SEMICONDUCTOR DIE PICKUP SYSTEM

BACKGROUND

Technical Field

[0001] The present invention relates to a semiconductor die pickup system used in a bonding apparatus (bonding system).

Related Art

[0002] A semiconductor die is manufactured by cutting a 6-inch or 8-inch wafer into a predetermined size. A dicing sheet is attached to the back surface of the wafer and the wafer is cut from the front surface side by a dicing saw or the like so that the cut semiconductor dies are not separated during the cutting. At this time, the dicing sheet attached to the back surface is cut slightly but not cut off, and holds each semiconductor die. Then, the cut semiconductor dies are picked up one by one from the dicing sheet and sent to the next step such as die bonding.

[0003] As a method for picking up the semiconductor die from the dicing sheet, a method has been proposed in which while the dicing sheet is adsorbed on the front surface of a disk-shaped adsorption piece and the semiconductor die is adsorbed to a collet, the semiconductor die is pushed up by a push-up block disposed in the central portion of the adsorption piece, and the collet is raised to pick up the semiconductor die from the dicing sheet (for example, see FIGS. 9 to 23 in patent literature 1). When the semiconductor die is released from the dicing sheet, it is effective to first release the peripheral portion of the semiconductor die and then release the central portion of the semiconductor die. Therefore, in the conventional technique described in patent literature 1, a method is

adopted in which there are three push-up blocks in which one pushes up the peripheral portion of the semiconductor die, one pushes up the center of the semiconductor die, and one pushes up the middle thereof. Initially the three blocks are raised to a predetermined height, then the middle and center blocks are raised higher than the peripheral block, and finally the center block is raised higher than the middle block.

[0004] In addition, a method has also been proposed, in which while the dicing sheet is adsorbed on the front surface of a disk-shaped ejector cap and the semiconductor die is adsorbed to a collet, the collet and each of the peripheral, middle, and center push-up blocks are raised to a predetermined height higher than the front surface of the ejector cap, and then the height of the collet is maintained at this height, the push-up blocks are descended to positions below the front surface of the ejector cap in the order of the peripheral push-up block and the middle push-up block, to release the dicing sheet from the semiconductor die (for example, see patent literature 2).

[0005] When the dicing sheet is released from the semiconductor die by the methods described in patent literature 1 and 2, as described in FIGS. 40, 42 and 44 of patent literature 1, FIGS. 4A to 4D and 5A to 5D of patent literature 2, the semiconductor die may be bent and deformed together with the dicing sheet while being attached to the dicing sheet before the semiconductor die is released. When the release action of the dicing sheet is continued in the state that the semiconductor die is bent and deformed, the semiconductor die may be damaged, and thus a method has been proposed in which as described in FIG. 31 of patent literature 1, the bending of the semiconductor die is detected according to a variation in the flow rate of sucked air from the collet, and as described in FIG. 43 of patent literature 1, when the intake flow rate is detected, it is determined that the semiconductor die is deformed and the push-up blocks are

temporarily descended, and then the push-up blocks are raised again. Besides, patent literature 3 also discloses that the bending (deflection) of the semiconductor die is detected (discriminated) according to the variation in the flow rate of the suction air from the collet.

[Literature of related art]

[Patent literature]

[0006] Patent literature 1: Japanese Patent No. 4945339

Patent literature 2: US Patent No. 8092645 Specification

Patent literature 3: Japanese Patent No. 5813432

SUMMARY

[Problems to be Solved]

[0007] In recent years, semiconductor dies have become extremely thin; for example, some dies have a thickness of about 20 μm. On the other hand, because the thickness of the dicing sheet is about 100 μm, the thickness of the dicing sheet becomes 4 to 5 times the thickness of the semiconductor die. When the thin semiconductor die is to be released from the dicing sheet, the deformation of the semiconductor die following the deformation of the dicing sheet tends to be more notable. In the conventional technique, there is a possibility of damage to a semiconductor die during pickup of the semiconductor die from the dicing sheet, and there is room for improvement.

[0008] In addition, in the conventional technique, sufficient examination has not been made on speeding up pickup of a semiconductor die. In order to suppress damage to the semiconductor die, it is necessary to promote the release of the semiconductor die from the dicing sheet, and the time required for a release action (pickup action) becomes long.

On the other hand, in order to improve productivity, it is also desired to shorten the time required for the release action and speed up the pickup.

[0009] For example, even if the same type of semiconductor dies are continuously picked up, the releasability of the semiconductor die from the dicing sheet may vary. For example, the releasability of the semiconductor die picked up first is good (the easiness of release is high), but the releasability of the semiconductor die picked up later is worse (the easiness of release becomes low). Alternatively, a case opposite to the above is also possible. In the former case, the semiconductor die is damaged unless the release action that further promotes release is changed. In the latter case, the semiconductor die is not damaged even if the release action is not changed, but the semiconductor die is originally picked up in a shorter time, but is picked up for a long time. When a plurality of semiconductor dies is continuously picked up, it is desired to achieve an appropriate balance between the occurrence suppression of damage to the semiconductor dies and the pickup speedup of the semiconductor dies.

[0010] The present invention aims to accurately suppress damage to a semiconductor die during pickup of the semiconductor die, and during continuous pickup of a plurality of semiconductor dies, achieve an appropriate balance between the suppression of damage to the semiconductor dies and the pickup speedup of the semiconductor dies.

[Means to Solve Problems]

[0011] A semiconductor die pickup system of the present invention, which picks up semiconductor dies attached to the front surface of a dicing sheet from the dicing sheet, includes: a collet that adsorbs the semiconductor die; a suction mechanism that is connected to the collet and sucks air from the front surface of the collet; a flow rate sensor that detects a suction air flow rate of the suction mechanism; a stage that includes an

adsorption surface for adsorbing the back surface of the dicing sheet; an opening pressure switching mechanism that switches the opening pressure of an opening arranged on the adsorption surface of the stage between a first pressure close to vacuum and a second pressure close to atmospheric pressure; and a setting part that sets a pickup parameter including the number of switches of the opening pressure during pickup of a semiconductor die; the setting part acquires a flow rate variation which is a time variation of the suction air flow rate detected by the flow rate sensor during pickup of a semiconductor die, calculates an evaluation value obtained by evaluating the releasability for releasing the semiconductor die from the dicing sheet based on the flow rate variation, and changes the pickup parameter during pickup of another semiconductor die after the semiconductor die is picked up based on the evaluation value.

[0012] In the semiconductor die pickup system of the present invention, the setting part may change, based on the evaluation value, the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die.

[0013] The semiconductor die pickup system of the present invention may further include a plurality of moving elements which is disposed at the opening and in which the front end surfaces move between a first position higher than the adsorption surface and a second position lower than the first position; during pickup of a semiconductor die, each of the plurality of moving elements may be sequentially moved at a predetermined time interval, or simultaneously moved in a predetermined combination of the moving elements from the first position to the second position; and the setting part may change the predetermined time during pickup of the another semiconductor die based on the evaluation value.

[0014] In the semiconductor die pickup system of the present invention, the setting part

may change, based on the evaluation value, the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die.

[0015] In the semiconductor die pickup system of the present invention, during pickup of a semiconductor die, an initial release may be performed in which the opening pressure is switched between the first pressure and the second pressure to release the dicing sheet sucked at the opening from the semiconductor die; and the flow rate variation may be a time variation of the suction air flow rate detected by the flow rate sensor during the initial release.

[0016] In the semiconductor die pickup system of the present invention, the number of switches may be the number of times for switching the opening pressure during the initial release between the first pressure and the second pressure.

[0017] In the semiconductor die pickup system of the present invention, the setting part may change, based on the evaluation value, a waiting time from the landing of the collet on the semiconductor die to the start of the lifting of the semiconductor die when the another semiconductor die is released from the dicing sheet.

[0018] The semiconductor die pickup system of the present invention may include a storage unit that stores an expected flow rate variation which is a time variation of the suction air flow rate during pickup of a semiconductor die when the semiconductor die is satisfactorily picked up from the dicing sheet; the setting part may obtain the evaluation value based on a correlation value between the flow rate variation and the expected flow rate variation during pickup of a semiconductor die.

[0019] The semiconductor die pickup system of the present invention may further include an inspection unit that performs crack inspection for a semiconductor die, and a

semiconductor die that has been subjected to the above switching a predetermined number of times or more during pickup of the semiconductor die may be targeted for crack inspection.

[0020] In the semiconductor die pickup system of the present invention, the setting part may acquire the flow rate variations of semiconductor dies constituting one or more wafers, obtain the evaluation values based on the respective flow rate variations, and change the pickup parameter during pickup of the another semiconductor die based on the plurality of evaluation values.

[0021] The semiconductor die pickup system of the present invention may include a storage unit that stores a table of parameter values of the pickup parameters associated with each of a plurality of level values and a current level value which is the level value of the parameter value of the pickup parameter currently applied; the parameter value of the pickup parameter may be read from the table using the current level value as a key, and the parameter value of the pickup parameter may be applied to pick up the semiconductor die; and the setting part may change, based on the evaluation value, the parameter value of the pickup parameter during pickup of the another semiconductor die by transitioning the current level value to another level value.

[0022] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may obtain, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values, reduce the number of switches during pickup of the another semiconductor die compared with the number of switches during pickup of the specific semiconductor die when the representative die evaluation value is

higher than a first predetermined value, and increase the number of switches during pickup of the another semiconductor die compared with the number of switches during pickup of the specific semiconductor die when the representative die evaluation value is lower than a second predetermined value which is a value lower than the first predetermined value.

[0023] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may obtain, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values, shorten the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die compared with the time during pickup of the specific semiconductor die when the representative die evaluation value is higher than a third predetermined value, and lengthen the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die compared with the time during pickup of the specific semiconductor die when the representative die evaluation value is lower than a fourth predetermined value which is a value lower than the third predetermined value.

[0024] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may obtain, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values, shorten the predetermined time during pickup of the another semiconductor die compared with the predetermined time during pickup of the specific semiconductor die when the representative die evaluation value is

higher than a fifth predetermined value, and lengthen the predetermined time during pickup of the another semiconductor die compared with the predetermined time during pickup of the specific semiconductor die when the representative die evaluation value is lower than a sixth predetermined value which is a value lower than the fifth predetermined value.

[0025] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may obtain, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values, increase the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die compared with the number of the moving elements during pickup of the specific semiconductor die when the representative die evaluation value is higher than a seventh predetermined value, and

reduce the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die compared with the number of the moving elements during pickup of the specific semiconductor die when the representative die evaluation value is lower than an eighth predetermined value which is a value lower than the seventh predetermined value.

[0026] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may obtain, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values, shorten the waiting time during pickup of

the another semiconductor die compared with the waiting time during pickup of the specific semiconductor die when the representative die evaluation value is higher than a ninth predetermined value, and lengthen the waiting time during pickup of the another semiconductor die compared with the waiting time during pickup of the specific semiconductor die when the representative die evaluation value is lower than a tenth predetermined value which is a value lower than the ninth predetermined value.

[0027] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may compare each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value, compare each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and change, based on the number of easy release detections and the number of difficult release detections, the number of switches during pickup of the another semiconductor die after pickup of the specific semiconductor die.

[0028] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may compare each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value, compare each of the evaluation values of

one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and change, based on the number of easy release detections and the number of difficult release detections, the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die after pickup of the specific semiconductor die.

[0029] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may compare each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value, compare each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and change, based on the number of easy release detections and the number of difficult release detections, the predetermined time during pickup of the another semiconductor die after pickup of the specific semiconductor die.

[0030] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may compare each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values

higher than the eleventh predetermined value, compare each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and change, based on the number of easy release detections and the number of difficult release detections, the number of the moving elements during pickup of the another semiconductor die after pickup of the specific semiconductor die.

[0031] In the semiconductor die pickup system of the present invention, the semiconductor die in which the evaluation value is calculated may be a specific semiconductor die, and the setting part may compare each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value, compare each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and change, based on the number of easy release detections and the number of difficult release detections, the waiting time during pickup of the another semiconductor die after pickup of the specific semiconductor die.

[Effect]

[0032] The present invention has an effect that can accurately suppress damage to a semiconductor die during pickup of the semiconductor die, and during continuous pickup of a plurality of semiconductor dies, achieve an appropriate balance between the suppression of damage to the semiconductor dies and the pickup speedup of the

semiconductor dies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 is an illustrative diagram showing a system configuration of a semiconductor die pickup system in an embodiment of the present invention.

FIG. 2 is a perspective view showing a stage of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 3 is an illustrative diagram showing a wafer attached to a dicing sheet.

FIG. 4 is an illustrative diagram showing semiconductor dies attached to the dicing sheet.

FIG. 5A is an illustrative diagram showing a configuration of a wafer holder.

FIG. 5B is an illustrative diagram showing the configuration of the wafer holder.

FIG. 6 is an illustrative diagram showing an action at a predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 7 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 8 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 9 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 10 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 11 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 12 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 13 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 14 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 15 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 16 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 17 is an illustrative diagram showing the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 18 is a diagram showing a time variation in the height of a collet, the position of a columnar moving element, the position of an intermediate annular moving element, the position of a peripheral annular moving element, the opening pressure, and the air leakage amount of the collet during the action at the predetermined level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 19 is a diagram showing an example of a parameter table in the embodiment of the present invention.

FIG. 20 is a diagram showing a time variation in the height of the collet, the position of the columnar moving element, the position of the intermediate annular moving element, the position of the peripheral annular moving element, and the opening pressure during an action at another level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 21 is a diagram showing a time variation in the height of the collet, the position of the columnar moving element, the position of the intermediate annular moving element, the position of the peripheral annular moving element, and the opening pressure during an action at still another level value of the semiconductor die pickup system in the embodiment of the present invention.

