

SEALING SHEET CUTTING METHOD AND SEALING SHEET CUTTING APPARATUS

Technical Field

[0001]

The present invention relates to a sealing sheet cutting method and a sealing sheet cutting apparatus for cutting a sealing sheet having a sealing layer composed of a resin composition formed therein into a semiconductor substrate shape, the sealing sheet joined to a semiconductor substrate for sealing semiconductor elements.

Background Art

[0002]

Various methods have been suggested and implemented in which a protective sheet joined to a circuit surface of a semiconductor wafer (hereinafter, referred to as a "wafer" appropriately) is cut along an external diameter of the semiconductor wafer. That is, the protective sheet is cut with a cutter along an arc part and a notch of the semiconductor wafer while an angle and a pivot direction of the cutter is changed. Specifically, the cutter pierces a portion of the protective tape adjacent to the notch, and cuts the protective tape to an inner end of the notch while a side face of the cutter contacts one incline face of the notch, and thereafter the cutter moves backward to its initial position along an orbit on which the protective tape is cut. Then, a direction of a blade of the cutter is changed to cut the protective tape along the arc part of the semiconductor wafer. When the cutter reaches the other opening end of the notch, the angle of the cutter is changed, and the cutter cuts the protective tape to the inner end of

the notch while the side face of the cutter contacts along the incline face of the notch to connect this second half cut to the first half cut of the protective tape, whereby the protective tape is cut out. See, for example, Japanese Unexamined Patent Publication No. 2009-125871A.

[0003]

Summary of Invention

Technical Problem

[0004]

In the traditional mode, a wafer thinned through back grinding is diced, and thereafter diced semiconductor elements are molded with resin individually to produce semiconductor devices. In recent years, the following method for obtaining enhanced production efficiency has been suggested. That is, a sealing sheet composed of a resin composition is joined to the entire element formation surface of the wafer subjected to the back grinding, and a sealing layer is cured. Then the wafer is diced.

[0005]

The sealing sheet has a thickness and rigidity larger than the protective tape. Accordingly, it is not easy to change a cutting angle of the cutter in a cutting process. Such inconvenience may arise. That is, when the cutting angle changes largely from the arc part to the notch of the wafer, the sealing layer may be chipped or the blade of the cutter may be broken. In addition, stress caused by a pressing force upon change of the angle may cause damages in the wafer. Such a problem may arise.

[0006]

The present invention has been made regarding the state of the art noted above,

and its primary object is to provide a sealing sheet cutting method and a sealing sheet cutting apparatus that allow accurate cut of a sealing sheet joined to a semiconductor wafer into a wafer shape.

Solution to Problem

[0007]

The present invention is configured as under to achieve the above object.

[0008]

One aspect of the present invention discloses a sealing sheet cutting method for cutting a sealing sheet joined to a semiconductor substrate and having a sealing layer composed of a resin composition formed therein. The method includes a joining step of joining the sealing sheet, larger than the semiconductor substrate, to the semiconductor substrate, a first cutting step of cutting the sealing sheet by contacting a first cutting blade of a first cutting mechanism along an external diameter of the semiconductor substrate while a portion of the sealing sheet with which a notch of the semiconductor substrate is covered remains, a collecting step of collecting the sealing sheet having pieces in a shape of the semiconductor substrate cut out therefrom, a second cutting step of forming a first cut from one opening end of the notch to an inner end of the notch while a second cutting blade of a second cutting mechanism contacts along the notch, and a third cutting step of forming a second cut from the other opening end of the notch to the inner end of the notch while the second cutting blade of the second cutting mechanism contacts along the notch, and connecting the first cut to the second cut, thereby cutting the sealing sheet into a shape of the notch.

[0009]

The method according to the aspect of the present invention yields a fixed cutting angle of the first cutting blade and cutting of the sealing sheet almost in the same shape as the semiconductor substrate. In addition, the second cutting blade allows cut from the both opening ends of the notch in a portion of the sealing sheet with which the notch is covered remains in the first cutting step. This eliminates necessity to change the cutting angle of the second cutting blade largely from the arc part to the notch part of the sealing sheet. In other words, excess stress caused by a pressing force upon change of the angle is not applied to the notch of the semiconductor substrate, the sealing layer, and the second cutting blade. This yields elimination of damages in the semiconductor substrate, and chipping of the sealing layer and the second cutting blade. Moreover, eliminated chipping of the second cutting blade lead to long-time usage of the second cutting blade.

[0010]

Moreover, it is preferred that the second cutting step and the third cutting step each include forming the cut in the sealing sheet while the second cutting blade pivotally supported on a holder so as to swing is biased elastically in a travelling direction of the second cutting edge.

