

DESCRIPTION

CUTTING APPARATUS AND METHOD FOR MANUFACTURING CUT PRODUCT

Technical Field

5 [0001] The present invention relates to a cutting apparatus and a method for manufacturing a cut product.

Background Art

[0002] JP 2019-202353A (Patent Document 1) discloses a cutting apparatus for
10 cutting a workpiece. This cutting apparatus is provided with a suction unit that holds a workpiece by suctioning the workpiece. The suction unit includes a chuck table, and the workpiece is held by being suctioned by the chuck table. A suction pump is connected to the suction unit. In this cutting apparatus, a liquid-ring vacuum pump, whose suction force does not decrease even when suctioning water, is used as the suction
15 pump (see Patent Document 1).

Citation List

Patent Document

[0003] Patent Document 1: JP 2019-202353A
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Summary of Invention

Technical Problem

[0004] When a liquid-ring vacuum pump is used to suction the cutting target (e.g., a substrate), new water is continuously supplied into the vacuum pump in order to suppress
25 a rise in the temperature of the sealing water. In other words, when a liquid-ring vacuum pump is used, a large amount of water is consumed. In order to solve this problem, it is conceivable to use a dry vacuum pump instead of a liquid-ring vacuum pump. In this

case, it is necessary to suppress the intrusion of water into the vacuum pump during the process of spraying water onto the cutting target, for example. Also, the cutting target needs to be suctioned continuously. However, Patent Document 1 does not disclose any means for solving such problems.

5 [0005] The present invention has been made to solve such problems, and an object of the present invention is to, in a cutting apparatus that uses a dry vacuum pump and a method for manufacturing a cut product, suppress the intrusion of water into the vacuum pump while also maintaining suctioning of a cutting target.

10 Solution to Problem

[0006] A cutting apparatus according to an aspect of the present invention includes a table, a cutting mechanism, a holding mechanism, and a water separation and discharge mechanism. The table is configured to hold a cutting target by suctioning the cutting target. The cutting mechanism is configured to divide the cutting target into individual
15 cutting target pieces by cutting the cutting target on the table. The holding mechanism is configured to hold the individual cutting target pieces by suctioning the cutting target pieces. The table or the holding mechanism is connected to a dry vacuum pump via a suction route. The water separation and discharge mechanism is located on the suction route and is configured to discharge water via a drainage route. The water separation
20 and discharge mechanism includes a first tank, and a second tank. The second tank is located downstream of the first tank on the drainage route. The first tank includes a partition plate partitioning the first tank into a region in which a connection port for the vacuum pump is located, and a region in which a connection port for the table or the holding mechanism is located. A gap is formed above the partition plate in the first tank.
25 The water separation and discharge mechanism further includes a valve mechanism. The valve mechanism is configured to change between a first state in which water flowing from the first tank into the second tank is stored in the second tank, and a second state in

which water is stored in the first tank and water stored in the second tank is discharged.

[0007] A method for manufacturing a cut product according to another aspect of the present invention uses the cutting apparatus described above. This method for manufacturing a cut product includes dividing the cutting target into individual cutting target pieces by cutting the cutting target on the table using the cutting mechanism.

Advantageous Effects of Invention

[0008] According to the present invention, in a cutting apparatus that uses a dry vacuum pump and a method for manufacturing a cut product, it is possible to suppress the intrusion of water into the vacuum pump while also maintaining suctioning of a cutting target.

Brief Description of Drawings

[0009] FIG. 1 is a plan view schematically showing a cutting apparatus.

FIG. 2 is a diagram schematically showing a first water separation and discharge mechanism in a first state.

FIG. 3 is a diagram schematically showing the first water separation and discharge mechanism in a second state.

FIG. 4 is a diagram schematically showing a plan view of a first tank.

FIG. 5 is a diagram schematically showing a cross-section taken along V-V in FIG. 4.

FIG. 6 is a diagram schematically showing a cross-section taken along VI-VI in FIG. 4.

FIG. 7 is a diagram schematically showing a hardware configuration of a computer.

FIG. 8 is a flowchart showing an example of a drainage procedure in the first water separation and discharge mechanism.

FIG. 9 is a flowchart showing an example of a drainage procedure in a second water separation and discharge mechanism.

FIG. 10 is a flowchart showing an example of an operation procedure when drainage is poor in the first water separation and discharge mechanism.

5 FIG. 11 is a diagram schematically showing another example of the first water separation and discharge mechanism in the first state.

FIG. 12 is a diagram schematically showing another example of the first water separation and discharge mechanism in the second state.

10 Description of Embodiments

[0010] Embodiments according to an aspect of the present invention (hereinafter also referred to as “the present embodiment”) will be described in detail below with reference to the drawings. In the drawings, identical or corresponding elements are denoted by the same reference numerals, and descriptions of those elements are not repeated. Also, 15 the illustrations in the drawings are schematic illustrations with elements omitted or exaggerated as appropriate to facilitate understanding.

[0011] [1. Configuration]

 <1-1. Overall configuration of cutting apparatus>

FIG. 1 is a plan view schematically showing a cutting apparatus 1 according to 20 the present embodiment. The cutting apparatus 1 is configured to cut a cutting target (a package substrate in the present embodiment) in order to divide the cutting target into individual cut products (electronic components (package components) in the case where the cutting target is a package substrate). In the package substrate, substrates or lead frames, each of which has a semiconductor chip mounted thereon, are sealed with resin.

25 [0012] An example of the cutting target is a substrate, which may be a substrate that is not sealed with resin (including a wafer) or a substrate that has been sealed with resin (a package substrate). Examples of package substrates include a BGA (Ball Grid Array)

package substrate, an LGA (Land Grid Array) package substrate, a CSP (Chip Size Package) package substrate, an LED (Light Emitting Diode) package substrate, and a QFN (Quad Flat No-leaded) package substrate.

