Description

Title of Invention: CHUCKING MECHANISM, ARTICLE MANUFACTURING APPARATUS, SEMICONDUCTOR MANUFACTURING APPARATUS

Technical Field

[0001] The present invention relates to an apparatus and a method for mounting, for example, a semiconductor chip on a lead frame or the like.

Background Art

[0002] There are various forms of electronic devices, and many electronic devices include, for example, a semiconductor package in which a semiconductor chip is mounted on a lead frame, or a circuit package in which an electronic component such as a semiconductor chip is mounted on a circuit board. The semiconductor package and the circuit package are manufactured by, for example, the following procedure. First, a large number of integrated circuits are formed on a semiconductor wafer, and the semiconductor wafer is cut and divided into semiconductor chips (dies) in a dicing step. Then, in a bonding step, an electronic component such as a semiconductor chip (die) is bonded to a lead frame or a circuit board. An apparatus used in this bonding step is a die bonding apparatus that is a so-called die bonder. The die bonder is an apparatus in which an electronic component is mounted on a lead frame or a substrate and bonding is performed using a bonding material such as solder, gold, or resin, but in some cases, the die bonder can also be used for an application in which an electronic component is mounted on another already bonded electronic component and bonded.

[0003] For example, in a case where an electronic component is bonded to a surface of a substrate or the like by the die bonder, the electronic component is chucked and picked up using a chucking nozzle called a collet, and conveyed to a predetermined position where bonding is to be performed. Then, bonding is performed by a bonding material being heated. The collet may be used only for pickup and conveyance of an electronic component, or may be used to apply a pressing force to the electronic component at the time of bonding. The collet is a holder that

includes a chucking hole and chucks and holds an electronic component by sucking air, and a collet suitable for the size and shape of the electronic component to be chucked is used.

[0004] In such a die bonder, in a case where the type of an electronic component to be bonded is changed, the collet needs to be replaced with a collet having a size and a shape suitable for an electronic component after the change. Furthermore, even in a case where electronic components of the same type are continuously bonded, the collet needs to be replaced with a new collet in a timely manner in order to prevent the collet from being worn and damaging the surface of an electronic component or to prevent soiling from adhering to the collet and contaminating the surface of an electronic component. Therefore, in the field of die bonders, an apparatus configured to replace a tool such as a collet is known.

[0005] For example, Patent Literature 1 discloses a bonding head in which a collet is detachably held by being fitted to a collet holder. A penetrating slit (penetrating opening) is formed in the collet holder, and a retaining pin is attached to the penetrating slit. By the retaining pin being engaged with a locking groove of the collet, the collet is locked to the collet holder.

[0006] Furthermore, Patent Literature 2 discloses a semiconductor manufacturing apparatus including a collet exchange portion for exchanging a collet, in which the collet exchange portion includes an opening and closing arm having a claw structure and a collet clamp portion. In the apparatus, a collet holder includes a relief portion of a claw, and the collet is attached to or detached from the collet holder by the opening and closing arm being controlled.

[0007] Furthermore, Patent Literature 3 discloses a bonding apparatus in which a bonding tool is detachably held by being chucked by a bonding head. A method is described in which a suction means for chucking the bonding tool is provided on a lower end surface of a tool holder, and in response to chucking the tool at the time of tool replacement, the tool holder and a tool accommodating portion are relatively horizontally moved to correct a chucking position of the bonding tool.

Citation List

Patent Literature

[0008]

Patent Literature 1: JP H10-135251 A

Patent Literature 2: JP 2018-206843 A

Patent Literature 3: JP 2004-200443 A

Summary of Invention

Technical Problem

[0009] In order to chuck and pick up an electronic component, to convey the electronic component while chucking and holding the electronic component, and to apply a sufficient pressing force to the electronic component at the time of bonding, a collet needs to chuck the electronic component using a sufficient suction force at the time of the operation. If air leakage occurs in a suction path to a chucking hole, a sufficient suction force cannot be obtained. However, in the conventional die bonder, in a case where the collet is replaced, air leakage may occur and the suction force may decrease.

[0010] For example, in the bonding head described in Patent Literature 1, the collet and the collet holder that are both rigid bodies are fitted to form an air suction path. In fitting, if the collet and the collet holder are attempted to be fitted in a state of insufficient alignment, a fitting surface may come into contact with a non-fitting surface and be damaged, or a corner portion and a smooth surface of a fitting structure may come into contact with each other and fitting portions damage each other. Also, in a case where machining accuracy of the corner portion and the fitting surface included in the fitting portions is not sufficient, damage due to contact may occur during fitting work. As a result, in a case where the collet is replaced, airtightness of the fitting surface may be insufficient, and air leakage may occur and bonding operation may not be performed well.

[0011] Furthermore, the semiconductor manufacturing apparatus described in Patent Literature 2 has a similar issue. That is, if the collet and the collet holder are attempted to be fitted by the opening and closing arm being operated in a state of insufficient alignment, a fitting surface may come into contact with a non-fitting surface and be damaged, or a corner portion and

a smooth surface of a fitting structure may come into contact with each other and fitting portions damage each other. Also, in a case where machining accuracy of the corner portion and the fitting surface included in the fitting portions is not sufficient, damage due to contact may occur during fitting work. As a result, in a case where the collet is replaced, airtightness of the fitting surface may be insufficient, and air leakage may occur and bonding operation may not be performed well.

[0012] Furthermore, although the bonding apparatus described in Patent Literature 3 holds the bonding tool by chucking, if machining accuracy of the lower end surface of the tool holder and the upper surface of the tool is not sufficient, air leakage may occur from a minute gap. As a result, in a case where the tool is replaced, attachment adjustment of the tool is repeatedly performed, and bonding operation may not be performed well until a holding orientation in which air leakage is less is determined.

[0013] Furthermore, in the die bonder, a lead frame that is a target to which an electronic component is bonded may be held by a lead frame holding body using chucking. In a case where the type of the lead frame is changed, the lead frame holding body needs to be replaced, but also in this case, an issue of air leakage may occur similarly to the replacement of the collet described above.

[0014] Therefore, there has been a demand for a die bonder in which, in a case of replacing a tool, such as a collet or a lead frame holding body, that chucks a workpiece, a tool can be attached in a state in which leakage is eliminated without requiring an excessive burden for alignment work at the time of attaching.

Solution to Problem

[0015] One aspect of the present invention is a chucking mechanism including a tool configured to chuck a workpiece by suction, a tool holder including a suction path, and a positioning portion that positions a relative position of the tool with respect to the tool holder in a case where the tool holder holds the tool, in which the positioning portion includes at least one convex portion arranged on one of the tool and the tool holder, the at least one convex portion

being formed from an elastic material and including a tapered surface, and at least one concave portion arranged on the other of the tool and the tool holder and configured to fit the convex portion.

[0016] Another aspect of the present invention is a chucking mechanism including a tool configured to chuck a workpiece by suction, a tool holder including a suction path, a holding means that causes the tool holder to detachably hold the tool by a magnetic force, and a flexible member configured to airtightly connect the tool and the suction path in a case where the tool holder holds the tool by a magnetic force.

Advantageous Effects of Invention

[0017] According to the present invention, there can be provided a die bonder in which, in a case of replacing a tool, such as a collet or a lead frame holding body, that chucks a workpiece, a tool can be attached in a state in which leakage is eliminated without requiring an excessive burden for alignment work at the time of attaching.

Other features and advantages of the present invention are apparent from the following description with reference to the accompanying drawings. Note that, in the accompanying drawings, the same or similar configurations are denoted by the same reference signs.

Brief Description of Drawings

[0018] Fig. 1 is a schematic perspective view of a die bonder according to an embodiment.

Fig. 2 is a schematic cross-sectional view illustrating a lead frame holding mechanism of a die bonder according to a first embodiment.

Fig. 3 is a perspective view of a chucking mechanism according to the first embodiment.

Fig. 4 is a cross-sectional view of the chucking mechanism according to the first embodiment.

Fig. 5A is a cross-sectional view illustrating a state before a collet is attached to a collet holder in the chucking mechanism according to the first embodiment.

Fig. 5B is a cross-sectional view illustrating a state in which the collet is attached to (held by) the collet holder in the chucking mechanism according to the first embodiment.

Fig. 5C is a cross-sectional view illustrating a state in which the collet chucks a

semiconductor chip in the chucking mechanism according to the first embodiment.

Fig. 6 is a top view of the collet and the collet holder according to the first embodiment as viewed from a Z direction.

Fig. 7A is a view in which the collet is moved above a semiconductor chip.

Fig. 7B is a view in which the collet chucks the semiconductor chip.

Fig. 7C is a view in which the collet picks up the semiconductor chip.

Fig. 8A is a top view of one of fitting portions as viewed from the Z direction.

Fig. 8B is a cross-sectional view illustrating a state before a convex portion and a concave portion are fitted to each other.

Fig. 9A is a cross-sectional view illustrating a state before fitting.

Fig. 9B is a view illustrating a state in which the collet (convex portion) and position regulation portions are in contact with each other.

Fig. 9C is a view illustrating a state in which the collet (convex portion) and the collet holder (concave portion) are close to each other.

Fig. 9D is a view illustrating a state in which the collet (convex portion) and the collet holder (concave portion) are in contact with each other.

Fig. 9E is a view illustrating a state in which fitting is completed.

Fig. 10 is a top view of the collet and the collet holder according to a first modification of the first embodiment as viewed from the Z direction.

Fig. 11A is a cross-sectional view illustrating a state before fitting in a second modification of the first embodiment.

Fig. 11B is a view illustrating a state in which the collet (convex portion) and the collet holder (concave portion) are in contact with each other in the second modification of the first embodiment.

Fig. 11C is a view illustrating a state in which fitting is completed in the second modification of the first embodiment.

Fig. 12A is a cross-sectional view illustrating a state before fitting in a third modification of

the first embodiment.

Fig. 12B is a view illustrating a state in which the collet (convex portion) and the collet holder (concave portion) are in contact with each other in the third modification of the first embodiment.

Fig. 12C is a view illustrating a state in which fitting is completed in the third modification of the first embodiment.

Fig. 13A is a cross-sectional view illustrating a state before fitting in a fourth modification of the first embodiment.

Fig. 13B is a view illustrating a state in which the collet (convex portion) and the collet holder (concave portion) are in contact with each other in the fourth modification of the first embodiment.

Fig. 13C is a view illustrating a state in which fitting is completed in the fourth modification of the first embodiment.

Fig. 13D is a plan view of the convex portion according to the fourth modification of the first embodiment.

Fig. 14 is a schematic plan view illustrating a lead frame holding mechanism according to a second embodiment.

Fig. 15 is a schematic cross-sectional view illustrating the lead frame holding mechanism according to the second embodiment.

Fig. 16 is a top view of the collet and the collet holder according to a fifth modification of the first embodiment as viewed from the Z direction.

Fig. 17 is a top view of the collet and the collet holder according to a sixth modification of the first embodiment as viewed from the Z direction.

Fig. 18 is a top view of the collet and the collet holder according to a seventh modification of the first embodiment as viewed from the Z direction.

Fig. 19 is a top view of the collet and the collet holder according to an eighth modification of the first embodiment as viewed from the Z direction.

Fig. 20 is a top view of the collet and the collet holder according to a ninth modification of the first embodiment as viewed from the Z direction.

Fig. 21 is a top view of the collet and the collet holder according to a tenth modification of the first embodiment as viewed from the Z direction.

Fig. 22 is a perspective view of a chucking mechanism according to a third embodiment.

Fig. 23 is a cross-sectional view of the chucking mechanism according to the third embodiment.

Fig. 24A is a cross-sectional view illustrating a state before a collet is attached to a collet holder in the chucking mechanism according to the third embodiment.

Fig. 24B is a cross-sectional view illustrating a state in which the collet is attached to (held by) the collet holder in the chucking mechanism according to the third embodiment.

Fig. 24C is a cross-sectional view illustrating a state in which the collet chucks a semiconductor chip in the chucking mechanism according to the third embodiment.

Fig. 25 is a top view of the collet and the collet holder according to the third embodiment as viewed from the Z direction.

Fig. 26 is a schematic plan view illustrating a lead frame holding mechanism according to a fourth embodiment.

Fig. 27 is a schematic cross-sectional view illustrating the lead frame holding mechanism according to the fourth embodiment.

Description of Embodiments

[0019] A chucking mechanism, an article manufacturing apparatus, a semiconductor manufacturing apparatus, and the like according to embodiments of the present invention will be described with reference to the drawings.

Note that, in the drawings referred to in the following description of the embodiments, elements denoted by the same reference signs have the same or similar functions unless otherwise specified.

