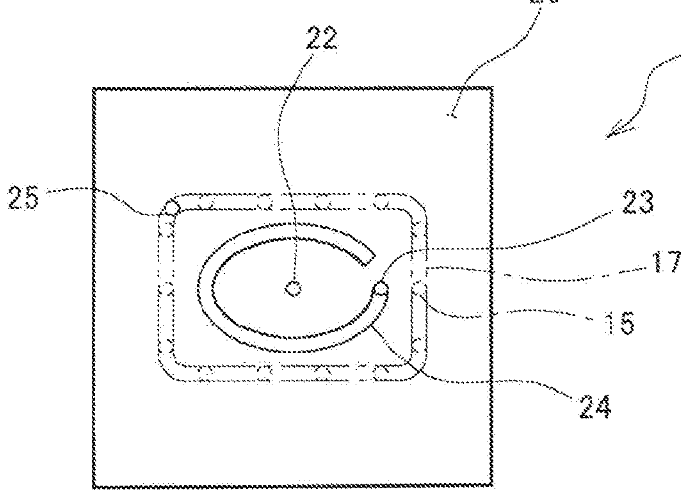


FIG. 3C

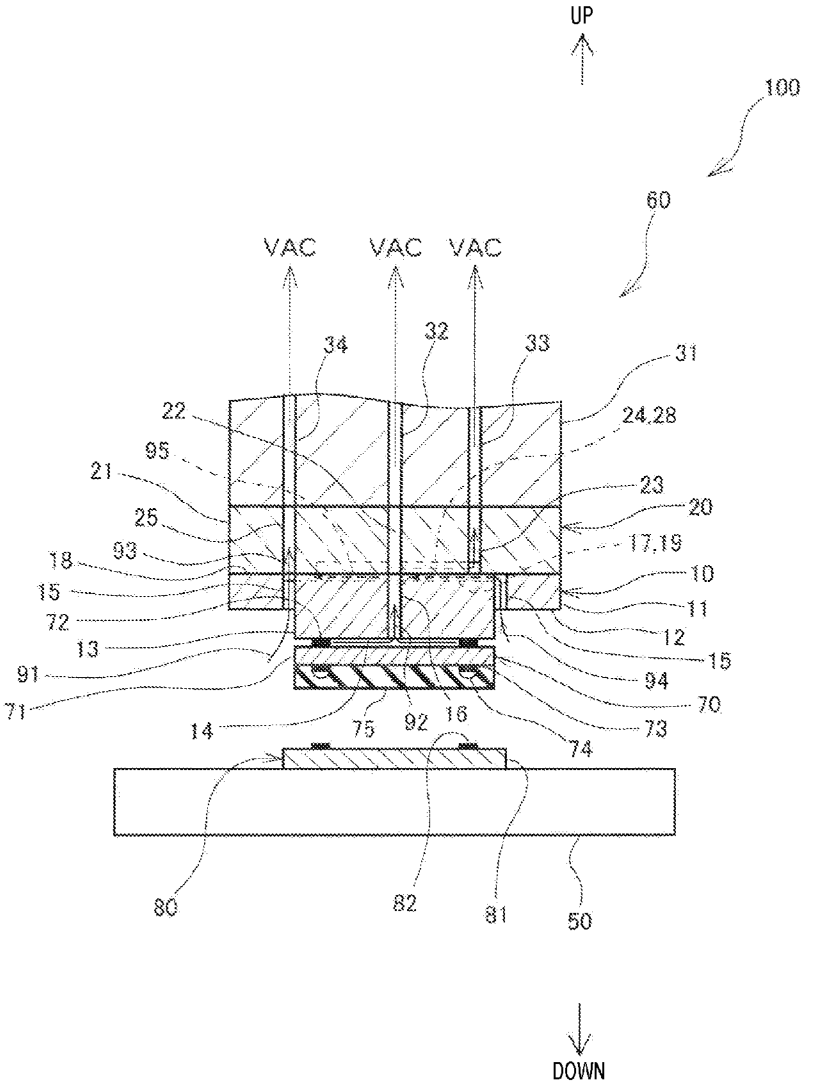
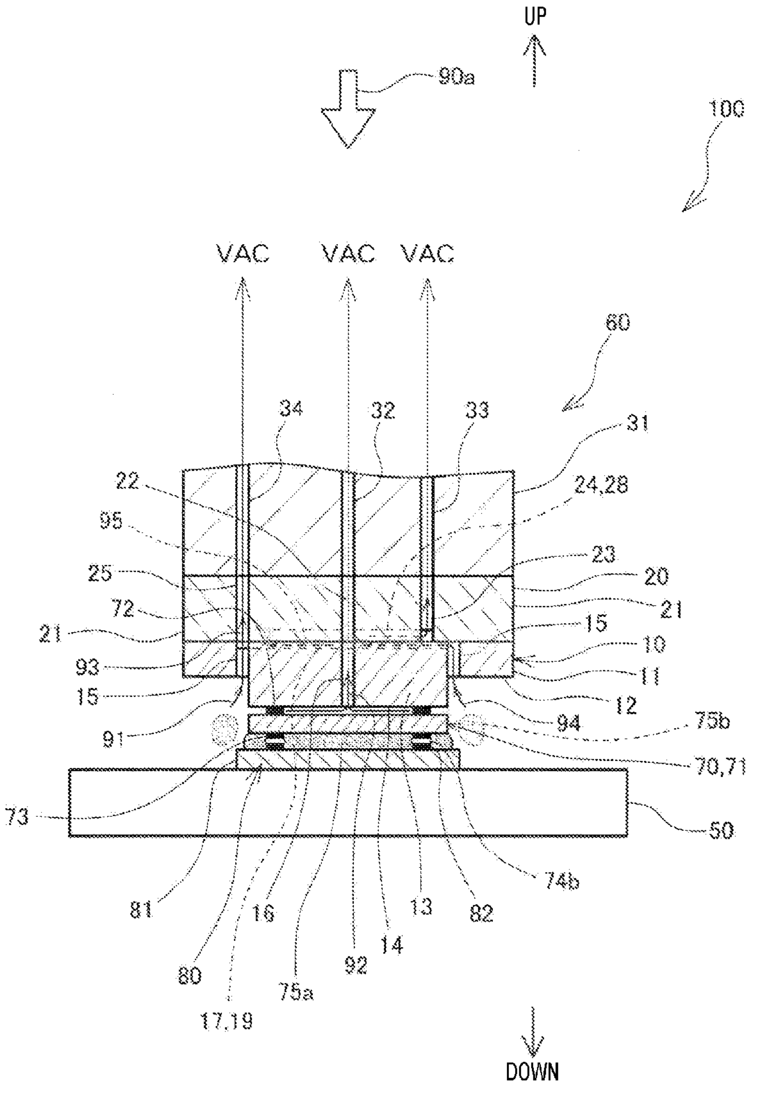