[0013] In this example, a package substrate P1 is used as the cutting target, and the cutting apparatus 1 divides the package substrate P1 into a plurality of electronic components S1 (not shown). Hereinafter, out of the two main surfaces of the package substrate P1, the resin-sealed surface will be referred to as the mold surface, and the surface opposite to the mold surface will be referred to as the ball/lead surface. Note that in the case where the cutting target is a substrate that is not sealed with resin, the ball/lead surface in the present embodiment corresponds to the surface that faces upward during cutting (cut surface), and the mold surface in the present embodiment corresponds to the surface on the side opposite to the cut surface.

[0014] As shown in FIG. 1, the cutting apparatus 1 includes a cutting module A1 and an inspection/storage module B1 as constituent elements. The cutting module A1 is configured to manufacture a plurality of electronic components S1 (cut products) by cutting the package substrate P1. The inspection/storage module B1 is configured to inspect each of the manufactured electronic components S1, and then store the electronic components S1 in trays. Various constituent elements of the cutting apparatus 1 can be removed from the other constituent elements and replaced.

[0015] The cutting module A1 mainly includes a substrate supply unit 3, a positioning unit 4, cutting tables 5, spindle units 6, and a transport unit 7. The cutting module A1 also includes a second water separation and discharge mechanism 42, a third water separation and discharge mechanism 43, a portion of a first water separation and discharge mechanism 41, vacuum pumps D2 and D3, and a portion of a vacuum pump D1.

[0016] A magazine M1 stores a plurality of package substrates P1, and the substrate supply unit 3 supplies the package substrates P1 one by one to the positioning unit 4 by

pushing out the package substrates P1 one by one from the magazine M1. At this time, the package substrates P1 are each arranged such that the ball/lead surface faces upward.

[0017] The positioning unit 4 positions the package substrate P1 pushed out from the substrate supply unit 3 by arranging the package substrate P1 on a rail unit 4a. After
5 that, the positioning unit 4 transports the positioned package substrate P1 to the cutting tables 5.

[0018] The cutting tables 5 each hold the package substrate P that is to be cut. In this example, the cutting apparatus 1 has a twin cut table configuration including two cutting tables 5. The vacuum pump D2 is connected to one of the cutting tables 5 via a
10 suction route VR2, and the vacuum pump D3 is connected to the other cutting table 5 via a suction route VR3. The vacuum pumps D2 and D3 are each a dry vacuum pump. The cutting tables 5 suction the package substrate P1 by suction generated by the vacuum pump D2 or the vacuum pump D3. The second water separation and discharge mechanism 42 is provided in the suction route VR2, and the third water separation and
15 discharge mechanism 43 is provided in the suction route VR3. The second water separation and discharge mechanism 42 and the third water separation and discharge mechanism 43 will be described in detail later.

[0019] Each of the cutting tables 5 includes a holding member 5a, a rotating mechanism 5b, and a moving mechanism 5c. The holding member 5a holds the package
20 substrate P1 transported by the positioning unit 4 by suctioning the package substrate P1 from below. The rotating mechanism 5b can rotate the holding member 5a in a $\theta 1$ direction shown in the figure. The moving mechanism 5c can move the holding member 5a along the Y axis shown in the figure.

[0020] The spindle units 6 each divide the package substrate P1 into a plurality of
25 electronic components S1 by cutting the package substrate P1. In this example, the illustrated cutting apparatus 1 has a twin spindle configuration including two spindle units 6. The spindle units 6 can be moved along the X axis and the Z axis shown in the figure.

Note that the cutting apparatus 1 may have a single spindle configuration including only one spindle unit 6.

[0021] Each of the spindle units 6 includes a blade 6a and a rotation shaft 6c. The blade 6a cuts the package substrate P1 by rotating at high speed, and thus divides the package substrate P1 into a plurality of electronic components S1. The blade 6a is attached to the rotation shaft 6c so as to be clamped between first and second flanges (not shown). The first and second flanges are fixed to the rotation shaft 6c by fastening members (not shown) such as nuts. The first flange is also called an inner flange, and the second flange is also called an outer flange.

[0022] The spindle unit 6 includes a cutting water nozzle, a cooling water nozzle, and a cleaning water nozzle, for example (none of which are shown). The cutting water nozzle sprays cutting water toward the blade 6a rotating at high speed. The cooling water nozzle sprays cooling water. The cleaning water nozzle sprays cleaning water to wash cutting debris or the like away.

[0023] Referring again to FIG. 1, when the package substrate P1 is placed on the cutting table 5, the cutting table 5 suctions the package substrate P1. Thereafter, an image of the package substrate P1 is captured by a first position checking camera 5d, and the position of the package substrate P1 is checked. The checking performed using the first position checking camera 5d is also called alignment. The checking performed using the first position checking camera 5d is, for example, checking of the position of a mark provided on the package substrate P1. The mark indicates a cutting position of the package substrate P1, for example.

[0024] After that, the cutting table 5 moves along the Y axis in the figure toward a corresponding one of the spindle units 6. After the cutting table 5 moves to a position below the spindle unit 6, the package substrate P1 is cut by moving the cutting table 5 and the spindle unit 6 relative to each other. In this case, since the ball/lead surface of the package substrate P1 faces upward, the ball/lead surface is the cut surface.

Thereafter, as necessary, an image of the package substrate P1 is captured by a second position checking camera 6b, and the position or the like of the package substrate P1 is checked. The checking performed using the second position checking camera 6b is, for example, the checking of a cutting position and a cutting width of the package substrate P1.

[0025] After the cutting of the package substrate P1 is complete, the cutting table 5 moves away from the spindle unit 6 along the Y axis in the figure while suctioning the separated electronic components S1. During this moving process, a first cleaner 5e cleans and dries the upper surfaces (ball/lead surfaces) of the electronic components S1.

Note that cleaning water is used in the cleaning of the electronic components S1.