[0011]

With the method according to the aspect of the present invention, when an excessive pressing force is applied to the second cutting edge while the sealing sheet on the notch of the semiconductor substrate is cut, the second cutting edge moves backward against the bias force in a travelling direction of the second cutting edge. This yields elimination of damages in the second cutting blade or the semiconductor substrate.

[0012]

Moreover, it is preferred that at least the third cutting step in the above method includes cutting the sealing sheet while the portion of the sealing sheet with which the notch is covered is sucked.

[0013]

With the method according to the aspect of the present invention, chips generated upon cutting the portion of the sealing sheet with which the notch is covered can be sucked and removed immediately. This yields minimized contamination of the semiconductor substrate with the chips.

[0014]

Moreover, the method according to the aspect of the present invention may further include an inspecting step of inspecting the portion of the sealing sheet with which the notch is covered for any cutting failure after the third cutting step.

[0015]

In this case, the cutting failure in the portion of the sealing sheet with which the notch is covered is detectable. That is, when the cutting failure is detected, at least either the second cutting step or the third cutting step is performed to reliably cut and remove the portion of the sealing sheet with which the notch is covered.

[0016]

Moreover, the sealing sheet may be cut in the first to third cutting steps while a heater heats the first cutting blade and the second cutting blade.

[0017]

With the method according to the aspect of the present invention, the sealing sheet can be cut while the sealing layer of the sealing sheet is softened with the heater.

Accordingly, the minute portion of the sealing sheet with which the notch is covered is reliably cut and removal.

[0018]

The present invention is also constituted as stated below to achieve the above object.

[0019]

Another aspect of the present invention discloses a sealing sheet cutting apparatus for cutting a sealing sheet having a sealing layer composed of a resin composition joined to a semiconductor substrate. The apparatus includes a first holding table holding the semiconductor substrate placed thereon, a joining mechanism joining the sealing sheet to the semiconductor substrate, a first cutting mechanism cutting the sealing sheet by contacting a first cutting blade along a contour of the semiconductor substrate while a portion of the sealing sheet with which a notch of the semiconductor substrate is covered remains, a sheet collecting mechanism collecting a residue of the sealing sheet with pieces in a shape of the semiconductor substrate cut out from the sealing sheet, a second holding table horizontally movable while holding the semiconductor substrate with the sealing sheet joined thereto, and turning around a central axis of the semiconductor substrate, a detector detecting the notch of the semiconductor substrate on the second holding table, and a second cutting mechanism cutting the portion of the sealing sheet with which the notch is covered while a blade edge of the second cutting blade contacts along the notch. Every time the second holding table is turned and moved horizontally so as for opening ends of the notch to face a tip of the second cutting blade, the sealing sheet is cut to form cuts toward an inner end of the notch by contacting the second cutting blade along the notch while the

second holding table reciprocates relative to the second cutting blade provided in the second cutting mechanism, and both the cuts are connected at the inner end of the notch, whereby the sealing sheet is cut.

[0020]

<Operation and Effect> With the configuration of the apparatus according to the aspect of the present invention, the first cutting blade and the second cutting blade can be used separately for the arc part and the notch part of the semiconductor substrate. Specifically, when the portion of the sealing sheet with which the notch is covered is cut, the second cutting blade for cutting only the portion of the sealing sheet with which the notch is covered is used. This yields no need to change the cutting angle of the cutting blade largely while cutting the sealing sheet, which situation is currently adopted. Consequently, the above method is implementable suitably.

[0021]

Moreover, it is preferred in the above apparatus that the second cutting blade is pivotally supported on a holder of the second cutting mechanism so as to swing while being biased elastically in a travelling direction of the second cutting blade.

[0022]

With the configuration of the apparatus according to the aspect of the present invention, when an excessive pressing force is applied to the second cutting blade while the portion of the sealing sheet with which the notch is covered is cut, the second cutting blade moves backward against the bias force in the travelling direction of the second cutting blade. This yields elimination of damages in the second cutting blade or the semiconductor substrate.

[0023]

Moreover, the apparatus may further include a suction mechanism for immediately sucking and removing chips caused by cutting of the portion of the sealing sheet with which the notch is covered.

[0024]

Such a configuration yields minimized contamination of the semiconductor substrate.

[0025]

Moreover, a heater may heat the first cutting blade and the second cutting blade for cutting while softening the sealing sheet.

[0026]

Moreover, the apparatus may further include a sensor detecting whether or not the portion of the sealing sheet with which the notch is covered is cut for detection of any cutting failure.

Advantageous Effects of Invention

[0027]

With the sealing sheet cutting method and the sealing sheet cutting apparatus according to the aspects of the present invention, the sealing sheet joined to the semiconductor substrate with the notch can be cut accurately along the contour of the semiconductor substrate.

