

0 shown in FIG. 4, in a pickup apparatus of a semiconductor die of a comparative example.

DESCRIPTION OF EMBODIMENTS

[0031] Hereinafter, a pickup apparatus 100 of a semiconductor die of an embodiment will be
5 described with reference to the drawings.

[0032] As shown in FIG. 1, the pickup apparatus 100 of a semiconductor die (hereinafter referred to as a pickup apparatus 100) of the embodiment includes a wafer holder 10, a stage 20, a collet 18, a wafer holder horizontal direction drive part 61, a stage up-down direction drive part 62, a collet drive part 63, vacuum valves 64 and 65, a vacuum device (VAC) 68, and a control part 70.

10 **[0033]** The wafer holder 10 includes an annular expanding ring 16 having a flange part and a ring retainer 17, and holds a wafer sheet 12 to which a semiconductor die 15 obtained by cutting a wafer 11 is attached on an upper surface 12a. The wafer holder 10 is moved in the horizontal direction by the wafer holder horizontal direction drive part 61.

[0034] Herein, the wafer sheet 12 to which the semiconductor die 15 is attached on the upper
15 surface 12a is held by the wafer holder 10 in the following manner. The wafer sheet 12 is attached to a back surface of the wafer 11, and a metal ring 13 is attached to an outer peripheral part of the wafer sheet 12. The wafer 11 is cut from a front surface side by a dicing saw or the like in a cutting process into each semiconductor die 15, and a gap 14 is formed between the semiconductor dies 15 during dicing. Even though the wafer 11 is cut apart, the wafer sheet 12
20 is not cut apart, and each semiconductor die 15 is held by the wafer sheet 12.

[0035] A lower surface 12b of the wafer sheet 12 to which the semiconductor die 15 is attached on the upper surface 12a is placed to be in contact with a holding surface 16a of the expanding ring 16, and is adjusted so that a position of the ring 13 is above a flange 16b of the expanding ring 16. Then, as shown by an arrow 80 in FIG. 1, the ring 13 is pressed on the flange 16b of the
25 expanding ring 16 from above by the ring retainer 17 and fixed on the flange 16b. Accordingly,

semiconductor die 154 increases toward the upper side, and the gap between the upper ends of the side surfaces of the semiconductor die 152 and the semiconductor die 154 widens to W2 which is wider than W0 described with reference to FIG. 5. Similarly, the gap between the upper ends of the side surfaces of the semiconductor die 153 and the semiconductor die 155 also widens to W2.

5 **[0054]** When the apex ~~22b~~^{20b} of the stage 20 is raised to the position of the height Z3, the lower surface 12b of the wafer sheet 12 is in contact with a portion of the curved surface of the corner part 25 on the outer side of the connecting line 25a, which is the outer peripheral end of the suction surface 22a. Since the radius R2 of this portion is smaller than the radius R1 of the suction surface 22a, a bend radius in the vicinity of the annular line 25c of the wafer sheet 12 is smaller
10 than a bend radius of the wafer sheet 12 bent along the suction surface 22a. Therefore, a spread angle of the gap between the side surfaces of the semiconductor die 152 and the adjacent semiconductor die 154 is larger than a spread angle of the gap between the side surfaces of the semiconductor die 151 and the semiconductor die 152. Therefore, the gap W2 is wider than the gap W1.

15 **[0055]** In this state, since the vacuum valve 64 is closed, the inside of the stage 20 is at atmospheric pressure, and the wafer sheet 12 is not sucked on the suction surface 22a, there is a gap between the corner part 25 on the outer peripheral side of the annular line 25c and the lower surface 12b of the wafer sheet 12. Further, as shown in FIG. 8, at this time, the height of the ridge line 25s is greater than a height 12e of the lower surface 12b of the wafer sheet 12 at the
20 position of the side surface 21a of the cylindrical part 21.

[0056] Next, the CPU 71 of the control part 70 opens the vacuum valve 64 to create a vacuum inside the stage 20. Accordingly, a vacuum is created at the opening 23 and the plurality of suction holes 24, and the lower surface 12b of the wafer sheet 12 is vacuum-sucked to the suction surface 22a (suction process).

25 **[0057]** When the apex 22b of the stage 20 is raised to the height Z3, as described with reference

Then, the side surfaces of the semiconductor die 153 attached on the wafer sheet 12 which is curved and deformed convexly downward and the adjacent semiconductor die 155 become narrower toward the upper side, and the width of the gap between the upper ends of the side surfaces is reduced from the initial width W_0 shown in FIG. 5 to W_4 which is narrower than W_0 .