FIG. 22 is a diagram showing an example of a time variation in the opening pressure, and an expected flow rate variation and actual flow rate variation in a predetermined period of initial release in the embodiment of the present invention.

FIG. 23 is a flowchart showing a flow of level transition control in the embodiment of the present invention.

FIG. 24 is a diagram showing an example of a threshold value table in the embodiment of the present invention.

FIG. 25 is an illustrative diagram of a level transition in the embodiment of the present invention.

FIG. 26 is an illustrative diagram of another level transition in the embodiment of this invention.

FIG. 27A is a diagram showing an example of another parameter table in the embodiment of the present invention.

FIG. 27B is a diagram showing an example of another parameter table in the embodiment of the present invention.

FIG. 28 is a flowchart showing a flow of level transition control in another embodiment of the present invention.

FIG. 29 is a flowchart showing a flow of level transition control in another embodiment of the present invention.

FIG. 30 is a functional block diagram of a control unit in the embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0034] <Configuration>

Hereinafter, a semiconductor die pickup system according to an embodiment of the present invention is described with reference to the drawings. As shown in FIG. 1, a semiconductor die pickup system 500 of the embodiment includes: a wafer holder 10 that holds a dicing sheet 12 in which a semiconductor die 15 is attached to a front surface 12a and that moves in a horizontal direction; a stage 20 disposed on the lower surface of the wafer holder 10 and including an adsorption surface 22 adsorbing a back surface 12b of the dicing sheet 12; a plurality of moving elements 30 that is disposed in an opening 23 arranged on the adsorption surface 22 of the stage 20; a stepped surface formation mechanism 300 that forms a stepped surface with respect to the adsorption surface 22; a stepped surface formation mechanism drive unit 400 that drives the stepped surface formation mechanism 300; a collet 18 that picks up the semiconductor die 15; an opening pressure switching mechanism 80 that switches the pressure of the opening 23 of the stage 20; an adsorption pressure switching mechanism 90 that switches the adsorption pressure of the adsorption surface 22 of the stage 20; a suction mechanism 100 that sucks air from the front surface 18a of the collet 18; a vacuum apparatus 140; a wafer holder horizontal direction drive unit 110 that horizontally drives the wafer holder 10; a stage vertical direction drive unit 120 that vertically drives the stage 20; a collet drive unit 130 that vertically and horizontally drives the collet 18; and a control unit 150 that controls the semiconductor die pickup system 500.

[0035] The stepped surface formation mechanism 300 and the stepped surface formation mechanism drive unit 400 are accommodated in a base portion 24 of the stage 20. The stepped surface formation mechanism 300 is located at the upper portion 28 of the stage 20, and the stepped surface formation mechanism drive unit 400 is located at the lower portion of the stage 20. The stepped surface formation mechanism 300 includes the plurality of moving elements 30 moving in the vertical direction. By the stepped surface formation mechanism drive unit 400, each front end surface of the plurality of moving elements 30 moves downward as indicated by an arrow a in FIG. 1. Details of the moving elements 30 are described later.

[0036] An opening pressure switching mechanism 80 that switches the pressure of the opening 23 of the stage 20 includes a three-way valve 81 and a drive unit 82 that switches open and close of the three-way valve 81. The three-way valve 81 has three ports, the first port is connected to the base portion 24 communicating with the opening 23 of the stage 20 by a pipe 83, the second port is connected to the vacuum apparatus 140 by a pipe 84, and the third port is connected to a pipe 85 open to the atmosphere. The drive unit 82 causes the first port and the second port to communicate with each other and cuts off the third port, and sets the pressure of the opening 23 as a first pressure P_1 close to vacuum, or causes the first port and the third port to communicate with each other and cuts off the second port, and sets the pressure of the opening 23 as a second pressure P_2 close to atmospheric pressure, thereby switching the pressure of the opening 23 between the first pressure P_1 and the second pressure P_2.

[0037] Similar to the opening pressure switching mechanism 80, the adsorption pressure switching mechanism 90 that switches the adsorption pressure of the adsorption surface 22 of the stage 20 includes a three-way valve 91 having three ports and a drive

unit 92 that switches open and close of the three-way valve 91; the first port is connected to an adsorption hole 27 communicating with a groove 26 of the stage 20 by a pipe 93, the second port is connected to the vacuum apparatus 140 by a pipe 94, and the third port is connected to a pipe 95 open to the atmosphere. The drive unit 92 causes the first port and the second port to communicate with each other and cuts off the third port, and sets the pressure of the groove 26 or the adsorption surface 22 as a third pressure P_3 close to vacuum, or causes the first port and the third port to communicate with each other and cuts off the second port, and sets the pressure of the groove 26 or the adsorption surface 22 as a fourth pressure P_4 close to atmospheric pressure, thereby switching the pressure of the groove 26 or the adsorption surface 22 between the third pressure P_3 and the fourth pressure P_4.

[0038] Similar to the opening pressure switching mechanism 80, the suction mechanism 100 that sucks air from the front surface 18a of the collet 18 includes a three-way valve 101 having three ports and a drive unit 102 that switches open and close of the three-way valve 101; the first port is connected to a suction hole 19 communicating with the front surface 18a of the collet 18 by a pipe 103, the second port is connected to the vacuum apparatus 140 by a pipe 104, and the third port is connected to a pipe 105 open to the atmosphere. The drive unit 102 causes the first port and the second port to communicate with each other and cuts off the third port, and sucks air from the front surface 18a of the collet 18 to set the pressure of the front surface 18a of the collet 18 as a pressure close to vacuum, or causes the first port and the third port to communicate with each other and cuts off the second port, and sets the pressure of the front surface 18a of the collet 18 as a pressure close to atmospheric pressure. A flow sensor 106 that detects a flow rate of air sucked from the front surface 18a of the collet 18 into the vacuum

apparatus 140 (suction air flow rate) is mounted on the pipe 103 connecting the suction hole 19 of the collet 18 and the three-way valve 101.

[0039] The wafer holder horizontal direction drive unit 110, the stage vertical direction drive unit 120, and the collet drive unit 130 are, for example, those driving the wafer holder 10, the stage 20, and the collet 18 in the horizontal direction, the vertical direction, or the like by a motor and a gear arranged inside.

[0040] The control unit 150 includes a CPU 151 that performs various types of calculation processing or control processing, a storage unit 152, and a device/sensor interface 153; the CPU 151, the storage unit 152, and the device/sensor interface 153 are computers connected by a data bus 154. A control program 155 and control data 156 are stored in the storage unit 152. In addition, as described in detail later, the storage unit 152 stores: a parameter table 159 (see FIG. 19) in which the level value when the semiconductor die 15 is picked up by the collet 18 and the parameter value of the release parameter are associated with each other, a threshold table 160 (see FIG. 24), a current level value 161 which is the level value applied during pickup, an expected flow rate variation 157 which is a time variation of the suction air flow rate detected by the flow rate sensor 106 during pickup when the release of the semiconductor die 15 from the dicing sheet 12 is good, and an actual flow rate variation 158 which is a time variation of the suction air flow rate actually detected by the flow rate sensor 106 during pickup. FIG. 30 is a functional block diagram of the control unit 150. The control unit 150 functions as a pickup control part 600 (control part) and a setting part 602 by executing the control program 155.

[0041] As shown in FIG. 1, the opening pressure switching mechanism 80, the adsorption pressure switching mechanism 90, the drive units 82, 92 and 102 of the three-

way valves 81, 91 and 101 of the suction mechanism 100, the stepped surface formation mechanism drive unit 400, the wafer holder horizontal direction drive unit 110, the stage vertical direction drive unit 120, the collet drive unit 130, and the vacuum apparatus 140 are respectively connected to the device/sensor interface 153, and driven according to commands of the control unit 150. In addition, the flow rate sensor 106 is connected to the device/sensor interface 153, and a detection signal is captured by the control unit 150 and processed.

[0042] Next, details of the adsorption surface 22 of the stage 20 and the moving elements 30 are described. As shown in FIG. 2, the stage 20 has a cylindrical shape, and the adsorption surface 22 having a planar shape is formed on the upper surface. A square opening 23 is arranged at the center of the adsorption surface 22, and the moving elements 30 are mounted on the opening 23. As shown in FIG. 6, a gap d is arranged between an inner surface 23a of the opening 23 and an outer peripheral surface 33 of the moving element 30. As shown in FIG. 2, the grooves 26 are arranged around the opening 23 so as to surround the opening 23. The adsorption hole 27 is arranged in each groove 26, and each adsorption hole 27 is connected to the adsorption pressure switching mechanism 90.

[0043] As shown in FIG. 2, the moving element 30 includes a columnar moving element 45 disposed at the center, two intermediate annular moving elements 40 and 41 disposed around the columnar moving element 45, and a peripheral annular moving element 31 disposed around the intermediate annular moving element 40 and disposed at the outermost periphery. Besides, the number of the intermediate annular moving elements is two here, but the number of the intermediate annular moving elements may be one or three or more. In the drawings of FIG. 6 or later, the number of the

intermediate annular moving elements 40 is one for the sake of simplicity. As shown in FIG. 6, front end surfaces 47, 38b, and 38a of the columnar moving element 45, the intermediate annular moving element 40, and the peripheral annular moving element 31 are respectively located at a first position protruding from the adsorption surface 22 of the stage 20 by a height H_0, and constitute the same surface (a stepped surface with respect to the adsorption surface 22). When the semiconductor die 15 is picked up, the peripheral annular moving element 31, the intermediate annular moving element 40, and the columnar moving element 45 are moved in this order from the first position to a second position lower than the first position at predetermined time intervals. Alternatively, a predetermined combination of the moving elements is simultaneously moved from the first position to the second position.

[0044] <Dicing sheet setting step>

Here, a step for setting the dicing sheet 12 to which the semiconductor dies 15 are attached on the wafer holder 10 is described.

[0045] As shown in FIG. 3, the dicing sheet 12 having adhesiveness is attached to the back surface of a wafer 11, and the dicing sheet 12 is mounted on a ring 13 made of metal. The wafer 11 is handled while being mounted on the ring 13 made of metal via the dicing sheet 12 in this manner. Then, as shown in FIG. 4, the wafer 11 is cut from the front surface side by a dicing saw or the like in a cutting step and becomes each semiconductor die 15. Cutout gaps 14 formed during dicing are formed between the semiconductor dies 15. The depth of the cutout gap 14 reaches from the semiconductor die 15 to a part of the dicing sheet 12, but the dicing sheet 12 is not cut off and each semiconductor die 15 is held by the dicing sheet 12.

[0046] In this manner, the semiconductor die 15 on which the dicing sheet 12 and the

ring 13 are mounted is mounted on the wafer holder 10 as shown in FIGS. 5A and 5B. The wafer holder 10 includes an expand ring 16 being annular and having a flange portion and a ring retainer 17 that fixes the ring 13 on the flange of the expand ring 16. The ring retainer 17 is driven by a ring retainer drive unit that is not shown in the direction of moving toward and away from the flange of the expand ring 16. The inner diameter of the expand ring 16 is larger than the diameter of the wafer on which the semiconductor dies 15 are disposed, the expand ring 16 has a predetermined thickness, and the flange which is located on the outer side of the expand ring 16 is mounted on the end surface side in the direction separated from the dicing sheet 12 so as to protrude to the outer side. In addition, the outer periphery of the expand ring 16 on the dicing sheet 12 side has a curved surface configuration so that the dicing sheet 12 can be smoothly stretched when the dicing sheet 12 is mounted on the expand ring 16. As shown in FIG. 5B, the dicing sheet 12 to which the semiconductor dies 15 are attached is substantially planar before being set on the expand ring 16.

[0047] As shown in FIG. 1, when set on the expand ring 16, the dicing sheet 12 is stretched along the curved surface of the upper portion of the expand ring by a step difference between the upper surface and the flange surface of the expand ring 16, and thus a tension force from the center toward the periphery of the dicing sheet 12 acts on the dicing sheet 12 fixed on the expand ring 16. In addition, because the dicing sheet 12 is extended due to this tension force, the gaps 14 between the semiconductor dies 15 attached on the dicing sheet 12 are widened.

[0048] <Pickup action>

Next, a pickup action of the semiconductor die 15 is described. The ease of release (releasability) of each semiconductor die 15 from the dicing sheet 12 varies depending on

the thickness of the semiconductor die 15, the thickness of the dicing sheet 12, the adhesiveness of the dicing sheet 12 to each semiconductor die 15, the placed environment of the semiconductor die pickup system 500 (temperature, humidity, and the like), and the like. In addition, the ease of release of each semiconductor die from the dicing sheet may also vary when the same type of semiconductor die 15 is continuously picked up. Therefore, in the semiconductor die pickup system 500 of this embodiment, the release action (pickup action) during pickup can be changed for each semiconductor die 15. The parameter table 159 shown in FIG. 19 is stored in the storage unit 152, and in the parameter table 159, the parameter values of the release parameters (pickup parameters) associated with each of a plurality of level values are defined. In the parameter table 159, level 1 with the shortest pickup time to level 8 with the longest pickup time are defined. Level 1 or a level value close to level 1 is set during pickup for the higher ease of release (easiness of release) of the semiconductor die 15 from the dicing sheet 12, and the parameter value of each release parameter defined by the level value is used to perform the release action (pickup action). Besides, this setting is performed by the control unit 150 functioning as a setting part. Details of each release parameter are described later. Hereinafter, the case in which level 4 of the parameter table 159 is set (selected) is taken as an example to describe the pickup action of the semiconductor die.