Brief Description of Drawings

[0028]

Figure 1 is a perspective view of a sealing sheet in an original master roll

according to one embodiment of the present invention.

Figure 2 is a longitudinal sectional view of the sealing sheet.

Figure 3 is a perspective view illustrating an overall configuration of a sealing sheet joining apparatus.

Figure 4 is a plan view of the sealing sheet joining apparatus.

Figure 5 is a perspective view of a principal part of the sealing sheet joining apparatus.

Figure 6 is a front view of a first cutting mechanism and its surroundings.

Figure 7 is a front view of a second cutting mechanism and its surroundings.

Figure 8 is a plan view of the second cutting mechanism and its surroundings.

Figure 9 is a schematic front view illustrating operation of joining the sealing sheet.

Figure 10 is a schematic front view illustrating operation of cutting the sealing sheet with the first cutting mechanism.

Figure 11 is a schematic front view illustrating operation of separating the sealing sheet.

Figure 12 is a schematic front view illustrating operation of collecting the sealing sheet with cut-out pieces.

Figure 13 is a partially enlarged view illustrating operation of cutting the sealing sheet with the second cutting mechanism.

Figures 14 and 15 are plan views each illustrating operation of cutting the sealing sheet with the second cutting mechanism.

Figure 16 is a front view of a cutter according to one modification of the present invention.

Figure 17 is a plan view of the cutter according to the modification.

Description of Embodiments

[0029]

The following describes one embodiment of the present invention with reference to drawings. In the present embodiment, the following is described as one example of the present invention in which a sealing sheet having a sealing layer composed of a resin composition is joined to a semiconductor substrate having a plurality of semiconductor elements on a surface thereof.

[0030]

<Sealing Sheet>

A sealing sheet T is supplied in a form of an original master roll that is made by winding a long sealing sheet T, as illustrated in Figures 1 and 2. Moreover, the sealing sheet T includes a sealing layer M, on both faces of which a first separating liner S1 and a second separating liner S2 for protection are attached.

[0031]

The sealing layer M is made of a sealing material, and is formed in a sheet shape. Examples of the sealing material include thermosetting resin such as thermosetting silicone resin, epoxy resin, thermosetting polyimide resin, phenol resin, urea resin, melamine resin, unsaturated polyester resin, diallyl phthalate resin, and thermosetting urethane resin. Moreover, examples of the sealing material include a thermosetting resin composition containing the thermosetting resin mentioned above and an additive at appropriate ratios.

[0032]

Examples of the additive include a filler and a phosphor. Examples of the filler include inorganic fine particles such as silica, titania, talc, alumina, aluminium nitride, and silicon nitride, and organic fine particles such as silicone particles. The phosphor has a wavelength conversion function. Examples of the phosphor include a yellow phosphor that allows conversion of blue light into yellow light, and a red phosphor that allows conversion of blue light into red light. Examples of the yellow phosphor include a garnet-type phosphor such as $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}$ (YAG (yttrium aluminium garnet):Ce). Examples of the red phosphor include a nitride phosphor such as $\text{CaAlSiN}_3:\text{Eu}$ and $\text{CaSiN}_2:\text{Eu}$.

[0033]

The sealing layer M is semi-solid prior to seal of the semiconductor elements. Specifically, the sealing layer M whose sealing material contains the thermosetting resin is prepared in a condition before it is completely cured (C-stage), i.e., in a semi-cured condition (B-stage).

[0034]

The sealing layer M has a size determined appropriately in accordance with sizes of the semiconductor elements and the substrates. Specifically, when the long sealing sheet is used, the sealing layer has a traverse length, i.e., a width of equal to or more than 100 mm, preferably equal to or more than 200 mm, and equal to or less than 1500 mm, preferably equal to or less than 700 mm. The sealing layer has a thickness determined appropriately in accordance with the sizes of the semiconductor elements. For instance, the thickness is equal to or more than 30 μm , preferably equal to or more than 100 μm , and equal to or less than 3000 μm , preferably equal to or less than 1000 μm .

[0035]

Examples of the material of the first separating liner S1 and the second separating liner S2 include a polymer sheet such as a polyethylene sheet, a polyester sheet (e.g., PET), a polystyrene sheet, a polycarbonate sheet, and a polyimide sheet, a ceramic sheet, and metal foil. Contact surfaces of the separating liners to the sealing layer may be subjected to a release treatment such as a fluorine treatment. The first separating liner and the second separating liner each have a size determined appropriately depending on separating conditions. The first separating liner and the second separating liner each have a thickness of equal to or more than 15 μm , preferably equal to or more than 25 μm , and equal to or less than 125 μm , preferably equal to or less than 75 μm .

[0036]

<Sealing Sheet Joining Apparatus>

The following describes an apparatus joining the above sealing sheet to a semiconductor substrate (hereinafter, simply referred to as a "substrate") with reference to drawings.