[0026] The transport unit 7 suctiones the electronic components S1 held on the cutting table 5 from above. A vacuum pump D1 is connected to the transport unit 7 via the suction route VR1. The vacuum pump D1 is a dry vacuum pump. The transport unit 7 suctiones the electronic components S1 by suction generated by the vacuum pump D1.

The first water separation and discharge mechanism 41 is provided in the suction route VR1. The first water separation and discharge mechanism 41 will be described in detail later. The transport unit 7 suctiones the electronic components S1 and transports the electronic components S1 to the inspection table 11 of the inspection/storage module B1.

During this transportation process, a second cleaner 7a cleans and dries the lower surfaces (mold surfaces) of the electronic components S1. The transport unit 7 that has suctioned the electronic components S1 moves downward in the Z-axis direction in the figure such that the electronic components S1 approach the second cleaner 7a, and the electronic components S1 are cleaned and dried in that state. When the cleaning and drying of the electronic components S1 are complete, the transport unit 7 that has suctioned the electronic components S1 moves upward in the Z-axis direction in the figure. Note that cleaning water is used in the cleaning of the electronic components S1.

[0027] The inspection/storage module B1 mainly includes the inspection table 11, a

first optical inspection camera 12, a second optical inspection camera 13, an arrangement unit 14, and an extraction unit 15. Note that the first optical inspection camera 12 may be provided in the cutting module A1. Also, the inspection/storage module B1 includes a portion of the first water separation and discharge mechanism 41 and a portion of the vacuum pump D1. The first water separation and discharge mechanism 41 and the vacuum pump D1 extend across the boundary between the cutting module A1 and the inspection/storage module B1.

[0028] The inspection table 11 holds the electronic components S1 for optical inspection of the electronic components S1. The inspection table 11 can be moved along the X axis in the figure. Furthermore, the inspection table 11 can be vertically inverted. The inspection table 11 includes a holding member that holds the electronic components S1 by suctioning the electronic components S1. The vacuum pump D1 is connected to the inspection table 11 via the suction route VR1. The inspection table 11 suctions the electronic components S1 on the holding member by suction generated by the vacuum pump D1.

[0029] The first optical inspection camera 12 and the second optical inspection camera 13 capture images of the two surfaces (ball/lead surface and mold surface) of the electronic components S1. Based on the image data generated by the first optical inspection camera 12 and the second optical inspection camera 13, various aspects of the electronic components S1 are inspected. The first optical inspection camera 12 and the second optical inspection camera 13 are each arranged in the vicinity of the inspection table 11 so as to capture an image of the upper portion of the image capturing target.

[0030] The first optical inspection camera 12 captures an image of the mold surfaces of the electronic components S1 that have been transported to the inspection table 11 by the transport unit 7. After that, the transport unit 7 places the electronic components S1 on the holding member of the inspection table 11. After the holding member suctions the electronic components S1, the inspection table 11 is vertically inverted. The

inspection table 11 moves to a position above the second optical inspection camera 13, and an image of the ball/lead surfaces of the electronic components S1 is captured by the second optical inspection camera 13.

[0031] The inspected electronic components S1 are then disposed on the arrangement unit 14. The vacuum pump D1 is connected to the arrangement unit 14 via the suction route VR1. The arrangement unit 14 suctions the inspected electronic components S1 by suction generated by the vacuum pump D1. The arrangement unit 14 can be moved along the Y axis in the figure. The inspection table 11 disposes the inspected electronic components S1 on the arrangement unit 14.

[0032] The electronic components S1 that were disposed on the arrangement unit 14 are transferred to a tray by the extraction unit 15. The electronic components S1 are classified as a “good component” or a “defective component” based on the results of the inspections performed using the first optical inspection camera 12 and the second optical inspection camera 13. The extraction unit 15 transfers each of the electronic components S1 to a good component tray 15a or a defective component tray 15b based on the classification results. In other words, good components are stored in the good component tray 15a, and defective components are stored in the defective component tray 15b. When the good component tray 15a or the defective component tray 15b is completely full with electronic components S1, it is replaced with a new tray.

[0033] The cutting apparatus 1 further includes a computer 50, a monitor 20, and a sound output unit 25. The monitor 20 is configured to display images. The monitor 20 is constituted by a display device such as a liquid crystal monitor or an organic EL (Electro Luminescence) monitor. The sound output unit 25 is configured to output sound. The sound output unit 25 is constituted by a sound output device such as a speaker, a buzzer, or a bell, for example.

[0034] The computer 50 controls various units of the cutting module A1 and the inspection/storage module B1, for example. For example, the computer 50 controls the

substrate supply unit 3, the positioning unit 4, the cutting tables 5, the spindle units 6, the transport unit 7, the inspection table 11, the first optical inspection camera 12, the second optical inspection camera 13, the arrangement unit 14, the extraction unit 15, the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, the third water separation and discharge mechanism 43, the vacuum pumps D1, D2, and D3, the monitor 20 and the sound output unit 25.

[0035] <1-2. Configuration of water separation and discharge mechanisms>

As described above, the cutting tables 5 are each connected to the vacuum pump D2 or the vacuum pump D3, and the transport unit 7, the inspection table 11, and the arrangement unit 14 are each connected to the vacuum pump D1. The cutting tables 5 are exposed to, for example, cutting water, cooling water, and cleaning water sprayed when cutting the package substrate P1, and also exposed to the cleaning water used in cleaning of the electronic components S1 by the first cleaner 5e. Due to the suction generated by the vacuum pumps D2 and D3, for example, such water intrudes into the suction routes VR2 and VR3. Furthermore, the transport unit 7 is exposed to the cleaning water used in the cleaning of the electronic components S1 by the second cleaner 7a, for example. Due to the suction generated by the vacuum pump D1, for example, such water intrudes into the suction route VR1.