[0020]

[First Embodiment]

Fig. 1 is a schematic perspective view for describing a die bonder according to an

embodiment. A die bonder 100 as a semiconductor manufacturing apparatus is an apparatus that picks up a semiconductor chip 11 (die) as a workpiece, conveys the semiconductor chip to an island portion 42 provided on a lead frame 41 as a mounting target member, places the semiconductor chip, and performs bonding. Note that Fig. 1 is a schematic view obtained by extracting a part of the die bonder 100 for convenience of description of the present invention, and some mechanical elements and electrical elements of, for example, a casing, a fixing pedestal, a power supply, and the like provided to exhibit a function as a practical apparatus are not illustrated.

[0021]

(Configuration of Die Bonder)

The die bonder 100 includes a wafer support device 14, a collet 21, a collet holder 22, a bonding arm 23, a conveyance portion 24, a supply portion camera 31, an island portion camera 32, and a control unit 200.

The control unit 200 is a computer for controlling operation of the die bonder 100, and internally includes a central processing unit (CPU), a read-only memory (ROM), a random access memory (RAM), an I/O port, and the like.

[0022] A program for executing various types of processing according to the present embodiment may be stored in the ROM together with other programs, but may be loaded from the outside into the RAM via a network. Alternatively, the program may be loaded into the RAM via a recording medium in which the program is recorded.

[0023] The I/O port is connected to an external device or a network, and can input and output data necessary for bonding from and to an external computer, for example. Furthermore, the I/O port is connected to a monitor or an input device (not illustrated), and can display operation status information of the die bonder to an operator or receive a command from the operator.

[0024] The control unit 200 is connected to components including the bonding arm 23, the conveyance portion 24, the supply portion camera 31, and the island portion camera 32, and controls these components by a control signal.

[0025] The wafer support device 14 is a device that supports a semiconductor wafer 13 diced (divided) into a large number of semiconductor chips 11. In the wafer support device 14, a predetermined region on which the semiconductor wafer 13 is placed is referred to as a supply portion 12, and the semiconductor chips 11 for die bonding are supplied from the supply portion 12.

[0026] The collet 21 (tool) includes a chucking portion configured to chuck a semiconductor chip 11 (workpiece). Specifically, a chucking hole configured to perform vacuum suction is provided on the lower end surface of the collet 21, and a semiconductor chip 11 can be chucked by the lower end surface being brought close to or in contact with the semiconductor chip 11 and the semiconductor chip 11 being sucked from the chucking hole. Furthermore, if vacuum suction is released after chucking, the chucked semiconductor chip 11 can be released.

[0027] The collet holder 22 (tool holder) is a holding mechanism that detachably holds the collet 21 (tool). The collet 21 suitable for the size and shape of a semiconductor chip 11 to be chucked is attached to the collet holder 22. As will be described in detail below, in the die bonder 100 of the present embodiment, the collet 21 is held by the collet holder 22 by a magnetic force.

[0028] The collet holder 22 includes a suction path, and in a case where the collet 21 is held by the collet holder 22, the chucking hole of the collet 21 and the suction path of the collet holder 22 are connected. By negative pressure being supplied from a vacuum pump or the like to the chucking hole of the collet 21 via the suction path, the collet 21 can chuck a semiconductor chip 11. As will be described in detail below, the die bonder 100 of the present embodiment includes a flexible member for airtightly connecting the chucking hole of the collet 21 and the suction path of the collet holder 22 in a case where the collet 21 is held by the collet holder 22 by a magnetic force.

[0029] The collet holder 22 is connected to the bonding arm 23, and the bonding arm 23 includes a movable mechanism for adjusting the position and orientation of the collet holder 22. For example, for picking up a semiconductor chip 11 from the supply portion 12, the bonding arm 23 adjusts the height of the collet holder 22 such that the lower end surface of the collet 21 is

brought close to or in contact with the semiconductor chip 11 to be picked up. Furthermore, for bonding a semiconductor chip 11 to an island portion 42 of the lead frame 41, the bonding arm 23 adjusts the position and orientation of the collet holder 22 such that the semiconductor chip 11 chucked by the collet 21 is brought close to or in contact with the island portion 42. Furthermore, the position and orientation of the collet holder 22 may be adjusted such that the semiconductor chip 11 is pressed against the island portion 42 using an appropriate force.

[0030] The bonding arm 23 is connected to the conveyance portion 24, and the conveyance portion 24 can move the bonding arm 23 such that the collet 21 can freely move between the supply portion 12 of the wafer support device 14 and island portions 42 of the lead frame 41. The conveyance portion 24 can move the bonding arm 23 in each of X, Y, and Z directions and a θ direction around a Z axis.

[0031] The supply portion camera 31 is a camera configured to image the vicinity of the supply portion 12. In order to check the position and orientation of a semiconductor chip 11 placed on the supply portion 12 and check the position and orientation of the collet 21 for picking up a semiconductor chip 11, the supply portion camera 31 transmits image data to the control unit 200. For performing pickup operation by the die bonder 100, the control unit 200 controls the position and orientation of the collet 21 using the image data transmitted from the supply portion camera 31.

[0032] The island portion camera 32 is a camera configured to image the vicinity of the island portions 42 of the lead frame 41. In order to check the position and orientation of the island portions 42 or check the position and orientation of the collet 21 for bonding a semiconductor chip 11, the island portion camera 32 transmits image data to the control unit 200. For performing bonding operation by the die bonder 100, the control unit 200 controls the position and orientation of the collet 21 using the image data transmitted from the island portion camera 32.

[0033]

(Die Bonding Method)

Before describing each part of the die bonder 100 in more detail, an outline of a die bonding method using the die bonder 100 will be described.

[0034] First, as preparation for starting die bonding, the semiconductor chips 11 as workpieces are placed on the supply portion 12. Furthermore, the lead frame 41 as a mounting target member is set on a lead frame holding body 40 (described below with reference to Fig. 2) as a mounting target member holding portion.

[0035] Thereafter, the control unit 200 of the die bonder 100 causes the supply portion camera 31 to image a semiconductor chip 11 to be picked up, checks the position and orientation of the semiconductor chip 11, and drives the conveyance portion 24 and the bonding arm 23 to move the collet 21.

[0036] After the collet 21 is positioned above the semiconductor chip 11 as illustrated in Fig. 7A, the collet 21 is lowered as illustrated in Fig. 7B to bring the lower end surface close to or in contact with the semiconductor chip 11, and the semiconductor chip 11 is chucked by suction through the chucking hole. Then, as illustrated in Fig. 7C, the collet 21 is raised to pick up the semiconductor chip 11. At that time, the control unit 200 can perform feedback control of operation of the conveyance portion 24, the bonding arm 23, a suction mechanism, and the like on the basis of image data obtained by imaging by the supply portion camera 31.

[0037] Furthermore, the control unit 200 causes the island portion camera 32 to image an island portion 42 to be bonded (predetermined position), and checks the position and orientation of the island portion. Then, the conveyance portion 24 and the bonding arm 23 are driven so that the collet 21 chucking the semiconductor chip 11 is moved above the island portion 42, for example, in a route indicated by an arrow in Fig. 1.

[0038] Then, the semiconductor chip 11 can be placed on the island portion 42 by the collet 21 being lowered to bring the semiconductor chip 11 in contact with or close to the island portion 42 and suction being stopped. Thereafter, a bonding material is heated so that the semiconductor chip 11 is bonded to the lead frame 41. Note that the control unit 200 may control the bonding arm 23 such that the collet 21 presses the semiconductor chip 11 against the lead frame 41 during

bonding. At that time, the control unit 200 can perform feedback control of operation of the conveyance portion 24, the bonding arm 23, the suction mechanism, a heating mechanism, and the like on the basis of image data obtained by imaging by the island portion camera 32.

[0039] After completing bonding of one semiconductor chip by the above procedure, the die bonder 100 sequentially picks up another semiconductor chip and bonds the semiconductor chip to a predetermined island portion. Note that an objective to be die-bonded is not limited to an island portion of the lead frame, and, for example, a first semiconductor chip may be die-bonded to a second semiconductor chip mounted on the lead frame.

[0040]

(Lead Frame Holding Mechanism)

Next, a mechanism for holding the lead frame 41 as a mounting target member will be described. Fig. 2 is a schematic cross-sectional view of a holding mechanism taken along a YZ plane direction in Fig. 1.

As illustrated in Fig. 2, the lead frame 41 is held by the lead frame holding body 40. The lead frame holding body 40 includes a rail portion 40b surrounding the periphery of the lead frame 41 and a receiving portion 40a supporting the bottom surface of the lead frame 41, and detachably holds the lead frame 41.

[0041] The rail portion 40b is a position regulation portion that regulates the position of the lead frame 41 in the horizontal plane so that the position falls within a predetermined range. For example, for setting the lead frame 41 in the lead frame holding body 40 in a region (not illustrated in Fig. 1) and moving the lead frame 41 to the position illustrated in Fig. 1, the position of the lead frame 41 is regulated such that the island portions 42 do not deviate beyond the size of the semiconductor chips 11. Specifically, for example, in the Y direction, the position and shape of the rail portion 40b are determined such that clearance of about 0.5 mm is left even in a case where the lead frame has the maximum size within dimensional tolerance.

[0042]

(Chucking Mechanism)

Next, a chucking mechanism for picking up a semiconductor chip 11 as a workpiece will be described with reference to Figs. 3 to 6, Figs. 8A and 8B, Figs. 9A and 9B, and the like. Note that, in the die bonder of the present embodiment, a dedicated collet is prepared for each type of workpiece (semiconductor chip), and a collet corresponding to the workpiece for bonding is selected and attached to the collet holder to form a chucking mechanism.

[0043] Fig. 3 is a perspective view of the chucking mechanism, and the chucking mechanism includes the collet 21, the collet holder 22, and the bonding arm 23. The collet holder 22 detachably holds the collet 21, and Fig. 3 illustrates a state in which the collet 21 is detached from the collet holder 22.

[0044] The bonding arm 23 includes a Z-direction actuator 121 for moving the collet 21 and the collet holder 22 in the Z-direction. The Z-direction actuator 121 can perform moving operation in the Z direction and pressing load feedback control for bonding under the control of the control unit 200. For performing operation such as pickup, placing, and bonding of a semiconductor chip 11, the Z-direction actuator 121 is operated to raise and lower the collet. At this time, the operation of the Z-direction actuator is controlled by the pressing load feedback so that a force equal to or greater than a predetermined load is not applied and the semiconductor chip 11 is not deformed or damaged.

[0045] Fig. 4 is a schematic cross-sectional view obtained by cutting the collet 21 and the collet holder 22 along a bending line B-B illustrated in Fig. 3, that is, a route passing through a convex portion 102c, a suction path 108, and a convex portion 102a. Fig. 6 is a top view of the collet 21 and the collet holder 22 as viewed from the Z direction.

[0046] The collet 21 includes, as components, a collet base 103, the convex portion 102a, a convex portion 102b, the convex portion 102c, a bearing surface 104a, a bearing surface 104b, a bearing surface 104c, position regulation portions 117a, position regulation portions 117b, position regulation portions 117c, and a workpiece chucking portion 106, which are integrated. The collet 21 includes the suction path 108 penetrating the inside, and a suction hole 109 for sucking a semiconductor chip 11 is arranged at the lower end of the suction path 108.

[0047] The collet holder 22 includes, as components, a concave portion 112a, a concave portion 112b, a concave portion 112c, a magnet 113, a bearing surface 114a, a bearing surface 114b, and a bearing surface 114c, which are integrated. The collet holder 22 includes a suction path 116 penetrating the inside, and the suction path 116 is connected to a negative pressure applying mechanism (vacuum pump, control valve, or the like) (not illustrated).

[0048] The magnet 113 of the collet holder 22 and the collet base 103 are arranged to face each other, and the collet base 103 is formed from a ferromagnetic material. For attaching the collet 21 to the collet holder 22, the collet base 103 is attracted by a magnetic force of the magnet 113, and the collet 21 is detachably held by the collet holder 22. Note that, in the present embodiment, a mechanism for detachably holding the collet using a magnetic force is not limited to this configuration, and, for example, the magnet may be included in the collet, and the collet holder may be formed from a ferromagnetic material.

Alternatively, a first magnet may be included in one of the collet and the collet holder, a second magnet may be included in the other, and the first magnet and the second magnet may be arranged such that opposite magnetic poles face each other.