[0037]

Figure 3 is a perspective view illustrating an overall configuration of a sealing sheet joining apparatus. Figure 4 is a plan view of the sealing sheet joining apparatus. Figure 5 is a perspective view illustrating a principal part of the sealing sheet joining apparatus.

[0038]

As illustrated in Figures 3 and 4, the sealing sheet joining apparatus includes a substrate supply/collection unit 1, a substrate transport mechanism 2, an alignment stage

3, a first holding table 4, a sheet supply unit 5, a separator collector 6, a joining unit 7, a first cutting mechanism 8, a separating unit 9, a sheet collector 10, and a second cutting mechanism 11. In the present embodiment, the substrate supply/collection unit 1, the substrate transport mechanism 2, the alignment stage 3, and the first holding table 4 are disposed on a top face of a base 12. The sheet supply unit 5 and the sheet collector 10 are disposed on a front face of an upright wall erected on the top face of the base 12. The joining unit 7 and the separating unit 9 are disposed to an opening at a lower part of the upright wall. A unit driver 13 is disposed behind the upright wall. Moreover, the second cutting mechanism 11 is disposed adjacent to a side face of the base 12. The following describes each of the above elements in detail.

[0039]

The substrate supply/collection unit 1 accommodates cassette C1 and C2, and loads the cassettes on a cassette table. Here, the cassette C1 contains substrate W with no sealing sheet T joined thereto. The cassette C2 contains substrate W with the sealing sheet T joined thereto. The cassette C1 and C2 each contain the substrates W in a stack manner whose circuit faces are directed upward and which are disposed at given interval vertically.

[0040]

The substrate transport mechanism 2 is provided with a robot arm 14. The robot arm 14 moves forward/backward in horizontal and vertical direction. In addition, the robot arm 14 can be pivoted. The robot arm 14 includes at a front end thereof a suction-holder 14a in a U-shape. The suction-holder 14a takes the substrate W from either the cassette C1 or C2 of the substrate supply/collection unit 1. Then, the suction-holder 14a transports the substrate W to the alignment stage 3, the first holding

table 4, the second cutting mechanism 11, and the substrate supply/collection unit 1, in this order, for collection.

[0041]

The alignment stage 3 detects an alignment notch on an outer periphery of the substrate W while a suction pad movable upward/downward from a holding surface of the alignment stage 3 suction-holds a rear face of the substrate W. Then the alignment stage 3 performs alignment in accordance with the detection result.

[0042]

The substrate transport mechanism 2 moves the substrate W to the first holding table 4 and places the substrate W in a given position. As illustrated in Figures 6 and 9, the first holding table 4 performs vacuum suction to the substrate W. Moreover, the first holding table 4 has a cutter travelling groove 15 on a top face thereof. The cutter travelling groove 15 is provided for turning a cutter 41 of a first cutting mechanism 8, to be mentioned later, along an outer contour of the substrate W to cut the sealing sheet T. The first holding table 4 further includes a suction holder 15a at the center thereof. The suction holder 15a moves outward upon transporting the substrate.

[0043]

The sheet supply unit 5 reels the sealing sheet T with a separator S fed out from the supply bobbin 16 using a feed roller 17 and a guide roller 18, and then guides the sealing sheet T to a separation guide bar 19 in a formed of a knife edge. Then, the sealing sheet T is folded back at a leading edge of the separation guide bar 19, whereby the separator S is separated from the sealing sheet T. The sealing sheet T with the separator S separated therefrom is guided to the joining unit 7. The separator S separated from the sealing sheet T is guided to the separator collector 6.

[0044]

The feed roller 17 sandwiches and guides the sealing sheet T between a pinch roller 19 and the feed roller 17. The feed roller 17 is rotated by a motor 21. If necessary, the feed roller 17 forcibly feeds the sealing sheet T.

[0045]

The supply bobbin 16 is interlocked with and coupled to an electromagnetic brake so as to receive appropriate rotational resistance. As a result, the sealing sheet T is prevented from being excessively unreeled from the supply bobbin 16.

[0046]

The separator collector 6 includes a collection bobbin 22 reeling the separator S separated from the sealing sheet T. A motor 23 controls forward/backward rotation of the collection bobbin 22.

[0047]

The joining unit 7 includes a joining roller 24 that is shiftable vertically with a cylinder. Moreover, the joining unit 7 is entirely supported so as to be movable horizontally along a guide rail 25. The joining unit 7 is allowed to reciprocate in a screw-feed manner through a screw shaft 27 rotated with a motor 26 in the forward/backward direction.