[0036] If the vacuum pumps D1, D2, and D3 were liquid-ring vacuum pumps, no problem would occur even if water intruded into the vacuum pumps. However, in the case where liquid-ring vacuum pumps are used, new water needs to be continuously supplied into the vacuum pumps in order to suppress a rise in the temperature of the sealing water. In other words, when a liquid-ring vacuum pump is used, a large amount of water is consumed. In order to solve this problem, in the cutting apparatus 1 according to the present embodiment, dry vacuum pumps are adopted as the vacuum pumps D1, D2, and D3.

[0037] In order to prevent water from intruding into the dry vacuum pumps D1, D2,

and D3, the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 are arranged in the suction routes VR1, VR2, and VR3. The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 are configured to isolate water that has intruded into the suction routes, and discharge the isolated water from the cutting apparatus 1 via a drainage route. By draining water with use of the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43, it is possible to suppress the intrusion of water into the vacuum pumps D1, D2, and D3.

[0038] As described above, the first water separation and discharge mechanism 41 is located on the suction route VR1 between the vacuum pump D1 and the transport unit 7, the inspection table 11, and the arrangement unit 14. The second water separation and discharge mechanism 42 is located on the suction route VR2 between the vacuum pump D2 and one of the cutting tables 5. The third water separation and discharge mechanism 43 is located on the suction route VR3 between the vacuum pump D3 and the other cutting table 5. The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 are arranged at different locations, but have substantially the same configuration. The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 can each change between a first state and a second state. The first state and the second state will be described later. The first water separation and discharge mechanism 41 will be described below as a representative example.

[0039] FIG. 2 is a diagram schematically showing the first water separation and discharge mechanism 41 in the first state. FIG. 3 is a diagram schematically showing the first water separation and discharge mechanism 41 in the second state. As shown in

FIGS. 2 and 3, the first water separation and discharge mechanism 41 includes a first tank 410, a second tank 420, a liquid level sensor 430, and valves V1, V2, and V3.

[0040] The first tank 410 is located on the suction route VR1. The first tank 410 is connected via a pipe to the transport unit 7, the inspection table 11, and the arrangement unit 14 that are located upstream in the suction route VR1. The first tank 410 is configured to store water supplied via the suction route VR1. Furthermore, the first tank 410 is connected via a pipe to the vacuum pump D1 located downstream in the suction route VR1. Also, the first tank 410 is connected via a pipe to the second tank 420 located downstream in the drainage route DR1. The first tank 410 is configured to discharge stored water to the second tank 420.

[0041] The liquid level sensor 430 is attached to the first tank 410. The liquid level sensor 430 is configured to detect the height of the liquid level (water level) in the first tank 410. Any of various known sensors such as a water level gauge can be used as the liquid level sensor 430.

[0042] FIG. 4 is a diagram schematically showing a plan view of the first tank 410. FIG. 5 is a diagram schematically showing a cross-section taken along V-V in FIG. 4. FIG. 6 is a diagram schematically showing a cross-section taken along VI-VI in FIG. 4. As shown in FIGS. 4, 5, and 6, the first tank 410 includes a first tank body 411, connection ports 412, 413, and 414, and a partition plate 415.

[0043] The first tank body 411 is made of metal and has a cylindrical shape, for example. The connection port 412 passes through the upper surface of the first tank body 411. The connection port 412 is connected to the pipe connected to the transport unit 7, the inspection table 11, and the arrangement unit 14. This pipe constitutes a portion of the suction route VR1. Note that the connection port 412 does not necessarily need to be provided in the top surface of the first tank body 411, and may be provided in the side surface of the first tank body 411, for example. Furthermore, in both the second water separation and discharge mechanism 42 and the third water separation and

discharge mechanism 43, the pipe connected to the cutting table 5 is connected to the connection port 412.

[0044] The connection port 413 passes through the side surface of the first tank body 411. The pipe connected to the vacuum pump D1 is connected to the connection port 413. This pipe constitutes a portion of the suction route VR1. Note that the connection port 413 does not necessarily need to be provided in the side surface of the first tank body 411, and may be provided in the top surface of the first tank body 411, for example. Furthermore, in the second water separation and discharge mechanism 42 and the third water separation and discharge mechanism 43, the pipe connected to the vacuum pump D2 and the pipe connected to the vacuum pump D3 are connected to the corresponding connection port 413.

[0045] The connection port 414 passes through the bottom surface of the first tank body 411. The pipe connected to the second tank 420 is connected to the connection port 414. This pipe constitutes a portion of the drainage route DR1. The first tank 410 drains water into the second tank 420 via the connection port 414.

[0046] The partition plate 415 is made of metal and has a rectangular shape, for example. The partition plate 415 is arranged upright at a position passing through the center of the first tank body 411 in plan view, and extends upward from the bottom surface of the first tank body 411. The partition plate 415 is joined to both the inner side surface and the inner bottom surface of the first tank body 411 via weld portions W1. The partition plate 415 partitions the interior of the first tank 410 into a region where the connection port 413 is located and a region where the connection port 412 is located. In other words, the connection port 413 is located in one region defined by the partition plate 415, and the connection port 412 is located in the other region defined by the partition plate 415. Note that since gaps are formed between adjacent weld portions W1, water that has intruded through the connection port 412 and fallen downward is stored in both of the two regions defined by the partition plate 415.

[0047] In the first tank 410, a gap is formed above the partition plate 415. In this example, the length of the gap is $X1$. By forming a gap above the partition plate 415, a path for the flow of air generated by suction by the vacuum pump D1 is secured. Also, the lower end of the connection port 412 is located at a position lower than the upper end of the partition plate 415. In this example, the lower end of the connection port 412 (or the upper end portion of the leading end of the connection port 412 in the case where the connection port 412 is provided on the side) is located at a position that is a length $X2$ lower than the upper end of the partition plate 415. This makes it unlikely for water that has intruded through the connection port 412 to be sucked into the connection port 413.

[0048] Referring again to FIGS. 2 and 3, the second tank 420 is located downstream of the first tank 410 in the drainage route DR1. The second tank 420 is arranged at a lower position than the first tank 410 in the height direction (Z-axis direction (FIG. 1)). Therefore, water that has flowed into the suction route VR1 flows from the first tank 410 to the second tank 420 due to gravity. The second tank 420 is configured to store water flowing in from the first tank 410.