5 Therefore, in the pickup apparatus 300 of a semiconductor die shown in FIG. 21, when the semiconductor dies 151 to 155 are picked up, the upper ends of the side surfaces of the semiconductor die 153 located at the peripheral edge of the stage 20 and the adjacent semiconductor die 155 may come into contact with each other, thus causing chipping or cracking. Particularly, when the initial width W_0 is narrow, there is a high possibility that chipping or
10 cracking would occur in the semiconductor dies 153 and 155.

[0064] In contrast, in the pickup apparatus 100 of the embodiment, as described above, since the wafer sheet 12 is vacuum-sucked to the suction surface 22a after the stage 20 is raised until the lower surface 12b of the wafer sheet 12 comes into contact with the spherical cap surface of the suction surface 22a and the curved surface of the corner part 25, the wafer sheet 12 remains
15 deformed convexly upward, and the wafer sheet 12 is prevented from being deformed convexly downward. Accordingly, the gap between the upper ends of the semiconductor dies 151 to 155 remains at W_1 and W_2 which are wider than the initial W_0 , and during the pickup operation, it is possible to prevent the upper ends of the side surfaces of the adjacent semiconductor dies 151 to 155 from coming into contact with each other and thus causing chipping or cracking.

20 **[0065]** In the above description, the control part 70 raises the apex 22b of the stage 20 to the height Z_3 , but the present invention is not limited thereto and the height may be Z_2 or higher; for example, after the apex 22b of the stage 20 is raised to the height Z_2 , the wafer sheet 12 may be vacuum-sucked to the suction surface 22a.

[0066] In this case, since the wafer sheet 12 does not hang on the curved surface of the corner
25 part 25, the spread angle of the gap between the side surfaces of the semiconductor die 153 and

indicating the outer peripheral end of the suction surface 122a. Further, an outer peripheral end of the corner part 125 and the side surface of the cylindrical part ~~24~~121 are connected by an annular connecting line 125b.

[0075] Herein, the inner peripheral part 122e is in a range of the suction surface 122a on an inner side of an annular line 122c between the inner suction hole 124a and the outer suction hole 124b, and is a spherical cap surface having a radius $R1$ and a central angle θ_i . The annular line 122c is an annular line which defines an outer peripheral end of the inner peripheral part 122e. Similar to the annular line 22c of the stage 20, the annular line 122c is arranged at a position where a tangential direction of the suction surface 122a at the annular line 122c is an extending direction of the lower surface 12b of the wafer sheet 12 when an apex 122b is raised to a height $Z1$.

[0076] The outer peripheral part 122f is in a range from the annular line ~~122c~~122 which is the outer peripheral end of the inner peripheral part 122e to the annular line 122d or the connecting line 125a which indicates the outer peripheral end of the suction surface 122a. The outer peripheral part 122f is a spherical segment surface having a radius $R1$ and an angle being θ_0 .

[0077] The inner suction hole 124a communicates with the inside of the cylindrical part ~~121~~21 of the stage ~~120~~20, and when the vacuum valve 64 attached to a pipe connected to the cylindrical part ~~121~~21 is opened, a vacuum is created at the inner suction hole 124a as well as the opening 123 by the vacuum device 68.

[0078] The outer suction hole 124b communicates with an outer cavity 126 surrounded by a partition wall 127 provided inside the cylindrical part ~~121~~21 of the stage ~~120~~20. When a vacuum valve 66 attached to a pipe connected to the outer cavity 126 is opened, a vacuum is created at the outer suction hole 124b by the vacuum device 68. The outer cavity 126 does not communicate with the opening 123 and the inner suction hole 124a. Therefore, by opening and closing the vacuum valves 64 and 66, the inner suction hole 124a and the outer suction hole 124b can be separately switched between a vacuum state and an atmospheric pressure state.

annular line 122c, and the gap between the upper ends of the side surfaces of the semiconductor die 152 and the adjacent semiconductor die 154 and the gap between the upper ends of the side surfaces of the semiconductor die 153 and the adjacent semiconductor die ~~155~~ 153 remain at W0.

[0086] Next, as shown in FIG. 16, the CPU 71 of the control part 70, as in the case described above with reference to FIG. 10, moves the collet 18 onto the semiconductor die 151, and vacuum-sucks the collet 18 to the semiconductor die 151. Then, the first push-up pin 31 and the second push-up pin 32 are integrally moved upward to push up the semiconductor die 151, and the collet 18 is raised in accordance with the rise of the first push-up pin 31 and the second push-up pin 32 to generate a lead for peeling between the wafer sheet 12 and the semiconductor die 151 at the peripheral edge of the semiconductor die 151.