[0048]

The separation unit 9 includes a separation roller 28, a feed-out roller 29, a guide roller 30, and a pinch roller 31. The feed-out roller 29 is driven with a motor. The separation unit 9 is entirely supported on a guide rail 25 so as to be movable horizontally along the guide rail 25. In addition, the separation unit 9 reciprocates in a screw-feed manner through a screw shaft 33 rotated with a motor 32 in a

forward/backward direction.

[0049]

The pinch roller 31 moves upward and downward with a cylinder. The pinch roller 31 cooperates with the feed-out roller 29 to pinch the sealing sheet T.

[0050]

As illustrated in Figures 5 and 6, the sheet collector 10 includes a collection bobbin 35. The collection bobbin 35 is driven with a motor, and is rotated in a direction of reeling the sealing sheet T cut into a circular shape.

[0051]

The first cutting mechanism 8 is provided with a support arm 43 below a movable table 42. The support arm 43 is movable upward and downward, and is turnable about a vertical axis X on the center of the holding table 4. The support arm 43 has a free end provided with a cutter unit 44. The cutter unit 44 includes a cutter 41 having a tapered blade edge directed downward. When the support arm 43 turns about the vertical axis X, the cutter 41 travels along an outer periphery of the substrate W. Consequently, the sealing sheet T is cut into a circular shape.

[0052]

As illustrated in Figures 7 and 8, the second cutting mechanism 11 includes a second holding table 50, a cutter unit 51, and a camera unit 52.

[0053]

The second holding table 50 has a suction surface having a smaller diameter than that of the substrate W. The suction surface vacuum-sucks the rear face of the substrate W transported from the substrate transport mechanism 2 and placed thereon in a given alignment position. Moreover, the holding table 50 is movable

forward/backward and horizontally with a first movable board 53 and the second movable board 54. Furthermore, the holding table 50 is turnable about the central axis X with a pivoting motor.

[0054]

Specifically, the first movable board 53 moves horizontally along a guide rail 55 on the base 12 between the substrate transport mechanism 2 and the cutter unit 51. The second movable board 54 moves horizontally along a guide rail 56 on the first movable board 53 orthogonal to the guide rail 55.

[0055]

The cutter unit 51 includes a movable board 63. The movable board 63 is connected to a cylinder 62 so as to move upward and downward along a guide rail 61 orthogonal to an upright wall 60. The movable board 63 includes a tapered cutter 64 whose tip is directed downward and which is detachably attached on the lower portion thereof via a cutter holder.

[0056]

A suction nozzle 65 is disposed on a lower part of the cutter unit 51 in a movable board 68 with a suction port thereof directed toward the cutter 64. The movable board 68 is connected to a cylinder 67 so as to be movable vertically along the guide rail 61. The suction nozzle 65 is in communication with an external vacuum unit 66.

[0057]

The camera unit 52 is provided adjacent to the second holding table 50 relative to a cutting position of the cutter unit 51. The camera unit 52 captures an image of the outer periphery the substrate W from the rear face. The captured image data is

transmitted to a controller 70. The controller 70 is to be described in detail later in the following description about operation of the apparatus.

[0058]

Next, the following describes a series of operation for joining a surface-protective sealing sheet T to the surface of the substrate W using the apparatus in the foregoing embodiment with reference to Figures 6 to 15.

[0059]

When a joining command is issued, the robot arm 14 in the substrate transport mechanism 2 moves to the cassette C1 placed on the cassette table. The substrate holder 14a of the robot arm 14 is inserted between the substrates W housed in the cassette C1. Then, the substrate holder 14a suction-holds the rear face of the substrate W, transports the substrate W out of the cassette C1, and places the substrate W on the alignment stage 3.

[0060]

The alignment stage 3 aligns the substrate W placed thereon using a notch formed at the outer periphery of the substrate W. The robot arm 14 again transports the aligned substrate W to place it on the first holding table 4.

[0061]

The holding table 4 suction-holds the substrate W placed thereon such that the center of the substrate W is aligned with the center of the holding table 4. At this time, as illustrated in Figure 6, the joining unit 7 and the separating unit 9 are each in its initial position on the left side. Moreover, the cutter 41 of the first cutting mechanism 8 is on standby at its initial position on the upper side.

[0062]

Firstly, the separation unit 9 operates a cylinder to move a pinch roller 31 downward to pinch the sealing sheet T with a feed-out roller 29.

[0063]

Secondly, as illustrated in Figure 9, the joining roller 24 moves downward, and the joining unit 7 moves forward. With the movement, the joining roller 24 rolls forward (to the right in the drawing) while pressing the sealing sheet T against the substrate W. At this time, the sealing sheet T having a width larger than the diameter of the substrate W is gradually joined to a surface of the substrate W from the left in the drawing.