[0049] The strength of a holding force for holding the collet by the collet holder is set to such an extent that the collet can be stably held during a series of bonding operation, but an excessive external force does not need to be applied for removing the collet, and a magnet having a magnetic force according to the setting is used. The reason is to facilitate attachment and detachment work for replacing the collet, and to prevent occurrence of unexpected breakage due to an excessive external force.

[0050] As illustrated in Fig. 6, the magnet 113 is symmetrically arranged so as to surround the periphery of the suction path 116 so that a necessary holding force is uniformly applied to each portion of the collet and the collet holder. However, as long as a necessary holding force is uniformly applied, the magnet may be arranged by other method. Note that a permanent magnet is used as the magnet 113, but an electromagnet may be used as long as it can be mounted.

[0051] In the chucking mechanism of the present embodiment, a flexible member 115 that is

elastically deformable is arranged between the collet 21 and the collet holder 22. In the example of Fig. 4, the flexible member 115 is fixed to a concave portion of the collet holder 22, but may be fixed to the collet 21, or may be clamped between the collet holder 22 and the collet 21 without being fixed to the collet holder 22 or the collet 21.

[0052] As illustrated in Fig. 6, the flexible member 115 is an annular member, and has a circular shape surrounding the periphery of the suction path 108 of the collet 21 and the periphery of the suction path 116 of the collet holder 22 in plan view from the Z direction. Note that the shape of the annulus in plan view is not limited to a circle, and may be an annulus of another shape, but a symmetrical shape is preferable from the viewpoint of stability and reproducibility of elastic deformation, and in particular, a circle is preferable.

[0053] The flexible member 115 is elastically deformed so as to be in close contact with both the upper end surface of the collet 21 and the lower end surface of the collet holder 22 in a case where the collet 21 is held by the collet holder 22 using a holding force of a degree in which an excessive external force is not required for removal. In other words, the flexible member 115 is formed from a material that can be easily elastically deformed using a holding force of the degree described above and can airtightly connect the suction path 108 and the suction path 116 (connect them to seal the atmosphere out). Therefore, the flexible member 115 can include, for example, any material of rubber, porous resin, or magnetic fluid. Preferably, the annular flexible member 115 is arranged concentrically around the suction path 116. The reason is because the flexible member 115 can be elastically deformed uniformly in the suction direction even using a weak suction force.

[0054]

(Method for Attaching Collet)

Next, a method for attaching the collet 21 to the collet holder 22 will be described with reference to Figs. 5A to 5C, 6, and the like.

Figs. 5A to 5C are schematic cross-sectional views obtained by cutting the collet 21 and the collet holder 22 along the bending line B-B illustrated in Fig. 3, that is, the route passing through

the convex portion 102c, the suction path 108, and the convex portion 102a. For the sake of convenience of illustration, the dimensions and shapes of respective portions are illustrated in unequal scale.

[0055] Fig. 5A illustrates a state before the collet 21 is attached to the collet holder 22, and Fig. 5B illustrates a state in which the collet 21 is attached to (held by) the collet holder 22. Fig. 5C illustrates a state in which the collet 21 held by the collet holder 22 chucks a semiconductor chip 11.

[0056] The convex portion 102a, the convex portion 102b, and the convex portion 102c of the collet 21 and the concave portion 112a, the concave portion 112b, and the concave portion 112c of the collet holder 22 act as positioning mechanisms that can be fitted to each other. That is, as illustrated in Fig. 5B, the collet holder 22 can hold the collet 21 without rattling because the collet holder 22 and the collet 21 are fitted and restrained with each other for holding the collet 21. In the present embodiment, three pairs of fitting portions each including a pair of a convex portion and a concave portion are provided, but an appropriate number of pairs can be provided in consideration of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like. However, in order to stabilize the orientation at the time of holding, the positioning mechanisms are desirably arranged symmetrically around a suction path.

[0057] The magnet 113 (magnet) included in the collet holder 22 and the collet base 103 (ferromagnetic material) included in the collet 21 act as holding means for detachably holding the collet in the collet holder by a magnetic force. That is, in response to the collet 21 being aligned and brought close to the collet holder 22, the collet base 103 is attracted by a magnetic force of the magnet 113, and the collet 21 is held by the collet holder 22. For replacing the collet, the collet can be detached from the collet holder by an external force larger than an attractive force of the magnet (holding force of the holding means) being applied.

[0058] The attractive force of the magnet (holding force of the holding means) needs to be set to a strength strong enough to prevent the collet from rattling due to weight or an inertial force in response to sucking, picking up, and conveying a semiconductor chip 11 (workpiece) as

illustrated in Fig. 5C. However, a stronger attractive force of the magnet (holding force of the holding means) is not necessarily better, and the attractive force is preferably set to a range in which an excessively large external force is not required for removing the collet from the collet base.

[0059] As illustrated in Fig. 5B, the positional relationship between the magnet 113 and the collet base 103 is desirably set such that the magnet 113 and the collet base 103 face each other with a minute interval therebetween in a case where the collet holder 22 holds the collet 21. The reason is because if the magnet 113 and the collet base 103 are brought in the positional relationship in which they are in contact with each other, the magnet 113 may be worn in response to attaching and detaching of the collet.

[0060] Therefore, in a case where the collet is attached, the lower surface of the collet holder 22 and the upper surface of the collet base 103 are separated by a distance L2 as illustrated in Fig. 5B. By the distance L2 being secured as clearance, a positional relationship in which the magnet 113 and the collet base 103 do not contact each other can be implemented. In order to secure the distance L2, the bearing surface 104a, the bearing surface 104b, and the bearing surface 104c of the collet 21 are provided at positions higher than the upper surface of the collet base 103. At the time of attaching, the bearing surface 104a, the bearing surface 104b, and the bearing surface 104c of the collet 21 are brought in contact with the bearing surface 114a, the bearing surface 114b, and the bearing surface 114c of the collet holder 22.

[0061] Note that, in the present embodiment, as illustrated in Figs. 3 and 6, three pairs of a collet side bearing surface and a collet holder side bearing surface are arranged so as to be equiangular and equidistant around the suction path. However, the embodiment of the present invention is not limited thereto, and an appropriate number and shape of collet side bearing surfaces and collet holder side bearing surfaces can be provided in consideration of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like. Furthermore, in order to secure the distance L2, in the present embodiment, the bearing surface 104a to the bearing surface 104c protrude from the upper surface of the collet base 103, but the bearing surface 114a

to the bearing surface 114c of the collet holder 22 may protrude from the lower surface of the collet holder 22. Furthermore, the bearing surfaces do not need to be installed in the vicinity of the positioning mechanisms (convex portion 102a to convex portion 102c, and concave portion 112a to concave portion 112c), and may be arranged at distant positions.

[0062] Next, the flexible member 115 will be described. The flexible member 115 is a member for airtightly connecting the suction hole 109 of the collet 21 (suction path 108) and the suction path 116 of the collet holder 22 in a case where the collet 21 is held by the collet holder 22 by a magnetic force.

[0063] The flexible member 115 of the present embodiment includes a base portion fitted with an annular groove provided in the collet holder 22 and an annular inclined surface having one end connected to the base portion (protruding from the base portion) so as to be inclined with respect to the Z direction. The direction in which the annular inclined surface is inclined is set such that the tip of the circle opens toward the collet, that is, as illustrated in Fig. 5B, an inner diameter D1 (circle diameter) on the side in contact with the collet is larger than an inner diameter D2 (circle diameter) on the collet holder side. In other words, the annular inclined surface is inclined in a direction in which the inner diameter D2 on the side connected to the base portion (collet base side in the example of Fig. 5B) is small and the inner diameter D1 on the opposite tip side not connected to the base portion is large.

[0064] In a case where the collet is not attached to the collet holder 22, as illustrated in Fig. 5A, the flexible member 115 protrudes from the lower surface of the collet holder 22 by L1 in the Z direction. Here, L1 is set to be larger than L2 described above.

[0065] In response to attaching the collet 21 to the collet holder 22, as illustrated in Fig. 5B, the flexible member 115 is elastically deformed by a holding force of the holding means. That is, the inclined surface protrudes from the lower surface of the collet holder 22 by L2 in the Z direction, and the lower end thereof is deformed so as to be brought in close contact with the upper surface of the collet base 103. Furthermore, the upper surface of the flexible member 115 is brought in close contact with the collet holder 22 by a holding force of the holding means. As a

result of the elastic deformation, the inclination of the inclined surface with respect to the Z direction is larger, and the inner diameter D1 is larger than before the collet 21 is attached.

[0066] The flexible member 115 in close contact with both the collet holder 22 and the collet 21 forms an airtight connection portion that connects the suction path 116 (suction hole 109) of the collet 21 and the suction path 116 of the collet holder 22 to seal the atmosphere out.

[0067] As illustrated in Fig. 5C, for holding a semiconductor chip 11 (workpiece) using the collet 21, the suction paths are vacuumed and chucking is performed at the suction hole 109. In the present embodiment, since the flexible member 115 that is elastically deformable is interposed, airtightness of the suction paths is excellent. In a conventional method in which a collet and a collet holder that are rigid are directly brought in contact with each other to connect suction paths, air leakage may occur from a minute gap, and attachment adjustment needs to be repeatedly performed for attaching the collet. On the other hand, in the present embodiment, the flexible member 115 is elastically deformed by a holding force of the holding mechanism using a magnetic force, and is in close contact with both the collet and the collet holder to connect the suction paths, so that the attachment adjustment of the collet does not need to be repeatedly performed. Moreover, in the present embodiment, since the relative positions of the collet and the collet holder are fixed by the positioning mechanisms described above, an unexpected twist, which leads to occurrence of leakage, does not occur in the flexible member 115 after the collet is attached. Furthermore, according to the present embodiment, occurrence of leakage can be suppressed by using a small and lightweight structure. The small and lightweight structure enables performance of advanced position control.

[0068] Note that, for carrying out the present invention, for example, a donut-shaped flexible member having a circular cut surface can also be used. However, in the present embodiment, since the flexible member 115 includes the base portion and the inclined surface as described above, the sealing property at the time of vacuuming the suction paths can be particularly excellent. That is, due to the pressure difference between the inside and the outside generated at the time of vacuuming the suction paths, the upper surface and the side surface of the base portion are more

strongly pressed against the groove of the collet holder, and the tip of the inclined surface opposite to the base portion is more strongly pressed against the upper surface of the collet. As described above, in the flexible member of the present embodiment, not only the flexible member is in close contact by a holding force by a magnetic force, but also the pressure of the atmosphere acts such that airtightness is further improved, so that the sealing property at the time of vacuuming is particularly excellent.

[0069]

(Fitting Portions)

In the present embodiment, a configuration of fitting mechanisms including the convex portion 102a to the convex portion 102c and the concave portion 112a to the concave portion 112c is devised such that alignment accuracy required at the stage of Fig. 5A can be loosened in a case where operation of attaching the collet to the collet holder is performed. Furthermore, as illustrated in Fig. 6, the arrangement of the position regulation portions 117a to the position regulation portions 117c is devised such that the accuracy of alignment required for the fitting mechanisms is ensured. This will be described with reference to Figs. 8A and 8B, Figs. 9A to 9E, and the like. Note that, in the following description, in a case where matters common to each of the convex portion 102a to the convex portion 102c are described, these may be collectively referred to as a convex portion 102. Similarly, in a case where each of the concave portion 112a to the concave portion 112c does not need to be individually distinguished, these may be collectively referred to as a concave portion 112. Similarly, in a case where each of the position regulation portions 117a to the position regulation portions 117c does not need to be individually distinguished, these may be collectively referred to as position regulation portions 117.

[0070] Fig. 8A is a top view of one of the three fitting mechanisms, that is, the convex portion 102c, the concave portion 112c, and the position regulation portions 117c, as viewed from the Z direction before fitting. Fig. 8B is a cross-sectional view illustrating a state before the convex portion 102c and the concave portion 112c are fitted to each other. Note that, as illustrated in

Fig. 3, the other two fitting mechanisms are provided at different positions on the collet base, but the shapes of convex portions, concave portions, and position regulation portions included in the fitting mechanisms are similar to those illustrated in Figs. 8A and 8B.

[0071] As illustrated in Fig. 8B, the convex portion 102 has a pin shape having a maximum outer diameter d2 in a state where the convex portion is not fitted. The convex portion 102 includes a slit 105 (slit 105c in a case of the convex portion 102c) having a predetermined depth from the tip toward the base portion. As the pin-shaped convex portion 102 is viewed from the distal end portion toward the basis portion, the pin-shaped convex portion 102 includes the distal end that is a flat surface having a diameter d1, a tapered surface 107 connected to the flat surface, a body portion having the maximum outer diameter, and the basis portion having an outer diameter that is smaller than that of the body portion. Note that the depth of the slit 105 is desirably at least the depth from the distal end portion to the body portion in order to appropriately perform elastic deformation described below, and in the example of Fig. 8B, an example is illustrated in which the depth further reaches the basis portion through the body portion.