UP
100
60
VAC
VAC
VAC
34
32
33
31
22
24,28
95
21
23
20
25
17,19
93
18
10
15
11
72
12
13
15
91
94
71
70
14
75
92
16
73
74
80
82
81
50
DOWN

FIG. 4


UP
90a
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VAC
VAC
VAC
60
34
32
33
31
22
24,28
95
23
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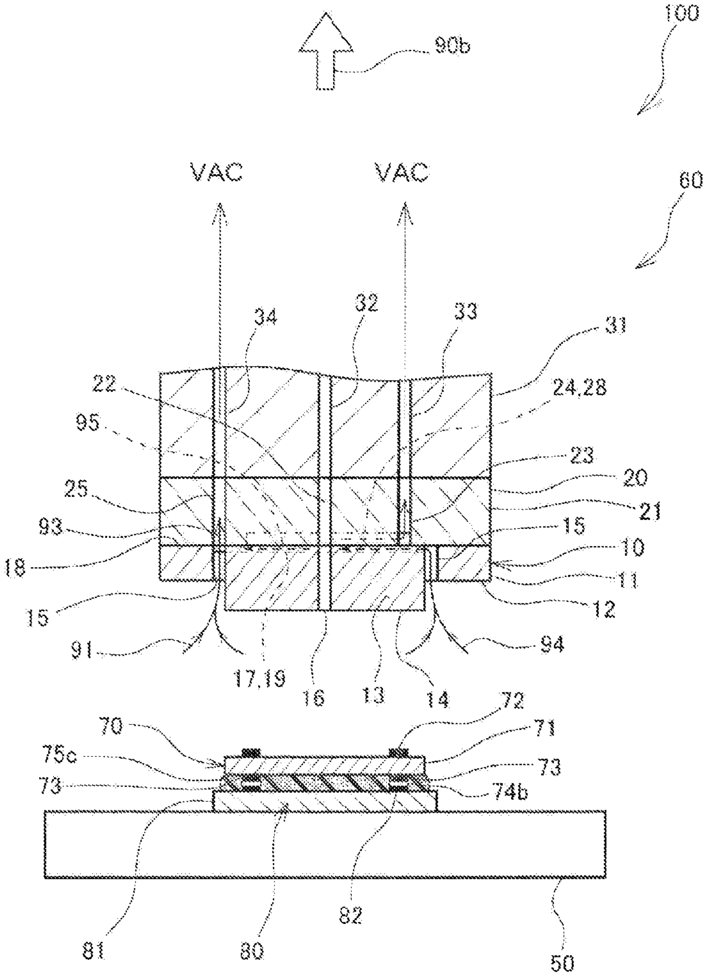
20
72
21
21
15
10
93
11
15
12
94
91
75b
70,71
73
50
81
16
13
82
74b
14
92
80
75a
17,19
DOWN

FIG. 5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90b
VAC
VAC
60
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33
31
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24,28
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23
20
25
21
93
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18
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11
15
12
91
94
17,19
16
13
14
70
72
71
75c
73
73
74b
81
80
82
50

