

DESCRIPTION

Abrasive Waterjet Type Cutting Apparatus

5 TECHNICAL FIELD

The present invention relates to a cutting apparatus having a nozzle from which high-pressure water containing abrasive grains, i.e. an abrasive waterjet, is sprayed out to cut or work on a workpiece attached to a fixing table.

BACKGROUND ART

10 Conventionally, the method of cutting or working on a workpiece by means of an abrasive waterjet is known. In this method, high-pressure fluid (waterjet) containing an abrasive substance is applied with pressure to eject the high-pressure fluid from the nozzle in order to cut or work on a workpiece. This method is disclosed in, for example, Japanese Patent Laying-Open No. 2000-767 on pages 2-4 and Figs. 1-4.

15 In the working method by means of an abrasive waterjet disclosed in the aforementioned Japanese Patent Laying-Open No. 2000-767, garnet, silica sand, cast steel, grit or the like is employed for the abrasive substance (abrasive grains). The abrasive substance in a wet state is delivered from an abrasive substance tank into the mixing chamber of the nozzle head via a supply pipe and supply inlet. At this stage, the
20 abrasive substance is fed into the mixing chamber by high-pressure air generated by a compressor. Then, the abrasive substance is mixed with high-pressure water in the mixing chamber.

As a result, the abrasive waterjet is sprayed out from the nozzle. The abrasive waterjet passes through grooves in a table on which a workpiece is supported (fixing
25 table) to be collected by a catcher. Subsequently, the abrasive substance is collected through a sieve and returned to the abrasive substance tank in the wet state to be used again. This technique is shown in Figs. 1 and 4 in Japanese Patent Laying-Open No. 2000-767.

In recent years, the cutting apparatus set forth above is used to cut an encapsulated body of a semiconductor chip that is an example of a workpiece. Specifically, the aforementioned cutting apparatus is used to cut an encapsulated body (substrate) in which chip-like components (semiconductor chips and the like) mounted on a circuit board are encapsulated all together in resin, along respective orthogonal cutting lines corresponding to a lattice pattern. For this cutting operation, a cutting position of high accuracy and a cutting width of approximately 200 μm are required.

When a conventional cutting apparatus is employed, the encapsulated body is first placed on a table having grooves, and cut along cutting lines extending in one direction. Then, the encapsulated body will be cut along cutting lines extending in another direction orthogonal to the one direction. In the cutting method employing such a cutting apparatus, the table having grooves extending in the one direction is replaced, after the encapsulated body is cut along cutting lines in one direction, with another table having grooves extending in a direction differing by 90° from the grooves of the previous table extending in the one direction. Thereafter, the encapsulated body is aligned at a predetermined position on the other table, and then cut along the cutting line extending in the other direction.

The reason why the tables have to be replaced is to avoid wear on the base portion of the table (fixing table) on which the encapsulated body qualified as the object of cutting is supported. Specifically, the purpose is to allow the abrasive waterjet to pass through the grooves formed in the table without being brought into contact with the base. This is described in the publication of Japanese Patent Laying-Open No. 2000-767 with reference to Fig. 4.

Thus, the abrasive waterjet cuts the workpiece (encapsulated body) secured on a different table, and then passes through the grooves in the different table without establishing contact therewith to be collected by a catcher.

According to the cutting method employing this conventional cutting apparatus, two tables are necessary, which will increase the cost for the cutting apparatus.

Furthermore, alignment of the encapsulated body relative to one table is required, in addition to the alignment of the encapsulated body relative to the different table. Accordingly, the efficiency of the cutting operation will be degraded. There is also the possibility of degradation in the cutting accuracy based on the cutting position, angle, and the like.

Patent Document 1: Japanese Patent Laying-Open No. 2000-767 (pages 2-4 and Figs. 1-4)

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

To solve the problem encountered in the cutting apparatus set forth above, specifically in order to cut an encapsulated body using only one table (fixing table) while preventing contact of the water containing abrasive grains with the base, the inventors of the present invention developed a cutting apparatus that can cut an encapsulated body under a state where a protection member is provided so as to cover the base of the table.

