

[DESCRIPTION]

[TITLE OF INVENTION]

FOREIGN MATTER REMOVAL DEVICE

[Technical Field]

5 [0001]

The present invention relates to a foreign matter removal device, and particularly, to a structure of a foreign matter removal device which performs removal of foreign matter with solid carbon dioxide particles.

[Background Art]

10 [0002]

In a process of manufacturing electronic components such as integrated circuits (ICs), many types of apparatus such as a die bonding apparatus for bonding a semiconductor die cut out from a wafer to a substrate, a wire bonding apparatus for connecting electrodes of a semiconductor die bonded to a substrate and electrodes of the substrate with wires, and a flip-chip bonding apparatus which inverts and fixes a semiconductor die, in which bumps have been formed on electrodes of the semiconductor die, to a substrate and connects the electrodes of the semiconductor die and electrodes of the substrate, are used. Further, recently, a bonding apparatus in which a semiconductor die is laminated and bonded on a semiconductor die of a wafer has also been used.

[0003]

In such a bonding apparatus, a semiconductor die is bonded to a predetermined position on a substrate, or electrodes of a semiconductor die and electrodes of a substrate are connected by wires.

25 [0004]

In such apparatuses, when foreign matter such as dust adheres to a surface of a substrate or the like, an adhesive force of the adhesive may deteriorate. Also, when dust or the like adheres to surfaces of electrodes of a substrate or surfaces of electrodes of a semiconductor die, quality of the bonding between the electrodes and the wires may
5 deteriorate in some cases.

[0005]

Therefore, a device which performs removal of foreign matter by blowing air to a substrate to blow off foreign matter that has been attached to a substrate and suctioning and recovering the blown off foreign matter has been proposed (for example, see Patent
10 Literature 1).

[0006]

Also, a technology of removing foreign matter from a semiconductor die or a substrate using liquid carbon dioxide (CO₂) is also utilized (for example, see Patent Literature 2). In this method, liquid carbon dioxide is injected from an injection nozzle
15 onto a substrate and dry ice particles that have frozen and became dry ice due to adiabatic expansion during injection are caused to collide with the substrate, thereby performing removal of foreign matter on a surface of a semiconductor die or a substrate.

[Citation List]

[Patent Literature]

20 [0007]

[Patent Literature 1] Japanese Unexamined Patent Application Publication No.
2012-199458

[Patent Literature 2] Japanese Unexamined Patent Application Publication No.
2000-117201

25 [Summary of Invention]

[Technical Problem]

[0008]

However, in the foreign matter removing method described in Patent Literature 2, when dry ice particles are vigorously injected in order to remove more fine foreign matter, there is a problem in that particle diameters of the dry ice particles increase and the fine foreign matter cannot be effectively removed. Further, when particle diameters of dry ice increase, there is a problem in that a substrate and a semiconductor die may be damaged by collision with the dry ice particles.

[0009]

Therefore, it is an objective of the present invention to remove fine foreign matter while minimizing damage to a substrate or a semiconductor die.

[Solution to Problem]

[0010]

A foreign matter removal device of the present invention includes a nozzle in which a pressurized flow of liquid carbon dioxide is caused to be expanded and cooled during the expansion to form solid carbon dioxide particles in the flow, a chamber connected to the nozzle and into which the solid carbon dioxide particles flow, an ejection port connected to the chamber and configured to eject the solid carbon dioxide particles toward a surface of a flat plate-like member, and a suction port disposed adjacent to the ejection port, in which a particle diameter of individual of the carbon dioxide particles ejected from the ejection port is adjusted by changing a distance between the nozzle and the chamber.

[0011]

In the foreign matter removal device of the present invention, it is also preferable to include a heater attached to an outer surface of the chamber and configured

to adjust a particle diameter of individual of the carbon dioxide particles ejected from the ejection port by changing a heating amount of the heater.

[0012]

In the foreign matter removal device of the present invention, it is also
5 preferable that the ejection port be a slit communicating with the chamber and configured to eject the carbon dioxide particles in a band shape toward the surface of the flat plate-like member.

[0013]

In the foreign matter removal device of the present invention, it is also
10 preferable that the ejection port be a plurality of holes communicating with the chamber and disposed in a straight line.