[0072] The concave portion 112 is a through hole, and has a shape in which semicircles are connected to both ends of a rectangle as viewed from the Z direction as illustrated in Fig. 8A. As viewed from the Z direction, in a case where the length of the concave portion 112 in the longitudinal direction is L and the length in the lateral direction is D, the convex portion 102 and the concave portion 112 are formed such that the relationship of following Formula 1 is satisfied.

$$d1 < D < d2 < L \ldots \text{(Formula 1)}$$

[0073] The convex portion 102 has a pin shape including the slit in the center as described above, and since the convex portion 102 is formed from an elastic material, the convex portion 102 can be elastically deformed in a direction in which the maximum outer diameter is smaller than d2 for fitting the concave portion 112 having the inner diameter D in the lateral direction.

[0074] As illustrated in Fig. 8A, the position regulation portions 117 are arranged on the collet 21 so as to face each other with the collet holder 22 interposed therebetween along the longitudinal direction of the concave portion 112. In the example of Fig. 8A, the lengths of the position

regulation portions are about the same as the length L of the concave portion 112 in the longitudinal direction. The dimensions of the position regulation portions 117 in the Z direction may be larger or smaller than the dimension of the convex portion 102 in the Z direction.

With reference to Figs. 9A to 9E, processing of fitting using the convex portion 102c and the concave portion 112c as an example will be described. As illustrated in Fig. 9A, it is assumed that the center of the convex portion 102c and the center of the concave portion 112c are shifted by ΔX2 (misaligned) before the start of fitting.

[0075] As illustrated in Fig. 9B, if fitting operation is started and the collet 21 and the collet holder 22 are relatively moved so as to be close to each other in the Z direction, tapered surfaces 118 of the position regulation portions 117c comes into contact with the outer edge of the collet holder 22 because the center of the convex portion 102c and the center of the concave portion 112c are misaligned. If the collet 21 is further brought close to the collet holder 22, a force acts in a direction in which the center of the convex portion 102c corresponds to the center of the concave portion 112c (horizontal direction) while the tapered surfaces 118 and the outer edge slide, and the collet holder 22 is inserted into the position regulation portions 117.

[0076] As illustrated in Fig. 9C, the fitting operation is further continued and the collet 21 and the collet holder 22 are relatively moved so as to be close to each other in the Z direction. Then, since the centers of the convex portion 102c and the concave portion 112c are misaligned, the tapered surface 107 of the convex portion 102c comes into contact with the opening edge of the concave portion 112c as illustrated in Fig. 9D.

[0077] If the collet is further brought close to the collet holder, a force acts in a direction in which the center of the convex portion 102c corresponds to the center of the concave portion 112c (horizontal direction) while the tapered surface 107 and the opening edge slide, and the convex portion 102c is inserted into the concave portion 112c.

[0078] Then, as illustrated in Fig. 9E, the convex portion 102c is elastically deformed such that the maximum outer diameter of the body portion of the convex portion 102cis equal to the inner diameter of the concave portion 112c, and the misalignment is eliminated and the fitting is

completed.

[0079] In the present embodiment, since d1 < D is set as expressed by Formula 1 and the tapered surface 107 connected to the flat surface at the tip of the convex portion 102 is provided, a positional shift between the convex portion 102 and the concave portion 112 can be absorbed.

Here, in a case where an allowable amount of a positional shift that can be absorbed is ΔX, ΔX can be expressed by following Formula 2.

$\Delta X = D - d1$ … (Formula 2)

[0080] Since the tapered surfaces 118 connected to the flat surfaces at the tips are also provided in the position regulation portions 117, a positional shift between the position regulation portions 117 and the collet holder 22 can be absorbed. Here, in a case where an allowable amount of a positional shift that can be absorbed between the position regulation portions 117 and the collet holder 22 is ΔX2, ΔX2 can be expressed by following Formula 3.

$\Delta X2 = Wo - W$ … (Formula 3)

By values of Wo and W being set such that ΔX2 is larger than ΔX, the allowable amount of a positional shift that can be absorbed by the position regulation portions 117 being provided can be increased.

[0081] Furthermore, by D < d2 being set as expressed by Formula 1, the convex portion 102 can be elastically deformed, and the convex portion 102 can be fitted to the concave portion 112 without rattling.

[0082] Furthermore, by d2 < L being set as expressed by Formula 1, there is a margin (play) in the X direction, and thus, the fitting operation can be performed without any issue, for example, even if the convex portion 102c and the concave portion 112c are misaligned in the X direction in Fig. 8A. In other words, in the case of the convex portion 102c and the concave portion 112c, as for the X direction in which the slit 105c extends in plan view, if the misalignment is ΔY or less as expressed in following Formula 4, the convex portion and the concave portion can be fitted smoothly.

$\Delta Y < L - d2$ … (Formula 4)

[0083] As illustrated in Fig. 9C, in a state in which fitting is completed, a deformation amount M in the fitted state in which the convex portion 102 is elastically deformed is expressed by following Formula 5.

$$M = d2 - D \quad \text{… (Formula 5)}$$

[0084] Here, assuming that a spring constant in a case where both sides of the slit are elastically deformed is k, a relationship between a force F in a direction of the elastic deformation (Y direction in a case of the convex portion 102c), the spring constant k, and the deformation amount M in the fitted state is expressed by following Formula 6.

$$F = k * M \quad \text{… (Formula 6)}$$

[0085] In order to make the fitting mechanisms highly rigid, the spring constant k may be increased or the deformation amount M in the fitted state may be increased. However, d2, D, and the spring constant k vary due to a machining error or the like at the time of manufacturing. d2 and D need to be determined in consideration of these, and then the deformation amount M in the fitted state needs to be determined. Furthermore, the spring constant k and the deformation amount M in the fitted state is desirably comprehensively determined in consideration of the frictional resistance during the fitting operation and the like.

[0086] Since the convex portion 102 is formed from an elastically deformable member, in a case where the deformation amount is equal to or larger than a certain value, the shape cannot be restored by elastic deformation, and the function of the fitting mechanisms is impaired. A relationship between an allowable maximum deformation amount N of the convex portion 102 in which the convex portion 102 maintains the fitting function and the deformation amount M in the fitted state is expressed by following Formula 7.

$$M < N \quad \text{… (Formula 7)}$$

[0087] Here, in a case where an external force acts on the collet holder 22 in a state in which the collet 21 and the collet holder 22 are positioned, the convex portion 102 is deformed by the deformation amount M in the fitted state or more. A movement amount L by which the convex portion 102 can move in a state in which the collet 21 and the collet holder 22 are positioned is

expressed by following Formula 8 in consideration that the position regulation portions 117 regulate the relative positions of the collet 21 and the collet holder 22.

$$L = Wi - W \ldots \text{(Formula 8)}$$

[0088] If the movement amount L is smaller than the maximum deformation amount N, the deformation amount of the convex portion 102 falls within a range in which the convex portion 102 is elastically deformable, and thus, even if an unexpected external force acts on the convex portion 102, the fitting function can be prevented from being impaired. That is, dimensions of W1 and W are desirably determined so as to satisfy a relationship expressed by following Formula 9.

$$Wi - W < N \ldots \text{(Formula 9)}$$

[0089] In the present embodiment, as illustrated in Fig. 6, three sets of fitting mechanisms including the convex portion 102a to the convex portion 102c, the concave portion 112a to the concave portion 112c, and the position regulation portions 117a to the position regulation portions 117c are arranged at equal angles so as to surround the magnet 113, the flexible member 115, and the suction path 116.

[0090] Among them, the convex portion 102a and the convex portion 102b are arranged along the Y direction, and a slit 105a and a slit 105b are also oriented along the Y direction. The corresponding concave portion 112a and concave portion 112b are also arranged along the Y direction, and oriented such that the longitudinal direction of each elongated hole is along the Y direction. Furthermore, the corresponding position regulation portions 117a and position regulation portions 117b are also arranged along the Y direction, and oriented such that the respective position regulation surfaces are along the Y direction. That is, in the two fitting structures, position regulation forces act in the same direction. Furthermore, the convex portion 102c and the corresponding concave portion 112c are arranged such that the slit 105c and the longitudinal direction of the elongated hole are along the X direction. Furthermore, the convex portion 102c and the corresponding position regulation portions 117c are arranged such that the slit 105c and the regulation surfaces of the position regulation portions are along the X direction.

That is, the direction of position regulation forces is orthogonal to that of the previous two fitting structures.

[0091] With such an arrangement, the positions in the X direction and the rotation direction around the Z axis are determined by the convex portion 102a, the concave portion 112a, the position regulation portions 117a, the convex portion 102b, the concave portion 112b, and the position regulation portions 117b, and the position in the Y direction is determined by the convex portion 102c, the concave portion 112c, and the position regulation portion 117c. As described above, in the fitting mechanisms at three positions, positions in three directions of the X direction, the Y direction, and the rotation direction around the Z axis can be determined as a whole by each elongate hole in the lateral direction being aligned by the action of sliding of the tapered surfaces and elastic deformation.

[0092] As described above, according to the present embodiment, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present embodiment are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the function of the position regulation portions can prevent the elastically deformable member that performs alignment from being deformed by an elastic deformation limit amount or more.

[0093]

(First Modification)

Next, a first modification of the first embodiment will be described with reference to Fig. 10. The first modification is different from the basic form of the first embodiment described with reference to Fig. 6 in the directions in which the convex portion 102a, the convex portion 102b,

the concave portion 112a, the concave portion 112b, the position regulation portions 117a, and the position regulation portions 117b are arranged in plan view from the Z direction.

[0094] That is, in the basic form, the slit 105a of the convex portion 102a and the slit 105b of the convex portion 102b are both arranged along the Y direction. Both the longitudinal direction of the concave portion 112a and the longitudinal direction of the concave portion 112b are arranged along the Y direction.

On the other hand, in the first modification, the slit 105a of the convex portion 102a and the slit 105b of the convex portion 102b are arranged in directions different from each other by 120 degrees. Both the longitudinal direction of the concave portion 112a and the longitudinal direction of the concave portion 112b are arranged in directions different from each other by 120 degrees. That is, the slit 105a, the slit 105b, and the slit 105c are arranged at intervals of 120 degrees around a communication hole. Similarly, the longitudinal direction of the concave portion 112a, the longitudinal direction of the concave portion 112b, and the longitudinal direction of the concave portion 112c are arranged at intervals of 120 degrees around the communication hole. Similarly, the longitudinal direction of the position regulation portions 117a, the longitudinal direction of the position regulation portions 117b, and the longitudinal direction of the position regulation portions 117c are arranged at intervals of 120 degrees around the communication hole.

[0095] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. The fitting mechanisms of the present modification can easily perform alignment in a case where a positional shift tends to occur in the rotation direction around the Z axis before the collet is attached to the collet holder. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner

surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0096]

(Second Modification)

Next, a second modification of the first embodiment will be described with reference to Figs. 11A to 11C. In the second modification, as illustrated in Fig. 11A, the inner diameter of the concave portion 112 changes depending on the position in the Z direction. That is, $W1 < W2$ is set, and a relationship with the maximum outer diameter of the convex portion 102 is set to $W2 < d2$.

[0097] Also in the present modification, in a case where the convex portion 102 and the concave portion 112 are misaligned, the tapered surface 107 slides on the inner edge of the concave portion 112 as illustrated in Fig. 11B, and the convex portion 102 and the concave portion 112 relatively move in a direction in which the misalignment is eliminated.

[0098] In the middle of the fitting, the body portion having the maximum outer diameter of the convex portion 102 is elastically deformed so as to correspond to the inner diameter W1 of the concave portion, and, in a case where the fitting is completed as illustrated in Fig. 11C, the body portion having the maximum outer diameter of the convex portion 102 reaches a portion having the inner diameter W2, and the elastic deformation of the convex portion 102 is alleviated.

[0099] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation.

[0100] Furthermore, in the present modification, in a case where an unexpected external force is applied in a direction in which the collet is to be detached after the collet is attached to the collet

holder, a tapered surface 107R at the lower portion of the convex portion 102 and a stepped portion of the inner diameter of the concave portion 112 come into contact with each other, and an elastic force of the convex portion 102 acts in a direction in which the fitting is maintained. That is, it can be said that a restraining portion that restrains the body portion of the convex portion is provided on the inner surface of the concave portion. In this way, since the fitting mechanisms act in a direction in which the holding of the collet by a magnetic force is assisted, the stability of the holding of the collet by the collet holder during die bonding operation is enhanced. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the function of the position regulation portions can prevent the elastically deformable member that performs alignment from being deformed by an elastic deformation limit amount or more.