[0049] The control unit 150 functions as a pickup control part by executing the control program 155 shown in FIG. 1 and controls the pickup action of the semiconductor die 15. The control unit 150 controls the release action for releasing the semiconductor die 15 from the dicing sheet 12 as a part of the pickup action. First, the control unit 150 causes the wafer holder horizontal direction drive unit 110 to horizontally move the wafer holder 10 to a position above the waiting position of the stage 20. Then, when the wafer holder

10 moves to a predetermined position above the waiting position of the stage 20, the control unit 150 temporarily stops the horizontal movement of the wafer holder 10. As described above, because the front end surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 are at the first position protruding from the adsorption surface 22 of the stage 20 by the height H_0 in the initial state, the control unit 150 causes the stage vertical direction drive unit 120 to raise the stage 20 until the front end surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 come into close contact with the back surface 12b of the dicing sheet 12 and a region slightly separated from the opening 23 of the adsorption surface 22 comes into close contact with the back surface 12b of the dicing sheet 12. Then, when the front end surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 and the region slightly separated from the opening 23 of the adsorption surface 22 come into close contact with the back surface 12b of the dicing sheet 12, the control unit 150 stops the rising of the stage 20. Then, the control unit 150 again causes the wafer holder horizontal direction drive unit 110 to adjust the horizontal position so that the semiconductor die 15 to be picked up is immediately above the front end surface (stepped surface) of the moving element 30 slightly protruding from the adsorption surface 22 of the stage 20.

[0050] As shown in FIG. 6, because the size of the semiconductor die 15 is smaller than that of the opening 23 of the stage 20 and larger than the width or depth of the moving element 30, when the position adjustment of the stage 20 is completed, the outer peripheral end of the semiconductor die 15 is between the inner surface 23a of the opening 23 of the stage 20 and the outer peripheral surface 33 of the moving element 30, that is, immediately above the gap d between the inner surface 23a of the opening 23 and the outer peripheral surface 33 of the moving element 30. In the initial state, the pressure

of the groove 26 of the stage 20 or the adsorption surface 22 is atmospheric pressure, and the pressure of the opening 23 is also atmospheric pressure. In the initial state, the front end surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 are at the first position protruding from the adsorption surface 22 of the stage 20 by the height H_0, and thus the height of the back surface 12b of the dicing sheet 12 in contact with the front end surfaces 47, 38b, and 38a is also the first position protruding from the adsorption surface 22 by the height H_0. In addition, the back surface 12b of the dicing sheet 12 is slightly floated from the adsorption surface 22 at the peripheral edge of the opening 23, and is in close contact with the adsorption surface 22 in the region separated from the opening 23. When the horizontal position adjustment is completed, the control unit 150 causes the collet drive unit 130 shown in FIG. 1 to descend the collet 18 onto the semiconductor die 15 and land the front surface 18a of the collet 18 on the semiconductor die 15.

[0051] FIG. 18 is a diagram showing a time variation in the height of the collet 18, the position of the columnar moving element 45, the position of the intermediate annular moving element 40, the position of the peripheral annular moving element 31, the opening pressure of the opening 23, and the air leakage amount of the collet 18 during the release action (pickup action) of level 4. As shown in (a) of FIG. 18, which shows the height of the front surface 18a of the collet 18, and shows a state in which the collet 18 is moved from a time slightly after time t = 0 (height Hc_1) to time t2. At time t1 during which the collet 18 is being moved, the control unit 150 causes the drive unit 102 of the suction mechanism 100 to switch the three-way valve 101 in a direction of communicating the suction hole 19 of the collet 18 and the vacuum apparatus 140. Thereby, the suction hole 19 becomes a negative pressure, and air flows into the suction hole 19 from the front surface 18a of the collet 18 (as indicated by an arrow 301 in FIG. 7), and thus the suction air flow rate (air leakage amount) detected by the flow rate sensor 106 increases from

time t1 to time t2 as shown in (f) of FIG. 18. At time t2, when the collet 18 lands on the semiconductor die 15, the semiconductor die 15 is adsorbed and fixed on the front surface 18a, and air cannot flow in from the front surface 18a. Thereby, at time t2, the air leakage amount detected by the flow rate sensor 106 starts to decrease. As shown in FIG. 6, the height of the front surface 18a of the collet 18 when the collet 18 lands on the semiconductor die 15 becomes a height Hc is obtained by adding the thickness of the dicing sheet 12 and the thickness of the semiconductor die 15 to the height of the front end surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 (the height H_0 from the surface 22).

[0052] Next, at time t2 shown in FIG. 18, the control unit 150 outputs a command to switch the adsorption pressure (not shown) of the adsorption surface 22 of the stage 20 from the fourth pressure P_4 close to atmospheric pressure to the third pressure P_3 close to vacuum. According to this command, the drive unit 92 of the adsorption pressure switching mechanism 90 switches the three-way valve 91 in the direction of communicating the adsorption hole 27 and the vacuum apparatus 140. Then, the air in the groove 26 is sucked out to the vacuum apparatus 140 through the adsorption hole 27 as indicated by an arrow 201 in FIG. 7, an arrow 211 in FIG. 10, an arrow 213 in FIG. 11, an arrow 221 in FIG. 13, an arrow 225 in FIG. 14, an arrow 242 in FIG. 16 and an arrow 245 in FIG. 17, the adsorption pressure becomes the third pressure P_3 close to vacuum. Then, the back surface 12b of the dicing sheet 12 at the peripheral edge of the opening 23 is vacuum-sucked to the front surface of the adsorption surface 22 as indicated by an arrow 202 in FIG. 7. Because the front surfaces 47, 38b, and 38a of the moving elements 45, 40, and 31 are at the first position protruding from the adsorption surface 22 of the stage 20 by the height H_0, a tension force F_1 obliquely downward acts on the dicing sheet 12. This tension force F_1 can be decomposed into a tension force F_2 that tensions the dicing sheet 12 laterally and a tension force F_3 that

tensions the dicing sheet 12 downward. The lateral tension force F_2 generates a shear stress τ between the semiconductor die 15 and the front surface 12a of the dicing sheet 12. The shear stress τ causes a deviation between the outer peripheral portion or the peripheral portion of the semiconductor die 15 and the front surface 12a of the dicing sheet 12. This deviation triggers release between the dicing sheet 12 and the outer peripheral portion or the peripheral portion of the semiconductor die 15.

[0053] As shown in (e) of FIG. 18, the control unit 150 outputs a command to switch the opening pressure from the second pressure P_2 close to atmospheric pressure to the first pressure P_1 close to vacuum at time t3. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 in the direction of communicating the opening 23 and the vacuum apparatus 140. Then, the air in the opening 23 is sucked into the vacuum apparatus 140 as indicated by an arrow 206 in FIG. 8, and as shown in (e) of FIG. 18, the opening pressure becomes the first pressure P_1 close to vacuum at time t4. Thereby, as indicated by an arrow 203 in FIG. 8, the dicing sheet 12 immediately above the gap d between the inner surface 23a of the opening 23 and the outer peripheral surface 33 of the moving element 30 is tensioned downward. In addition, the peripheral portion of the semiconductor die 15 located immediately above the gap d is tensioned to the dicing sheet 12 and bent and deformed downward as indicated by an arrow 204. Thereby, the peripheral portion of the semiconductor die 15 is separated from the front surface 18a of the collet 18. Due to the deviation generated between the outer peripheral portion of the semiconductor die 15 and the front surface 12a of the dicing sheet 12 when the adsorption pressure becomes the third pressure P_3 close to vacuum, the trigger for releasing from the front surface 12a of the dicing sheet 12is formed in the peripheral portion of the semiconductor die 15, and

thus the peripheral portion of the semiconductor die 15 begins to release from the front surface 12a of the dicing sheet 12 while being bent and deformed as indicated by the arrow 204 in FIG. 8.

[0054] As shown in FIG. 8, when the peripheral portion of the semiconductor die 15 is separated from the front surface 18a of the collet 18, air flows into the suction hole 19 of the collet 18 as indicated by an arrow 205 in FIG. 8. The flow rate of the inflow air (air leakage amount) is detected by the flow rate sensor 106. Thereby, as shown in (f) of FIG. 18, the air leakage amount that turned to decrease at time t2 and continued to decrease starts to increase again at time t3. Specifically, as the opening pressure from time t3 to time t4 decreases from the second pressure P_2 close to atmospheric pressure to the first pressure P_1 close to vacuum, the semiconductor die 15 is tensioned downward together with the dicing sheet 12 and bent and deformed, and thus the amount of air leakage flowing into the suction hole 19 of the collet 18 increases from time t3 to time t4.

[0055] Then, as shown in (e) of FIG. 18, the control unit 150 holds the opening 23 of the stage 20 at the first pressure P_1 close to vacuum in a period from time t4 to time t5 (time HT4). This time HT4 is a "holding time of first pressure" of level 4 defined in the parameter table 159 of FIG. 19. The HT4 is 130 ms in the example of FIG. 19. While being held at the first pressure P_1, as indicated by an arrow 207 in FIG. 9, the peripheral portion of the semiconductor die 15 returns to the front surface 18a the collet 18 due to the vacuum of the suction hole 19 of the collet 18 and the elasticity of the semiconductor die 15. Thereby, the air leakage amount starts to decrease at time t4 in (f) of FIG. 18 and continues to decrease, and the air leakage amount is almost zero slightly before time t5 when the semiconductor die 15 is vacuum-adsorbed to the front surface 18a of the collet 18. At this time, the peripheral portion of the semiconductor die 15 is released

from the front surface 12a of the dicing sheet 12 located immediately above the gap d (initial release). Then, as shown in (e) of FIG. 18, the control unit 150 outputs a command to switch the opening pressure from the first pressure P_1 close to vacuum to the second pressure P_2 close to atmospheric pressure at time t5. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 so as to communicate the pipe 85 open to the atmosphere and the opening 23. Thereby, because air flows into the opening 23 as indicated by an arrow 210 in FIG. 10, as shown in (e) of FIG. 18, the opening pressure increases from the first pressure P_1 close to vacuum to the second pressure P_2 close to atmospheric pressure from time t5 to time t6.

[0056] The period from time t1 to time t6 in FIG. 18 is the initial release. When the releasability between the semiconductor die 15 and the dicing sheet 12 is poor (the easiness of release is low), after the peripheral portion of the semiconductor die 15 is tensioned to the dicing sheet 12 as indicated by the arrow 204 in FIG. 8, it takes a lot of time for the peripheral portion of the semiconductor die 15 to return to the front surface 18a of the collet 18 as indicated by the arrow 207 in FIG. 9. In this semiconductor die 15, the release between the peripheral portion of the semiconductor die 15 and the dicing sheet 12 is promoted applying a release action (level value) in which the opening pressure is held at the first pressure P_1 for a long time (from time t4 to time t5 in (e) of FIG. 18) or the opening pressure is frequently switched between the first pressure P_1 close to vacuum and the second pressure P_2 close to atmospheric pressure.

[0057] On the other hand, when the releasability between the semiconductor die 15 and the dicing sheet 12 is good (the easiness of release is high), after the peripheral portion of the semiconductor die 15 is tensioned to the dicing sheet 12 as indicated by an arrow 204

in FIG. 8, it takes a short time for the peripheral portion of the semiconductor die 15 to return to the front surface 18a of the collet 18 as indicated by the arrow 207 in FIG. 9. In this semiconductor die 15, the pickup speed is increased applying a release action (level value) in which the opening pressure is held at the first pressure P_1 for a short time or the opening pressure is switched less number of times between the first pressure P_1 close to vacuum and the second pressure P_2 close to atmospheric pressure. Besides, in an example of level 4 of FIG. 18, the opening pressure during the initial release is switched once (when switching from the second pressure P_2 to the first pressure P_1 and then from the first pressure P_1 to the second pressure P_2 is counted as once). This is the "number of switches of opening pressure during initial release" of level 4 (FSN4) defined in the parameter table 159 of FIG. 19.

[0058] In addition, as described above, because the time until the peripheral portion of the semiconductor die 15 returns to the front surface 18a of the collet 18 after being tensioned to the dicing sheet 12 varies according to the easiness of release of the semiconductor die 15, the time variation of the air leakage amount (actual flow variation) detected by the flow sensor 106 also varies. Therefore, as described in detail later, it is possible to determine the releasability (easiness of release) of the semiconductor die 15 from the dicing sheet 12 based on the actual flow rate variation.

[0059] The description of the pickup action is continued. At t6 in FIG. 18, when the opening pressure increases to the second pressure P_2 close to atmospheric pressure, as indicated by an arrow 212 in FIG. 10, the dicing sheet 12 located immediately above the gap d that is tensioned downward at the vacuum returns upward due to a tension force applied when fixed to the wafer holder 10. In addition, the dicing sheet 12 at the peripheral edge of the opening 23 is in a state of being slightly floated from the adsorption

surface 22 due to the above tension force.

[0060] When the opening pressure reaches the second pressure P_2 close to atmospheric pressure at time t6 as shown in (e) of FIG. 18, as shown in (d) of FIG. 18, the control unit 150 outputs a command to set the height of the front end surface 38a of the peripheral annular moving element 31 to the second position lower than the first position (the initial position at which the height from the adsorption surface 22 is H_0) by a height H_1. According to this command, the stepped surface formation mechanism drive unit 400 shown in FIG. 1 is driven to lower the peripheral annular moving element 31 as indicated by an arrow 214 in FIG. 11. The front end surface 38a of the peripheral annular moving element 31 is moved to the second position lower than the first position (initial position) by the height H_1 and slightly lower than the adsorption surface 22 (the position lower than the adsorption surface 22 by a height (H_1-H_0)).