[0064]

As illustrated in Figure 10, when the joining unit 7 reaches a termination position beyond the first holding table 4, the cutter 41 at the standby position on the upper side moves downward into the cutter travelling groove 15 on the first holding table 4, thereby piercing the sealing sheet T.

[0065]

Next, when the cutter 41 moves downward and stops at a given cutting level, the support arm 43 is rotated in a given direction. Such rotation causes the cutter 41 to turn about the vertical axis X, whereby the sealing sheet T is cut along the contour of the substrate W.

[0066]

Upon completion of cutting the sealing sheet T along the outer periphery of the substrate W, the cutter 41 moves upward to its original standby position, as illustrated in Figure 11. Simultaneously, the pinch roller 31 of the separation unit 9 moves upward to release pinching of the sealing sheet T. Then the separation unit 9 entirely moves to

a separation termination position.

[0067]

At this time, the feed-out roller 29 drives at a speed synchronized with a moving speed of the separation unit 9 to feed out the sealing sheet T cut into a circular shape to the sheet collector 10.

[0068]

Upon completion of joining the sealing sheet, the separation unit 9 and the joining unit 7 each return to its original standby position, as illustrated in Figure 12. At this time, the sealing sheet T is unreeled from the tape supplying unit 5 by a length in response to the moving speeds of the separation unit 9 and the joining unit 7.

[0069]

When the separation unit 9 and the joining unit 7 reach their standby positions, the holding table 4 releases suction-holding of the substrate W. Thereafter, the suction holder 14a of the robot arm 14 holds the substrate W to move it above the first holding table 4. Moreover, the robot arm 14 transports the substrate W to the second cutting mechanism 11.

[0070]

The robot arm 14 places the substrate W on the second holding table 50 on standby. When the second holding table 50 suction-holds the substrate W, the suction holder 14a releases suction of the substrate W. The second holding table 50 moves to a position determined in advance where the outer periphery of the substrate W lies within the field of view of the camera unit 52.

[0071]

When the holding table 50 reaches a given position, the camera unit 52

captures an image of the outer periphery of the substrate W while the holding table 50 turns. The captured image data is transmitted to the controller 70. The controller 70 determines the center of the substrate W and a position of the notch using pattern matching between a reference image captured in advance and an actual image currently captured. The controller 70 moves the cutter 64 downward to a given position, and moves the suction nozzle 65 upward to a given position in accordance with the determined result. Thereafter, the controller 70 aligns the center of the substrate W in accordance with the determined resultant by moving horizontally and turning the second holding table 50 such that the cutter 64 faces to a bottom end of the V-shaped notch, as illustrated by dashed-dotted lines in Figure 14(a).

[0072]

Then, the controller 70 aligns the substrate W by turning the second holding table 50 in the forward/backward and horizontal direction, and turning around the center of the second holding table 50 such that one side face of the notch from the one of the opening ends to the inner end thereof contacts the side face of the cutter 64 in parallel, as illustrated in Figure 14(b).

[0073]

Upon completion of the alignment, the second holding table 50 is fixed, and the second holding table 50 moves by a given distance toward the cutter 64 as illustrated in Figure 14(c). That is, the blade edge of the cutter 64 cuts toward the inner end of the notch while contacting along the side face of the notch. When the blade edge of the cutter 64 reaches the inner end of the notch, the second holding table 50 moves backward to pull the blade edge out of the notch.

[0074]

Since the notch in the present embodiment has a depth of several millimeters or less, it is only necessary to move the second holding table 50 horizontally. The blade edge and the side face of the notch are kept parallel while the second holding table 50 moves horizontally in the direction orthogonal to the travelling direction during cutting the sealing sheet T in accordance with the angle θ made with the dashed-dotted lines and the blade edge of the cutter 64 and the depth of the notch. When the cutter 64 is pulled out from the inner end of the notch, the second holding table 50 is moved in a direction opposite to that in which the cutter 64 travels.

[0075]

Then, as illustrated in Figure 15(a), the controller 70 aligns the substrate W by turning the second holding table 50 in the forward/backward and horizontal directions, and turning around the center of the second holding table 50 such that the other of the side faces of the notch from the other opening end to the inner end of the notch contacts the side face of the cutter 64 in parallel.

[0076]

Upon completion of the alignment, the second holding table 50 is fixed, and the second holding table 50 moves by a given distance toward the cutter 64 as illustrated in Figure 15(b), which is similar to the first cutting operation. That is, as illustrated in Figure 15(c), the cutter 64 cuts to the inner end while the blade edge of the cutter 64 contacts along the side face of the notch to connect this second cut to the first cut, whereby the sealing sheet T is cut into the notch shape.