[0087] Then, as shown in FIG. 17, the CPU 71 of the control part 70 further raises the first push-up pin 31 to push up the semiconductor die 151 and raises the collet 18 in accordance with the rise of the first push-up pin 31 to pick up the semiconductor die 151 by the collet 18 (pickup process).

[0088] As described above, the pickup apparatus 110 of the embodiment raises the apex 122b of the stage 120 to the height Z1 so that the wafer sheet 12 is in contact with the inner peripheral part 122e of the suction surface 122a, deforms the wafer sheet 12 to be convex upward along the inner peripheral part 122e, and widens the gap between the upper ends of the side surface of the semiconductor die 151 attached on the inner peripheral part 122e and the side surfaces of the adjacent semiconductor dies 152 and 153 to W1 which is wider than the initial W0. Further, the outer suction hole 124b remains at atmospheric pressure, the wafer sheet 12 located above the outer peripheral part 122f remains separated from the outer peripheral part 122f of the suction surface 122a, the gap between the upper ends of the side surfaces of the semiconductor dies 152 and 153 attached to the upper surface 12a of the wafer sheet 12 located on the upper side of the outer peripheral part 122f and the adjacent semiconductor dies 154 and 155 remains at the initial W0.

122f on the other side and the lower surface 12b of the wafer sheet 12.

[0099] In this state, as in the second pickup operation, when a vacuum is created at the inner suction hole 124a and the outer suction hole 124b, the wafer sheet 12 located with a gap opened on the outer peripheral part 122f on the other side is pulled downward and sucked on the outer peripheral part 122f. Therefore, the wafer sheet 12 is curved and deformed convexly downward at the peripheral edge of the stage 20 as in the pickup apparatus 300 of the comparative example described with reference to FIG. 21. Therefore, the upper ends of the side surfaces of the semiconductor die 152 located at the peripheral edge of the stage 20 and the adjacent semiconductor die 154 may come into contact with each other, thus causing chipping or cracking.

[0100] Therefore, in the pickup apparatus 110, when the stage 20 is deviated from the center of the expanding ring 16 and the semiconductor die 151 attached to the outer peripheral portion of the wafer sheet 12 is to be picked up, as in the first pickup operation, a vacuum may be created only at the inner suction hole 124a without creating a vacuum at the outer suction hole 124b to pick up the semiconductor die 151, and when the semiconductor die 151 attached to the central portion of the wafer sheet 12 is to be picked up, as in the second pickup operation, a vacuum may be created at the inner suction hole 124a and the outer suction hole 124b to pick up the semiconductor die 151.

[0101] Accordingly, also in the case of picking up the semiconductor die 151 attached to the peripheral portion of the wafer sheet 12, it is possible to prevent the upper ends of the side surfaces of the semiconductor die 152 located at the peripheral edge of the stage 20 and the adjacent semiconductor die 154 ~~155~~ from coming into contact with each other, thus causing chipping or cracking.

[0102] In the above description, although the suction surface 122a has been described as being divided into two parts, including the inner peripheral part 122e provided with the inner suction hole 124a and the outer peripheral part 122f provided with the outer suction hole 124b, the present

invention is not limited thereto, and for example, an intermediate part may also be provided between the inner peripheral part 122e and the outer peripheral part 122f to divide the suction surface 122a into three parts and change the region for vacuum-sucking the wafer sheet 12 according to the amount of deviation of the stage 20 from the center of the expanding ring 16.

5 **[0103]** Further, the inner peripheral part 122e provided with the inner suction hole 124a and the outer peripheral part 122f provided with the outer suction hole 124b may also be divided into a plurality of parts in the circumferential direction to change the region for vacuum-sucking the wafer sheet 12 according to the position of the center of the stage 20 with respect to the center of the expanding ring 16.

10 Reference Signs List

[0104] 10 Wafer holder; 11 Wafer; 12 Wafer sheet; 12a Upper surface; 12b Lower surface; 12f Fixing annular line; 13 Ring; 14 Gap; 15, 151 to 155 Semiconductor die; 16 Expanding ring; 18 Collet; 19 Suction hole; 20, 120 Stage; ~~20b, 120b Apex~~; 21, 121 Cylindrical part; 21a, 121a Side surface; 21c, 121c Center; 22, 122 Upper end plate; 22a, 122a Suction surface; 22b, 122b Apex; 15 22c, 25c, 122c, 122d, 125c Annular line; 22t Tangential plane; 23, 123 Opening; 24, 124 Suction hole; 25, 125 Corner part; 25a, 25b, 125a, 125b Connecting line; 25s, 125s Ridge line; 29 Moving element drive mechanism; 30 Moving element; 31 First push-up pin; 32 Second push-up pin; 61 Wafer holder horizontal direction drive part; 62 Stage up-down direction drive part; 63 Collet drive part; 64, 65, 66 Vacuum valve; 68 Vacuum device; 70 Control part; 71 CPU; 72 Memory; 20 100, 110, 300 Pickup apparatus; 122e Inner peripheral part; 122f Outer peripheral part; 124a Inner suction hole; 124b Outer suction hole; 126 Outer cavity; 127 Partition wall