[0061] Next, the control unit 150 keeps the state from time t6 to time t7 as shown in FIG. 18. At this time, because the pressure of the opening 23 becomes the second pressure P_2 close to atmospheric pressure, as shown in FIG. 11, a gap is formed between the back surface 12b of the dicing sheet 12 located immediately above the gap d and the front end surface 38a of the peripheral annular moving element 31.

[0062] As shown in (e) of FIG. 18, the control unit 150 outputs a command to switch the opening pressure from the second pressure P_2 close to atmospheric pressure to the first pressure P_1 close to vacuum at time t7. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 so as to communicate the opening 23 and the vacuum apparatus 140. Thereby, the air in the opening 23 is sucked into the vacuum apparatus 140 as indicated by an arrow 215 in FIG. 12, and the opening pressure becomes the first pressure P_1 close to vacuum at time

t8. When the opening pressure decreases from the second pressure P_2 close to atmospheric pressure to the first pressure P_1 close to vacuum, as indicated by an arrow 216 in FIG. 12, the dicing sheet 12 located immediately above (facing) the front end surface 38a of the peripheral annular moving element 31 is tensioned downward so that the back surface 12b contacts the front end surface 38a. Thereby, as indicated by an arrow 217 in FIG. 12, a part of the semiconductor die 15 located immediately above the front end surface 38a of the semiconductor die 15 is bent and deformed downward, and separated from the front surface 18a of the collet 18, and air flows into the adsorption hole 19 of the collet 18 as indicated by an arrow 218 in FIG. 12. The amount of the air leakage flowing into the suction hole 19 is detected by the flow rate sensor 106. As shown in (f) of FIG. 18, the air leakage amount increases in a period of time t7 to time t8 during which the opening pressure decreases. Then, near time t8 at which the opening pressure reaches the first pressure P_1, the semiconductor die 15 in the region facing the front end surface 38a returns toward the front surface 18a of the collet 18 as indicated by an arrow 224 in FIG. 13. Thereby, the air leakage amount starts to decrease near time t8 in (f) of FIG. 18, and when the semiconductor die 15 is vacuum-adsorbed to the front surface 18a of the collet 18 as shown in FIG. 13, the air leakage amount returns to almost zero. At this time, the region of the semiconductor die 15 facing the front end surface 38a is released from the front surface 12a of the dicing sheet 12. Besides, the time until the region of the semiconductor die 15 facing the front end surface 38a returns to the front surface 18a of the collet 18 as indicated by the arrow 224 in FIG. 13 after being tensioned to the dicing sheet 12 as indicated by the arrow 217 in FIG. 12 varies according to the releasability between the semiconductor die 15 and the dicing sheet 12.

[0063] Next, as shown in (e) of FIG. 18, the control unit 150 outputs a command to

increase the opening pressure from the first pressure P_1 close to vacuum to the second pressure P_2 close to atmospheric pressure at time t9. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 so as to communicate the opening 23 and the pipe 85 open to the atmosphere. Thereby, air flows into the opening 23 as indicated by an arrow 220 in FIG. 13, and the pressure of the opening 23 increases to the second pressure P_2 close to atmospheric pressure at time t10. Thereby, as indicated by an arrow 223 in FIG. 13, the dicing sheet 12 immediately above the gap d is separated from the front end surface 38a of the peripheral annular moving element 31 and displaced upward.

[0064] At time t10 in FIG. 18, the control unit 150 outputs a command to move the front end surface 38b of the intermediate annular moving element 40 to the second position lower than the first position (the position at which the height from the adsorption surface 22 is H_0) by the height H_1, and a command to move the front end surface 38a of the peripheral annular moving element 31 at the second position to a third position lower than the first position (initial position) by the height H_2 (the position lower than the adsorption surface 22 by H_2-H_0). According to this command, the stepped surface formation mechanism drive unit 400 shown in FIG. 1 is driven to lower the intermediate annular moving element 40 as indicated by an arrow 227 in FIG. 14, and lower the peripheral annular moving element 31 as indicated by an arrow 226. The front end surface 38b of the intermediate annular moving element 40 moves to the second position lower than the first position (the position higher than the adsorption surface by the height H_0) by the height H_1 (the position lower than the adsorption surface 22 by H_1-H_0), and the front end surface 38a of the peripheral annular moving element 31 moves to the third position lower than the first position (initial position) by the height H_2 (the position lower

than the adsorption surface 22 by H_2-H_0). Thereby, as shown in FIG. 14, the front end surfaces 38a, 38b, and 47 are stepped surfaces having steps with respect to each other and become stepped surfaces with respect to the adsorption surface 22.

[0065] Next, the control unit 150 keeps the state from time t10 to time t11 as shown in FIG. 18. Then, the control unit 150 outputs a command to switch the opening pressure from the second pressure P_2 close to atmospheric pressure to the first pressure P_1 close to vacuum at time t11 in (e) of FIG. 18. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 so as to communicate the opening 23 and the vacuum apparatus 140. Thereby, the air in the opening 23 is sucked into the vacuum apparatus 140 as indicated by an arrow 228 in FIG. 15, and the opening pressure becomes the first pressure P_1 close to vacuum at time t12. Then, as indicated by arrows 229 and 230 in FIG. 15, the dicing sheet 12 is tensioned toward the front end surface 38a of the peripheral annular moving element 31 descended to the third position and the front end surface 38b of the intermediate annular moving element 40 descended to the second position, and displaced downward. Accordingly, the region of the semiconductor die 15 facing the front end surfaces 38a and 38b is also separated from the front surface 18a of the collet 18 and bent and deformed downward as indicated by an arrow 231 in FIG. 15. Then, as indicated by an arrow 232 in FIG. 15, air flows into the suction hole 19 from the space between the front surface 18a of the collet 18 and the semiconductor die 15. The amount of the air leakage flowing into the suction hole 19 is detected by the flow rate sensor 106. As shown in (f) of FIG. 18, the air leakage amount increases in a period of time t11 to time t12 during which the opening pressure decreases. Then, near time t12 at which the opening pressure reaches the first pressure P_1, the semiconductor die 15 of the region facing the front end surfaces 38a and

38b returns toward the front surface 18a of the collet 18 as indicated by an arrow 244 in FIG. 16. Thereby, the air leakage amount starts to decrease near time t12 in (f) of FIG. 18, and when the semiconductor die 15 is vacuum-adsorbed to the front surface 18a of the collet 18 as shown in FIG. 16, the air leakage amount becomes almost zero. Besides, the time for returning to the front surface 18a of the collet 18 varies according to the releasability between the semiconductor die 15 and the dicing sheet 12.

[0066] Next, as shown in (e) of FIG. 18, the control unit 150 outputs a command to switch the opening pressure from the first pressure P_1 close to vacuum to the second pressure P_2 close to atmospheric pressure at time t13. According to this command, the drive unit 82 of the opening pressure switching mechanism 80 switches the three-way valve 81 so as to communicate the opening 23 and the pipe 85 open to the atmosphere. Then, air flows into the opening 23 as indicated by an arrow 241 in FIG. 16 and the opening pressure increases, and thus the dicing sheet 12 is displaced upward as indicated by an arrow 243 in FIG. 16. As shown in (e) of FIG. 18, at time t14, the opening pressure becomes the second pressure P_2 close to the atmospheric pressure. In this state, as shown in FIG. 16, the semiconductor die 15 of the region corresponding to the front end surface 47 of the columnar moving element 45 is attached to the dicing sheet 12, but most of the region of the semiconductor die 15 is released from the dicing sheet 12.

[0067] Next, at time t14 in FIG. 18, the control unit 150 outputs a command to move the front end surface 47 of the columnar movement element 45 to the second position lower than the first position (the position at which the height from the adsorption surface 22 is H_0) by the height H_1, and a command to move the front end surface 38b of the intermediate annular moving element 40 at the second position to the third position lower than the first position (initial position) by the height H_2 (the position lower than the

adsorption surface 22 by H_2-H_0). According to this command, the stepped surface formation mechanism drive unit 400 shown in FIG. 1 is driven to lower the columnar moving element 45 as indicated by an arrow 260 in FIG. 17, and lower the intermediate annular moving element 40 as indicated by an arrow 246. The front end surface 47 of the columnar movement element 45 moves to the second position lower than the first position (the position higher than the adsorption surface by the height H_0) by the height H_1, and the front end surface 38b of the intermediate annular moving element 40 moves to the third position lower than the first position (initial position) by the height H_2. Thereby, as shown in FIG. 17, the semiconductor die 15 is released from the dicing sheet 12.

[0068] The control unit 150 outputs a command to raise the collet 18 at time t15 in FIG. 18. According to this command, the collet drive unit 130 shown in FIG. 1 drives the motor to raise the collet 18 as shown in FIG. 17. When the collet 18 rises, the semiconductor die 15 is picked up in a state of being adsorbed by the collet 18.

[0069] After the semiconductor die 15 is picked up, at time t16, the control unit 150 returns the front end surfaces 38a, 38b, and 47 of the moving elements 31, 40, and 45 to the first position and switches, and switches the adsorption pressure of the adsorption surface 22 of the stage 20 from the third pressure P_3 close to vacuum to the fourth pressure P_4 close to atmospheric pressure by the adsorption pressure switching mechanism 90. Thereby, the pickup is completed.

[0070] The period from time t6 to time t16 in FIG. 18 described above is the main release. In this main release, by moving the front end surfaces from the first position to the second position in the order from the outer moving element 30 to the inner moving element 30, and switching the opening pressure between the first pressure P_1 and the

second pressure P_2, the region closer to the inner side than the peripheral portion of the semiconductor die 15 is released from the front surface 12a of the dicing sheet 12. Besides, in the main release described above, the opening pressure is switched between the first pressure P_1 and the second pressure P_2, but each moving element 30 may be moved in order in the state where the opening pressure is held at the first pressure close to vacuum.

[0071] Here, the release parameters of the release action in FIG. 18 described above are confirmed. The release action in FIG. 18 described above is performed by applying the parameter values of the release parameters defined by level 4 of the parameter table 159 of FIG. 19. Specifically, the parameter values of the following release parameters are applied. The ”number of switches of opening pressure during initial release (when switching from the second pressure P_2 to the first pressure P_1 and then from the first pressure P_1 to the second pressure P_2 is counted as once, the same applies below) ” is FSN4 = 1. The ”number of switches of opening pressure during main release” is SSN4 = 2. The ”holding time of first pressure” which is a time for holding the opening pressure at the first pressure P_1 is HT4 = 130 ms. The ”number of moving elements descended simultaneously” is DN4 = 0. The ”descending time interval between moving elements” when the front end surfaces of the moving elements 30 are made to descend in order from the first position to the second position is IT4 = 240 ms. In addition, the ”collet waiting time”, which is a time from when the collet 18 lands on the semiconductor die 15 to when lifting of the semiconductor die 15 is started, is WT4 = 710 ms. Then, the ”pickup time” is PT4 = 820 ms.

[0072] <Parameter table>

Here, the parameter table 159 in FIG. 19 is described in more detail. The release

action can be performed by selecting (setting) one level value from levels 1 to 8 of the parameter table 159 according to the releasability of the semiconductor die 15 from the dicing sheet 12, and applying the parameter value of each release parameter defined by the level value. The higher level value (low-speed level) is selected for the more difficult release.

[0073] The parameter value of each release parameter in the parameter table 159 has the following tendency according to the variation of the level value. As shown in FIG. 19, the "number of switches of opening pressure during initial release" increases from level 1 to level 8. However, this does not mean that the number of switches always increases every time the level value varies, and the number of switches may be the same for a plurality of adjacent level values. The same applies to the other release parameters and does not mean that the parameter value varies every time the level value varies, and the parameter value may be the same for a plurality of adjacent level values. The "number of switches of opening pressure during main release" increases from level 1 to level 8. In addition, the "holding time of first pressure" is lengthened from level 1 to level 8. The "descending time interval between moving elements" is lengthened from level 1 to level 8. In addition, the "collet waiting time" is lengthened from level 1 toward level 8. The "pickup time" varies as the level value varies, and becomes longer from level 1 to level 8. Besides, the "pickup time" is similar to the "collet waiting time", but includes, in addition to the collet waiting time, the time until the collet 18 is descended from a predetermined position to land on the semiconductor die 15 and the time for the semiconductor die 15 to rise to a predetermined position after the lifting of the semiconductor die 15 is started. Besides, the release parameter can also be referred to as a "pickup parameter". "Setting the pickup parameter" can be defined as setting the

parameter value of the pickup parameter (release parameter), and "changing the pickup parameter" can be defined as changing the parameter value of the pickup parameter (release parameter). In addition, the parameter table 159 in FIG. 19 can also be referred to as a "condition table", and the parameter value of the release parameter can also be referred to as a "pickup condition". Besides, the specific parameter values shown in FIG. 19 are merely examples, and obviously may be other values.

[0074] Here, as an example of the release action other than the release action of level 4 described above, the release actions of level 1 and level 8 are described. First, the release action of level 8 is described. Level 8 is a level value to be set for the semiconductor die 15 that is extremely difficult to release. FIG. 20 is a diagram showing the height of the collet 18, the position of the columnar moving element 45, the position of the intermediate annular moving element 40, the position of the peripheral annular moving element 31, and the opening pressure of the opening 23 during the release action of level 8. The following can be understood by comparing the release action of level 8 in FIG. 20 with the release action of level 4 in FIG. 18.