FIG. 6

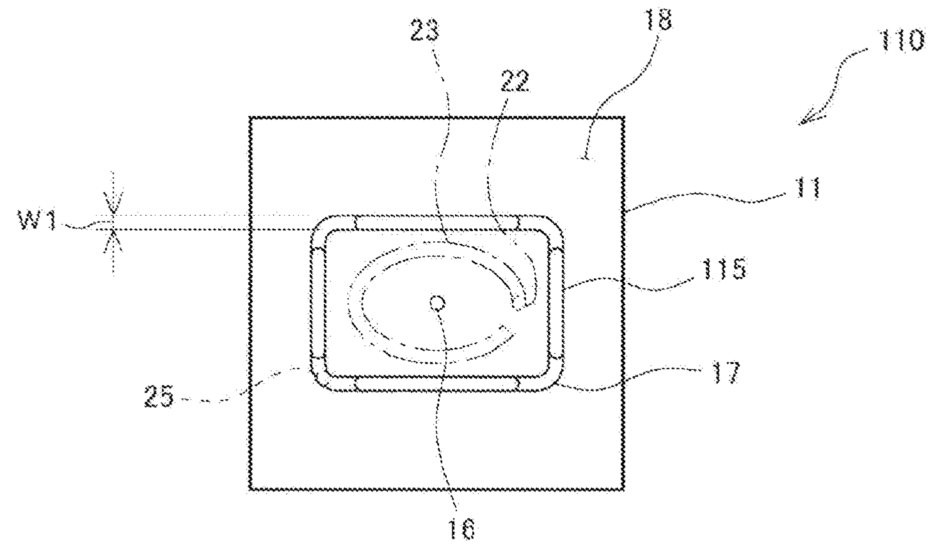

FIG. 7A

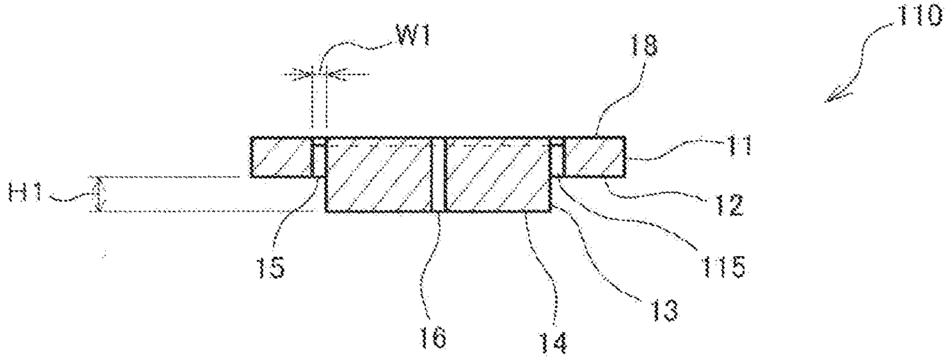

FIG. 7B

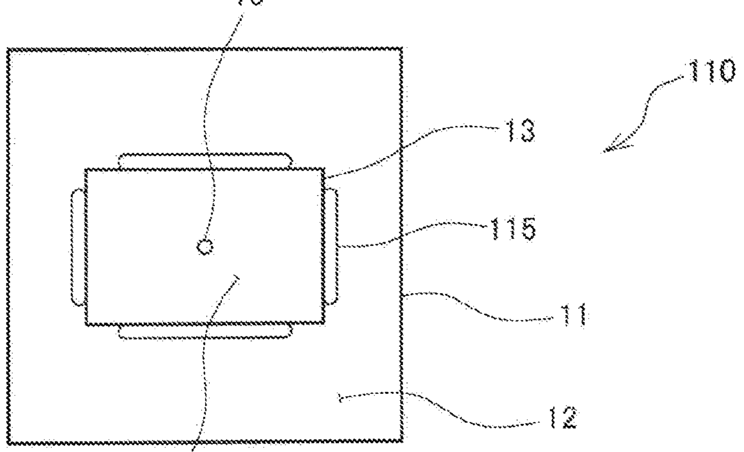

FIG. 7C

# ELECTRONIC COMPONENT MOUNTING DEVICE

## TECHNICAL FIELD

**[0001]** The present invention relates to a structure of an electronic component mounting apparatus that heats a semiconductor die and mounts the semiconductor die on a substrate or another semiconductor die.

## BACKGROUND ART

**[0002]** Methods of heating a semiconductor die which has been sucked to an attachment with a vacuum using a heating tool and mounting the semiconductor die on a substrate by pressing the semiconductor die onto the substrate on which a thermosetting resin has been applied have been often used. When a thermosetting resin is heated, volatile components thereof are gasified, and the gasified volatile components condense into a liquid or solidify into a solid by cooling. Accordingly, the volatile components of the thermosetting resin which have been gasified by heating may be sucked into a vacuum flow passage from a slight gap between the heating tool and the attachment or a slight gap between the attachment and the semiconductor die and condense or solidify in a switching valve to cause an operation failure in vacuum suctioning or solidify in a gap between the heating tool and the attachment to cause a heating failure in the semiconductor die. Accordingly, a method of covering the surroundings of the heating tool and the attachment with a cover and blowing air from the cover to prevent gasified volatile components from being sucking into a slight gap between the heating tool and the attachment or a vacuum suction hole has been proposed (for example, see Patent Literature 1).

**[0003]** In thermocompression of a semiconductor die of placing a conductive adhesive on a glass substrate, pressing a semiconductor die which has been sucked to a thermocompression head thereon, and melting the conductive adhesive to mount the semiconductor die on the glass substrate, foreign matter such as contaminants may be attached to the thermocompression head with vapor which is generated when the conductive adhesive is heated and melted. For the purpose of prevention thereof, a method of causing a nozzle sucking vapor to protrude downward from the thermocompression head and sucking the vapor which is generated when the conductive adhesive is heated and melted has been proposed (for example, see Patent Literature 2).

**[0004]** In order to prevent a thermally decomposed flux (solder paste) from damaging the surface of a semiconductor die or the surface of a package in mounting the semiconductor die on a substrate by soldering, a method of disposing a suction pipe on a side surface of a collet for sucking the semiconductor die and sucking the thermally decomposed flux from the suction pipe has been proposed (for example, see Patent Literature 3).

## CITATION LIST

### Patent Literature

**[0005]** [Patent Literature 1]

**[0006]** Japanese Patent Application Laid-Open No. 2012-165313

**[0007]** [Patent Literature 2]

**[0008]** Japanese Patent Application Laid-Open No. H07-161742

**[0009]** [Patent Literature 3]

**[0010]** Japanese Patent Application Laid-Open No. S55-121655

## SUMMARY OF INVENTION

### Technical Problem

**[0011]** Recently, stacked mounting of stacking and bonding semiconductor dies having protruding electrodes disposed on both surfaces thereof in a plurality of stages has been often performed. In such stacked mounting, solder bumps are formed on the protruding electrodes of a semiconductor die which is bonded, a nonconductive film (NCF) is attached to the surfaces thereof, the semiconductor die is inverted, and the opposite surface thereof is sucked to a bonding tool. Thereafter, when the bumps of the semiconductor chip are pressed against electrodes of another semiconductor die using the bonding tool and the temperature of the bonding tool is increased to a melting temperature of solder (about 250° C.), the nonconductive film (NCF) decreases in viscosity to fill a gap between the semiconductor chips. Thereafter, the solder is melted and resin curing progresses. Then, when the bonding tool is raised, the temperature of the solder is decreased, the solder is solidified, and the stacked mounting of semiconductor chips is finished.