[0101]

(Third Modification)

Next, a third modification of the first embodiment will be described with reference to Figs. 12A to 12C. In the third modification, the convex portion 102 does not include a slit, and the convex portion 102 is formed using an elastic material having an elastic coefficient smaller than that of the basic form. Also in the present modification, the maximum outer diameter of the body portion of the convex portion 102 is set to be larger than the inner diameter of the concave portion 112.

[0102] Also in the present modification, in a case where the convex portion 102 and the concave portion 112 are misaligned, the tapered surface 107 slides on the inner edge of the concave portion 112 as illustrated in Fig. 12B, and the convex portion 102 and the concave portion 112 relatively move in a direction in which the misalignment is eliminated.

In a case where the fitting is completed as illustrated in Fig. 12C, the body portion of the

convex portion 102 is compressed in the radial direction, and the outer diameter of the convex portion 102 is equal to the inner diameter of the concave portion 112.

[0103] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the function of the position regulation portions can prevent the elastically deformable member that performs alignment from being deformed by an elastic deformation limit amount or more.

[0104]

(Fourth Modification)

Next, a fourth modification of the first embodiment will be described with reference to Figs. 13A to 13D. In the fourth modification, the shape of the convex portion 102 is changed, and a biasing portion for elastically biasing and restraining the convex portion 102 at the time of fitting is provided in the concave portion 112.

[0105] As illustrated in the side view of Fig. 13A and the plan view of Fig. 13D, the convex portion 102 of the present modification is a convex portion having a so-called D-cut pin shape obtained by cutting a part of a circle into a D-shape in plan view. A groove 105k is formed on a flat side surface of the convex portion 102. A gap is provided on the inner side surface of the concave portion 112, a rigid ball 202 is arranged to protrude from the gap, and the rigid ball 202 is biased toward the gap side by a leaf spring 201. In a case where the convex portion 102 is fitted, the rigid ball 202 biased by the leaf spring 201 is engaged with the groove 105k to act as a restraining portion.

[0106] Also in the present modification, in a case where the convex portion 102 and the concave portion 112 are misaligned, the tapered surface 107 slides on the inner edge of the concave portion 112 as illustrated in Fig. 13B, and the convex portion 102 and the concave portion 112 relatively move in a direction in which the misalignment is eliminated.

In a case where the fitting is completed as illustrated in Fig. 13C, the rigid ball 202 included in the concave portion 112 is engaged with the groove 105k, and the convex portion 102 is restrained by the concave portion 112.

[0107] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0108]

(Fifth Modification)

Next, a fifth modification of the first embodiment will be described with reference to Fig. 16. In the fifth modification, the number of the position regulation portions 117 is reduced to two.

As illustrated in Fig. 16, the position regulation portions 117 of the present modification include two positions: the position regulation portions 117a corresponding to the convex portion 102a and the concave portion 112a; and position regulation portions 117c corresponding to the convex portion 102c and the concave portion 112c.

[0109] Since the position regulation portions 117a can regulate the position in the X direction, elastic deformation members of the convex portion 102a and the convex portion 102b can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102a and the concave portion 112a and the convex portion 102b and the concave portion 112b can be fitted after the position regulation portions 117a absorb a positional shift in the X direction at the time of the fitting operation. Since the position regulation portions 117c can regulate the position in the Y direction, an elastic deformation member of the convex portion 102c can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102c and the concave portion 112c can be fitted after the position regulation portions 117c absorb a positional shift in the Y direction at the time of the fitting operation.

[0110] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0111]

(Sixth Modification)

Next, a sixth modification of the first embodiment will be described with reference to Fig. 17. In the sixth modification, the number of the position regulation portions 117 is reduced to two.

As illustrated in Fig. 17, the position regulation portions 117 of the present modification include two position regulation portions: the position regulation portions 117a corresponding to the convex portion 102a and the concave portion 112a; and position regulation portions 117c corresponding to the convex portion 102c and the concave portion 112c. The position regulation portions 117a are arranged at positions away from the convex portion 102 and the concave portion 112.

[0112] Since the position regulation portions 117a can regulate the position in the X direction, elastic deformation members of the convex portion 102a and the convex portion 102b can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102a and the concave portion 112a and the convex portion 102b and the concave portion 112b can be fitted after the position regulation portions 117a absorb a positional shift in the X direction at the time of the fitting operation. Since the position regulation portions 117c can regulate the position in the Y direction, an elastic deformation member of the convex portion 102c can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102c and the concave portion 112c can be fitted after the position regulation portions 117c absorb a positional shift in the Y direction at the time of the fitting operation.

[0113] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit

amount or more.

[0114]

(Seventh Modification)

Next, a seventh modification of the first embodiment will be described with reference to Fig. 18. In the seventh modification, the number of the position regulation portions 117 is reduced to two.

As illustrated in Fig. 18, the position regulation portions 117 of the present modification include two position regulation portions: the position regulation portions 117a corresponding to the convex portion 102a and the concave portion 112a; and position regulation portions 117c corresponding to the convex portion 102c and the concave portion 112c. The position regulation portions 117a are arranged at positions away from the convex portion 102a and the concave portion 112a.

[0115] Since the position regulation portions 117a can regulate the position in the X direction, elastic deformation members of the convex portion 102a and the convex portion 102b can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102a and the concave portion 112a and the convex portion 102b and the concave portion 112b can be fitted after the position regulation portions 117a absorb a positional shift in the X direction at the time of the fitting operation. Since the position regulation portions 117c can regulate the position in the Y direction, an elastic deformation member of the convex portion 102c can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102c and the concave portion 112c can be fitted after the position regulation portions 117c absorb a positional shift in the Y direction at the time of the fitting operation.

[0116] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment

operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0117]

(Eighth Modification)

Next, an eighth modification of the first embodiment will be described with reference to Fig. 19. In the eighth modification, the position regulation portions 117 are provided so as to correspond to the concave portions 112 having biasing portions illustrated in the fourth modification.

As illustrated in Fig. 19, the position regulation portions 117 of the present modification are provided in three positions: a position regulation portion 117a corresponding to the convex portion 102a and the concave portion 112a; a position regulation portion 117b corresponding to the convex portion 102b and the concave portion 112b; and a position regulation portion 117c corresponding to the convex portion 102c and the concave portion 112c. However, since the elastic deformation directions of the biasing portions in the fitted state are one direction, the position regulation portions 117 are arranged so as to regulate deformation in the one direction corresponding to the deformation directions of the biasing portions.

[0118] Since the position regulation portion 117a and the position regulation portion 117b can regulate the position in the X direction, elastic deformation members of the concave portion 112a and the concave portion 112b can be prevented from being deformed by an elastic deformation limit amount or more. Since the position regulation portion 117c can regulate the position in the Y direction, the elastic deformation member of the concave portion 112c can be prevented from being deformed by an elastic deformation limit amount or more.

[0119] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0120]

(Ninth Modification)

Next, a ninth modification of the first embodiment will be described with reference to Fig. 20. In the ninth modification, the number of the position regulation portions 117 is reduced to two.

As illustrated in Fig. 20, the position regulation portions 117 of the present modification include two position regulation portions: the position regulation portions 117a; and the position regulation portions 117c. The position regulation portions 117a are arranged at positions away from the convex portion 102a and the concave portion 112a, and the position regulation portions 117c are arranged at positions away from the convex portion 102c and the concave portion 112c.

[0121] Since the position regulation portions 117a can regulate the position in the X direction, elastic deformation members of the convex portion 102a and the convex portion 102b can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102a and the concave portion 112a and the convex portion 102b and the concave portion 112b can be fitted after the position regulation portions 117a absorb a positional shift in the X direction at the time of the fitting operation. Since the position regulation portions

117c can regulate the position in the Y direction, an elastic deformation member of the convex portion 102c can be prevented from being deformed by an elastic deformation limit amount or more. Furthermore, the convex portion 102c and the concave portion 112c can be fitted after the position regulation portions 117c absorb a positional shift in the Y direction at the time of the fitting operation.

[0122] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more.

[0123]

(Tenth Modification)

Next, a tenth modification of the first embodiment will be described with reference to Fig. 21. In the tenth modification, a position regulation portion 117 is provided at one position in consideration of the deformation directions of the concave portions 112 having the biasing portions illustrated in the fourth modification.

[0124] As illustrated in Fig. 21, in the position regulation portion 117 of the present modification, a protruding shape is provided in the collet 21 so as to regulate deformation in one direction corresponding to the deformation directions of the biasing portions. An elastic fitting portion of the protruding shape is arranged away from the collet holder 22 by a distance less than or equal to an elastic deformation limit amount.

Since the position regulation portion 117 can regulate the position in the X direction, the elastic deformation member of the concave portion 112 can be prevented from being deformed by an elastic deformation limit amount or more. Since the position regulation portion 117 can regulate the position in the Y direction, the elastic deformation member of the concave portion 112 can be prevented from being deformed by an elastic deformation limit amount or more.

[0125] Also in the present modification, even if the positions of a convex portion and a concave portion are slightly misaligned, alignment is automatically performed by the action of sliding of the tapered surfaces and elastic deformation of the fitting mechanisms, and thus the collet can be attached to the collet holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present modification are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts on the collet in a state in which the collet is attached to the collet holder, the elastically deformable member that performs alignment can be prevented from being deformed by an elastic deformation limit amount or more. Note that, in Fig. 21, the protruding shape is a cylindrical shape, but the protruding shape is not necessarily a cylindrical shape, and the protruding shape may be formed in any three-dimensional shape such as a rectangular parallelepiped. Furthermore, in Fig. 21, the collet holder 22 includes a cutout shape corresponding to the protruding shape, but it is not always necessary to form such a shape.

[0126]

[Second Embodiment]

A second embodiment of the present invention will be described with reference to the drawings. However, detailed description of parts common to the first embodiment will be omitted as much as possible.

As illustrated in Fig. 1, a die bonder according to the second embodiment also includes elements of a wafer support device, a collet, a collet holder, a bonding arm, a conveyance portion,

a supply portion camera, an island portion camera, a control unit, and the like. In the die bonder according to the second embodiment, a chucking mechanism that picks up a semiconductor chip may have a configuration similar to or different from that of the first embodiment, but a lead frame holding mechanism that holds a lead frame has a configuration different from that of the first embodiment.

[0127] In the lead frame holding mechanism of the first embodiment (see Fig. 2), the lead frame holding body 40 includes the rail portion 40b so that the position of the lead frame 41 can be regulated. However, since a certain degree of clearance needs to be secured in consideration of the dimensional tolerance of lead frames, the position of the lead frame 41 may slightly fluctuate.

[0128] Therefore, in the second embodiment, a lead frame is chucked by suction holes being provided in a lead frame holding body so that the lead frame can be easily held without rattling. Furthermore, the lead frame holding body is held by a holding body holder by a magnetic force, and a suction path of the lead frame holding body and a suction path of the holding body are connected by a flexible member that can be airtightly connected. For replacing the lead frame holding body according to the type of the lead frame to be handled, a lead frame holding body can be attached to the holding body holder while leakage is eliminated without requiring an excessive burden for attachment adjustment work.

[0129] That is, the die bonder according to the second embodiment is a semiconductor manufacturing apparatus in which a holding body holder (tool holder) detachably holds a lead frame holding body (tool) configured to chuck a lead frame (workpiece) by a magnetic force, and includes a flexible member by which suction paths can be airtightly connected.

[0130] In the die bonder according to the second embodiment, a dedicated lead frame holding body is prepared for each type of lead frames. For performing bonding, a lead frame holding body corresponding to the type of the lead frame is selected and attached to the holding body holder to form a lead frame holding mechanism.

[0131] Fig. 14 is a schematic plan view for describing that the holding body holder of the die

bonder according to the second embodiment can hold the lead frame holding body of a plurality of forms. Fig. 15 schematically illustrates a cross section of the lead frame holding mechanism of the second embodiment, and is a YZ cross-sectional view taken along a line passing through a convex portion 71a and a convex portion 71c illustrated in Fig. 14.