[0075] In the release action of level 8 in FIG. 20, the "number of switches of opening pressure during initial release" is increased to four times (FSN8). Thereby, even when the periphery of the semiconductor die 15 is difficult to release from the dicing sheet 12, the periphery of the semiconductor die 15 can be sufficiently released from the dicing sheet 12. It is an image of shaking off the dicing sheet 12 attached to the periphery of the semiconductor die 15 by switching the opening pressure many times, and release can be reliably performed though it takes time. In addition, in FIG. 20, the "holding time of first pressure" (HT8) during the initial release is set to 150 ms (see FIG. 19, and the same applies below; for the detailed parameter values, see the same drawing) and lengthened.

Thereby, the periphery of the semiconductor die 15 can be promoted to be naturally released from the dicing sheet 12. Besides, in the example of FIG. 19, there is no great difference in the "holding time of first pressure" between levels 4 and 8, but it is also considered to make the difference larger.

[0076] In addition, in the release action of level 8 in FIG. 20, the "number of switches of opening pressure during main release" is increased to four times (SSN8). Thereby, even when the region closer to the inner side than the periphery of the semiconductor die 15 is difficult to release from the dicing sheet 12, reliable release can be performed so as to shake off the dicing sheet 12 attached to the semiconductor die 15. In FIG. 20, the "holding time of first pressure" (HT8) during the actual release is set to 150 ms and lengthened. Thereby, the region closer to the inner side than the periphery of the semiconductor die 15 can be promoted to be naturally released from the dicing sheet 12. Besides, in the parameter table 159 shown in FIG. 19, the "holding time of first pressure" (HT8) is common between the initial release and the main release, but the "holding time of first pressure" different between the initial release and the main release may be defined in the parameter table 159. In addition, as shown in FIG. 20, when there is a plurality of time for holding at the first pressure P_1 by switching the opening pressure a plurality of times during the initial release or during the main release, each of the plurality of "holding time of first pressure" may be defined in the parameter table 159 and the parameter values thereof may be different from each other. For example, the plurality of "holding time of first pressure" is arranged in the order of application in the release action and defined in the parameter table 159.

[0077] In addition, in the release action of level 8 in FIG. 20, the "descending time interval between moving elements" (IT8) is set to 450 ms and lengthened. If the time

from descending the front end surface 38a of the peripheral annular moving element 31 from the first position to the second position until descending the front end surface 38b of the intermediate annular moving element 40 from the first position to the second position is lengthened, the region of the semiconductor die 15 facing the front end surface 38a of the peripheral annular moving element 31 can be promoted to be naturally released from the dicing sheet 12. Similarly, the time from descending the front end surface 38b of the intermediate annular moving element 40 from the first position to the second position until descending the front end surface 47 of the columnar moving element 45 from the first position to the second position is lengthened, the region of the semiconductor die 15 facing the front end surface 38b of the intermediate annular moving element 40 can be promoted to be naturally released from the dicing sheet 12. Besides, the descending time interval between the peripheral annular moving element 31 and the intermediate annular moving element 40 and the descending time interval between the intermediate annular moving element 40 and the columnar moving element 45 may be different, and in this case, each descending time interval is defined in the parameter table 159. Besides, as shown in FIG. 2, the number of the intermediate annular moving elements 40 and 41 may be two or more, and in this case, descending is performed in the order from the intermediate annular moving element 40 on the outer peripheral side to the intermediate annular moving element 41 on the inner peripheral side. When the number of the intermediate annular moving elements 40 and 41 is two or more in this manner, the descending time interval between the intermediate annular moving element 40 and another intermediate annular moving element 41 may be defined in the parameter table 159. Besides, for example, the time from a time point at which the pickup action is started (time t1 in FIG. 20) to a time point at which the peripheral annular moving element

31 (the moving element 30 to be descended first) is descended from the first position to the second position may be defined in the parameter table 159.

[0078] In addition, in the release action of level 8 in FIG. 20, the "collet waiting time" (WT8) is set to 1590 ms and lengthened. Then, in FIG. 20, the "pickup time" (PT8) is 1700 ms, which is long.

[0079] Next, the release action of level 1 is described. Level 1 is a level value to be set for the semiconductor die 15 that is extremely easy to release. FIG. 21 is a diagram showing the height of the collet 18, the position of the columnar moving element 45, the position of the intermediate annular moving element 40, the position of the peripheral annular moving element 31, and the opening pressure of the opening 23 during the release action of level 1. The following can be understood by comparing the release action of level 1 in FIG. 21 with the release action of level 4 in FIG. 18.

[0080] In the release action of level 1 of FIG. 21, the "holding time of first pressure" (HT1) during the initial release is set to 100 ms and shortened. When the semiconductor die 15 is easily released from the dicing sheet 12, the periphery of the semiconductor die 15 is sufficiently released from the dicing sheet 12 even if the "holding time of first pressure" is shortened. By shortening the "holding time of first pressure" in this manner, the time required for the release action can be shortened.

[0081] In addition, in the release action of level 1 in FIG. 21, the "number of switches of opening pressure during main release" is reduced to once (SSN1). When the semiconductor die 15 is easily released from the dicing sheet 12, the region closer to the inner side than the periphery of the semiconductor die 15 is sufficiently released from the dicing sheet 12 even if the "number of switches of opening pressure during main release" is once. In addition, in FIG. 21, the front end surfaces 38a, 38b, and 47 of the three

moving elements 30 (the peripheral annular moving element 31, the intermediate annular moving element 40, the columnar moving element 45) are simultaneously descended from the first position to the second position or lower at time ts1, and the "number of moving elements descended simultaneously" is increased to three (DN1). When the semiconductor die 15 is easily released from the dicing sheet 12, the region closer to the inner side than the periphery of the semiconductor die 15 is immediately released from the dicing sheet 12 even if the plurality of moving elements 30 are simultaneously descended. Besides, when the peripheral annular moving element 31 and the intermediate annular moving element 40 are simultaneously descended and the columnar moving element 45 is descended after a predetermined time, the "number of moving elements descended simultaneously" is two. Besides, in the parameter table 159 of FIG. 19, two release parameters of the "number of moving elements descended simultaneously" and the "descending time interval between moving elements" are defined, but instead of the two release parameters, the "descending time interval between the annular moving element 31 and the intermediate annular moving element 40", the "descending time interval between the intermediate annular moving element 40 and the columnar moving element 45", and the "descending time interval between the intermediate annular moving element 40 and another intermediate annular moving element 41" can be defined. In this case, one or more of these descending time intervals are set to 0 in order to simultaneously descend the plurality of moving elements 30.

[0082] In addition, in the release action of level 1 in FIG. 21, the "collet waiting time" (WT1) is set to 460 ms and shortened. Then, in FIG. 21, the "pickup time" (PT1) is 570 ms, which is short.

[0083] As described above, the parameter value of each release parameters is made

different according to the level value, that is, the release action (pickup action) is made different. It is possible to suppress damage to the semiconductor die 15 or pickup error during pickup by setting a level value close to level 8 for the semiconductor die 15 that is difficultly released to perform the release action. On the other hand, it is possible to perform the pickup in a short time by setting a level value close to level 1 for the semiconductor die 15 that is easily released to perform the release action. Besides, the plurality of level values can be referred to as values indicating the length of time required for pickup.

[0084] <Detection method for releasability>

Next, a detection method for the releasability of the semiconductor die 15 from the dicing sheet 12 is described. The releasability of the semiconductor die 15 from the dicing sheet 12 can be detected from the time variation (actual flow rate variation) of the suction air flow rate of the collet 18 detected by the flow rate sensor 106.

[0085] FIG. 22 is a diagram showing the time variation in the opening pressure during the initial release and the air leakage amount (suction air flow rate) of the collet 18 detected by the flow rate sensor 106, and the meaning of each timing of t1, t2, t3, and t4 is the same as those timings shown in FIG. 18. A solid line 157 in the graph of the air leakage amount in FIG. 22 indicates the expected flow rate variation 157 which is a time variation of the air leakage amount when the release of the semiconductor die 15 from the dicing sheet 12 is good (when the easiness of release is extremely high), and the expected flow rate variation 157 is stored in the storage unit 152 in advance. Specifically, the expected flow rate variation 157 stored in the storage unit 152 may be a set of many suction air flow rates acquired at a predetermined sampling cycle, and may be the suction air flow rates associated with many discrete times t. A one-dot dashed

line 158a and a two-dot dashed line 158b in the graph of the air leakage amount in FIG. 22 are examples of the actual flow rate variation 158 which is a time variation of the air leakage amount actually detected when the semiconductor die 15 is picked up from the dicing sheet 12. The actual flow rate variation 158 is stored in the storage unit 152 every time the specific semiconductor die 15 is picked up. Specifically, the actual flow rate variation 158 stored in the storage unit 152 may be in a form that can be compared with the expected flow rate variation 157. For example, similar to the expected flow rate variation 157, the actual flow rate variation 158 may be a set of many suction air flow rates acquired at a predetermined sampling cycle, and may be the suction air flow rates associated with many discrete times t. Besides, the actual flow rate variation can be simply referred to as a "flow rate variation". In addition, the actual flow rate variation can be referred to as "actual flow rate information", and the expected flow rate variation can be referred to as "expected flow rate information".

[0086] When the release of the semiconductor die 15 from the dicing sheet 12 is good, if the opening pressure starts to vary toward the first pressure P_1 close to vacuum at time t3, the periphery of the semiconductor die 15 is separated from the front surface 18a of the collet 18 (see FIG. 8), but the periphery of the semiconductor die 15 immediately returns to the front surface 18a of the collet 18 (see FIG. 9). Therefore, as the expected flow rate variation 157 in FIG. 22, the air leakage amount starts to increase from time t3, but immediately turns to decrease (turns to decrease at time tr_exp). In the expected flow rate variation 157, the increased air leakage amount is small.

[0087] On the other hand, when the releasability of the semiconductor die 15 from the dicing sheet 12 is poor (when the easiness of release is low), if the opening pressure starts to vary toward the first pressure P_1 close to vacuum at time t3, the periphery of the

semiconductor die 15 is separated from the front surface 18a of the collet 18, and the periphery of the semiconductor die 15 returns to the front surface 18a of the collet 18 after some time. Therefore, as the actual flow rate variation 158a in FIG. 22, the air leakage amount starts to increase at time t3, continues to increase, and then turns to decrease at time tr_rel later than time tr_exp. In addition, in the actual flow rate variation 158a, the increased air leakage amount is large.

[0088] In addition, when the releasability of the semiconductor die 15 from the dicing sheet 12 is extremely poor (when the easiness of release is extremely low), after the periphery of the semiconductor die 15 is separated from the front surface 18a of the collet 18, the periphery of the semiconductor die 15 does not return to the front surface 18a of the collet 18 even after some time. Therefore, as the actual flow rate variation 158b in FIG. 22, the air leakage amount remains large even at time tc_end when a predetermined time has elapsed from time t4 at which the opening pressure reaches the first pressure P_1 close to vacuum.

[0089] In this manner, as the releasability of the semiconductor die 15 from the dicing sheet 12 deteriorates, the actual flow rate variation 158 deviates from the expected flow rate variation 157. Therefore, the actual flow rate variation 158 is compared with the expected flow rate variation 157, and it is determined that the closer the actual flow rate variation 158 is to the expected flow rate variation 157, the better the releasability is (the higher the easiness of release is). Alternatively, it is determined that the stronger the correlation between the actual flow rate variation 158 and the expected flow rate variation 157, the better the releasability (the higher the easiness of release). In the embodiment, the actual flow rate variation 158 and the expected flow rate variation 157 are compared to obtain the correlation value thereof. The correlation value is a value of 0-1.0, which

is 1.0 when the actual flow rate variation 158 and the expected flow rate variation 157 completely match each other, and it is determined that the closer the correlation value is to 0-1.0, the higher the easiness of release is. Besides, in the embodiment, the range of the correlation value is set as 0-1.0, but it is evident that the correlation value may not be in this range.

[0090] The period for comparing the actual flow rate variation 158 and the expected flow rate variation 157 is, for example, time t1 (the time at which air is started to be sucked from the front surface 18a of the collet 18) to time tc_end (the time when a predetermined time has elapsed from time t4 at which the opening pressure initially reaches the first pressure P_1) in FIG. 22, which is part of the initial release period. Alternatively, the comparison period may be a period from time t3 (the time at which the opening pressure starts to vary toward the first pressure P_1) to tc_end, which is part of the initial release period. The comparison period may be another period, but preferably a period during which the release action is not changed even if the above level value is changed. In this manner, only one pattern of the expected flow rate variation 157 may be stored in the storage unit 152, and it is not necessary to store the pattern of the expected flow rate variation 157 for each level value in the storage unit 152.

[0091] Besides, as the releasability of the semiconductor die 15 from the dicing sheet 12, a value other than the correlation value between the actual flow rate variation 158 and the expected flow rate variation 157 may be obtained. For example, it may be determined that the smaller the difference between the value of the expected flow rate variation 157 at time tc_end in FIG. 22 and the value of the actual flow rate variation 158 at the same time, the better the releasability (the higher the easiness of release). In addition, for example, it may be determined that the smaller the difference between time

tr_exp that is a timing at which the air leakage flow rate in the expected flow rate variation 157 varies from increase to decrease and time tr_rel that is a timing at which the air leakage flow rate in the actual flow rate variation 158 varies from increase to decrease, the higher the easiness of release. In addition, for example, it may be determined that the smaller the difference between the maximum value of the air leakage flow rate of the expected flow rate variation 157 detected after time t3 in FIG. 22 and the maximum value of the air leakage flow rate of the actual flow rate variation 158 detected after the same time, the higher the easiness of release.