[0014]

In the foreign matter removal device of the present invention, it is also
preferable that the ejection port inject the carbon dioxide particles to be inclined in a
15 direction of the suction port.

[0015]

In the foreign matter removal device of the present invention, it is also
preferable to further include an air inlet which causes compressed air to flow into the
chamber, in which the chamber mixes the carbon dioxide particles and the compressed
20 air.

[Advantageous Effects of Invention]

[0016]

The present invention can remove fine foreign matter while minimizing damage
to a substrate or a semiconductor die.

25 [Brief Description of Drawings]

[0017]

Fig. 1 is a perspective view illustrating a foreign matter removal device according to an embodiment of the present invention.

Fig. 2 is a cross-sectional view of a cleaning head of the foreign matter removal
5 device illustrated in Fig. 1.

Fig. 3 is an explanatory perspective view illustrating a structure of a main body and a lid of the cleaning head of the foreign matter removal device illustrated in Fig. 1, and an assembly of the lid to the main body.

Fig. 4 is a view of a lower surface of the cleaning head illustrated in Fig. 1 on
10 which a suction port and a slit are disposed when viewed from above, and is an explanatory view illustrating an operation of the foreign matter removal device of the embodiment of the present invention.

Fig. 5 is a graph showing change in particle diameter with respect to a flight distance of dry ice particles.

15 Fig. 6 is a graph showing change in particle diameter of dry ice particles with respect to an atmosphere temperature.

Fig. 7 is a cross-sectional view of a cleaning head of a foreign matter removal device of another embodiment of the present invention.

Fig. 8 is a view of a lower surface of a cleaning head of a foreign matter removal
20 device of another embodiment of the present invention on which a suction port and an injection port are disposed when viewed from above, and is an explanatory view illustrating an operation of the foreign matter removal device of another embodiment of the present invention.

[Description of Embodiments]

25 [0018]

Hereinafter, a foreign matter removal device 100 of the present embodiment will be described with reference to the drawings. As illustrated in Fig. 1, the foreign matter removal device 100 of the present embodiment includes a cleaning head 20 and a drive unit 40 that moves the cleaning head 20 in a conveying direction and a perpendicular direction. In Fig. 1, a conveying direction of a substrate 13 which is a flat plate-like member guided by guide rails 11 and 12 and conveyed in a horizontal direction will be described as an X direction, a direction perpendicular to the X direction on the same plane as the X direction will be described as a Y direction, and a direction perpendicular to an XY plane will be described as a Z direction. Further, a stage 45 which vacuum-adsorbs and heats the substrate 13 is disposed on a side below the substrate 13.

[0019]

As illustrated in Fig. 1, the cleaning head 20 is formed in a rectangular parallelepiped shape in which a lid 22 is attached to a rear surface 21b of a main body 21, and an inlet connection pipe 25 through which solid carbon dioxide particles (hereinafter referred to as dry ice particles) for removing foreign matter are supplied and a suction connection pipe 26 connected to a vacuum device (not illustrated) are attached on an upper portion thereof.

[0020]

As illustrated in Fig. 1, one side surface of the cleaning head 20 is connected to an arm 28 via a connecting member 27. The arm 28 is reciprocated in the Y direction by the drive unit 40. The cleaning head 20 is attached to the arm 28 to be slightly inclined with respect to a surface of the substrate 13. A gap is formed between the surface of the substrate 13 and a lower surface of the cleaning head 20, and the cleaning head 20 moves on an upper side of the substrate 13 in the Y direction along the surface of the substrate 13.

[0021]

Next, a structure of the cleaning head 20 of the foreign matter removal device 100 of the present embodiment will be described with reference to Fig. 2, Fig. 3(a), and Fig. 3(b). As illustrated in Fig. 2, Fig. 3(a), and Fig. 3(b), the cleaning head 20 is constituted by the main body 21 and the lid 22 fixed to the rear surface 21b of the main body 21.

[0022]

As illustrated in Fig. 3(a), a rectangular suction port 24 is hollowed out on a lower surface of the main body 21. Also, on the rear surface 21b of the main body 21, a recess 29a constituting a chamber 29 to be described below is formed. A lower side of the recess 29a is formed as an inclined surface 29b which is inclined toward the suction port 24.