[0132] Fig. 14 schematically illustrates a large-sized lead frame 51 and a small-sized lead frame 61 handled by the die bonder of the present embodiment. A lead frame holding body 50 dedicated to the large-sized lead frame 51 and a lead frame holding body 60 dedicated to the small-sized lead frame 61 are prepared in advance. For performing die bonding operation, a lead frame holding body corresponding to the lead frame is selected and attached to a holding body holder 70. Note that, for convenience of description, only two types of lead frame holding bodies of the lead frame holding body 50 and the lead frame holding body 60 are illustrated in Fig. 14, but the lead frame holding bodies that can be attached to the die bonder are not limited to these two types.

[0133] Fig. 15 illustrates a state in which the lead frame holding body 50 is attached to the holding body holder 70 and the lead frame 51 is chucked to the lead frame holding body 50. Note that, a large number of islands 52 for bonding semiconductor elements are arranged on the lead frame 51.

[0134] The lead frame holding body 50 includes a suction path 53 for sucking the lead frame 51, a concave portion 72a, a concave portion 72b, and a concave portion 72c, which are formed in a base body formed from a ferromagnetic material. The suction path 53 penetrates the base body in the Z direction, and an upper end of the suction path 53 is a suction hole for sucking the lead frame 51.

[0135] The holding body holder 70 includes the convex portion 71a, a convex portion 71b, the convex portion 71c, a magnet 74, and position regulation portions 77, which are integrated. The holding body holder 70 includes a suction path 73 penetrating the inside, and the suction path 73 is connected to a negative pressure applying mechanism (vacuum pump, control valve, or the like) (not illustrated).

[0136] The concave portion 72a, the concave portion 72b, and the concave portion 72c of the lead frame holding body 50 and the convex portion 71a, the convex portion 71b, and the convex portion 71c of the holding body holder 70 act as positioning mechanisms that can be fitted to each other. That is, as illustrated in Fig. 15, the holding body holder 70 can hold the lead frame holding body 50 without rattling because the holding body holder 70 and the lead frame holding body 50 are fitted and restrained with each other in a case where the lead frame holding body 50 is held by the holding body holder 70. In the present embodiment, three sets of a convex portion, a concave portion, and position regulation portions are provided, but an appropriate number of pairs can be provided at appropriate positions in consideration of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like.

[0137] The convex portion 71a to the convex portion 71c, the concave portion 72a to the concave portion 72c, and position regulation portions 77a to position regulation portions 77c of the present embodiment form fitting mechanisms similar to the convex portion 102a to the convex portion 102c, the concave portion 112a to the concave portion 112c, and the position regulation portions 117a to the position regulation portions 117c of the first embodiment.

That is, the top portions of the convex portion 71a to the convex portion 71c are connected to tapered surfaces, and the maximum outer diameters of the body portions of the convex portion 71a to the convex portion 71c in a state in which fitting is not performed are set to be larger than the inner diameters of the concave portion 72a to the concave portion 72c. Furthermore, since tapered surfaces 78 connected to flat surfaces at the tips are also provided in the position regulation portions 77, a positional shift between the position regulation portions 77 and the lead frame holding body 50 can be absorbed.

As a result, even if the positions of a convex portion and a concave portion are slightly misaligned in a case where the lead frame holding body 50 is attached to the holding body holder 70, alignment is automatically performed by the action of the fitting mechanisms, and thus attaching can be performed without requiring an excessive burden for alignment operation. Furthermore, the deformation amount of the convex portion 71 falls within a range in which the

convex portion 71 is elastically deformable by the position regulation portions 77, and thus, even if an unexpected external force acts on the convex portion 71, the fitting function can be prevented from being impaired.

[0138] In a case where the lead frame holding body 50 is attached to the holding body holder 70, the base body of the lead frame holding body 50 receives an attractive force by a magnetic force of the magnet 74, and the lead frame holding body 50 is detachably held by the holding body holder 70. Note that, in the present embodiment, a mechanism for detachable holding using a magnetic force is not limited to this configuration, and, for example, the magnet may be included in the lead frame holding body, and the holding body holder may be formed from a ferromagnetic material. Alternatively, a first magnet may be included in one of the lead frame holding body and the holding body holder, a second magnet may be included in the other, and the first magnet and the second magnet may be arranged such that magnetic poles opposite to each other face each other.

[0139] The strength of the holding force of the holding body holder 70 for holding the lead frame holding body 50 is set to such a degree that the lead frame holding body 50 can be stably held during bonding operation, but an excessive external force does not need to be applied in a case where the lead frame holding body 50 is removed. Furthermore, a magnet having a magnetic force according to the setting is used. The reason is to facilitate attachment and detachment work for replacing the lead frame holding body 50, and to prevent occurrence of unexpected breakage due to an excessive external force. Note that a permanent magnet is used as the magnet 74, but an electromagnet may be used as long as it can be mounted.

[0140] As illustrated in Fig. 15, in the lead frame holding mechanism of the present embodiment, a flexible member 75 formed from an elastic material is arranged between the lead frame holding body 50 and the holding body holder 70. In the example of Fig. 15, the flexible member 75 is fixed to a concave portion of the holding body holder 70, but may be fixed to the lead frame holding body 50, or may be clamped between the holding body holder 70 and the lead frame holding body 50 without being fixed to the holding body holder 70 or the lead frame

holding body 50.

[0141] The flexible member 75 is an annular member, and has a circular shape surrounding the periphery of the suction path 53 of the lead frame holding body 50 and the periphery of the suction path 73 of the holding body holder 70 in plan view from the Z direction. Note that the shape of the annulus in plan view is not limited to a circle, and may be an annulus of another shape, but a circle is preferable from the viewpoint of stability and reproducibility of elastic deformation.

[0142] The flexible member 75 is elastically deformed so as to be in close contact with both the lower end surface of the lead frame holding body 50 and the upper end surface of the holding body holder 70 in a case where the lead frame holding body 50 is held by the holding body holder 70 using the holding force of the degree described above. In other words, the flexible member 75 is formed from an elastic material that can be elastically deformed using the holding force of the degree described above and can airtightly connect the suction path 53 and the suction path 73 (connect them to seal the atmosphere out). The flexible member 75 can include, for example, any material of rubber, porous resin, or magnetic fluid.

[0143] As illustrated in Fig. 15, for holding a lead frame (workpiece) using the lead frame holding body 50, the suction paths are vacuumed and chucking is performed at the suction hole. In the present embodiment, since the flexible member 75 that is elastically deformable is interposed, airtightness of the suction paths is excellent. In the present embodiment, the flexible member 75 is elastically deformed by a holding force of a holding mechanism using a magnetic force, and is in close contact with both the lead frame holding body and the holding body holder to connect the suction paths, so that the attachment adjustment of the lead frame holding body does not need to be repeatedly performed. Moreover, in the present embodiment, since the relative positions of the lead frame holding body and the holding body holder are fixed by the positioning mechanisms described above, an unexpected twist, which leads to occurrence of leakage, does not occur in the flexible member 75 after the lead frame holding body is attached. If the flexible member is used as in the present embodiment, airtightness at the time of vacuuming

can be particularly excellent.

[0144] As described above, according to the present embodiment, even if the positions of a convex portion and a concave portion of the fitting mechanisms are slightly misaligned, alignment is automatically performed, and thus the lead frame holding body can be attached to the holding body holder without requiring an excessive burden for alignment operation. Since the fitting mechanisms of the present embodiment are not a part of the airtight sealing surfaces of the suction paths, leakage does not occur in the suction paths even if the tapered surface of the convex portion slides on the edge or the inner surface of the concave portion and is worn during fitting. Furthermore, even if an unexpected external force acts, the function of elastic deformation important for positioning is not impaired.

[0145]

[Third Embodiment]

(Chucking Mechanism)

Next, a chucking mechanism for picking up a semiconductor chip as a workpiece will be described with reference to Figs. 22 to 25. Note that, in the die bonder of the present embodiment, a dedicated collet is prepared for each type of workpiece (semiconductor chip), and a collet corresponding to the workpiece for bonding is selected and attached to the collet holder to form a chucking mechanism. Note that detailed description of parts common to the first embodiment will be omitted as much as possible.

[0146] Fig. 22 is a perspective view of the chucking mechanism, and the chucking mechanism includes a collet 921, a collet holder 922, and a bonding arm 923. The collet holder 922 detachably holds the collet 921, and Fig. 22 illustrates a state in which the collet 921 is detached from the collet holder 922.

[0147] The bonding arm 923 includes a Z-direction actuator 9121 for moving the collet 921 and the collet holder 922 in the Z-direction. The Z-direction actuator 9121 can perform moving operation in the Z direction and pressing load feedback control for bonding under the control of a control unit. For performing operation such as pickup, placing, and bonding of a semiconductor

chip 911, the Z-direction actuator 9121 is operated to raise and lower the collet. At this time, the operation of the Z-direction actuator is controlled by the pressing load feedback so that a force equal to or greater than a predetermined load is not applied and the semiconductor chip 911 is not deformed or damaged.

[0148] Fig. 23 is a schematic cross-sectional view obtained by cutting the collet 921 and the collet holder 922 along a bending line B-B illustrated in Fig. 22, that is, a route passing through a convex portion 9102c, a suction path 9108, and a convex portion 9102a. Fig. 25 is a top view of the collet 921 and the collet holder 922 as viewed from the Z direction.

[0149] The collet 921 includes, as components, a collet base 9103, the convex portion 9102a, a convex portion 9102b, the convex portion 9102c, a bearing surface 9104a, a bearing surface 9104b, a bearing surface 9104c, and a workpiece chucking portion 9106, which are integrated. The collet 921 includes the suction path 9108 penetrating the inside, and a suction hole 9109 for sucking a semiconductor chip 911 is arranged at the lower end of the suction path 9108.

[0150] The collet holder 922 includes, as components, a concave portion 9112a, a concave portion 9112b, a concave portion 9112c, a magnet 9113, a bearing surface 9114a, a bearing surface 9114b, and a bearing surface 9114c, which are integrated. The collet holder 922 includes a suction path 9116 penetrating the inside, and the suction path 9116 is connected to a negative pressure applying mechanism (vacuum pump, control valve, or the like) (not illustrated).

[0151] The magnet 9113 of the collet holder 922 and the collet base 9103 are arranged to face each other, and the collet base 9103 is formed from a ferromagnetic material. For attaching the collet 921 to the collet holder 922, the collet base 9103 is attracted by a magnetic force of the magnet 9113, and the collet 921 is detachably held by the collet holder 922. Note that, in the present embodiment, a mechanism for detachably holding the collet using a magnetic force is not limited to this configuration, and, for example, the magnet may be included in the collet, and the collet holder may be formed from a ferromagnetic material. Alternatively, a first magnet may be included in one of the collet and the collet holder, a second magnet may be included in the other, and the first magnet and the second magnet may be arranged such that opposite magnetic

poles face each other.

[0152] The strength of a holding force for holding the collet by the collet holder is set to such an extent that the collet can be stably held during a series of bonding operation, but an excessive external force does not need to be applied for removing the collet, and a magnet having a magnetic force according to the setting is used. The reason is to facilitate attachment and detachment work for replacing the collet, and to prevent occurrence of unexpected breakage due to an excessive external force.

[0153] As illustrated in Fig. 25, the magnet 9113 is symmetrically arranged so as to surround the periphery of the suction path 9116 so that a necessary holding force is uniformly applied to each portion of the collet and the collet holder. However, as long as a necessary holding force is uniformly applied, the magnet may be arranged by other method. Note that a permanent magnet is used as the magnet 9113, but an electromagnet may be used as long as it can be mounted.

[0154] In the chucking mechanism of the present embodiment, a flexible member 9115 that is elastic deformable is arranged between the collet 921 and the collet holder 922. In the example of Fig. 23, the flexible member 9115 is fixed to a concave portion of the collet holder 922, but may be fixed to the collet 921, or may be clamped between the collet holder 922 and the collet 921 without being fixed to the collet holder 922 or the collet 921.

[0155] As illustrated in Fig. 25, the flexible member 9115 is an annular member, and has a circular shape surrounding the periphery of the suction path 9108 of the collet 921 and the periphery of the suction path 9116 of the collet holder 922 in plan view from the Z direction. Note that the shape of the annulus in plan view is not limited to a circle, and may be an annulus of another shape, but a symmetrical shape is preferable from the viewpoint of stability and reproducibility of elastic deformation, and in particular, a circle is preferable.

[0156] The flexible member 9115 is elastically deformed so as to be in close contact with both the upper end surface of the collet 921 and the lower end surface of the collet holder 922 in a case where the collet 921 is held by the collet holder 922 using a holding force of a degree in which an excessive external force is not required for removal. In other words, the flexible

member 9115 is formed from a material that can be easily elastically deformed using the holding force of the degree described above and can airtightly connect the suction path 9108 and the suction path 9116 (connect them to seal the atmosphere out). Therefore, the flexible member 9115 can include, for example, any material of rubber, porous resin, or magnetic fluid. Preferably, the annular flexible member 9115 is arranged concentrically around the suction path 9116. The reason is because the flexible member 9115 can be elastically deformed uniformly in the suction direction even using a weak suction force.