[0049] In the drainage route DR1, the valve V1 is provided between the first tank 410 and the second tank 420. The valve V1 can be opened and closed. When the valve V1 is in the open state, water stored in the first tank 410 flows into the second tank 420. When the valve V1 is in the closed state, water is stored in the first tank 410, and the flow of water from the first tank 410 to the second tank 420 is stopped.

[0050] The drainage route DR1 branches at a position between the valve V1 and the second tank 420. The branch is connected to the outside air via the valve V2. The valve V2 can be opened and closed. When the valve V2 is in the open state, the pressure in the drainage route DR1 becomes the atmospheric pressure. In the drainage route DR1, the valve V3 is provided downstream of the second tank 420. The valve V3 is a drainage valve, and is constituted by a check valve.

[0051] For example, when the valve V1 is in the open state and the valve V2 is in the

closed state, an area Z1 including the drainage route DR1, the second tank 420, and the valve V3 is in a vacuum state, and thus the valve V3 automatically enters the closed state. In this case, water flowing into the suction route VR1 passes through the first tank 410 and is stored in the second tank 420. The above-mentioned first state refers to this state in which the valve V1 is in the open state and the valve V2 and the valve V3 are in the closed state (see FIG. 2).

[0052] On the other hand, when the valve V1 is in the closed state and the valve V2 is in the open state, an area Z2 that does not include the drainage route DR1, the second tank 420, and the valve V3 is in a vacuum state, and thus the valve V3 automatically enters the open state. In this case, the water flowing into the suction route VR1 is stored in the first tank 410, and the water stored in the second tank 420 is discharged to the outside of the cutting apparatus 1 via a water outlet. The above-mentioned second state refers to this state in which the valve V1 is in the closed state and the valve V2 and the valve V3 are in the open state (see FIG. 3).

[0053] As mentioned above, the first water separation and discharge mechanism 41 can change between the first state and the second state. By controlling the valves to change between the first state and the second state at appropriate timings, water can be appropriately drained while maintaining the suctioning of the electronic components S1 by the vacuum pump D1. The timings of changing between the first state and the second state will be described later.

[0054] <1-3. Hardware configuration of computer>

FIG. 7 is a diagram schematically showing the hardware configuration of the computer 50. As shown in FIG. 7, the computer 50 includes a control unit 70, an input/output I/F (interface) 90, an acceptance unit 95, and a storage unit 80, and these elements are electrically connected to each other via a bus.

[0055] The control unit 70 includes a CPU (Central Processing Unit) 72, a RAM (Random Access Memory) 74, a ROM (Read Only Memory) 76, and the like. The

control unit 70 is configured to control constituent elements of the computer 50 and constituent elements of the cutting apparatus 1 according to information processing.

[0056] The input/output I/F 90 is configured to communicate with various constituent elements included in the cutting apparatus 1 via signal lines. The input/output I/F 90 is used in the transmission of data from the computer 50 to various constituent elements of the cutting apparatus 1 and in the reception of data transmitted from various constituent elements of the cutting apparatus 1 to the computer 50. The acceptance unit 95 is configured to accept instructions from the user. The acceptance unit 95 includes one or more of the following: a touch panel, a keyboard, a mouse, and a microphone, for example.

[0057] The storage unit 80 is an auxiliary storage device such as a hard disk drive or a solid state drive, for example. The storage unit 80 is configured to store a control program 81, for example. Various operations in the cutting apparatus 1 are realized by execution of the control program 81 by the control unit 70. When the control unit 70 is to execute the control program 81, the control program 81 is loaded to the RAM 74. The control unit 70 then controls various constituent elements by using the CPU 72 to interpret and execute the control program 81 loaded to the RAM 74.

[0058] [2. Operation]

<2-1. Drainage operation in first water separation and discharge mechanism>

FIG. 8 is a flowchart showing an example of a drainage procedure in the first water separation and discharge mechanism 41. The processing shown in this flowchart is executed by the control unit 70 of the computer 50 when the first water separation and discharge mechanism 41 is in the second state (FIG. 3). Note that the processing shown in this flowchart is performed every time the processing of one package substrate P1 ends.

[0059] Referring to FIG. 8, the control unit 70 determines whether or not the first cleaner 5e has completed cleaning (washing) the ball/lead surface of the electronic components S1 suctioned to the cutting table 5 (step S100). If it is determined that the cleaning of the ball/lead surface is not complete (NO in step S100), the control unit 70

waits until the cleaning of the ball/lead surface is complete.

[0060] On the other hand, if it is determined that the cleaning of the ball/lead surface is complete (YES in step S100), the control unit 70 controls the valves V1 and V2 such that the first water separation and discharge mechanism 41 changes from the second state to the first state (step S110). Specifically, the control unit 70 controls the valve V1 to switch from the closed state to the open state, and also controls the valve V2 to switch from the open state to the closed state. As a result, the valve V3 is in the closed state, and before water intrudes into the suction route VR1 from the transport unit 7 due to the cleaning performed by the second cleaner 7a, the amount of water that can be stored in the first water separation and discharge mechanism 41 can be increased while maintaining the suctioning of the electronic components S1 by the vacuum pump D1. Note that the switching of the state of the valve V1 and the switching of the state of the valve V2 are performed at the same time.

[0061] Thereafter, the control unit 70 determines whether or not the second cleaner 7a has completed cleaning the mold surface (the surface opposite to the cut surface) of the electronic components S1 that are suctioned to the transport unit 7, and the rising of the transport unit 7 in the Z-axis direction (FIG. 1) is complete (step S120). If the cleaning performed by the second cleaner 7a and the rising of the transport unit 7 are not complete (NO in step S120), the control unit 70 waits until the cleaning performed by the second cleaner 7a and the rising of the transport unit 7 are complete. The timing at which the cleaning performed by the second cleaner 7a and the rising of the transport unit 7 are complete is the timing when, in the first water separation and discharge mechanism 41, the highest amount of water is stored in the second tank 420, and water is unlikely to be stored in the first tank 410.