This cutting table is disclosed in, for example, Japanese Patent Application No. 2005-276904 that was not yet published at the time of filing the present application. Japanese Patent Application No. 2005-276904 is incorporated herein by reference in the present application.

In accordance with this cutting apparatus, an encapsulated body is cut along two directions crossing each other using the same fixing table without wear on the fixing table. This is described in Japanese Patent Application No. 2005-276904 with reference to Fig. 6. In other words, this cutting apparatus is dispensed with preparing a plurality of fixing tables, exchanging fixing tables, and alignment of the encapsulated body a plurality of times in the case where an encapsulated body is to be cut along two crossing directions.

However, it was found that the cutting apparatus set forth above had a problem different from the aforementioned problems. For the sake of understanding the problem, Fig. 7(A) in Japanese Patent Application No. 2005-276904 is to be referred to.

The cutting apparatus set forth above includes a fixing table. The fixing table includes a plurality of protrusions. Each of the plurality of protrusions has a through hole extending in the axial direction and a recess at the tip. At the fixing table, an encapsulated body adheres to the tip of the protrusions by a suction action sequentially through the through holes and recesses. Accordingly, the encapsulated body is secured by the fixing table, i.e. secured to each protrusion and the frame provided around the protrusions. Under this state, an abrasive waterjet is sprayed out at high pressure from a nozzle. Thus, the encapsulated body is cut along a cutting line in one direction (X direction) among the cutting lines extending in two crossing directions.

According to a cutting method employing the cutting apparatus set forth above, high-pressure water containing abrasive grains used in cutting will collide against the protection member, but not against the upper surface of the base in the groove.

The pressure (jet force) of the high-pressure water (abrasive waterjet) will hardly be reduced by the collision with the protection member. In other words, the high-pressure water (abrasive waterjet) is blasted back from the upper surface of the protection member without reduction in pressure. This high-pressure water will collide against the side face of the protrusion provided adjacent to the protection member. The pressure of the high-pressure water at this stage is substantially equal to the pressure of the high-pressure water immediately before collision with the protection member.

The protection member is formed of a material higher in hardness than the abrasive grains so as to withstand the pressure of the high-pressure water. However, the protrusion set forth above is not formed of such a material. Therefore, the side face of the protrusion will be abraded significantly.

Furthermore, the high-pressure water will be more or less dispersed in every direction without colliding against the protection member when the cutting operation of the encapsulated body is terminated. The scattering high-pressure water will cause wear on the protrusion and frame member located close to the protection member.

If the protrusion and frame member are partially worn, the encapsulated body cannot be secured reliably. Therefore, the protrusion and frame member will have to be exchanged with another protrusion and frame member. In this case, all the components of the fixing table, including the protrusion and frame member that may be continually used, must be exchanged. If the frequency of exchanging all the components of the fixing table is increased, the cost for exchanging all the components of the fixing table will become higher than the cost of the protection member.

In view of the foregoing problems, an object of the present invention is to provide an abrasive waterjet type cutting apparatus that can prevent wear on a base, as well as wear on sections other than the base of a fixing table for holding an encapsulated body.

MEANS FOR SOLVING THE PROBLEMS

According to an aspect of the present invention, a cutting apparatus includes a fixing table where a position of a workpiece is fixed, and a nozzle from which an abrasive waterjet containing abrasive grains for cutting the workpiece is sprayed out. The fixing table includes a plurality of protrusions and a plurality of bases. Each of the plurality of protrusions is partitioned by a groove so as to correspond to a plurality of package products subsequent to the cutting of the workpiece, and includes a through hole for drawing in the workpiece or one of the plurality of package products. Each of the plurality of bases links protrusions aligned along at least one direction together among the plurality of protrusions. A region of the plurality of protrusions and the plurality of bases against which the abrasive waterjet collides is formed of a material higher in hardness than the abrasive grains.