[0157]

(Method for Attaching Collet)

Next, a method for attaching the collet 921 to the collet holder 922 will be described with reference to Figs. 24A to 24C, and 25.

Figs. 24A to 24C are schematic cross-sectional views obtained by cutting the collet 921 and the collet holder 922 along the bending line B-B illustrated in Fig. 22, that is, the route passing through the convex portion 9102c, the suction path 9108, and the convex portion 9102a. For the sake of convenience of illustration, the dimensions and shapes of respective portions are illustrated in unequal scale.

Fig. 24A illustrates a state before the collet 921 is attached to the collet holder 922, and Fig. 24B illustrates a state in which the collet 921 is attached to (held by) the collet holder 922. Fig. 24C illustrates a state in which the collet 921 held by the collet holder 922 chucks a semiconductor chip 911.

[0158] The convex portion 9102a, the convex portion 9102b, and the convex portion 9102c of the collet 921 and the concave portion 9112a, the concave portion 9112b, and the concave portion 9112c of the collet holder 922 act as positioning mechanisms that can be fitted to each other. That is, as illustrated in Fig. 24B, the collet holder 922 can hold the collet 921 without rattling because the collet holder 922 and the collet 921 are fitted and restrained with each other for holding the collet 921. In the present embodiment, three pairs of a convex portion and a concave portion are provided, but an appropriate number of pairs can be provided in consideration

of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like. However, in order to stabilize the orientation at the time of holding, the positioning mechanisms are desirably arranged symmetrically around a suction path.

[0159] The magnet 9113 (magnet) included in the collet holder 922 and the collet base 9103 (ferromagnetic material) included in the collet 921 act as holding means for detachably holding the collet in the collet holder by a magnetic force. That is, in response to the collet 921 being aligned and brought close to the collet holder 922, the collet base 9103 is attracted by a magnetic force of the magnet 9113, and the collet 921 is held by the collet holder 922. For replacing the collet, the collet can be detached from the collet holder by an external force larger than an attractive force of the magnet (holding force of the holding means) being applied.

[0160] The attractive force of the magnet (holding force of the holding means) needs to be set to a strength strong enough to prevent the collet from rattling due to weight or an inertial force in response to sucking, picking up, and conveying a semiconductor chip 911 (workpiece) as illustrated in Fig. 24C. However, a stronger attractive force of the magnet (holding force of the holding means) is not necessarily better, and the attractive force is preferably set to a range in which an excessively large external force is not required for removing the collet from the collet base.

[0161] As illustrated in Fig. 24B, the positional relationship between the magnet 9113 and the collet base 9103 is desirably set such that the magnet 9113 and the collet base 9103 face each other with a minute interval therebetween in a case where the collet holder 922 holds the collet 921. The reason is because if the magnet 9113 and the collet base 9103 are brought in the positional relationship in which they are in contact with each other, the magnet 9113 may be worn in response to attaching and detaching of the collet.

[0162] Therefore, in a case where the collet is attached, the lower surface of the collet holder 922 and the upper surface of the collet base 9103 are separated by a distance L2 as illustrated in Fig. 24B. By the distance L2 being secured as clearance, a positional relationship in which the magnet 9113 and the collet base 9103 do not contact each other can be implemented. In order

to secure the distance L2, the bearing surface 9104a, the bearing surface 9104b, and the bearing surface 9104c of the collet 921 are provided at positions higher than the upper surface of the collet base 9103. At the time of attaching, the bearing surface 9104a, the bearing surface 9104b, and the bearing surface 9104c of the collet 921 are brought in contact with the bearing surface 9114a, the bearing surface 9114b, and the bearing surface 9114c of the collet holder 922.

[0163] Note that, in the present embodiment, as illustrated in Figs. 22 and 25, three pairs of a collet side bearing surface and a collet holder side bearing surface are arranged so as to be equiangular and equidistant around the suction paths. However, the embodiment of the present invention is not limited thereto, and an appropriate number and shape of collet side bearing surfaces and collet holder side bearing surfaces can be provided in consideration of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like. Furthermore, in order to secure the distance L2, in the present embodiment, the bearing surface 9104a to the bearing surface 9104c protrude from the upper surface of the collet base 9103, but the bearing surface 9114a to the bearing surface 9114c of the collet holder 922 may protrude from the lower surface of the collet holder 922. Furthermore, the bearing surfaces do not need to be installed in the vicinity of the positioning mechanisms (convex portion 9102a to convex portion 9102c, and concave portion 9112a to concave portion 9112c), and may be arranged at distant positions.

[0164] Next, the flexible member 9115 will be described. The flexible member 9115 is a member for airtightly connecting the suction hole 9109 of the collet 921 (suction path 9108) and the suction path 9116 of the collet holder 922 in a case where the collet 921 is held by the collet holder 922 by a magnetic force.

[0165] The flexible member 9115 of the present embodiment includes a base portion fitted with an annular groove provided in the collet holder 922 and an annular inclined surface having one end connected to the base portion so as to be inclined with respect to the Z direction. The direction in which the annular inclined surface is inclined is set such that the tip of the circle opens toward the collet, that is, as illustrated in Fig. 24B, an inner diameter D1 (circle diameter) on the side in contact with the collet is larger than an inner diameter D2 (circle diameter) on the collet

holder side. In other words, the annular inclined surface is inclined in a direction in which the inner diameter D2 on the side connected to the base portion (collet base side in the example of Fig. 24B) is small and the inner diameter D1 on the opposite tip side not connected to the base portion is large.

[0166] In a case where the collet is not attached to the collet holder 922, as illustrated in Fig. 24A, the collet 921 protrudes from the lower surface of the collet holder 922 by L1 in the Z direction. Here, L1 is set to be larger than L2 described above.

[0167] In response to attaching the collet 921 to the collet holder 922, as illustrated in Fig. 24B, the flexible member 9115 is elastically deformed by a holding force of the holding means. That is, the inclined surface protrudes from the lower surface of the collet holder 922 by L2 in the Z direction, and the lower end thereof is deformed so as to be brought in close contact with the upper surface of the collet base 9103. Furthermore, the upper surface of the flexible member 9115 is brought in close contact with the collet holder 922 by a holding force of the holding means. As a result of the elastic deformation, the inclination of the inclined surface with respect to the Z direction is larger, and the inner diameter D1 is larger than before the collet 921 is attached.

[0168] The flexible member 9115 in close contact with both the collet holder 922 and the collet 921 forms an airtight connection portion that connects the suction path 9116 (suction hole 9109) of the collet 921 and the suction path 9116 of the collet holder 922 to seal the atmosphere out.

[0169] As illustrated in Fig. 24C, for holding a semiconductor chip 911 (workpiece) using the collet 921, the suction paths are vacuumed and chucking is performed at the suction hole 9109. In the present embodiment, since the flexible member 9115 that is elastically deformable is interposed, airtightness of the suction paths is excellent. In a conventional method in which a collet and a collet holder that are rigid are directly brought in contact with each other to connect suction paths, air leakage may occur from a minute gap, and attachment adjustment needs to be repeatedly performed for attaching the collet. On the other hand, in the present embodiment, the flexible member 9115 is elastically deformed by a holding force of the holding mechanism using

a magnetic force, and is in close contact with both the collet and the collet holder to connect the suction paths, so that the attachment adjustment of the collet does not need to be repeatedly performed. Moreover, in the present embodiment, since the relative positions of the collet and the collet holder are fixed by the positioning mechanisms described above, an unexpected twist, which leads to occurrence of leakage, does not occur in the flexible member 9115 after the collet is attached. Furthermore, according to the present embodiment, occurrence of leakage can be suppressed by using a small and lightweight structure. The small and lightweight structure enables performance of advanced position control.

[0170] Note that, for carrying out the present invention, for example, a donut-shaped flexible member having a circular cut surface can also be used. However, in the present embodiment, since the flexible member 9115 includes the base portion and the inclined surface as described above, the sealing property at the time of vacuuming the suction paths can be particularly excellent. That is, due to the pressure difference between the inside and the outside generated at the time of vacuuming the suction paths, the upper surface and the side surface of the base portion are more strongly pressed against the groove of the collet holder, and the tip of the inclined surface opposite to the base portion is more strongly pressed against the upper surface of the collet. As described above, in the flexible member of the present embodiment, not only the flexible member is in close contact by a holding force by a magnetic force, but also the pressure of the atmosphere acts such that airtightness is further improved, so that the sealing property at the time of vacuuming is particularly excellent.

[0171]

[Fourth Embodiment]

A fourth embodiment of the present invention will be described with reference to the drawings. However, detailed description of parts common to the third embodiment will be omitted as much as possible.

A die bonder according to the fourth embodiment also includes elements of a wafer support device, a collet, a collet holder, a bonding arm, a conveyance portion, a supply portion camera, an

island portion camera, a control unit, and the like. In the die bonder according to the fourth embodiment, a chucking mechanism that picks up a semiconductor chip may have a configuration similar to or different from that of the third embodiment, but a lead frame holding mechanism that holds a lead frame has a configuration different from that of the third embodiment.

[0172] In the lead frame holding mechanism of the third embodiment, a lead frame holding body 940 includes a rail portion 940b so that the position of a lead frame 941 can be regulated. However, since a certain degree of clearance needs to be secured in consideration of the dimensional tolerance of lead frames, the position of the lead frame 941 may slightly fluctuate.

[0173] Therefore, in the fourth embodiment, a lead frame is chucked by suction holes being provided in a lead frame holding body so that the lead frame can be easily held without rattling. Furthermore, the lead frame holding body is held by a holding body holder by a magnetic force, and a suction path of the lead frame holding body and a suction path of the holding body are connected by a flexible member that can be airtightly connected. For replacing the lead frame holding body according to the type of the lead frame to be handled, a lead frame holding body can be attached to the holding body holder while leakage is eliminated without requiring an excessive burden for attachment adjustment work.

[0174] That is, the die bonder according to the fourth embodiment is a semiconductor manufacturing apparatus in which a holding body holder (tool holder) detachably holds a lead frame holding body (tool) configured to chuck a lead frame (workpiece) by a magnetic force, and includes a flexible member by which suction paths can be airtightly connected.

[0175] In the die bonder according to the fourth embodiment, a dedicated lead frame holding body is prepared for each type of lead frames. For performing bonding, a lead frame holding body corresponding to the type of the lead frame is selected and attached to the holding body holder to form a lead frame holding mechanism.

[0176] Fig. 26 is a schematic plan view for describing that the holding body holder of the die bonder according to the fourth embodiment can hold the lead frame holding body of a plurality of forms. Fig. 27 schematically illustrates a cross section of the lead frame holding mechanism

of the second embodiment, and is a YZ cross-sectional view taken along a line passing through a convex portion 971a and a convex portion 971c illustrated in Fig. 26.

[0177] Fig. 26 schematically illustrates a large-sized lead frame 951 and a small-sized lead frame 961 handled by the die bonder of the present embodiment. A lead frame holding body 950 dedicated to the large-sized lead frame 951 and a lead frame holding body 960 dedicated to the small-sized lead frame 961 are prepared in advance. For performing die bonding operation, a lead frame holding body corresponding to the lead frame is selected and attached to a holding body holder 970. Note that, for convenience of description, only two types of lead frame holding bodies of the lead frame holding body 950 and the lead frame holding body 960 are illustrated in Fig. 26, but the lead frame holding bodies that can be attached to the die bonder are not limited to these two types.

[0178] Fig. 27 illustrates a state in which the lead frame holding body 950 is attached to the holding body holder 970 and the lead frame 951 is chucked to the lead frame holding body 950. Note that, a large number of islands 952 for bonding semiconductor elements are arranged on the lead frame 951.

[0179] The lead frame holding body 950 includes a suction path 953 for sucking the lead frame 951, a concave portion 972a, a concave portion 972b, and a concave portion 972c, which are formed in a base body formed from a ferromagnetic material. The suction path 953 penetrates the base body in the Z direction, and an upper end of the suction path 953 is a suction hole for sucking the lead frame 951.

[0180] The holding body holder 970 includes the convex portion 971a, a convex portion 971b, the convex portion 971c, and a magnet 974, which are integrated. The holding body holder 970 includes a suction path 973 penetrating the inside, and the suction path 973 is connected to a negative pressure applying mechanism (vacuum pump, control valve, or the like) (not illustrated).