**[0012]** In the semiconductor die which is subjected to stacked mounting, since protruding electrodes are also formed on a surface thereof which is sucked to the bonding tool, a gap corresponding to the height of the protruding electrodes is formed between the surface of the bonding tool and the semiconductor die when the semiconductor die is sucked to the tip of the bonding tool with the vacuum. When the nonconductive film (NCF) is heated to 200° C. or higher, low-molecular-weight components such as acryl monomers are gasified. Accordingly, when the temperature of the bonding tool is raised to a melting temperature of solder (about 250° C.), the gasified components of the nonconductive film (NCF) are sucked into a vacuum suction hole in the bonding tool from the gap.

**[0013]** In such stacked mounting, when a semiconductor die is picked up, it is necessary to decrease the temperature of the bonding tool to, for example, about 100° C. such that the nonconductive film (NCF) does not decrease in viscosity. The pressure of the vacuum suction hole is in a vacuum state when a semiconductor die is being sucked, and vacuum suction needs to be stopped to detach the semiconductor die from the bonding tool after the semiconductor die has been bonded. Accordingly, a process of sucking the gasified components of the nonconductive film (NCF) in a gas state into a vacuum suction hole formed in the bonding tool when the bonding tool is heated to about 250° C. at the time of bonding the electrodes in a state in which a semiconductor die is sucked, allowing the sucked gasified components to stay in the vacuum suction hole when vacuum suctioning is stopped, and condensing the gasified components staying therein into a liquid when the bonding tool is cooled to about 100° C. is repeated. Accordingly, there is a problem in that the gasified components condense into a liquid, the liquid accumulates in a slight gap in the bonding tool, and the liquid may eventually leak to the surroundings of the bonding tool to damage the bonding tool or the like.

**[0014]** Therefore, an objective of the present invention is to prevent a bonding tool from being damaged in an electronic component mounting apparatus that bonds a semiconductor die having protruding electrodes disposed on both surfaces thereof to a substrate or another semiconductor die and seals a gap between the semiconductor die and the substrate or another semiconductor die using a resin.

## Solution to Problem

**[0015]** According to the present invention, there is provided an electronic component mounting apparatus including: a bonding tool including a base and an island that protrudes from the base and sucks a semiconductor die having protruding electrodes disposed on both surfaces of the semiconductor die onto a surface of the island with a vacuum; and a heater that is disposed on a base side of the bonding tool and heats the semiconductor die which is sucked to the island with a vacuum, wherein the electronic component mounting apparatus heats the semiconductor die, bonds the protruding electrodes on a surface of the semiconductor die opposite to the island to a substrate or other electrodes of another semiconductor die, and seals a gap between the surface of the semiconductor die opposite to the island and a surface of the substrate or the other semiconductor die using a resin, and wherein a plurality of continuous vacuum suction holes are provided at positions adjacent to an outer peripheral surface of the island of the base.

**[0016]** In the electronic component mounting apparatus according to the present invention, a plurality of types of bonding tools having different total areas of the continuous vacuum suction holes may be able to be attached to the electronic component mounting apparatus in accordance with a height of the protruding electrodes on a surface of the semiconductor die on the island side.

**[0017]** In the electronic component mounting apparatus according to the present invention, when the height of the protruding electrodes of the surface of the semiconductor die on the island side is large, a bonding tool having the larger total area of the continuous vacuum suction holes may be able to be attached to the electronic component mounting apparatus than when the height of the protruding electrodes of the surface of the semiconductor die on the island side is small.

**[0018]** In the electronic component mounting apparatus according to the present invention, a diameter of each continuous vacuum suction hole may be substantially equal to a height of the island.

**[0019]** In the electronic component mounting apparatus according to the present invention, each continuous vacuum suction hole may be rectangular, oval, or elliptical, and a width of a short side thereof is substantially equal to a height of the island.

**[0020]** In the electronic component mounting apparatus according to the present invention, other continuous vacuum suction holes communicating with the continuous vacuum suction holes provided in the base may be provided in the heater, a cooling pipe that cools gas sucked from the continuous vacuum suction holes to condense or solidify the gas may be connected to the other continuous vacuum suction holes, and a recovery container that stores a liquid or a solid condensing or solidifying in the cooling pipe may be connected to the cooling pipe.

## Advantageous Effects of Invention

**[0021]** According to the present invention, it is possible to prevent a bonding tool from being damaged in an electronic component mounting apparatus that bonds a semiconductor die having protruding electrodes disposed on both surfaces thereof to a substrate or another semiconductor die and seals a gap between the semiconductor die and the substrate or another semiconductor die using a resin.

## BRIEF DESCRIPTION OF DRAWINGS

**[0022]** FIG. **1** is a system diagram illustrating a configuration of a flip-chip bonding apparatus according to an embodiment of the present invention.

**[0023]** FIG. **2**A is a top view of a bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0024]** FIG. **2**B is a sectional view of the bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0025]** FIG. **2**C is a bottom view of the bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0026]** FIG. **3**A is a top view of a heater which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0027]** FIG. **3**B is a sectional view of the heater which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0028]** FIG. **3**C is a bottom view of the heater which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0029]** FIG. **4** is a diagram illustrating a state in which a semiconductor die of a second stage is sucked to the bonding tool in a process of stacking and mounting a semiconductor die having electrodes disposed on both surfaces thereof using the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0030]** FIG. **5** is a diagram illustrating a state in which the bonding tool is moved down to press electrodes of the semiconductor die of the second stage onto electrodes of a semiconductor die of a first stage and the semiconductor die of the second stage is being heated using the heater after the process illustrated in FIG. **4**.