[0023]

As illustrated in Fig. 3(b), the lid 22 includes a flange 22a which is in close contact with a planar portion of the rear surface 21b of the main body 21 other than the recess 29a, and a wedge-shaped inclined portion 22b parallel to the inclined surface 29b of the main body 21. As illustrated in Fig. 3(b), when the flange 22a is screwed to the rear surface 21b by aligning the inclined portion 22b of the lid 22 with the inclined surface 29b of the main body, a chamber 29 extending linearly in the X direction is formed between the recess 29a of the main body 21 and the flange 22a of the lid 22 as illustrated in Fig. 2. Between the inclined surface 29b of the main body 21 and the inclined portion 22b of the lid 22, a slit 23 which is an injection port for injecting a mixed fluid of gaseous carbon dioxide and dry ice particles in a band shape toward the surface of the substrate 13 is formed. As illustrated in Fig. 2, the slit 23 is inclined in a direction of the suction port 24. Also, as illustrated in Fig. 4, a length of the suction

port 24 in the X direction is longer than a length of the slit 23 in the X direction and extends to vicinities of both side surfaces of the cleaning head 20 further than the slit 23. Further, Fig. 4 is a view of the lower surface of the cleaning head 20 on which the suction port 24 and the slit 23 are disposed when viewed from above.

5 [0024]

As illustrated in Fig. 2, a sleeve 30 is connected to the inlet connection pipe 25, and a nozzle 31 is connected to the sleeve 30. The sleeve 30 has threaded portions 30a and 30b respectively provided on an inlet side and an outlet side, the threaded portion 30a on the inlet side engages with a threaded portion 31b on an outlet side of the nozzle, and the threaded portion 30b on the outlet side engages with a threaded portion 25a on an inlet side of the inlet connection pipe 25. The sleeve 30 can change a distance from an outlet of the nozzle 31 to the chamber 29 by adjusting an engagement length of the threaded portion 30a on the inlet side with the threaded portion 31b on the outlet side of the nozzle and an engagement length of the threaded portion 30b on the outlet side with the threaded portion 25a on the inlet side of the inlet connection pipe 25. The nozzle 31 is connected to a liquid carbon dioxide supply device which supplies pressurized liquid carbon dioxide. Further, as illustrated in Fig. 2, a heater 35 is attached to a back surface of the lid 22.

[0025]

20 An operation of the foreign matter removal device 100 configured as described above will be described with reference to Fig. 2 and Figs. 4 to 6. When the substrate 13 is conveyed to above the stage 45 by a conveying device (not illustrated), the stage 45 vacuum-adsorbs and fixes the substrate 13 and turns on the built-in heater to heat the substrate 13 to, for example, about 80°C.

25 [0026]

Next, pressurized liquid carbon dioxide supplied from a liquid carbon dioxide supply device (not illustrated) is caused to flow into the nozzle 31. The liquid carbon dioxide flowed into the nozzle 31 is compressed up to a throttle portion 31c of the nozzle 31, adiabatically expands upon passing through the throttle portion 31c, and a temperature thereof drops. Due to this drop in temperature, the liquid carbon dioxide changes to solid carbon dioxide particles (dry ice particles). Also, some of the liquid carbon dioxide is changed to gaseous carbon dioxide. As indicated by an arrow 91 in Fig. 2, this mixed fluid of gaseous carbon dioxide and dry ice particles passes through the sleeve 30 and the inside of the inlet connection pipe 25 from the nozzle 31, and then flows into the chamber 29 of the cleaning head 20. The mixed fluid of gaseous carbon dioxide and dry ice particles flowed into the chamber 29 is injected obliquely downward through the slit 23 toward the surface of the substrate 13. Since the substrate 13 has been heated to about 80°C by the stage 45, when the dry ice particles collide with fine foreign matter 50 on the surface of the substrate 13, the dry ice particles instantaneously sublime, expand, and become gaseous carbon dioxide. The fine foreign matter 50 that has adhered to the surface of the substrate 13 is removed from the surface of the substrate 13 by a fluid force during the sublimation and expansion. Since the mixed fluid of gaseous carbon dioxide and dry ice particles is injected from the slit 23 to be inclined in a direction of the suction port 24 as indicated by an arrow 95 in Fig. 4, the fine foreign matter 50 removed from the surface of the substrate 13 is suctioned into the suction port 24 provided adjacent to the slit 23 as indicated by an arrow 92 in Fig. 2 and is suctioned into a vacuum device (not illustrated) from the suction connection pipe 26. Here, the fine foreign matter 50 refers to, for example, that having a size of less than 50 μm .