[0181] The concave portion 972a, the concave portion 972b, and the concave portion 972c of the lead frame holding body 950 and the convex portion 971a, the convex portion 971b, and the convex portion 971c of the holding body holder 970 act as positioning mechanisms that can

be fitted to each other. That is, as illustrated in Fig. 27, the holding body holder 970 can hold the lead frame holding body 950 without rattling because the holding body holder 970 and the lead frame holding body 950 are fitted and restrained with each other in a case where the lead frame holding body 950 is held by the holding body holder 970. In the present embodiment, three pairs of a convex portion and a concave portion are provided, but an appropriate number of pairs can be provided at appropriate positions in consideration of positioning accuracy, mechanical strength, space margin, manufacturing cost, and the like.

[0182] In a case where the lead frame holding body 950 is attached to the holding body holder 970, the base body of the lead frame holding body 950 receives an attractive force by a magnetic force of the magnet 974, and the lead frame holding body 950 is detachably held by the holding body holder 970. Note that, in the present embodiment, a mechanism for detachable holding using a magnetic force is not limited to this configuration, and, for example, the magnet may be included in the lead frame holding body, and the holding body holder may be formed from a ferromagnetic material. Alternatively, a first magnet may be included in one of the lead frame holding body and the holding body holder, a second magnet may be included in the other, and the first magnet and the second magnet may be arranged such that magnetic poles opposite to each other face each other.

[0183] The strength of the holding force of the holding body holder 970 for holding the lead frame holding body 950 is set to such a degree that the lead frame holding body 950 can be stably held during bonding operation, but an excessive external force does not need to be applied in a case where the lead frame holding body 950 is removed. Furthermore, a magnet having a magnetic force according to the setting is used. The reason is to facilitate attachment and detachment work for replacing the lead frame holding body 950, and to prevent occurrence of unexpected breakage due to an excessive external force. Note that a permanent magnet is used as the magnet 974, but an electromagnet may be used as long as it can be mounted.

[0184] As illustrated in Fig. 27, in the lead frame holding mechanism of the present embodiment, a flexible member 975 formed from an elastic material is arranged between the lead

frame holding body 950 and the holding body holder 970. In the example of Fig. 27, the flexible member 975 is fixed to a concave portion of the holding body holder 970, but may be fixed to the lead frame holding body 950, or may be clamped between the holding body holder 970 and the lead frame holding body 950 without being fixed to the holding body holder 970 or the lead frame holding body 950.

[0185] The flexible member 975 is an annular member, and has a circular shape surrounding the periphery of the suction path 953 of the lead frame holding body 950 and the periphery of the suction path 973 of the holding body holder 970 in plan view from the Z direction. Note that the shape of the annulus in plan view is not limited to a circle, and may be an annulus of another shape, but a circle is preferable from the viewpoint of stability and reproducibility of elastic deformation.

[0186] The flexible member 975 is elastically deformed so as to be in close contact with both the lower end surface of the lead frame holding body 950 and the upper end surface of the holding body holder 970 in a case where the lead frame holding body 950 is held by the holding body holder 970 using the holding force of the degree described above. In other words, the flexible member 975 is formed from an elastic material that can be elastically deformed using the holding force of the degree described above and can airtightly connect the suction path 953 and the suction path 973 (connect them to seal the atmosphere out). The flexible member 975 can include, for example, any material of rubber, porous resin, or magnetic fluid.

[0187] As illustrated in Fig. 27, for holding a lead frame (workpiece) using the lead frame holding body 950, the suction paths are vacuumed and chucking is performed at the suction hole. In the present embodiment, since the flexible member 975 that is elastically deformable is interposed, airtightness of the suction paths is excellent. In the present embodiment, the flexible member 975 is elastically deformed by a holding force of the holding mechanism using a magnetic force, and is in close contact with both the lead frame holding body and the holding body holder to connect the suction paths, so that the attachment adjustment of the lead frame holding body does not need to be repeatedly performed. Moreover, in the present embodiment,

since the relative positions of the lead frame holding body and the holding body holder are fixed by the positioning mechanisms described above, an unexpected twist, which leads to occurrence of leakage, does not occur in the flexible member 975 after the lead frame holding body is attached. If the flexible member is used as in the present embodiment, airtightness at the time of vacuuming can be particularly excellent.

[0188]

[Other Embodiments]

Note that the present invention is not limited to the above-described embodiments and modifications, and many modifications can be made within the technical idea of the present invention. Furthermore, the effects described in the embodiments merely enumerate the most suitable effects resulting from the present invention, and the effects according to the present invention are not limited to those described in the embodiments.

For example, the die bonder may include both the chucking mechanism of a semiconductor element as in the first embodiment and the chucking mechanism of a lead frame as in the second embodiment. Furthermore, for example, the die bonder may include both the chucking mechanism of a semiconductor element as in the third embodiment and the chucking mechanism of a lead frame as in the fourth embodiment.

[0189] Furthermore, in the first embodiment, as positioning mechanisms that define the relative positions of the collet and the collet holder, the collet includes the convex portions and the collet holder includes the concave portions, but on the contrary, the collet may include the concave portions and the collet holder may include the convex portions. Alternatively, the convex portions and the concave portions may be arranged on both the collet and the collet holder. The position regulation portions may be arranged on either or both of the collet and the collet holder according to the arrangement of the convex portions and the concave portions.

[0190] Furthermore, in the second embodiment, as the positioning mechanisms that define the relative positions of the lead frame holding body and the holding body holder, the holding body holder includes the convex portions and the lead frame holding body includes the concave

portions, but on the contrary, the holding body holder may include the concave portions and the lead frame holding body may include the convex portions. Alternatively, the convex portions and the concave portions may be arranged on both the lead frame holding body and the holding body holder. The position regulation portions may be arranged on either or both of the lead fram holding body and the holding body holder according to the arrangement of the convex portions and the concave portions.

[0191] Furthermore, in the embodiment, the tapered surfaces are included in the convex portions formed from an elastic material, but the tapered surfaces may be included in the concave portions. That is, as long as sliding surfaces acting in a direction in which misalignment is eliminated in a case where the convex portions are inserted into the concave portions can be formed, the tapered surfaces can be included only in the convex portions, only in the concave portions, or both of them.

[0192] Furthermore, in the third embodiment, as positioning mechanisms that define the relative positions of the collet and the collet holder, the collet includes the convex portions and the collet holder includes the concave portions, but on the contrary, the collet may include the concave portions and the collet holder may include the convex portions.

[0193] Furthermore, in the fourth embodiment, as the positioning mechanisms that define the relative positions of the lead frame holding body and the holding body holder, the holding body holder includes the convex portions and the lead frame holding body includes the concave portions, but on the contrary, the holding body holder may include the concave portions and the lead frame holding body may include the convex portions.

[0194] Furthermore, a workpiece chucked by the collet is not limited to a semiconductor element (semiconductor chip), and may be an electronic component such as a resistive element or a condenser. The die bonder according to the present invention can be widely used in a method for manufacturing an article that mounts an electronic component or the like on a circuit board or the like, in addition to a method for manufacturing a semiconductor in which semiconductor chips are die-bonded.

Industrial Applicability

[0195] The present invention can be widely implemented in an apparatus for die-bonding a semiconductor chip, an apparatus that mounts an electronic component or the like on a circuit board or the like, and the like.

The present invention is not limited to the above embodiments, and various changes and modifications can be made without departing from the spirit and scope of the present invention. Therefore, in order to make the scope of the present invention public, the following claims are attached.

Reference Signs List

[0196]

11 Semiconductor chip

14 Wafer support device

21 Collet

22 Collet holder

24 Conveyance portion

40 Lead frame holding body

41 Lead frame

50 Lead frame holding body

51 Lead frame

53 Suction path

60 Lead frame holding body

61 Lead frame

70 Holding body holder

71a, 71b, 71c Convex portion

72a, 72b, 72c Concave portion

73 Suction path

74 Magnet

75 Flexible member

77 Position regulation portion

100 Die bonder

102a, 102b, 102c Convex portion

103 Collet base

105a, 105b, 105c Slit

105k Groove

107 Tapered surface

108 Suction path

109 Suction hole

112a, 112b, 112c Concave portion

113 Magnet

115 Flexible member

116 Suction path

117a, 117b, 117c Position regulation portion

118 Tapered surface

200 Control unit

Claims

1. A chucking mechanism comprising:

a tool configured to chuck a workpiece by suction;

a tool holder comprising a suction path; and

a positioning portion that positions a relative position of the tool with respect to the tool holder in a case where the tool holder holds the tool,

wherein the positioning portion comprises:

at least one convex portion arranged on one of the tool and the tool holder, the at least one convex portion being formed from an elastic material and comprising a tapered surface; and

at least one concave portion arranged on the other of the tool and the tool holder and configured to fit the convex portion.

2. The chucking mechanism according to claim 1,

wherein a slit that extends from a top portion to a predetermined depth is formed in the convex portion, and

a length of the concave portion along a direction in which the slit extends is larger than a length of the concave portion in a direction orthogonal to the direction in plan view.

3. The chucking mechanism according to claim 2,

wherein, as for the direction orthogonal to the direction in which the slit extends in a plan view, a length of the convex portion is larger than a length of the concave portion in a state in which the convex portion is not fitted into the concave portion, and

a length of the convex portion is equal to a length of the concave portion in a state in which the convex portion is fitted into the concave portion.

4. The chucking mechanism according to claim 2 or 3,

wherein the positioning portion comprises a plurality of the convex portions and a

plurality of the concave portions, and the convex portions comprise a plurality of convex portions in which the slits extend in a same direction in plan view.

5. The chucking mechanism according to any one of claims 1 to 4, further comprising a position regulation portion that is arranged on one of the tool and the tool holder and eliminates deformation of the convex portion.

6. The chucking mechanism according to any one of claims 1 to 5,

wherein the concave portion comprises a restraining portion that restrains the convex portion in a case where the concave portion fits the convex portion.

7. The chucking mechanism according to any one of claims 1 to 6,

wherein the positioning portion is arranged at least three positions.

8. The chucking mechanism according to any one of claims 1 to 7 further comprising:

a holding means that causes the tool holder to detachably hold the tool by a magnetic force; and

a flexible member configured to airtightly connect the tool and the suction path in a case where the tool holder holds the tool by the magnetic force.

9. The chucking mechanism according to claim 8,

wherein the flexible member comprises a base portion and an inclined surface having one end connected to the base portion.

10. The chucking mechanism according to claim 9,

wherein the inclined surface is annular in plan view, and is inclined in a direction in which a circle diameter on a side connected to the base portion is small and a circle diameter on

a side not connected to the base portion is large.

11. The chucking mechanism according to any one of claims 8 to 10,

wherein the flexible member comprises any one of rubber, porous resin, or magnetic fluid.

12. The chucking mechanism according to any one of claims 8 to 11,

wherein the holding means comprises a magnet fixed to one of the tool and the tool holder and a ferromagnetic body fixed to the other.

13. The chucking mechanism according to any one of claims 8 to 11,

wherein the holding means comprises a first magnet fixed to one of the tool and the tool holder and a second magnet fixed to the other, and the first magnet and the second magnet are arranged such that different magnetic poles face each other.

14. The chucking mechanism according to any one of claims 1 to 13, wherein the workpiece is an electronic component, and the tool is a collet.

15. An article manufacturing apparatus comprising:

the chucking mechanism according to claim 14; and

a mounting target member holding portion that holds a mounting target member,

wherein the collet chucks the electronic component and places the electronic component on a predetermined position of the mounting target member.

16. A semiconductor manufacturing apparatus comprising:

the chucking mechanism according to claim 14; and

a lead frame holding body that holds a lead frame,

wherein the collet chucks a first semiconductor chip, places the first semiconductor chip on the lead frame or a second semiconductor chip mounted on the lead frame, and performs bonding.

17. The chucking mechanism according to any one of claims 1 to 13,

wherein the workpiece is a lead frame, and the tool is a lead frame holding body.

18. A semiconductor manufacturing apparatus comprising:

the chucking mechanism according to claim 17; and

a conveyance portion that conveys a first semiconductor chip,

wherein the conveyance portion conveys the first semiconductor chip, places the first semiconductor chip on the lead frame held by the lead frame holding body or a second semiconductor chip mounted on the lead frame, and performs bonding.

19. A chucking mechanism comprising:

a tool configured to chuck a workpiece by suction;

a tool holder comprising a suction path;

a holding means that causes the tool holder to detachably hold the tool by a magnetic force; and

a flexible member configured to airtightly connect the tool and the suction path in a case where the tool holder holds the tool by the magnetic force.