**[0031]** FIG. **6** is a diagram illustrating a state in which the bonding tool is moved up after the process illustrated in FIG. **5**.

**[0032]** FIG. **7**A is a top view of another bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0033]** FIG. **7**B is a sectional view of another bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

**[0034]** FIG. **7**C is a bottom view of another bonding tool which is used for the flip-chip bonding apparatus according to the embodiment of the present invention.

## Description of Embodiments

**[0035]** Hereinafter, a flip-chip bonding apparatus **100** which is an embodiment of an electronic component mounting apparatus according to the present invention will be described with reference to the accompanying drawings. As illustrated in FIG. **1**, the flip-chip bonding apparatus **100** according to this embodiment includes a bonding stage **50**

that sucks and fixes a semiconductor die **80** or a substrate to a top surface thereof and a bonding head **60** that is driven in an approaching and separating direction (a vertical direction in FIG. **1**) or in a horizontal direction relative to the bonding stage **50** using a drive device which is not illustrated. The bonding head **60** includes a body **31** that is connected to the drive device which is not illustrated, a heater **20** that is attached to a bottom surface **35** of the body **31**, and a bonding tool **10** that is sucked and fixed to a bottom surface **26** of the heater **20** with a vacuum. A semiconductor die **70** is sucked to a surface **14** of the bonding tool **10** with a vacuum.

**[0036]** As illustrated in FIG. **2**B, the bonding tool **10** includes a base **11** having a rectangular plate shape and an island **13** that protrudes from a bottom surface **12** of the base **11** in a rectangular pedestal shape and sucks the semiconductor die **70** illustrated in FIG. **1** to the surface **14** with a vacuum. A vacuum hole **16** for sucking the semiconductor die **70** with a vacuum is provided at the center of the bonding tool **10** to penetrate the base **11** and the island **13**. As illustrated in FIG. **2**C, a plurality of continuous vacuum suction holes **15** are provided at positions on the base **11** adjacent to an outer peripheral surface of the island **13**. In this embodiment, a diameter d1 of each continuous vacuum suction hole **15** is set to be equal to a protruding height H1 of the island **13** from the bottom surface **12** of the base **11**. As illustrated in FIG. **2**A, the continuous vacuum suction holes **15** communicate with an annular groove **17** which is provided on the top surface **18** of the base **11** in contact with the bottom surface **26** of the heater **20**. The number of continuous vacuum suction holes **15** is set such that a ratio of a total area of a plurality of continuous vacuum suction holes **15** provided on a short side of the island **13** to a total area of a plurality of continuous vacuum suction holes **15** provided on a long side of the island **13** is substantially the same as a length ratio of the short side to the long side of the island **13**. Accordingly, air can be sucked from the surroundings of the island **13** with a good balance.

**[0037]** The heater **20** has, for example, a rectangular plate shape in which a heating resistor element formed of platinum, tungsten, or the like is embedded in a ceramic such as aluminum nitride and has a size substantially equal to that of the bonding tool **10**. As illustrated in FIG. **3**A to FIG. **3**C, a vacuum hole **22** that communicates with the vacuum hole **16** of the bonding tool **10** is provided at the center thereof. As illustrated in FIG. **3**C, a C-shaped groove **24** is provided in a region corresponding to the inside of the annular groove **17** of the top surface **18** of the bonding tool **10**, and a vacuum hole **23** penetrating the heater **20** in a thickness direction thereof is provided at one end of the groove **24**. As illustrated in FIG. **3**C, a vacuum hole **25** is provided at a position corresponding to a corner of the annular groove **17** of the top surface **18** of the bonding tool **10**. The vacuum holes **22**, **23**, and **25** are formed to the top surface **27** as illustrated in FIG. **3**A.

**[0038]** As illustrated in FIG. **1**, vacuum holes **32**, **33**, and **34** are provided at positions on the body **31** corresponding to the vacuum holes **22**, **23**, and **25** of the heater **20**, and the vacuum holes **22**, **23**, and **25** of the heater **20** communicate with the vacuum holes **32**, **33**, and **34**, respectively.

**[0039]** As illustrated in FIG. **1**, when the top surface **18** of the bonding tool **10** is aligned with the bottom surface **26** of the heater **20**, the C-shaped groove **24** provided on the bottom surface **26** of the heater **20** illustrated in FIG. **3**C is closed by a plane on an inner peripheral side of the groove **17** provided on the top surface **18** of the bonding tool **10** to form a channel **28** communicating with the vacuum hole **23** as illustrated in FIG. **1** and FIG. **2**A. The groove **17** provided on the top surface **18** of the bonding tool **10** illustrated in FIG. **2**A is closed by a plane on an outer peripheral side of the C-shaped groove **24** of the bottom surface **26** of the heater **20** to form a channel **19** that communicates with the vacuum hole **25** of the heater **20** and communicates with the plurality of continuous vacuum suction holes **15** of the bonding tool **10** which are open to the base **11** as illustrated in FIG. **1** and FIG. **3**C. The vacuum hole **16** at the center of the bonding tool **10** communicates with the vacuum hole **25** of the heater **20**.

**[0040]** The vacuum hole **33** of the body **31** is connected to a vacuum pump **44** via a pipe **42**. The vacuum hole **32** is connected to the vacuum pump **44** via a pipe **41** in which an electromagnetic valve **43** is disposed in the middle thereof. The vacuum hole **34** is connected to a cooling pipe **46** via a pipe **45**, and the cooling pipe **46** is connected to an air-tight recovery container **47**. The recovery container **47** and the vacuum pump **44** are connected to each other via a pipe **48**.