[0092] In addition, it is also considered to detect the releasability of the semiconductor die 15 from the dicing sheet 12 without using the expected flow rate variation 157. For example, it may be determined that the smaller the value of the actual flow rate variation 158 at time tc_end in FIG. 22, the better the releasability (the higher the easiness of release). Besides, the correlation value or an index value indicating the releasability of the semiconductor die 15 from the dicing sheet 12 instead of the correlation value, which is obtained based on the actual flow rate variation 158, may be referred to as an "evaluation value".

[0093] <Level transition based on releasability>

Next, the transition of the level value applied during pickup (the level value of the parameter table 159) is described. As described below, the semiconductor die pickup system 500 acquires the actual flow rate variations 158 during pickup of one or more specific semiconductor dies 15, obtain the correlation values of the respective specific semiconductor dies 15 based on the acquired one or more actual flow rate variations 158, and changes the level value applied during pickup of another semiconductor die 15 after pickup of the specific semiconductor dies 15 based on the one or more correlation values.

[0094] For example, the releasability of the semiconductor die 15 from the dicing sheet 12 may vary even if the same type of semiconductor die 15 is continuously picked up from the same type of dicing sheet 12. By transitioning the level value applied during pickup according to the variation of releasability, the semiconductor die 15 can be stably picked up without damage even if the releasability becomes poor (the releasability becomes low). On the other hand, the pickup can be performed in a shorter time when the releasability becomes good (the easiness of release becomes high).

[0095] In addition, for example, the type of the semiconductor die 15, the type of the dicing sheet 12 or the like may vary, and the optimum level value for pickup may be unknown. In this case, first, level 8 of the parameter table 159 (see FIG. 19) that enables the most stable pickup is applied to perform the pickup, and the level value is gradually transitioned to level 1 (the highest speed) based on the correlation value of the specific semiconductor die 15. Thereby, the optimum level value is searched, and an optimum pickup in which stability and high speed are balanced can be realized.

[0096] Next, specific transition control for level value is described. FIG. 23 is a flowchart showing a flow of level transition control in the embodiment. In the embodiment, all the semiconductor dies 15 are treated as a specific semiconductor die 15, and there is an opportunity to transition the level value every time the semiconductor die 15 of one or more wafers is picked up. The transition of the level value includes a transition from the level value applied to the current pickup (current level value) to the next level value (see FIG. 25) and a transition that does not limit the level value of the transition destination (see FIG. 26). The details are described below.

[0097] First, the control unit 150 sets a level value (current level value 161) applied during first pickup, and stores the level value in the storage unit 152. Here, the current level

value 161 is set to level 4 of the parameter table 159 in FIG. 19. Besides, this setting and each step of the flow in FIG. 23 are performed by the control unit 150 functioning as a setting part. However, the control of the pickup action of the semiconductor die 15 is performed by the control unit 150 functioning as a pickup control part. In S100 of FIG. 23, the control unit 150 initializes a variable n to 0. The variable n is a variable for counting the number of wafers that have been picked up. Then, in S102, the wafer is replaced to prepare for picking up the semiconductor die 15 of the new wafer. In S104, the control unit 150 picks up the semiconductor die 15. The current level value = 4 is used as a key to read the parameter value of each release parameter of level 4 from the parameter table 159, and the read parameter value of each release parameter is applied to pick up the semiconductor die 15. At this time, the suction air flow rate of the collet 18 is detected by the flow rate sensor 106, and the suction air flow rate is input to the control unit 150. The control unit 150 (setting part) acquires the actual flow rate variation 158 which is a time variation of the suction air flow rate, and stores the same in the storage unit 152 (S1041).

[0098] Then, in S106, the control unit 150 calculates a correlation value (evaluation value) between the actual flow rate variation 158 and the expected flow rate variation 157 stored in storage unit 152 in advance, and stores the correlation value in the storage unit 152. Then, in S108, the control unit 150 confirms whether the pickup of all the semiconductor dies 15 of a single wafer has been completed. If all the semiconductor dies 15 of the single wafer have not been picked up (S108: No), the pickup of the semiconductor die 15 in S104 and the acquisition of the actual flow rate variation 158 in S1041, and the calculation of the correlation value calculation in S106 are repeatedly performed. When all the semiconductor dies 15 of the single wafer have been picked

up (S108: Yes), the process proceeds to S110.

[0099] Next, in S110, the control unit 150 adds one to the variable n (increases the variable n). Then, in S112, the control unit 150 confirms whether the variable n is a constant Y or more. The constant Y is an integer of 1 or more and defines the number of wafers. In S112, the control unit 150 confirms whether the number of picked-up wafers (variable n) has reached the number of wafers indicated by the constant Y. When S112 is No, the process returns to S102, and S102 to S110 are repeated. When S112 is Yes, the process proceeds to S114.

[0100] In S114, the control unit 150 acquires, from the correlation values (evaluation values) of the plurality of semiconductor dies 15 (specific semiconductor dies 15) obtained by repeatedly executing S106, a representative correlation value (representative die value) which is the representative value of the correlation values. The representative correlation value is, for example, an average value or a central value of a plurality of correlation values, but is not limited thereto and may be a representative value obtained using known statistical processing.

[0101] Next, in S116, the control unit 150 confirms whether the representative correlation value acquired in S114 is smaller than a threshold TH1. FIG. 24 is an example of the threshold table 160. The threshold table 160 is stored in the storage unit 152 in advance. The threshold table 160 is a table in which the threshold TH1 and a threshold TH2 are defined for each level value, and defines the range of the easiness of release (correlation value) of the semiconductor die 15 assumed by each level value. For example, level 4 which is the current level value indicates a level value to be used when the easiness of release (correlation value) of the semiconductor die 15 from the dicing sheet 12 is 0.81 (threshold TH1) to 0.85 (threshold TH2), and indicates that another level

value should be used when the easiness of release is not within that range. The same applies to the threshold values TH1 and TH2 of other level values; level 1 in which the threshold value TH1 is not defined indicates a level value to be used when the easiness of release (correlation value) is 0.96 (threshold value TH1) or more, and level 8 in which the threshold value TH1 is not defined indicates a level value to be used when the easiness of release (correlation value) is 0.65 (threshold value TH2) or more.

[0102] In S116, the control unit 150 reads the threshold value TH1 = 0.81 of level 4 which is the current level value 161 from the threshold value table 160 in the storage unit 152, and confirms whether the representative correlation value is smaller than 0.81 (threshold TH1). Then, when S116 is Yes, in S120, the control unit 150 increases the current level value 161 by one (changes into to a low-speed level value) to level 5, and stores the current level 161 = 5 in the storage unit 152. This is a transition from level 4 to level 5 in the level transition diagram shown in FIG. 25. Then, after S120, the process returns to S100 again to perform processing. When the representative correlation value is smaller than the threshold value TH1 of level 4 (current level value 161) in this manner, the actual easiness of release of the semiconductor die 15 is lower than the easiness of release assumed by level 4, and thus the representative correlation value is transitioned to a lower-speed level value to perform the pickup in which damage to the semiconductor die 15 or pickup error is suppressed.

[0103] On the other hand, when S116 is No, the process proceeds to S118. In S118, the control unit 150 reads the threshold value TH2 = 0.85 from the threshold value table 160 in the storage unit 152, and confirms whether the representative correlation value is larger than 0.85 (threshold TH2). Then, when S118 is Yes, in S122, the control unit 150 reduces the current level value 161 by one (changes into a high-speed level value) to level

3, and stores the current level value 161 = 3 in the storage unit 152. This is a transition from level 4 to level 3 in the level transition diagram shown in FIG. 25. Then, after S122, the process returns to S100 again to perform processing. When the representative correlation value is larger than the threshold value TH2 of the level 4 (current level value 161) in this manner, the actual easiness of release of the semiconductor die 15 is higher than the easiness of release assumed by level 4, and thus the representative correlation value is transitioned to a higher-speed level value to shorten the pickup time of the semiconductor die 15.

[0104] When S118 in FIG. 23 is No, the level value is not changed and the process returns to S100 to perform the processing. In this case, because the actual easiness of release of the semiconductor die 15 is within the range of the easiness of release assumed by level 4 (current level value 161), the parameter values of the release parameters of level 4 are applied to continuously perform the pickup. The control unit 150 repeatedly performs the level transition control described above.

[0105] Besides, in the above description, in each of S116 and S118, the representative correlation value is compared with each of the threshold values TH1 and TH2 of one level value (level 4 which is the current level value) in the threshold table 160, and the level value is increased by one (changed into a low speed level) in S120, or the level value is reduced (changed to a high speed level) in S122, or the level value is kept. However, in each of S116 and S118, the representative correlation value is compared with each of the threshold values TH1 and TH2 of the plurality of level values in the threshold table 160, and the level value may be increased by two levels or more at once in S120, or the level value may be reduced by two levels or more at once in S122, or the level value may be kept. Specifically, for example, when the current level value = 4, in S116, the control

unit 150 compares the representative correlation value and each threshold value TH1 of levels 4, 5, 6, and 7 in the threshold value table 160 of FIG. 24, and acquires the highest level value among the level values satisfying the condition (the representative correlation value < TH1). For example, if the representative correlation value is 0.70, level 6 which is the largest level value among the level values satisfying the condition (the representative correlation value < TH1) is acquired. Then, in S120, the control unit 150 transitions the current level value 161 to level 7 which is the level value one level higher than the level value = 6 acquired in S116. This is a transition from level 4 to level 7 in the level transition diagram shown in FIG. 26. Besides, in the level transition diagram of FIG. 26, only the line showing the transition from level 4 to another level value is drawn, and the line showing the transition from another level value to a level value other than the another level value is omitted. In addition, similarly, for example, when the current level value 161 = 4, in S118, the control unit 150 compares the representative correlation value and each threshold value TH2 of levels 4, 3, and 2 in the threshold value table 160 of FIG. 24, and acquires the smallest level value among the level values satisfying the condition (the representative correlation value > TH2). For example, if the representative correlation value is 0.92, level 3 is acquired as the smallest level value among the level values satisfying the condition (the representative correlation value > TH2). Then, in S122, the control unit 150 transitions the current level value 161 to level 2 which is the level value one level lower than the level value = 3 acquired in S118. This is a transition from level 4 to level 2 in the level transition diagram shown in FIG. 26. In this manner, if the level value can be increased by two levels or more at once or reduced by two levels or more at once, the level value can reach the optimum level value for pickup earlier.

[0106] <Effect>

Next, the effects of the semiconductor die pickup system 500 described above are described. According to the semiconductor die pickup system 500 described above, by applying the release action of the semiconductor die 15 including switching the opening pressure of the opening 23 arranged on the adsorption surface 22 of the stage 20 between the first pressure close to vacuum and the second pressure close to atmospheric pressure, damage to the semiconductor die 15 during pickup or pickup error can be accurately suppressed.

[0107] In addition, the semiconductor die pickup system 500 described above acquires the time variation of the suction air flow rate of the collet 18 (actual flow rate variation 158) during pickup of a specific semiconductor die 15 (each semiconductor die 15 of one or more wafers in the flow of FIG. 23). Then, based on the acquired actual flow rate variation 158, the level value applied during pickup of another semiconductor die 15 after pickup of the specific semiconductor die 15 is changed. That is, the release action (parameter value of each release parameter (pickup parameter)) applied during pickup of the another semiconductor die 15 is changed. Thus, for example, in the case where the semiconductor die 15 is continuously picked up, when the releasability of the semiconductor die 15 from the dicing sheet 12 varies, the release action (pickup action) is changed according to the variation in the releasability. When the releasability becomes poor (the easiness of release is low), the release action is changed to further promote the release, and thus the damage to the semiconductor die 15 or the pickup error can be accurately suppressed. On the other hand, when the releasability becomes good (the easiness of release is high), the release action is changed to a shorter-time one, and thus the pickup time can be shortened. In this manner, it is possible to achieve an

appropriate balance between the suppression of damage to the semiconductor die 15 or pickup error and the pickup speedup of the semiconductor die 15.

[0108] The semiconductor die pickup system 500 described above is overwhelmingly advantageous compared with the case in which the release action of the semiconductor die 15 currently being picked up is changed in real time while the suction air flow rate of the collet 18 is confirmed.

[0109] First, when the release action is changed in real time, a series of processing, such as (1) detecting the suction air flow rate, (2) determining whether to change the release action from the detection result, (3) changing the release action from the determination result or proceeding the action forward without change, is repeated many times during pickup of the single semiconductor die 15. If the determination in (2) is not completed, the process cannot proceed to (3) (the action cannot proceed forward), which may cause a delay in pickup. Because the pickup of the semiconductor die 15 is executed by millions for example, the pickup delay per one semiconductor die 15 eventually becomes a huge delay. On the other hand, the semiconductor die pickup system 500 of the embodiment described above detects the suction air flow rate during pickup, which is used for pickup of subsequent semiconductor dies 15, has no effect on the current pickup action. That is, the action cannot proceed if there are not (2) and (3) during the pickup action and the determination is not completed. Thus, the pickup action can be extremely fast. In addition, in the semiconductor die pickup system 500 described above, for example, a plurality of CPUs 151 is arranged in the control unit 150, and it is possible to perform control of the pickup action in one CPU 151 and simultaneously (in the background) perform acquisition of the actual flow rate variation 158, calculation of the correlation value from the actual flow rate variation 158, and

acquisition of the level value of a subsequent semiconductor die from the correlation value in another CPU 151, which enables further speedup.

[0110] In addition, when the release action is changed in real time, the above (1) to (3) are performed during the pickup action, and thus the control becomes extremely complicated. On the other hand, the semiconductor die pickup system 500 described above can greatly simplify control.