CLAIMS:

[Claim 1] A pickup apparatus of a semiconductor die which picks up a semiconductor die attached to an upper surface of a wafer sheet, the pickup apparatus of a semiconductor die comprising:

5 a stage which comprises a suction surface sucking a lower surface of the wafer sheet and an opening provided in the suction surface;

 a stage drive mechanism which drives the stage in an up-down direction; and

 a moving element which is arranged in the opening of the stage and moves so that a tip of the moving element protrudes from the suction surface,

10 the pickup apparatus of a semiconductor die comprising:

 a moving element drive mechanism which drives the moving element in the up-down direction;

 a collet which picks up the semiconductor die;

 a vacuum device which creates a vacuum inside the stage; and

15 a control part which adjusts operations of the stage drive mechanism, the moving element drive mechanism, the collet, and the vacuum device,

 wherein the stage has a cylindrical shape, the suction surface is a spherical cap surface which is curved convexly upward, the opening of the stage is arranged at a center of the suction surface, and the suction surface is composed of an inner peripheral part around the opening and
20 an outer peripheral part on an outer side of the inner peripheral part, comprises, in the inner peripheral part, an inner suction hole communicating with the vacuum device, and comprises, in the outer peripheral part, an outer suction hole communicating with the vacuum device,

 the control part raises, by the stage drive mechanism, the stage until the lower surface of the wafer sheet is in contact with an outer peripheral end of the inner peripheral part of the stage
25 to push up the wafer sheet,

after pushing up the wafer sheet, the control part creates, by the vacuum device, a vacuum at the inner suction hole to suck the wafer sheet to the inner peripheral part of the suction surface, and

5 after sucking the wafer sheet to the suction surface, the control part protrudes, by the moving element drive mechanism, the moving element from the suction surface to push up the semiconductor die to be picked up from under the wafer sheet, and picks up, by the collet, the semiconductor die from the wafer sheet.

[Claim 2] The pickup apparatus of a semiconductor die according to claim 1, wherein
10 when pushing up the wafer sheet, the control part raises the stage until the lower surface of the wafer sheet is in contact with an outer peripheral end of the outer peripheral part of the stage, and

when sucking the wafer sheet, the control part creates, by the vacuum device, a vacuum at the inner suction hole and the outer suction hole to suck the wafer sheet to the inner peripheral part and the outer peripheral part of the suction surface.

15 [Claim 3] The pickup apparatus of a semiconductor die according to claim 2, wherein when pushing up the wafer sheet, the control part raises the stage until the lower surface of the wafer sheet is in contact with a corner part between a side surface in a cylindrical shape of the stage and the suction surface.

[Claim 4] The pickup apparatus of a semiconductor die according to claim 3, wherein
20 the corner part is composed of a curved surface connecting the side surface of the stage and the suction surface, and

when pushing up the wafer sheet, the control part raises the stage until a height of a ridge line between the side surface of the stage and the suction surface at the corner part is equal to or greater than a height of the lower surface of the wafer sheet at the side surface of the stage.

25 ~~[Claim 5] (Canceled)~~

[Claim 65] The pickup apparatus of a semiconductor die according to claim 2, wherein
in a case of picking up the semiconductor die attached to the upper surface of a peripheral
portion of the wafer sheet,

when pushing up the wafer sheet, the control part raises the stage until the lower surface
5 of the wafer sheet is in contact with the outer peripheral end of the inner peripheral part of the
stage, and

when sucking the wafer sheet, the control part creates, by the vacuum device, a vacuum at
the inner suction hole to suck the wafer sheet to the inner peripheral part of the suction surface,
and

10 in a case of picking up the semiconductor die attached to the upper surface of a central
portion of the wafer sheet,

when pushing up the wafer sheet, the control part raises the stage until the lower surface
of the wafer sheet is in contact with the outer peripheral end of the outer peripheral part of the
stage, and

15 when sucking the wafer sheet, the control part creates, by the vacuum device, a vacuum at
the inner suction hole and the outer suction hole to suck the wafer sheet to the inner peripheral
part and the outer peripheral part of the suction surface.