**[0041]** With the above-mentioned configuration is employed, when the vacuum pump **44** is driven, the channel **28** constituted by the vacuum hole **33** connected to the pipe **42**, the vacuum hole **23** and the groove **24** of the heater **20** communicating with the vacuum hole **33**, and the top surface **18** of the bonding tool **10** is brought into a vacuum state, and the bonding tool **10** is sucked to the bottom surface **26** of the heater **20** with a vacuum. When the electromagnetic valve **43** is opened, the vacuum hole **32** of the body **31** connected to the pipe **41** and the vacuum hole **22** of the heater **20** and the vacuum hole **16** of the bonding tool **10** communicating with the vacuum hole **32** are brought into a vacuum state, and the semiconductor die **70** can be sucked to the surface **14** of the bonding tool **10** with a vacuum. When the vacuum pump **44** is driven, the channel **19** constituted by the recovery container **47** connected to the vacuum pump **44** via the pipe **48**, the cooling pipe **46** connected to the recovery container **47**, the vacuum hole **34** of the body **31** connected to the cooling pipe **46** via the pipe **45**, the vacuum hole **25** of the heater **20** communicating with the vacuum hole **34**, the groove **17** provided on the top surface **18** of the bonding tool **10**, and the bottom surface **26** of the heater **20** is brought into a vacuum state, and air around the island **13** is sucked from the plurality of continuous vacuum suction holes **15**.

**[0042]** A process of mounting a semiconductor die **70** of a second stage in which protruding electrodes **72** are formed on one surface of a die body **71**, protruding electrodes **73** are formed on the other surface, bumps **74** are formed at the tips of the protruding electrodes **73** out of solder or the like, and a nonconductive film (NCF) **75** is attached to the other surface on which the protruding electrodes **73** are provided on a semiconductor die **80** of a first stage in which protruding electrodes **82** are formed on the top surface of a die body **81** using the flip-chip bonding apparatus **100** will be described below with reference to FIG. **4** to FIG. **6**. The protruding electrodes **72** and **73** may be formed of, for example, copper.

**[0043]** First, as illustrated in FIG. **4**, the semiconductor die **80** of the first stage is sucked to the top surface of the bonding stage **50** with a vacuum. The vacuum pump **44** illustrated in FIG. **1** is driven to form a vacuum in the vacuum hole **33** of the body **31**, the vacuum hole **23** of the heater **20**, and the channel **19** of the heater **20** and the top surface **18** of the bonding tool **10** is sucked to the bottom surface **26** of the heater **20** with a vacuum. Then, the bonding head **60** is moved over a semiconductor die **70** which is placed on an inversion and transfer device for the semiconductor die **70** which is not illustrated such that the protruding electrodes **72** face the top side. Then, the electromagnetic valve **43** is opened to form a vacuum in the vacuum hole **32** of the body **31**, the vacuum hole **25** of the heater **20**, and the vacuum hole **16** of the bonding tool **10** and to suck the surface of the semiconductor die **70** of the second stage on the protruding electrodes **72** side to the surface **14** of the island **13** of the bonding tool **10** with a vacuum. Thereafter, by moving the bonding head **60** such that the position of the semiconductor die **70** of the second stage matches the position of the semiconductor die **80** of the first stage sucked onto the bonding stage **50** with a vacuum, the state illustrated in FIG. **4** is obtained. In this state, the temperature of the bonding tool **10** is about 100° C. and the bumps **74** are not melted yet. The nonconductive film (NCF) **75** has not reached a low viscosity state yet.

**[0044]** As illustrated in FIG. **4**, a gap corresponding to the height of the protruding electrodes **72** is formed between the surface **14** of the bonding tool **10** and the die body **71** of the semiconductor die **70**, and air around the semiconductor die **70** is likely to enter the vacuum hole **16** via the gap as indicated by an arrow **92** in FIG. **4** even in a state in which the semiconductor die **70** is sucked to the surface **14** of the bonding tool **10** with a vacuum. In contrast, air around the island **13** or around the semiconductor die **70** is sucked into the channel **19** from the plurality of continuous vacuum suction holes **15** disposed around the island **13** as indicated by arrows **91** and **94** in FIG. **4**. In this way, since air around the island **13** and the semiconductor die **70** is sucked from the plurality of continuous vacuum suction holes **15**, little air around the side surfaces of the semiconductor die **70** is sucked into the vacuum hole **16** which is disposed at the center of the bonding tool **10**.

**[0045]** Then, as illustrated in FIG. **5**, the bonding head **60** is moved down by a drive device which is not illustrated as indicated by an outlined arrow **90***a* in FIG. **5**, the bumps **74** of the semiconductor die **70** of the second stage sucked to the surface **14** of the bonding tool **10** with a vacuum are pressed onto the protruding electrodes **82** of the semiconductor die **80** of the first stage sucked to the bonding stage **50** with a vacuum, and the semiconductor die **70** of the second stage is heated to about 250° C. using the heater **20** to melt the bumps **74**. Then, the nonconductive film (NCF) **75** attached to the protruding electrodes **73** side of the semiconductor die **70** of the second stage decreases in viscosity and fills a gap between the die body **81** of the semiconductor die **80** of the first stage and the die body **71** of the semiconductor die **70** of the second stage. Thereafter, the protruding electrodes **82** of the semiconductor die **80** of the first stage and the protruding electrodes **73** of the semiconductor die **70** of the second stage are metallically bonded by the melted bumps **74**, and the resin filled into the gap from the die body **71** of the semiconductor die **70** is thermally cured to be a thermosetting resin **75***a*.