[0062] On the other hand, if it is determined that the cleaning performed by the second cleaner 7a and the rising of the transport unit 7 are complete (YES in step S120), the control unit 70 controls the valves V1 and V2 such that the first water separation and

discharge mechanism 41 changes from the first state to the second state (step S130). Specifically, the control unit 70 controls the valve V1 to switch from the open state to the closed state, and also controls the valve V2 to switch from the closed state to the open state. As a result, the valve V3 is in the open state, and after the electronic components S1 have been subjected to the last water processing step while suctioned to the transport unit 7, the water stored in the second tank 420 can be discharged to the outside of the cutting apparatus 1 while maintaining the suctioning of the electronic components S1 by the vacuum pump D1. Note that the switching of the state of the valve V1 and the switching of the state of the valve V2 are performed at the same time.

10 [0063] <2-2. Drainage operation in second and third water separation and discharge mechanisms>

The drainage procedures of the second water separation and discharge mechanism 42 and the third water separation and discharge mechanism 43 are substantially the same. Below, the drainage procedure in the second water separation and discharge mechanism 42 will be described as a representative example.

15 [0064] FIG. 9 is a flowchart showing an example of the drainage procedure in the second water separation and discharge mechanism 42. The processing shown in this flowchart is executed by the control unit 70 of the computer 50 when the second water separation and discharge mechanism 42 is in the second state. Note that the processing shown in this flowchart is performed every time the processing of one package substrate P1 ends.

20 [0065] Referring to FIG. 9, the control unit 70 determines whether or not the package substrate P1 has been placed on the cutting table 5 (step S200). If it is determined that the package substrate P1 has not been placed on the cutting table 5 (NO in step S200), the control unit 70 waits until the package substrate P1 is placed on the cutting table 5.

25 [0066] On the other hand, if it is determined that the package substrate P1 has been placed on the cutting table 5 (YES in step S200), the control unit 70 controls the valves

V1 and V2 such that the second water separation and discharge mechanism 42 changes from the second state to the first state (step S210). Specifically, the control unit 70 controls the valve V1 to switch from the closed state to the open state, and also controls the valve V2 to switch from the open state to the closed state. As a result, the valve V3 is in the closed state, and before cutting water, cooling water, and cleaning water intrude into the suction route VR2 from the cutting table 5, the amount of water that can be stored in the second water separation and discharge mechanism 42 can be increased while maintaining the suctioning of the electronic components S1 by the vacuum pump D2. Note that the switching of the state of the valve V1 and the switching of the state of the valve V2 are performed at the same time.

[0067] After that, the control unit 70 determines whether or not the first cleaner 5e has completed cleaning (washing) the ball/lead surface of the electronic components S1 suctioned to the cutting table 5 (step S220). If it is determined that the cleaning of the ball/lead surface is not complete (NO in step S220), the control unit 70 waits until the cleaning of the ball/lead surface is complete. The timing at which the cleaning of the ball/lead surface of the electronic components S1 by the first cleaner 5e is complete is the timing when, in the second water separation and discharge mechanism 42, the highest amount of water is stored in the second tank 420, and water is unlikely to be stored in the first tank 410.

[0068] On the other hand, if it is determined that the cleaning of the ball/lead surface is complete (YES in step S220), the control unit 70 controls the valves V1 and V2 such that the second water separation and discharge mechanism 42 changes from the first state to the second state (step S230). Specifically, the control unit 70 controls the valve V1 to switch from the open state to the closed state, and also controls the valve V2 to switch from the closed state to the open state. As a result, the valve V3 is in the open state, and after the electronic components S1 have been subjected to the last water processing step while suctioned to the cutting table 5, the water stored in the second tank 420 can be

discharged to the outside of the cutting apparatus 1 while maintaining the suctioning of the electronic components S1 by the vacuum pump D2. Note that the switching of the state of the valve V1 and the switching of the state of the valve V2 are performed at the same time.

5 [0069] <2-3. Operation in case of poor drainage>

The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 perform the same operation when poor drainage occurs. In the following, the operation of the first water separation and discharge mechanism 41 when poor
10 drainage occurs will be described as a representative example.

[0070] FIG. 10 is a flowchart showing an example of an operation procedure when drainage is poor in the first water separation and discharge mechanism 41. The processing shown in this flowchart is executed by the control unit 70 of the computer 50 when the cutting apparatus 1 is operating.

15 [0071] Referring to FIG. 10, the control unit 70 determines whether or not the height of the liquid level (water surface) in the first tank 410 is a predetermined height or more by referring to the output of the liquid level sensor 430 (step S300). If it is determined that the height of the liquid level in the first tank 410 is less than the predetermined height (NO in step S300), the control unit 70 continues to make the determination in step S300.

20 [0072] On the other hand, if it is determined that the liquid level in the first tank 410 is the predetermined height or more (YES in step S300), the control unit 70 controls the sound output unit 25 to output a warning sound (step S310). Upon hearing the warning sound, a worker can recognize that poor drainage has occurred in the first water separation and discharge mechanism 41.

25 [0073] [3. Characteristics]

As described above, in the cutting apparatus 1 according to the present embodiment, the first water separation and discharge mechanism 41, the second water

separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 can each change between the first state, in which water flowing from the first tank 410 into the second tank 420 is stored in the second tank 420, and the second state, in which water is stored in the first tank 410 and water stored in the second tank 420 is discharged to the outside of the cutting apparatus 1. Therefore, according to this cutting apparatus 1, by appropriately changing the states of the water separation and discharge mechanisms, it is possible to suppress the intrusion of water into the vacuum pumps while maintaining the suctioning of substrates such as the electronic components S1.