[0027]

Similarly to the dry ice particles, the gaseous carbon dioxide ejected together

with the dry ice particles from the slit 23 is also injected obliquely downward from the slit 23 toward the surface of the substrate 13 to blow off and remove foreign matter 51 larger than the fine foreign matter 50 that has adhered to the surface of the substrate 13. The foreign matter 51 blown off by the gaseous carbon dioxide is also suctioned into the suction port 24 provided adjacent to the slit 23 and is suctioned into a vacuum device (not illustrated) from the suction connection pipe 26.

[0028]

Then, as illustrated in Fig. 4, when the cleaning head 20 is caused to reciprocate in the Y direction while injecting the mixed fluid of gaseous carbon dioxide and dry ice particles from the slit 23 as indicated by the arrow 95 in Fig. 4, the fine foreign matter 50 and the foreign matter 51 in a region B of the substrate 13 illustrated in Fig. 4 through which the cleaning head 20 has passed are removed. Further, a region A on a downstream side of the region B in the conveying direction illustrated in Fig. 4 is a region in which removal of the fine foreign matter 50 and the foreign matter 51 on the surface of the substrate 13 has been completed, and a region C on an upstream side of the region B in the conveying direction is a region in which removal of the fine foreign matter 50 and the foreign matter 51 on the surface of the substrate 13 has not yet been performed.

[0029]

In the foreign matter removal device 100 of the present embodiment, as illustrated in Fig. 4, a length in the Y direction of the suction port 24 is longer than a length in the Y direction of the slit 23 and extends to vicinities of both side surfaces of the cleaning head 20 further than the slit 23. Therefore, even when the fine foreign matter 50 and the foreign matter 51 removed from the surface of the substrate 13 by the mixed fluid of gaseous carbon dioxide and dry ice particles ejected from the slit 23 are

blown off in a direction inclined in the X direction from the Y direction, the blown off fine foreign matter 50 and foreign matter 51 can be suctioned by the suction port 24. Therefore, re-adhesion of the fine foreign matter 50 and the foreign matter 51 to the surface of the substrate 13 in the region A in which removal of foreign matter has been completed can be minimized, and cleanliness of the substrate 13 can be improved.

[0030]

Here, when a particle diameter of the dry ice particles injected to the substrate 13 is too large, the fine foreign matter 50 cannot be effectively removed and the substrate 13 is damaged by collision with the dry ice particles. According to a test, it has been found that when the particle diameter of the dry ice particles is on the submicron order, the fine foreign matter 50 can be removed without causing a damage to the substrate 13 or a semiconductor die attached to the substrate 13.

[0031]

On the other hand, the particle diameter of the dry ice particles ejected from the nozzle 31 decreases as a flight distance L from the outlet of the nozzle 31 increases as illustrated in Fig. 5. Also, as illustrated in Fig. 6, the particle diameter of the dry ice particles ejected from the nozzle 31 decreases as an atmosphere temperature T during flight increases. Therefore, in the foreign matter removal device 100 of the present embodiment, the particle diameter of the dry ice particles ejected from the slit 23 can be adjusted by changing the flight distance L from the outlet of the nozzle 31 to the chamber 29 by adjusting the engagement length of the threaded portion 30a on the inlet side of the sleeve 30 with the threaded portion 31b on the outlet side of the nozzle and the engagement length of the threaded portion 30b on the outlet side with the threaded portion 25a on the inlet side of the inlet connection pipe 25. Further, in the foreign matter removal device 100 of the present embodiment, the particle diameter of the dry

ice particles ejected from the slit 23 can be adjusted by changing a temperature of the chamber 29 using the heater 35 attached to the back surface of the lid 22 constituting the chamber 29.