**[0046]** At this time, as illustrated in FIG. **5**, gasified components of the nonconductive film (NCF) **75** stays as a gas **75***b* around the semiconductor die **70**. The accumulated gas **75***b* flows into the channel **19** from the plurality of continuous vacuum suction holes **15** disposed around the island **13** as indicated by arrows **91** and **94**, passes through the channel **19** as indicated by an arrow **95**, and flows into the cooling pipe **46** via the vacuum hole **25** of the heater **20**, the vacuum hole **34** of the body **31**, and the pipe **45** as indicated by an arrow **93**. The gas **75***b* is cooled from the temperature of about 250° C. to room temperature in the cooling pipe **46**. Then, the gas **75***b* condenses into a liquid or solidifies into a solid and collects on the bottom of the recovery container **47**. In contrast, an air component which does not condense and does not solidify flows into the recovery container **47** from the cooling pipe **46**, is sucked to the vacuum pump **44** via the pipe **48**, and is discharged to the outside. Since air around the island **13** and the semiconductor die **70** is sucked from the plurality of continuous vacuum suction holes **15** as described above, little air around the side surfaces of the semiconductor die **70** is sucked into the vacuum hole **16** which is disposed at the center of the bonding tool **10**. Accordingly, the gas **75***b* generated around the semiconductor die **70** does not also enter the vacuum hole **16**, the vacuum hole **22** of the heater **20**, and the vacuum hole **32** of the body **31**.

**[0047]** Then, by closing the electromagnetic valve **43** illustrated in FIG. **1** to stop the evacuation of the vacuum hole **16** and then moving the bonding head **60** up as indicated by an outlined arrow **90***b* using a drive device which is not illustrated as illustrated in FIG. **6**, the semiconductor die **80** of the first stage and the semiconductor die **70** of the second stage bonded to the semiconductor die **80** of the first stage remain on the bonding stage **50**. Then, when the temperature decreases, the melted bumps **74** are solidified to be bonding metal **74***b*, and the thermosetting resin **75***a* is cured to be a filling resin **75***c* that fills the gap between the top surface of the die body **81** of the semiconductor die **80** of the first stage and the bottom surface of the die body **71** of the semiconductor die **70** of the second stage.

**[0048]** Even in the state in which the semiconductor die **70** of the second stage is mounted on the semiconductor die **80** of the first stage and the bonding head **60** is moved up as illustrated in FIG. **6**, the plurality of continuous vacuum suction holes **15** continue to suck air around the island **13** of the bonding tool **10**. Accordingly, after mounting of the semiconductor die **70** of the second stage has been completed, the gas **75***b* remaining around the island **13** is continuously sucked and cooled in the cooling pipe **46**, and condensed or solidified components are recovered into the recovery container **47**. Since the plurality of continuous vacuum suction holes **15** continues to suck air, the gas **75***b* does not stay in the vacuum hole **34** of the body **31**, the vacuum hole **25** of the heater **20**, and the channel **19** of the bonding tool **10**. Accordingly, when the temperatures of the bonding tool **10** and the heater **20** are decreased for a next mounting process, the gas **75***b* staying in the vacuum hole **34** of the body **31**, the vacuum hole **25** of the heater **20**, and the channel **19** of the bonding tool **10** condenses into a liquid and the inner and outer surfaces of the bonding tool **10** are not damaged. Since the gas **75***b* little enters the vacuum hole **16** of the bonding tool **10**, the vacuum hole **22** of the heater **20**, and the vacuum hole **32** of the body **31** as described above, it is possible to prevent the gas **75***b* from condensing into a liquid in the vacuum holes **16**, **22**, and **32** and damaging the inner and outer surfaces of the bonding tool **10** when the temperatures of the bonding tool **10** and the heater **20** are lowered for a next mounting process.

**[0049]** Another bonding tool **110** which is used for the flip-chip bonding apparatus **100** according to an embodiment of the present invention will be described below with reference to FIG. **7**A to FIG. **7**C. The same elements as described above with reference to FIG. **1** to FIG. **6** will be referred to by the same reference signs and description thereof will not be repeated.

**[0050]** As described above with reference to FIG. **4**, a gap corresponding to the height of the protruding electrodes **72** is formed between the surface of the die body **71** of the semiconductor die **70** of the second stage and the surface **14** of the bonding tool **10** and air around the semiconductor die **70** is likely to be sucked from the gap, but air around the semiconductor die **70** is prevented from being sucked into the vacuum hole **16** of the bonding tool **10** by sucking the air around the semiconductor die **70** using the continuous vacuum suction holes **15** disposed around the island **13**. In contrast, as the height of the protruding electrodes **72** increases, the size of the gap between the die body **71** of the semiconductor die **70** and the surface **14** of the bonding tool **10** increases and a force for sucking air around the semiconductor die **70** also increases. Therefore, when the height of the protruding electrodes **72** increases, it is necessary to increase an amount of air sucked from the surroundings of the island **13** and to prevent air around the semiconductor die **70** from being sucked into the vacuum hole **16** of the bonding tool **10** by increasing an opening area of the continuous vacuum suction holes **15** with the increase of the height of the protruding electrodes **72**.

**[0051]** Therefore, in the bonding tool **110** illustrated in FIG. **7**A to FIG. **7**C, a plurality of continuous vacuum suction holes **115** having an elliptical shape are disposed in the base **11** around the island **13**, the total area of the continuous vacuum suction holes **115** is set to be larger than the total area of the continuous vacuum suction holes **15** of the bonding tool **10** described above with reference to FIG. **2**A to FIG. **2**C to increase an amount of air which is sucked from the surroundings of the island **13**, and air around the semiconductor die **70** is prevented from being sucked into the vacuum hole **16** of the bonding tool **10** even when the semiconductor die **70** in which a height of the protruding electrodes **72** is great is sucked to the surface **14** with a vacuum. Each continuous vacuum suction hole **115** of the bonding tool **110** in this embodiment has an elliptical shape in which a short side width W1 has the same length as the protruding height H1 of the island **13** from the bottom surface **12** of the base **11**. Similarly to the bonding tool **10** described above with reference to FIG. **2**A to FIG. **2**C, the number of continuous vacuum suction holes **15** is set such that a ratio of the total area of a plurality of continuous vacuum suction holes **15** provided on the short side of the island **13** to the total area of a plurality of continuous vacuum suction holes **15** provided on the long side of the island **13** is substantially the same as a length ratio of the short side to the long side of the island **13**, thereby sucking air from the surroundings of the island **13** with a good balance.