[0111] In addition, when the release action is changed in real time, it is very difficult for the operator to grasp what kind of release action is applied to each semiconductor die 15 to perform pickup. On the other hand, because the semiconductor die pickup system 500 described above does not change the release action during the pickup action, it is easy to grasp what kind of release action is applied to each semiconductor die 15 to perform pickup. This grasp is very important. For example, if the number of switches of the opening pressure which is one of the release parameters is increased, the semiconductor die 15 is sufficiently released from the dicing sheet 12 even when the release is difficult, and the occurrence of damage to the semiconductor die 15 or pickup error can be suppressed. On the other hand, by increasing the number of switches of the opening pressure, the semiconductor die 15 may be repeatedly bent and deformed, and the damage to the semiconductor die 15 may increase. For this semiconductor die 15, it is preferable to actively perform crack inspection for example. That is, it is preferable to grasp the release action applied to each semiconductor die 15 and perform quality control of each semiconductor die 15. The semiconductor die pickup system 500 described above can perform this quality control extremely easily.

[0112] Besides, the advantages of the semiconductor die pickup system 500 of the embodiment over the case of changing the release action in real time have been described

above, but the embodiment of changing the release action in real time is excluded from the present invention. That is, in the semiconductor die pickup system 500 of the present invention, the release action of the semiconductor die 15 which is currently being picked up may be changed in real time while the suction air flow rate of the collet 18 is confirmed. For example, in the semiconductor die 15 that is currently being picked up, the release action during the main release may be changed based on the actual flow rate variation 158 acquired during the initial release.

[0113] <Level value for each type of release parameter>

Next, a case in which a level value is set for each type of the release parameters is described. In the parameter table 159 of FIG. 19 described above, the level values commonly used for a plurality of types of release parameters are prepared. However, as shown in FIGS. 27A and 27B, parameter tables 159a and 159b may be prepared for each type of the release parameters, and the level value may be prepared for each type of the release parameters. Levels A-1 to A-8 of the "number of switches of opening pressure during initial release" are defined in the parameter table 159a of FIG. 27A, and levels B-1 to B-8 of the "number of switches of opening pressure during main release" are defined in the parameter table 159b of FIG. 27B. Besides, although not shown in the drawing, similar parameter tables are prepared individually for other release parameters. Then, the threshold table 160 shown in FIG. 24 is also prepared for each type of the release parameters, and the thresholds TH1 and TH2 corresponding to the level value of each release parameter are defined. For example, a threshold table that defines each of the thresholds TH1 and TH2 as shown in FIG. 24 in association with levels A-1 to A-8 in FIG. 27A is prepared, and another threshold table that defines each of the thresholds TH1 and TH2 as shown in FIG. 24 in association with levels B-1 to B-8 in FIG. 27B is prepared.

Similarly, separate threshold tables are prepared for other release parameters. In addition, the current level value is stored in the storage unit 152 for each type of the release parameters.

[0114] Then, in the flow of FIG. 23, in S104, the current level value for each type of the release parameters is used as a key to read the parameter value from each of the parameter tables for each type of the release parameters, and the semiconductor die 15 is picked up. For example, the current level value (one level value of A-1 to A-8) for the "number of switches of opening pressure during initial release" is used as a key to read, from the parameter table 159a (FIG. 27A) for the "number of switches of opening pressure during initial release", the "number of switches of opening pressure during initial release" corresponding to this current level value, and the semiconductor die 15 is picked up. Similarly, the current level value (one level value of B-1 to B-8) for the "number of switches of opening pressure during main release" is used as a key to read, from the parameter table 159b (FIG. 27B) for the "number of switches of opening pressure during main release", the "number of switches of opening pressure during main release" corresponding to this current level value, and the semiconductor die 15 is picked up.

[0115] In addition, in the flow of FIG. 23, the threshold value table prepared for each type of the release parameters and the current level value for each type of the release parameters are used to execute S116, S118, S120, and S122 for each type of the release parameters, and the current level value for each type of the release parameters is individually transited. For example, in S116 and 118, the current level value (one level value of A-1 to A-8) for the "number of switches of opening pressure during initial release" and the threshold table for the "number of switches of opening pressure during initial release" are used, the threshold values TH1 and TH2 are read from the threshold table

using the current level value as a key, and each of the read threshold values TH1 and TH2 is compared with the representative correlation value; according to the comparison result, in S120 and S122, the current level value (one level value of A-1 to A-8) for the “number of switches of opening pressure during initial release” is transitioned to another level value (one level value of A-1 to A-8). Similarly, in S116 and S118, the current level value (one level value of B-1 to B-8) of the “number of switches of opening pressure during main release” and the threshold value table for the “number of switches of opening pressure during main release” are used, the threshold values TH1 and TH2 are read from the threshold value table using the current level value as a key, and each of the read threshold values TH1 and TH2 is compared with the representative correlation value; according to the comparison result, in S120 and S122, the current level value (one level value of B-1 to B-8) for the “number of switches of opening pressure during main release” is transitioned to another level value (one level value of B-1 to B-8). The same applies to other release parameters.

[0116] In this manner, the current level value is managed for each type of the release parameters, and transitioned to a low-speed level or a high-speed level for each type of the release parameters, and thus the semiconductor die 15 can be picked up by combining the parameter values of more various release parameters according to the releasability of the semiconductor die 15.

[0117] <Level transition control of another embodiment>

Next, level transition control of another embodiment is described. FIGS. 28 and 29 are flowcharts showing a flow of the level transition control in another embodiment. In this embodiment, all the semiconductor dies 15 are treated as a specific semiconductor die 15, and there is an opportunity to transition the level value every time the

semiconductor die 15 of one or more wafers is picked up. The details are described below.

[0118] First, the control unit 150 stores the level value (current level 161) applied during first pickup in the storage unit 152. Here, the current level value 161 is set to level 4 of the parameter table 159 in FIG. 19. Besides, this setting and each step of the flow in FIGS. 28 and 29 are performed by the control unit 150 functioning as a setting part. However, the control of the pickup action of the semiconductor die 15 is performed by the control unit 150 functioning as a pickup control part. In S200 of FIG. 28, the control unit 150 initializes variables n1 and n2 to 0. The variables n1 and n2 are variables for counting the number of wafers. Then, in S202, the wafer is replaced to prepare for picking up the semiconductor die 15 of the new wafer. In S204, the control unit 150 initializes variables m1 and m2 to 0. The variable m1 is a variable for counting the number of the semiconductor dies 15 that are detected as being difficultly released on the single wafer (the number of difficult release detections), and the variable m2 is a variable for counting the number of the semiconductor dies 15 that are detected as being easily released on the single wafer (the number of easy release detections).

[0119] Next, in S206, the control unit 150 performs the pickup of the semiconductor die 15. In this case, the current level value = 4 is used as a key to read the parameter value of each release parameter from the parameter table 159, and the read parameter value is applied to pick up the semiconductor die 15. At this time, the suction air flow rate of the collet 18 is detected by the flow rate sensor 106, and the suction air flow rate is input to the control unit 150. The control unit 150 (setting part) acquires the actual flow rate variation 158 which is a time variation of the suction air flow rate, and stores the same in the storage unit 152 (S2061). Then, in S208, the control unit 150 calculates

the correlation value (evaluation value) between the actual flow rate variation 158 and the expected flow rate variation 157 stored in the storage unit 152 in advance, and stores the correlation value in the storage unit 152.

[0120] Then, in S210, the control unit 150 confirms whether the correlation value calculated in S208 is lower than the threshold value TH1 (the twelfth predetermined value). This threshold value TH1 is a threshold value TH1 defined in the threshold value table 160 shown in FIG. 24, and the threshold value TH1 = 0.81 of level 4 of the current level value 161 is used here. If S210 is Yes, the control unit 150 adds one to the variable m1 (the number of difficult release detections) (increases the variable m1) in S212. If S210 is No, the control unit 150 proceeds to S214 without executing S212.

[0121] In S214, the control unit 150 confirms whether the correlation value calculated in S208 is higher than the threshold TH2 (the eleventh predetermined value). This threshold value TH2 is a threshold value TH2 defined in the threshold value table 160 shown in FIG. 24, and the threshold value TH2 = 0.85 of level 4 of the current level value is used here. If S214 is Yes, the control unit 150 adds one to the variable m2 (the number of easy release detections) (increases the variable m2) in S216. If S214 is No, the control unit 150 proceeds to S218 without executing S216.

[0122] In S218, the control unit 150 confirms whether the pickup of all the semiconductor dies 15 of the single wafer has been completed. If the pickup of all the semiconductor dies 15 of the single wafer has not been completed (S218: No), S206 to S216 are repeated, and if the pickup has been completed (S218: Yes), the process proceeds to S220 of FIG. 29.

[0123] In S220 of FIG. 29, the control unit 150 confirms whether the variable m1 (the number of difficult release detections) is larger than a constant Q. The constant Q is an

integer of 0 or more. When S220 is Yes, the control unit 150 initializes the variable n2 to 0 in S224. Then, in S226, the control unit 150 adds one to the variable n1 (increases the variable n1). In this manner, the variable n1 counts the number of wafers satisfying the condition of S220. Then, in S228, the control unit 150 confirms whether the variable n1 is larger than a constant Y1. The constant Y1 is an integer of 0 or more. In S228, it is confirmed whether the number of wafers satisfying the condition of S220 (variable n1) is larger than a predetermined number (constant Y1). If S228 is Yes, in S230, the control unit 150 increases the current level value 161 by one (changes into a low-speed level value) to level 5, and stores the current level value = 5 in the storage unit 152. Then, in S240, the control unit 150 initializes the variables n1 and n2 to 0. Then, after S240, the process returns to S202 of FIG. 28 to repeat the processing. In this manner, when the number of wafers (variable n1) satisfying the condition of S220 (the number m1 of difficult release detections of the single wafer is larger than the constant Q) is larger than the predetermined number (constant Y1), it is determined that the actual easiness of release of the semiconductor die 15 is lower than the easiness of release assumed by level 4, and transition to a lower-speed level value is made to perform pickup in which the damage to the semiconductor die 15 or the pickup error is suppressed. When S228 is No, the level value is not changed, and the process returns to S202 of FIG. 28 to repeat the processing.

[0124] On the other hand, when S220 is No, the process proceeds to S222. In S222, the control unit 150 confirms whether the variable m2 (the number of easy release detections) is larger than a constant P. The constant P is an integer of 0 or more. When S222 is Yes, the control unit 150 initializes the variable n1 to 0 in S232. Then, in S234, the control unit 150 adds one to the variable n2 (increases the variable n2). In this

manner, the variable n2 counts the number of wafers satisfying the condition of S222. Then, in S236, the control unit 150 confirms whether the variable n2 is larger than a constant Y2. The constant Y2 is an integer of 0 or more. In S236, it is confirmed whether the number of wafers satisfying the condition of S222 (variable n2) is larger than a predetermined number (constant Y2). If S236 is Yes, in S238, the control unit 150 reduces the current level value 161 by one (changes to a high-speed level value) to level 3, and stores the current level value = 3 in the storage unit 152. Then, in S240, the control unit 150 initializes the variables n1 and n2 to 0. Then, after S240, the process returns to S202 of FIG. 28 to repeat the processing. As described above, when the number of wafers (variable n2) satisfying the condition of S222 (the number m2 of easy release detections of the single wafer is larger than the constant P) is larger than the predetermined number (constant Y2), it is determined that the actual easiness of release of the semiconductor die 15 is higher than the easiness of release assumed by level 4 (current level value), and transition to a higher-speed level value is made to shorten the pickup time of the semiconductor die 15. When S222 is No and S236 is No, the level value is not changed, and the process returns to S202 of FIG. 28 to repeat the processing.

[0125] In the embodiments described above, it is possible to accurately suppress damage to the semiconductor die 15 during pickup of the semiconductor die 15, and during continuous pickup of a plurality of semiconductor dies 15, it is possible to achieve an appropriate balance between the suppression of damage to the semiconductor dies 15 and the pickup speedup of the semiconductor dies 15.

[0126] <Other>

In each of the embodiments described above, the actual flow rate variation 158 is acquired for all the semiconductor dies 15. That is, all the semiconductor dies 15 are set as a

specific semiconductor die 15. However, the semiconductor die 15 (specific semiconductor die 15) for which the actual flow rate variation 158 is acquired may not be all the semiconductor dies 15. For example, one or more semiconductor dies 15 of the single wafer may be the specific semiconductor die 15.

[0127] Further, in each of the embodiments described above, an opportunity to transition the level value is given every time the semiconductor die 15 of one or more wafers is picked up. However, the opportunity to transition the level value may be given every time one semiconductor die 15 is picked up or a plurality of semiconductor dies 15 is picked up. For example, when a large number of semiconductor dies 15 is sequentially picked up, the greater the fluctuation (or assumed fluctuation) in the releasability of the semiconductor dies 15, the more frequently the opportunity to transition the level value is given.

[0128] In addition, in each of the embodiments described above, the pickup is performed by applying a new level value from the semiconductor die 15 immediately after the specific semiconductor die 15 (the semiconductor die 15 for which the actual flow rate variation 158 is acquired) is picked up. However, after the specific semiconductor die 15 is picked up, a predetermined number of semiconductor dies 15 may be picked up, and then the semiconductor die 15 may be picked up applying a new level value. Besides, in the specification, "pickup of another semiconductor die 15 after pickup of the specific semiconductor die 15" does not only means "pickup of the semiconductor die 15 immediately after pickup of the specific semiconductor die 15", but includes the pickup of the semiconductor die 15 after sandwiching of the pickup of the predetermined number of semiconductor dies 15 as described above.