[Claim 76] The pickup apparatus of a semiconductor die according to any one of claims 1
to 4 and 65, wherein

20 the moving element is composed of: a first push-up pin arranged at a center of the stage;
and

a second push-up pin in a cylindrical shape arranged on an outer circumference of the first
push-up pin,

the moving element drive mechanism drives the first push-up pin and the second push-up
25 pin in the up-down direction, and

when picking up the semiconductor die,

after protruding, by the moving element drive mechanism, the second push-up pin from the suction surface, the control part protrudes the first push-up pin to a position higher than a tip of the second push-up pin.

5 [Claim 87] A pickup method of a semiconductor die which picks up a semiconductor die attached to an upper surface of a wafer sheet, the pickup method of a semiconductor die comprising:

a preparation process of preparing a pickup apparatus comprising: a stage which comprises a suction surface sucking a lower surface of the wafer sheet and an opening provided in the suction
10 surface; a moving element which is arranged in the opening of the stage and moves so that a tip of the moving element protrudes from the suction surface; and a collet which picks up the semiconductor die, wherein the stage has a cylindrical shape, the suction surface is a spherical cap surface which is curved convexly upward, the opening of the stage is arranged at a center of the suction surface, and the suction surface is composed of an inner peripheral part around the opening
15 and an outer peripheral part on an outer side of the inner peripheral part, comprises an inner suction hole in the inner peripheral part, and comprises an outer suction hole in the outer peripheral part;

a push-up process of raising the stage to push up the wafer sheet until the lower surface of the wafer sheet is in contact with an outer peripheral end of the inner peripheral part of the stage;

a suction process of creating, after the push-up process, a vacuum at the inner suction hole
20 to suck the wafer sheet to the inner peripheral part of the suction surface; and

a pickup process of protruding, after the suction process, the moving element from the suction surface to push up the semiconductor die to be picked up from under the wafer sheet, and picking up the semiconductor die by the collet.

[Claim 98] The pickup method of a semiconductor die according to claim 87, wherein
25 in the push-up process, the stage is raised until the lower surface of the wafer sheet is in

contact with an outer peripheral end of the outer peripheral part of the stage, and

in the suction process, a vacuum is created at the inner suction hole and the outer suction hole to suck the wafer sheet to the inner peripheral part and the outer peripheral part of the suction surface.

5 [Claim ~~109~~] The pickup method of a semiconductor die according to claim ~~98~~, wherein
in the push-up process, the stage is raised until the lower surface of the wafer sheet is in contact with a corner part between a side surface in a cylindrical shape of the stage and the suction surface.

10 [Claim ~~110~~] The pickup method of a semiconductor die according to claim ~~109~~, wherein
in the pickup apparatus of a semiconductor die prepared in the preparation process, the corner part is composed of a curved surface connecting the side surface of the stage and the suction surface, and

in the push-up process, the stage is raised until a height of a ridge line between the side surface of the stage and the suction surface at the corner part is equal to or greater than a height of
15 the lower surface of the wafer sheet at the side surface of the stage.

~~[Claim 12] (Canceled)~~

20 [Claim ~~1311~~] The pickup method of a semiconductor die according to claim ~~98~~, wherein
in a case of picking up the semiconductor die attached to the upper surface of a peripheral portion of the wafer sheet,

in the push-up process, the stage is raised until the lower surface of the wafer sheet is in contact with the outer peripheral end of the inner peripheral part of the stage, and

in the suction process, a vacuum is created at the inner suction hole to suck the wafer sheet to the inner peripheral part of the suction surface, and

25 in a case of picking up the semiconductor die attached to the upper surface of a central portion of the wafer sheet,

in the push-up process, the stage is raised until the lower surface of the wafer sheet is in contact with the outer peripheral end of the outer peripheral part of the stage, and

in the suction process, a vacuum is created at the inner suction hole and the outer suction hole to suck the wafer sheet to the inner peripheral part and the outer peripheral part of the suction surface.

[Claim ~~14~~12] The pickup method of a semiconductor die according to any one of claims ~~87~~ to ~~11~~ and ~~13~~, wherein

in the pickup apparatus of a semiconductor die prepared in the preparation process, the moving element is composed of a first push-up pin arranged at a center of the stage and a second push-up pin in a cylindrical shape arranged on an outer circumference of the first push-up pin, and

in the pickup process, after the second push-up pin is protruded from the suction surface, the first push-up pin is protruded to a position higher than a tip of the second push-up pin, and the semiconductor die is picked up by the collet.