**[0052]** The external dimensions of the bonding tool **110** and the size of the island **13** in this embodiment are the same as the external dimensions of the bonding tool **10** and the size of the island **13** which have described above with reference to FIG. **2**A to FIG. **2**C, and the shape of the groove **17** which is formed on the top surface **18** is also the same. Accordingly, the bonding tool **10** described above with reference to FIG. **2**A to FIG. **2**C can be used when a semiconductor die **70** in which a height of the protruding electrodes **72** is small is mounted using the flip-chip bonding apparatus **100** according to this embodiment, and the bonding tool **110** which has been described above with reference to FIG. **7**A to FIG. **7**C and in which the total area of the continuous vacuum suction holes **15** is larger than that of the bonding tool **10** described above with reference to FIG. **2**A to FIG. **2**C can be used when a semiconductor die **70** in which a height of the protruding electrodes **72** is small is mounted.

**[0053]** The shape of each continuous vacuum suction hole **115** is elliptical in this embodiment, but the shape of each continuous vacuum suction hole **115** is not limited thereto and may be, for example, rectangular or oval. When such shapes are employed, the short side width W1 may be set to be equal to the protruding height H1 of the island **13** from the bottom surface **12** of the base **11**.

**[0054]** As described above, with the flip-chip bonding apparatus **100** according to this embodiment, it is possible to prevent the bonding tool **10** from being damaged when the semiconductor die **70** of the second stage having protruding electrodes **72** and **73** disposed on both surfaces thereof is bonded to the semiconductor die **80** of the first stage and a gap between the semiconductor die **70** of the first stage and the semiconductor die **80** of the second stage is sealed with the nonconductive film (NCF) **75**.

**[0055]** In the above description, the nonconductive film (NCF) **75** is used to seal the gap between the semiconductor die **70** of the first stage and the semiconductor die **80** of the second stage, but the present invention is not limited thereto and can be applied to a case in which another type of sealing resin is employed.

## REFERENCE SIGNS LIST

**[0056]** **10**, **110** Bonding tool
**[0057]** **11** Base
**[0058]** **12**, **26**, **35** Bottom surface
**[0059]** **13** Island
**[0060]** **14** Surface
**[0061]** **15**, **115** Continuous vacuum suction hole
**[0062]** **16**, **22**, **23**, **25**, **32**, **33**, **34** Vacuum hole
**[0063]** **17**, **24** Groove
**[0064]** **18**, **27** Top surface
**[0065]** **19**, **28** Channel
**[0066]** **20** Heater
**[0067]** **31** Body
**[0068]** **41**, **42**, **45**, **48** Pipe
**[0069]** **43** Electromagnetic valve
**[0070]** **44** Vacuum pump
**[0071]** **46** Cooling pipe
**[0072]** **47** Recovery container
**[0073]** **50** Bonding stage
**[0074]** **60** Bonding head
**[0075]** **70**, **80** Semiconductor die
**[0076]** **71**, **81** Die body
**[0077]** **72**, **73**, **82** Protruding electrode
**[0078]** **74** Bump
**[0079]** **74***b* Connection metal
**[0080]** **75** Nonconductive film (NCF)
**[0081]** **75***a* Thermosetting resin
**[0082]** **75***b* Gas
**[0083]** **75***c* Filling resin
**[0084]** **100** Flip-chip bonding apparatus

**1**. An electronic component mounting apparatus, comprising:

a bonding tool including a base and an island that protrudes from the base and sucks a semiconductor die having protruding electrodes disposed on both surfaces of the semiconductor die onto a surface of the island with a vacuum; and

a heater that is disposed on a base side of the bonding tool and heats the semiconductor die that is sucked to the island with a vacuum,

wherein the electronic component mounting apparatus heats the semiconductor die, bonds the protruding electrodes of the surface of the semiconductor die opposite to the island to a substrate or other electrodes of another semiconductor die, and seals a gap between the surface of the semiconductor die opposite to the island and a surface of the substrate or the another semiconductor die using a resin, and

wherein a plurality of continuous vacuum suction holes are provided at positions adjacent to an outer peripheral surface of the island of the base.

**2**. The electronic component mounting apparatus according to claim **1**, wherein a plurality of types of bonding tools having different total areas of the continuous vacuum suction holes are able to be attached to the electronic component mounting apparatus in accordance with a height of the protruding electrodes on the surface of the semiconductor die on the island side.

**3**. The electronic component mounting apparatus according to claim **2**, wherein, when the height of the protruding electrodes of the surface of the semiconductor die on the island side is large, a bonding tool having a larger total area of the continuous vacuum suction holes is able to be attached to the electronic component mounting apparatus than when the height of the protruding electrodes of the surface of the semiconductor die on the island side is small.

**4**. The electronic component mounting apparatus according to claim **1**, wherein a diameter of each continuous vacuum suction hole is substantially equal to a height of the island.

**5**. The electronic component mounting apparatus according to claim **1**, wherein each continuous vacuum suction hole is rectangular, oval, or elliptical, and a width of a short side of each continuous vacuum suction hole is substantially equal to a height of the island.

**6**. The electronic component mounting apparatus according to claim **1**, wherein other continuous vacuum suction holes communicating with the continuous vacuum suction holes provided in the base are provided in the heater, a cooling pipe that cools a gas sucked from the continuous vacuum suction holes to condense or solidify the gas is connected to the other continuous vacuum suction holes, and a recovery container that stores a liquid or a solid condensing or solidifying in the cooling pipe is connected to the cooling pipe.

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