[0074] Also, in the first tank 410, the region in which the connection port 413 connected to the vacuum pump D1, D2, or D3 is located and the region in which the connection port 412 connected to the route for suctioning the electronic components S1 or the package substrate P1 is located are defined by the partition plate 415, and water can be stored in both of the regions defined by the partition plate 415. A gap is formed above the partition plate 415. According to the cutting apparatus 1 of the present embodiment, water can be separated from intake air with this simple configuration. Furthermore, each time the processing of one package substrate P1 is complete, drainage processing is performed in the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43, thereby making it possible to make the capacities of the first tank 410 and the second tank 420 as small as possible.

[0075] Note that the package substrate P1 and the electronic components S1 are each an example of a “cutting target” in the present invention. The cutting table 5 is an example of a “table” in the present invention. The spindle unit 6 is an example of a “cutting mechanism” in the present invention. The transport unit 7 is an example of a “holding mechanism” in the present invention. The suction routes VR1, VR2, and VR3 are each an example of a “suction route” in the present invention. The vacuum pumps

D1, D2, and D3 are each an example of a “vacuum pump” in the present invention. The drainage route DR1 is an example of a “drainage route” in the present invention. The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 are each an example of a “water separation and discharge mechanism” in the present invention. The first tank 410 is an example of a “first tank” in the present invention, and the second tank 420 is an example of a “second tank” in the present invention. The partition plate 415 is an example of a “partition plate” in the present invention. A configuration that includes the valves V1, V2, and V3 is an example of a “valve mechanism” in the present invention. The control unit 70 of the computer 50 is an example of a “control unit” in the present invention. The valve V3 is an example of a “drainage valve” in the present invention.

[0076] [4. Other embodiments]

The idea of the above embodiment is not limited to the embodiment described above. Hereinafter, examples of other embodiments to which the idea of the above embodiment is applicable will be described.

[0077] <4-1>

In the cutting apparatus 1 according to the embodiment described above, the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 each include the valves V1 and V2. However, the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 do not each need to include the valves V1 and V2. The first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 need only each include a valve mechanism that changes between the first state in which water flowing from the first tank 410 into the second tank 420 is stored in

the second tank 420, and the second state in which water is stored in the first tank 410 and water stored in the second tank 420 is discharged, for example. One example of such a valve mechanism is a three-way valve. Another example of the first water separation and discharge mechanism 41 will be described below.

[0078] FIG. 11 is a diagram schematically showing a first water separation and discharge mechanism 41A in the first state. FIG. 12 is a diagram schematically showing the first water separation and discharge mechanism 41A in the second state. As shown in FIGS. 11 and 12, in the first water separation and discharge mechanism 41A, a three-way valve VA is provided between the first tank 410 and the second tank 420. The three-way valve VA can change between a state in which the first tank 410 and the second tank 420 are in communication with each other (FIG. 11) and a state in which the second tank 420 is in communication with the atmosphere (FIG. 12). In other words, the three-way valve VA can change between a first state (FIG. 11) in which water is discharged from the first tank 410 to the second tank 420 and water is stored in the second tank 420, and a second state (FIG. 12) in which water is stored in the first tank 410 and water stored in the second tank 420 is discharged. The three-way valve VA may be used instead of the valves V1 and V2 in the cutting apparatus 1 according to the embodiment described above. Note that in the first state, an area Z3 is in a vacuum state, and in the second state, an area Z4 is in a vacuum state.

[0079] <4-2>

Furthermore, in the cutting apparatus 1 according to the embodiment described above, the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43 are provided in the suction routes VR1, VR2, and VR3, respectively. However, a water separation and discharge mechanism does not necessarily need to be provided in each suction route. For example, liquid-ring vacuum pumps may be used as the vacuum pumps D2 and D3, and water separation and discharge mechanisms may

not be provided in the suction routes VR2 and VR3. As another example, a liquid-ring vacuum pump may be used as the vacuum pump D1, and a water separation and discharge mechanism may not be provided in the suction route VR1.

[0080] <4-3>

5 Furthermore, in the cutting apparatus 1 according to the embodiment described above, a check valve is used as the valve V3 included in the first water separation and discharge mechanism 41, the second water separation and discharge mechanism 42, and the third water separation and discharge mechanism 43. However, the valve V3 does not necessarily need to be a check valve. The valve V3 may be configured as an on-off
10 valve (a so-called stop valve). In this case, for example, in order to store water in the second tank 420, the valve V3 is changed to the closed state, and in order to discharge water from the second tank 420, the valve V3 is changed to the open state.

[0081] <4-4>

Also, the valve V2 connected to the atmosphere is provided in the path where
15 the drainage route DR1 branches between the valve V1 and the second tank 420. However, the valve V2 need only be provided at a location where the downstream side of the valve V1 (more specifically, inside the second tank 420) can be brought to atmospheric pressure in the drainage route DR1, and the drainage route DR1 does not necessarily need to branch. For example, a pipe may be connected to the upper surface
20 of the second tank 420, and the valve V2 may be provided in that pipe.

[0082] <4-5>

Furthermore, in the cutting apparatus 1 according to the embodiment described above, a warning sound is emitted when the height of the water surface in the first tank 410 reaches a predetermined height or higher. However, the warning sound does not
25 necessarily need to be emitted when the height of the water surface in the first tank 410 reaches the predetermined height or higher. For example, when the height of the water surface in the first tank 410 reaches a predetermined height or higher, the cutting

apparatus 1 may be forcibly stopped. This makes it possible to prevent the overflow of water from the first tank 410.