[0032]

5 The engagement length of the threaded portions 30a and 30b of the sleeve 30 and an amount of heat for heating the heater 35 may be adjusted so that the particle diameter of the dry ice particles ejected from the slit 23 is on the submicron order by a test or the like. Further, the particle diameter of the dry ice particles may be adjusted by using either one of the engagement length of the threaded portions 30a and 30b of the
10 sleeve 30 or the heating by the heater 35.

[0033]

As described above, in the foreign matter removal device 100 according to the present embodiment, since the particle diameter of the dry ice particles can be adjusted to the submicron order by the flight distance L from the outlet of the nozzle 31 to the
15 chamber 29 or heating of the chamber 29, the fine foreign matter 50 of less than 50 μm that has adhered to a surface of the substrate 13 or a semiconductor die can be effectively removed without damaging the substrate 13 or the semiconductor die.

[0034]

Next, a foreign matter removal device 200 according to another embodiment of
20 the present invention will be described with reference to Fig. 7. Portions the same as those in the foreign matter removal device 100 described above with reference to Figs. 1 to 6 are denoted by the same reference signs, and the description thereof will be omitted.

[0035]

As illustrated in Fig. 7, the foreign matter removal device 200 of the present
25 embodiment has an air inlet 25c on a side surface of the sleeve 30. The foreign matter

removal device 200 causes compressed air to flow into a chamber 29 together with gaseous carbon dioxide and dry ice particles, mixes the gaseous carbon dioxide, the dry ice particles, and the compressed air in the chamber 29, and performs removal of fine foreign matter 50 and foreign matter 51 of a substrate 13 by ejecting the mixed fluid of compressed air, gaseous carbon dioxide, and dry ice particles from a slit 23. Since the foreign matter removal device 200 of the present embodiment can increase a flow rate of the fluid ejected from the slit 23 more than that in the foreign matter removal device 100 described above, even in a case of a large amount of adhesion of the foreign matter 51 larger than the fine foreign matter 50, it is possible to effectively perform removal of the fine foreign matter 50 and the foreign matter 51. Also, the particle diameter of the dry ice particles ejected from the slit 23 can be adjusted by adjusting a temperature of the air caused to be flowed in from the air inlet 25c.

[0036]

In the embodiment illustrated in Fig. 7, although it has been described that the air inlet 25c is provided to cause compressed air to flow into the sleeve 30, the air inlet 25c may be disposed at any position as long as the position allows compressed air to flow into the chamber 29 so that the gaseous carbon dioxide, the dry ice particles, and the compressed air are mixed, and may be disposed, for example, at a lid 22.

[0037]

Next, a foreign matter removal device 200 according to another embodiment of the present invention will be described with reference to Fig. 8. Portions the same as those in the foreign matter removal device 100 described above with reference to Figs. 1 to 6 are denoted by the same reference signs, and the description thereof will be omitted.

[0038]

As illustrated in Fig. 8, in a foreign matter removal device 300 of the present

embodiment, holes 61 communicating with a chamber 29 and disposed in a straight line are formed as an ejection port in place of the slit 23 of the foreign matter removal device 100 described with reference to Figs. 1 to 6. As illustrated in Fig. 8, when a cleaning head 20 is caused to reciprocate in a Y direction while injecting a mixed fluid of gaseous carbon dioxide and dry ice particles from the holes 61 as indicated by an arrow 96 in Fig. 8, fine foreign matter 50 and foreign matter 51 in a region B of a substrate 13 illustrated in Fig. 8 through which the cleaning head 20 has passed are removed. The foreign matter removal device 300 of the present embodiment achieves the same effects as in the foreign matter removal device 100 described with reference to Figs. 1 to 6.

10 [0039]

Although the foreign matter removal devices 100 and 200 have been described as having the cleaning head 20 attached to the arm 28 to be inclined from a vertical direction to the lid 22 side, when the slit 23 is configured to be inclined with respect to the main body 21 as illustrated in Fig. 2, the cleaning head 20 may be attached to the arm 28 in a state in which the cleaning head 20 is standing vertically.