[0129] The semiconductor die 15 that is picked up with a large number of switches of

the opening pressure as described above may be more damaged than the other semiconductor dies 15. Therefore, the semiconductor die 15 for which the opening pressure has been switched a predetermined number of times or more during pickup of the semiconductor die 15 may be the target of crack inspection or the like. For example, the collet 18 transports the semiconductor die 15 for which the opening pressure has been switched a predetermined number of times or more to a place different from the other semiconductor dies 15 (inspection module, inspection unit that performs crack inspection, or the like), and an inspection module or the like is used to inspect the semiconductor die 15 for cracks or sagging.

[0130] In addition, in each of the embodiments described above, the period during which the expected flow rate variation 157 and the actual flow rate variation 158 are compared for obtaining the correlation value (evaluation value) is a predetermined period in the initial release. However, the period for comparing the expected flow rate variation 157 and the actual flow rate variation 158 may be may be the entire period of the initial release, the entire period of the main release, the predetermined period in the main release, the combination period of the initial release and the main release, or the like. The expected flow rate variation 157 is stored in the storage unit 152 in advance only for a period of being compared with the actual flow rate variation 158.

[0131] In addition, in the embodiment described above, the correlation value between the actual flow rate variation and the expected flow rate variation is obtained as an index for grasping the releasability of the semiconductor die 15. The correlation value is a value of 0-1.0, and the larger the value is, the more easily the semiconductor die 15 is released from the dicing sheet 12, which is the easiness of release. On the other hand, the value obtained by subtracting the correlation value from 1.0 (1.0-correlation value) is

a value of 0-1.0, and the larger the value is, the more difficultly the semiconductor die 15 is released from the dicing sheet 12, which is the difficulty of release. Instead of the correlation value (easiness of release), the difficulty of release can be used as an index (evaluation value) for grasping the releasability of the semiconductor die 15. In the embodiment described above, the threshold value table 160 in FIG. 24 (a table in which the larger threshold values TH1 and TH2 are set for the lower level value) on the basis of the correlation value (easiness of release) and the range of values taken by the correlation value (0-1.0). However, the threshold value table 160 (a table in which the smaller threshold values TH1 and TH2 are set for the lower level value) on the basis of the difficulty of release (1.0-correlation value) and the range of values taken by the difficulty of release (0-1.0) may be used. Besides, the easiness of release or the difficulty of release can also be referred to as the releasability.

[0132] In addition, in the release action described above, the adsorption pressure of the adsorption surface 22 of the stage 20 is held at the third pressure P_3 close to vacuum during the initial release and the main release. However, during the initial release or the main release, or during the initial release and the main release, the adsorption pressure may be switched once or several times between the third pressure P_3 close to vacuum and the fourth pressure P_4 close to atmospheric pressure. As one of the release parameters, the "number of switches of adsorption pressure" which is the number of times for switching the adsorption pressure of the adsorption surface 22 of the stage 20 between the third pressure P3 and the fourth pressure P4 may be added, and the "number of switches of adsorption pressure" may be increased when the releasability of the semiconductor die 15 is poor, so that the release of the semiconductor die 15 from the dicing sheet 12 is promoted.

[0133] The semiconductor die pickup system 500 can also be referred to as a semiconductor die pickup apparatus. In addition, the semiconductor die pickup system 500 can be a part of a bonding apparatus (bonder, bonding system) or a die bonding apparatus (die bonder, die bonding system), and can also be called by these names.

[0134] <Appendix>

Besides, the first predetermined value, the third predetermined value, the fifth predetermined value, the seventh predetermined value, and the ninth predetermined value described in "Means to Solve Problems" correspond to the threshold values TH2 that are compared with the representative correlation value (representative die evaluation value) in S118 of the flow in FIG. 23. Similarly, the second predetermined value, the fourth predetermined value, the sixth predetermined value, the eighth predetermined value, and the tenth predetermined value described in "Means to Solve Problems" correspond to the threshold values TH1 that are compared with the representative correlation value (representative die evaluation value) in S116 of the flow of FIG. 23.

[0135] Although the respective embodiments of the present invention have been described above, the present invention is not limited to the respective embodiments, and it is evident that the present invention can be implemented in various forms without departing from the scope of the present invention.

[Reference Signs List]

[0136]

10	wafer holder
11	wafer
12	dicing sheet
12a	front surface
12b	back surface

13	ring
14	gap
15	semiconductor die
16	expand ring
17	ring retainer
18	collet
18a	front surface
19	suction hole
20	stage
22	adsorption surface
23	opening
23a	inner surface
24	base portion
26	groove
27	adsorption hole
30	moving element
31	peripheral annular moving element
33	outer peripheral surface
38a, 38b, 47	front end surface
40, 41	intermediate annular moving element
45	columnar moving element
80	opening pressure switching mechanism
81, 91, 101	three-way valve
82, 92, 102	drive unit

83-85, 93-95, 103-105	pipes
90	adsorption pressure switching mechanism
100	suction mechanism
106	flow rate sensor
110	wafer holder horizontal direction drive unit
120	stage vertical direction drive unit
130	collet drive unit
140	vacuum apparatus
150	control unit
151	CPU
152	storage unit
153	device/sensor interface
154	data bus
155	control program
156	control data
157	expected flow rate variation
158, 158a, 158b	actual flow rate variation
159, 159a, 159b	parameter table
160	threshold table
161	current level value
300	stepped surface formation mechanism
400	stepped surface formation mechanism drive unit
500	semiconductor die pickup system
600	pickup control part (control part)

602	setting part

WHAT IS CLAIMED IS:

1. A semiconductor die pickup system, which picks up semiconductor dies attached to the front surface of a dicing sheet from the dicing sheet, comprising:

a collet that adsorbs the semiconductor die;

a suction mechanism that is connected to the collet and sucks air from the front surface of the collet;

a flow rate sensor that detects a suction air flow rate of the suction mechanism;

a stage that comprises an adsorption surface for adsorbing the back surface of the dicing sheet;

an opening pressure switching mechanism that switches the opening pressure of an opening arranged on the adsorption surface of the stage between a first pressure close to vacuum and a second pressure close to atmospheric pressure; and

a setting part that sets a pickup parameter comprising the number of switches of the opening pressure during pickup of a semiconductor die;

wherein the setting part

acquires a flow rate variation which is a time variation of the suction air flow rate detected by the flow rate sensor during pickup of the semiconductor die, calculates an evaluation value obtained by evaluating the releasability for releasing the semiconductor die from the dicing sheet based on the flow rate variation, and

changes the pickup parameter during pickup of another semiconductor die after the semiconductor die is picked up based on the evaluation value.

2. The semiconductor die pickup system according to claim 1,

wherein the setting part

changes, based on the evaluation value, the time for holding the opening

pressure at the first pressure during pickup of the another semiconductor die.

3. The semiconductor die pickup system according to claim 1 or 2, further comprising:

a plurality of moving elements which is disposed at the opening and in which the front end surfaces move between a first position higher than the adsorption surface and a second position lower than the first position;

wherein during pickup of the semiconductor die, each of the plurality of moving elements is sequentially moved at a predetermined time interval, or simultaneously moved in a predetermined combination of the moving elements from the first position to the second position; and

the setting part

changes the predetermined time during pickup of the another semiconductor die based on the evaluation value.

4. The semiconductor die pickup system according to claim 3,

wherein the setting part

changes, based on the evaluation value, the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die.

5. The semiconductor die pickup system according to claim 3,

wherein during pickup of the semiconductor die, an initial release is performed in which the opening pressure is switched between the first pressure and the second pressure to release the dicing sheet sucked at the opening from the semiconductor die; and

the flow rate variation is a time variation of the suction air flow rate detected

by the flow rate sensor during the initial release.

6. The semiconductor die pickup system according to claim 5,

wherein the number of switches is the number of times for switching the opening pressure during the initial release between the first pressure and the second pressure.

7. The semiconductor die pickup system according to claim 1 or 2,

Wherein, during the another semiconductor die is released from the dicing sheet, the setting part

changes, based on the evaluation value, a waiting time from the landing of the collet on the semiconductor die to the start of the lifting of the semiconductor die.

8. The semiconductor die pickup system according to claim 1 or 2, further comprising

a storage unit that stores an expected flow rate variation which is a time variation of the suction air flow rate during pickup of the semiconductor die when the semiconductor die is satisfactorily picked up from the dicing sheet,

wherein the setting part

obtains the evaluation value based on a correlation value between the flow rate variation and the expected flow rate variation during pickup of the semiconductor die.

9. The semiconductor die pickup system according to claim 1 or 2, further comprising

an inspection unit that performs crack inspection for the semiconductor die,

wherein the semiconductor die that has been subjected to the switching a predetermined number of times or more during pickup of the semiconductor die is targeted for crack inspection.

10. The semiconductor die pickup system according to claim 1 or 2,

wherein the setting part

acquires the flow rate variations of semiconductor dies constituting one or more wafers, obtains the evaluation values based on the respective flow rate variations, and

changes the pickup parameter during pickup of the another semiconductor die based on the plurality of evaluation values.

11. The semiconductor die pickup system according to claim 1 or 2, further comprising a storage unit that stores

a table of parameter values of the pickup parameters associated with each of a plurality of level values and

a current level value which is the level value of the parameter value of the pickup parameter currently applied;

wherein the parameter value of the pickup parameter is read from the table using the current level value as a key, and the parameter value of the pickup parameter is applied to pick up the semiconductor die; and

the setting part

changes, based on the evaluation value, the parameter value of the pickup parameter during pickup of the another semiconductor die by transitioning the current level value to another level value.

12. The semiconductor die pickup system according to claim 1 or 2,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

obtains, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values,

reduces the number of switches during pickup of the another semiconductor die compared with the number of switches during pickup of the specific semiconductor die when the representative die evaluation value is higher than a first predetermined value, and

increases the number of switches during pickup of the another semiconductor die compared with the number of switches during pickup of the specific semiconductor die when the representative die evaluation value is lower than a second predetermined value which is a value lower than the first predetermined value.

13. The semiconductor die pickup system according to claim 2,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

obtains, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values,

shortens the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die compared with the time during pickup of the specific semiconductor die when the representative die evaluation value is higher than a third predetermined value, and

lengthens the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die compared with the time during pickup of the

specific semiconductor die when the representative die evaluation value is lower than a fourth predetermined value which is a value lower than the third predetermined value.

14. The semiconductor die pickup system according to claim 3,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

obtains, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values,

shortens the predetermined time during pickup of the another semiconductor die compared with the predetermined time during pickup of the specific semiconductor die when the representative die evaluation value is higher than a fifth predetermined value, and

lengthens the predetermined time during pickup of the another semiconductor die compared with the predetermined time during pickup of the specific semiconductor die when the representative die evaluation value is lower than a sixth predetermined value which is a value lower than the fifth predetermined value.

15 The semiconductor die pickup system according to claim 4,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

obtains, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values,

increases the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die compared with the number of the moving elements during pickup of the specific semiconductor die when the representative die evaluation value is higher than a seventh predetermined value, and

reduces the number of the moving elements moved simultaneously from the first position to the second position during pickup of the another semiconductor die compared with the number of the moving elements during pickup of the specific semiconductor die when the representative die evaluation value is lower than an eighth predetermined value which is a value lower than the seventh predetermined value.

16. The semiconductor die pickup system according to claim 7,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

obtains, from the evaluation values of one or more of the specific semiconductor dies, a representative die evaluation value which is a representative value of the evaluation values,

shortens the waiting time during pickup of the another semiconductor die compared with the waiting time during pickup of the specific semiconductor die when the representative die evaluation value is higher than a ninth predetermined value, and

lengthens the waiting time during pickup of the another semiconductor die compared with the waiting time during pickup of the specific semiconductor die when the representative die evaluation value is lower than a tenth predetermined value which is a value lower than the ninth predetermined value.

17. The semiconductor die pickup system according to claim 1 or 2,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

compares each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value,

compares each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and

changes, based on the number of easy release detections and the number of difficult release detections, the number of switches during pickup of the another semiconductor die after pickup of the specific semiconductor die.

18. The semiconductor die pickup system according to claim 2,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

compares each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value,

compares each of the evaluation values of one or more of the specific

semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and

changes, based on the number of easy release detections and the number of difficult release detections, the time for holding the opening pressure at the first pressure during pickup of the another semiconductor die after pickup of the specific semiconductor die.

19. The semiconductor die pickup system according to claim 3,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

compares each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value,

compares each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and

changes, based on the number of easy release detections and the number of difficult release detections, the predetermined time during pickup of the another semiconductor die after pickup of the specific semiconductor die.

20. The semiconductor die pickup system according to claim 4,

wherein the semiconductor die in which the evaluation value is calculated is a

specific semiconductor die, and

the setting part

compares each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value,

compares each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which is the number of the evaluation values lower than the twelfth predetermined value, and

changes, based on the number of easy release detections and the number of difficult release detections, the number of the moving elements during pickup of the another semiconductor die after pickup of the specific semiconductor die.

21. The semiconductor die pickup system according to claim 7,

wherein the semiconductor die in which the evaluation value is calculated is a specific semiconductor die, and

the setting part

compares each of the evaluation values of one or more of the specific semiconductor dies with an eleventh predetermined value, to obtain the number of easy release detections which is the number of the evaluation values higher than the eleventh predetermined value,

compares each of the evaluation values of one or more of the specific semiconductor dies with a twelfth predetermined value which is a value lower than the eleventh predetermined value, to obtain the number of difficult release detections which

is the number of the evaluation values lower than the twelfth predetermined value, and

changes, based on the number of easy release detections and the number of difficult release detections, the waiting time during pickup of the another semiconductor die after pickup of the specific semiconductor die.