[0077]

At this time, the movable board 68 moves upward so as for the suction nozzle 65 to suck the portion of the sealing sheet T with which the notch is covered from the

rear face of the substrate W. Accordingly, chips generated upon cutting the portion of the sealing sheet T with which the notch V is covered and the pieces of the sealing sheet T cut out into the shape of the notch are sucked and removed.

[0078]

Moreover, a sensor may detect whether or not the suction nozzle 65 sucks the pieces of the sealing sheet T cut into the shape of the notch V upon suction of the sealing sheet T. Examples of the sensor include a non-contact optical sensor provided on the suction nozzle 65. Alternatively, upon suction of the piece of the sealing sheet T, a pressure gauge may detect a variation in pressure, or a flow meter may detect a variation in flow rate.

[0079]

Upon completion of cutting the sealing sheet T with which the notch is covered, the cutter unit 51 and the cutter holder 68 each return to its standby position. Simultaneously, the second holding table 50 moves to a position where the substrate W is transported to the robot arm 14.

[0080]

When the robot arm 14 suction-holds the substrate W, the second holding table 50 releases suction-holding of the substrate W. Thereafter, the robot arm 14 transports the substrate W to the cassette C2.

[0081]

Thus, one sealing-sheet joining process is completed as described above. Thereafter, the foregoing joining process is performed to a given number of substrates W until completion of the joining process.

[0082]

Thus, a series of operations of the apparatus according to the present embodiment is completed.

[0083]

As noted above, the first cutting mechanism 8 cuts out the sealing sheet T into a circular shape substantially equal to the shape of the substrate W. Thereafter, the second cutting mechanism 11 cuts the portion of the sealing sheet T with which the notch V is covered with the second cutting edge 64. Accordingly, excessive pressure conventionally caused by the variation in cutting angle of the cutter is not applied to the substrate W and the cutter 64 during cutting the portion of the sealing sheet T with which the notch V is covered with the second cutting edge 64. Consequently, the sealing layer M of the substrate W has no cracking or break, and the cutter 64 has minimized nicked teeth.

[0084]

In addition, the cutter 64 faces the suction nozzle 65 across the substrate W upon cutting the sealing sheet T with which the notch V is covered. This yields immediate suction and removal of dusts, such as chips and solid particles, and the pieces of the sealing sheet T upon cutting the sealing sheet T. Accordingly, contamination of the substrate W can be suppressed.

[0085]

The present invention may be embodied as followings.

[0086]

(1) In the second cutting mechanism 11 of the apparatus according to the above embodiment, the cutter 64 may be pivotally supported so as to swing forward/backward relative to the cutting direction of the sealing sheet T, as illustrated in Figure 16. In

addition, the cutter 64 includes a long hole 71 on an upper part thereof into which a screw 72 is inserted for fixation so that an angle of the cutter 64 is variable. Such may be adopted.

[0087]

Moreover, it is preferred in the above configuration of the present embodiment that the cutter 64 is elastically biased in the cutting direction of the sealing sheet T. That is, when excessive pressure is applied to the blade edge while the sealing sheet T is cut, the cutter 64 swing backward against the elastic bias. This yields reliable avoidance of cracking or break of the substrate W and nicked teeth of the cutter 64.

[0088]

(2) In the apparatus of the above embodiment, the heater may heat at least the cutter 64 out of the cutter 41 of the first cutting mechanism 8 and the cutter 64 of the second cutting mechanism 11. Specifically, the heater may be embedded in the cutter unit 51 for heating the cutter 64. Such a construction allows the sealing sheet T to be cut while being softened through heat of the cutter 64.

[0089]

(3) In the above embodiments, the portion of the sealing sheet T with which the arc part of the substrate W is covered is cut firstly, and then the portion of the sealing sheet T with which the notch V is covered is cut with the second cutting mechanism 11 provided separately. This is not limitative. For instance, the portion of the sealing sheet T with which the notch V is covered is cut, and thereafter the portion of the sealing sheet T with which the arc part of the substrate W is covered is cut. Such may be adopted.

[0090]

In this case, the first holding table 4 may function as the suction nozzle 65 in the second cutting mechanism 11. For instance, the first holding table 4 is a chuck table. Accordingly, a groove for sucking the substrate W is separated from a portion for sucking and collecting the piece of the sealing sheet. Only the pieces of the sealing sheet T are collected with a different suction line. Such may be adopted. Alternatively, the alignment stage 3 may detect a position of the notch, and the robot arm 14 may place the substrate W in accordance with positional information such that the notch V reaches the cutting position. Moreover, the first holding table 4 may move forward/backward and horizontally in a tape supply direction and may turn around the central axis thereof for yielding enhanced positional accuracy.

[0091]

(4) In the above embodiments, the substantially circular substrate W has been described as one example of the workpiece. Alternatively, the above embodiments are applicable to a substrate in a rectangular shape, such as an oblong or a square, having a notch formed in. Moreover, the shape of the notch formed in the substrate W is not limited to a V-shape. The shape includes a recessed and curved shape.