[0083] <4-6>

Also, in the embodiment described above, in step S100 of FIG. 8, it is determined
5 whether or not the cleaning (washing) performed by the first cleaner 5e is complete. However, in step S100 of FIG. 8, it may be determined whether or not drying performed by the first cleaner 5e is complete. If it is determined that drying is complete, the first water separation and discharge mechanism 41 may be changed from the second state to the first state. Furthermore, in step S120 of FIG. 8, it may be determined whether or not
10 drying performed by the second cleaner 7a is complete. If it is determined that drying is complete, the first water separation and discharge mechanism 41 may be changed from the first state to the second state. Furthermore, in step S220 of FIG. 9, it is determined whether or not the first cleaner 5e has completed the cleaning (washing) of the ball/lead surface of the electronic components S1. However, in step S220 of FIG. 9, it may be
15 determined whether or not drying performed by the first cleaner 5e is complete. If it is determined that drying is complete, the first water separation and discharge mechanism 41 may be changed from the first state to the second state.

[0084] <4-7>

Furthermore, in the cutting apparatus 1 according to the embodiment described
20 above, in the case of switching the states of the valves V1 and V2 included in the water separation and discharge mechanisms, the states of the valves V1 and V2 are switched at the same time. However, the states of valves V1 and V2 do not necessarily need to be switched at the same time. For example, when switching the states of the water separation and discharge mechanisms from the first state to the second state, a
25 configuration is possible in which the valve V1 is switched from the open state to the closed state, and then the valve V2 is switched from the closed state to the open state. As another example, when switching the states of the water separation and discharge

mechanisms from the second state to the first state, a configuration is possible in which the valve V2 is switched from the open state to the closed state, and then the valve V1 is switched from the closed state to the open state.

[0085] The embodiments of the present invention described above are illustrative.

5 In other words, the detailed description and accompanying drawings have been disclosed for the purpose of illustration. Therefore, some of the components described in the detailed description and the attached drawings may not be essential for solving the problem. Accordingly, simply because non-essential components are described in the detailed description and accompanying drawings, such non-essential components are not
10 intended to be immediately identified as essential.

[0086] Furthermore, the above embodiments are merely illustrative of the present invention in all respects. Various improvements and changes can be made to the above embodiments within the scope of the present invention. In other words, when implementing the present invention, specific configurations can be adopted as appropriate
15 depending on the embodiment.

List of Reference Numerals

20	[0087]	1	Cutting apparatus
		3	Substrate supply unit
		4	Positioning unit
		4a	Rail unit
		5	Cutting table
		5a	Holding member
		5b	Rotating mechanism
	25	5c	Moving mechanism
		5d	First position checking camera
		5e	First cleaner

	6	Spindle unit
	6a	Blade
	6b	Second position checking camera
	6c	Rotation shaft
5	7	Transport unit
	7a	Second cleaner
	11	Inspection table
	12	First optical inspection camera
	13	Second optical inspection camera
10	14	Arrangement unit
	15	Extraction unit
	15a	Good component tray
	15b	Defective component tray
	20	Monitor
15	25	Sound output unit
	41,41A	First water separation and discharge mechanism
	42	Second water separation and discharge mechanism
	43	Third water separation and discharge mechanism
	50	Computer
20	70	Control unit
	72	CPU
	74	RAM
	76	ROM
	80	Storage unit
25	81	Control program
	90	Input/output I/F
	410	First tank

	411	First tank body
	412,413,414	Connection port
	415	Partition plate
	420	Second tank
5	430	Liquid level sensor
	A1	Cutting module
	B1	Inspection/storage module
	D1,D2,D3	Vacuum pump
	DR1	Drainage route
10	M1	Magazine
	P1	Package substrate
	S1	Electronic component
	V1,V2,V3	Valve
	VA	Three-way valve
15	VR1,VR2,VR3	Suction route
	W1	Weld portion
	Z1,Z2,Z3,Z4	Area

CLAIMS

1. A cutting apparatus comprising:

a table configured to hold a cutting target by suctioning the cutting target;

5 a cutting mechanism configured to divide the cutting target into individual cutting target pieces by cutting the cutting target on the table; and

a holding mechanism configured to hold the individual cutting target pieces by suctioning the cutting target pieces,

10 wherein the table or the holding mechanism is connected to a dry vacuum pump via a suction route,

the cutting apparatus further comprises a water separation and discharge mechanism located on the suction route and configured to discharge water via a drainage route,

the water separation and discharge mechanism includes

15 a first tank, and

a second tank located downstream of the first tank on the drainage route,

the first tank includes a partition plate partitioning the first tank into a region in which a connection port for the vacuum pump is located, and a region in which a connection port for the table or the holding mechanism is located,

20 a gap is formed above the partition plate in the first tank, and

the water separation and discharge mechanism further includes a valve mechanism configured to change between a first state in which water flowing from the first tank into the second tank is stored in the second tank, and a second state in which water is stored in the first tank and water stored in the second tank is discharged.

25

2. The cutting apparatus according to claim 1, further comprising:

a control unit configured to control the valve mechanism to change from the first

state to the second state each time processing is performed on one cutting target,

wherein the control unit controls the valve mechanism to change from the first state to the second state after the cutting target is subjected to a last water processing step while the cutting target is suctioned to the table or the holding mechanism.

5

3. The cutting apparatus according to claim 2,

wherein the suction route connects the holding mechanism and the vacuum pump to each other, and

the control unit controls the valve mechanism to change from the first state to the second state after completion of water cleaning performed on a surface opposite to a cut surface of the cutting target while the cutting target is held by the holding mechanism.

10

4. The cutting apparatus according to claim 2,

wherein the suction route connects the table and the vacuum pump to each other,

15 and

the control unit controls the valve mechanism to change from the first state to the second state after completion of water cleaning performed on a cut surface of the cutting target while the cutting target is held by the table.

20

5. The cutting apparatus according to any one of claims 1 to 4,

wherein the valve mechanism includes a drainage valve located downstream of the second tank on the drainage route, and

the drainage valve is a check valve.

25

6. A method for manufacturing a cut product using the cutting apparatus according to any one of claims 1 to 5, comprising:

manufacturing a cut product by dividing the cutting target into individual cutting

target pieces by cutting the cutting target on the table using the cutting mechanism.