[0040]

In each of the embodiments described above, although it has been described that a mixed fluid of gaseous carbon dioxide and dry ice particles, or a mixed fluid of gaseous carbon dioxide, dry ice particles, and air is injected toward the substrate 13 that is a flat plate-like member, the foreign matter removal devices 100, 200, and 300 of the present embodiments are also applicable for removing the fine foreign matter 50 and the foreign matter 51 that have adhered to a surface of, for example, a semiconductor wafer, a lead frame in which a semiconductor die is bonded on a substrate, or the like. Also, the foreign matter removal devices 100, 200, and 300 of the respective embodiments can also be incorporated, for example, in an electronic component mounting apparatus such

as a die bonding apparatus, a wire bonding apparatus, a flip-chip bonding apparatus. Further, the foreign matter removal devices 100, 200, and 300 of the present embodiments can also be applied to removal of foreign matter on a surface of a flat plate-like member, for example, such as glass or film when a plate-like member is

5 conveyed.

[Reference Signs List]

[0041]

	11, 12 Guide rail
	13 Substrate
10	20 Cleaning head
	21 Main body
	21b rear surface
	22 Lid
	22a Flange
15	22b Inclined portion
	23 Slit
	24 Suction port
	25 Inlet connection pipe
	25a, 30a, 30b, 31a, 31b Threaded portion
20	25c Air inlet
	26 Suction connection pipe
	27 Connecting member
	28 Arm
	29 Chamber
25	29a Recess

	29b Inclined surface
	30 Sleeve
	31 Nozzle
	31c Throttle portion
5	35 Heater
	40 Drive unit
	45 Stage
	50 Fine foreign matter
	51 Foreign matter
10	61 Hole
	91, 92, 95 Arrow
	100, 200, 300 Foreign matter removal device

[CLAIMS]

[Claim 1]

A foreign matter removal device comprising:

5 a nozzle in which a pressurized flow of liquid carbon dioxide is caused to be expanded and cooled during the expansion to form solid carbon dioxide particles in the flow;

a chamber connected to the nozzle and into which the solid carbon dioxide particles flow;

10 an ejection port connected to the chamber and configured to eject the solid carbon dioxide particles toward a surface of a flat plate-like member; and

a suction port disposed adjacent to the ejection port, wherein

a particle diameter of individual of the carbon dioxide particles ejected from the ejection port is adjusted by changing a distance between the nozzle and the chamber.

[Claim 2]

15 The foreign matter removal device according to claim 1, comprising a heater attached to an outer surface of the chamber and configured to adjust a particle diameter of individual of the carbon dioxide particles ejected from the ejection port by changing a heating amount of the heater.

[Claim 3]

20 The foreign matter removal device according to claim 1 or 2, wherein the ejection port is a slit communicating with the chamber and configured to eject the carbon dioxide particles in a band shape toward the surface of the flat plate-like member.

[Claim 4]

25 The foreign matter removal device according to claim 1 or 2, wherein the ejection port is a plurality of holes communicating with the chamber and disposed in a

straight line.

[Claim 5]

The foreign matter removal device according to claim 1, wherein the ejection port injects the carbon dioxide particles to be inclined in a direction of the suction port.

5 [Claim 6]

The foreign matter removal device according to claim 2, wherein the ejection port injects the carbon dioxide particles to be inclined in a direction of the suction port.

[Claim 7]

10 The foreign matter removal device according to claim 3, wherein the ejection port injects the carbon dioxide particles to be inclined in a direction of the suction port.

[Claim 8]

The foreign matter removal device according to claim 4, wherein the ejection port injects the carbon dioxide particles to be inclined in a direction of the suction port.

[Claim 9]

15 The foreign matter removal device according to claim 1 or 2, further comprising:

an air inlet which causes compressed air to flow into the chamber, wherein the chamber mixes the carbon dioxide particles and the compressed air.

[Claim 10]

20 The foreign matter removal device according to claim 3, further comprising:

an air inlet which causes compressed air to flow into the chamber, wherein the chamber mixes the carbon dioxide particles and the compressed air.

[Claim 11]

The foreign matter removal device according to claim 4, further comprising:

25 an air inlet which causes compressed air to flow into the chamber, wherein

the chamber mixes the carbon dioxide particles and the compressed air.