[0092]

When the notch is recessed and curved, the cutter holder and the cutter 64 may rotate around the vertical shaft axis so as for the tip of the cutter 64 to travel along to a recessed and curved portion of the notch. For instance, as illustrated in Figures 17(a) to 17(c), pin cylinders 73 contact against both side faces of the cutter 64, respectively, forward of the cutting direction. The cutter 64 is freely rotatable around the vertical shaft axis. Then bias forces of rods of the pin cylinders 73 are controlled so as for the tip of the cutter 64 to contact to the side face of the notch by an appropriate bias force.

Claims

1. A sealing sheet cutting method for cutting a sealing sheet joined to a semiconductor substrate and having a sealing layer composed of a resin composition formed therein, the method comprising:

a joining step of joining the sealing sheet, larger than the semiconductor substrate, to the semiconductor substrate;

a first cutting step of cutting the sealing sheet by contacting a first cutting blade of a first cutting mechanism along an external diameter of the semiconductor substrate while a portion of the sealing sheet with which a notch of the semiconductor substrate is covered remains;

a collecting step of collecting the sealing sheet having pieces in a shape of the semiconductor substrate cut out therefrom;

a second cutting step of forming a first cut from one opening end of the notch to an inner end of the notch while a second cutting blade of a second cutting mechanism contacts along the notch; and

a third cutting step of forming a second cut from the other opening end of the notch to the inner end of the notch while the second cutting blade of the second cutting mechanism contacts along the notch, and connecting the first cut to the second cut, thereby cutting the sealing sheet into a shape of the notch.

2. The sealing sheet cutting method according to claim 1, wherein

the second cutting step and the third cutting step each comprise forming the cut in the sealing sheet while the second cutting blade pivotally supported on a holder so as

to swing is biased elastically in a cutting direction of the second cutting blade.

3. The sealing sheet cutting method according to claim 1, wherein
at least the third cutting step out of the second cutting step and the third cutting step comprises cutting the sealing sheet while the portion of the sealing sheet with which the notch is covered is sucked.
4. The sealing sheet cutting method according to claim 1, further comprising:
an inspecting step of inspecting the portion of the sealing sheet with which the notch is covered for any cutting failure after the third cutting step.
5. The sealing sheet cutting method according to claim 1, wherein
the first to third cutting steps each include cutting the sealing sheet while a heater heats the first cutting blade and the second cutting blade.
6. A sealing sheet cutting apparatus for cutting a sealing sheet having a sealing layer composed of a resin composition joined to a semiconductor substrate, the sealing sheet cutting apparatus comprising:
a first holding table holding the semiconductor substrate placed thereon;
a joining mechanism joining the sealing sheet to the semiconductor substrate;
a first cutting mechanism cutting the sealing sheet by contacting a first cutting blade along a contour of the semiconductor substrate while a portion of the sealing sheet with which a notch of the semiconductor substrate is covered remains;
a sheet collecting mechanism collecting a residue of the sealing sheet with

pieces in a shape of the semiconductor substrate cut out from the sealing sheet;

a second holding table horizontally movable while holding the semiconductor substrate with the sealing sheet joined thereto, and turning around a central axis of the semiconductor substrate;

a detector detecting the notch of the semiconductor substrate on the second holding table; and

a second cutting mechanism cutting the portion of the sealing sheet with which the notch is covered while a blade edge of the second cutting blade contacts along the notch, wherein

every time the second holding table is turned and moved horizontally so as for opening ends of the notch to face a tip of the second cutting blade, the sealing sheet is cut to form cuts toward an inner end of the notch by contacting the second cutting blade along the notch while the second holding table reciprocates relative to the second cutting blade provided in the second cutting mechanism, and both the cuts are connected at the inner end of the notch, whereby the sealing sheet is cut.

7. The sealing sheet cutting apparatus according to claim 6, wherein

the second cutting blade is pivotally supported on a holder of the second cutting mechanism so as to swing while being biased elastically in a cutting direction of the second cutting blade.

8. The sealing sheet cutting apparatus according to claim 6, further comprising:

a suction mechanism disposed opposite to the second cutting blade across the semiconductor substrate and sucking the portion of the sealing sheet with which the

notch is covered.

9. The sealing sheet cutting apparatus according to claim 6, further comprising:
a heater heating the second cutting blade.
10. The sealing sheet cutting apparatus according to claim 6, further comprising:
a sensor detecting whether or not the portion of the sealing sheet with which
the notch is covered is cut; and
a discriminating unit discriminating cutting failure for the portion of the sealing
sheet with which the notch is covered in accordance with a detection signal from the
sensor.