According to another aspect of the present invention, a cutting apparatus includes a fixing table where a position of a workpiece is fixed, and a nozzle from which an abrasive waterjet containing abrasive grains for cutting the workpiece is sprayed out. The fixing table includes a plurality of protrusions and a plurality of bases. Each of the plurality of protrusions is partitioned by a groove so as to correspond to a plurality of

package products subsequent to the cutting of the workpiece, and includes a through hole for drawing in the workpiece or one of the plurality of package products. Each of the plurality of bases links protrusions aligned along at least one direction together among the plurality of protrusions. The cutting apparatus further includes a container in which the fixing table is placed in an interior cavity and into which liquid is poured into the interior cavity. The fixing table is immersed in the liquid to avoid direct collision with the abrasive waterjet in the container.

The cutting apparatus of the aspects set forth above of the present invention preferably includes a mount member provided between the workpiece or plurality of package products and the plurality of protrusions, and on which the workpiece or each of the plurality of package products is placed. In this case, the mount member preferably contains a material lower in hardness than the abrasive grains.

The features of the cutting apparatus of one aspect may be combined with the features of the cutting apparatus of the other aspect set forth above.

EFFECTS OF THE INVENTION

According to the present invention, wear on a region other than the base of the fixing table where an encapsulated body is fixed can be also prevented.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view of an abrasive waterjet type cutting apparatus according to an embodiment.

Fig. 2 is a perspective view of a fixing table of a cutting apparatus according to an embodiment and an encapsulated body (substrate) that is the object of cutting.

Fig. 3 is an exploded perspective view of a fixing table according to an embodiment.

Fig. 4 is a sectional view of a fixing table when a cutting apparatus according to

an embodiment is carrying out a cutting operation on a workpiece.

Fig. 5 is a perspective view of a plurality of package products produced by the cutting operation of an encapsulated body (substrate) according to an embodiment.

DESCRIPTION OF THE REFERENCE SIGNS

5 1 encapsulated body; 1a substrate; 1b resin mold; 2 abrasive waterjet; 3 package product; 4 delivery mechanism; 5 conveyer rail; 6 non-mount face; 7, 7x, 7y cutting line; 8 pump unit; 9 nozzle system pipe; 10 nozzle; 11 CCD (Charge Coupled Device) camera; 12 transfer mechanism; 50 fixing table; 51 fix position; 52 cut position; 53 alignment position; 54 mount member; 55 groove; 56 protrusion; 57 base; 58 fix-and-
10 support member; 59 side frame member; 60 side member; 61 setting table; 62 recess; 63 through hole; 64 upper surface; 65 protection member; 66 arrow indicating intake action; 100 cutting apparatus; A carry stage; B prestage; C cut stage; D rinse-and-dry stage.

BEST MODES FOR CARRYING OUT THE INVENTION

15 An abrasive waterjet type cutting apparatus according to an embodiment of the present invention will be described hereinafter with reference to Figs. 1-3. An abrasive waterjet cutting apparatus 100 will be simply referred to as cutting apparatus 100 hereinafter.

20 For the sake of simplification, all the drawings employed for the description set forth below are schematically drawn and may be partially omitted or depicted in an exaggerated form. In the embodiment set forth below, an encapsulated body 1 having semiconductor chips and the like mounted on a circuit board and sealed together by resin is employed as an example of a workpiece that is the object of cutting by cutting apparatus 100. Encapsulated body 1 is cut along two crossing cutting lines including a
25 curvilinear section.

 In the cutting method employing this cutting apparatus, a cutting position of high accuracy and a cutting width of approximately 200 μm are required. Although a cutting apparatus has been described by the inventors of the present application in the

aforementioned Japanese Patent Application No. 2005-276904 (not yet published at the time of filing the present application), the cutting apparatus disclosed therein is definitely only an embodiment of the cutting apparatus of the present invention, and the cutting apparatus of the present invention is not limited thereto.

5 Referring to Fig. 1, cutting apparatus 100 according to the present embodiment includes a carry stage A, a prestage B, a cut stage C, and a rinse-and-dry stage D. Carry stage A carries an encapsulated body 1 to cutting apparatus 100. Prestage B receives encapsulated body 1 from carry stage A to carry encapsulated body 1 to the next stage. Cut stage C receives encapsulated body 1 from prestage B. On cut stage
10 C, encapsulated body 1 is cut into a plurality of package products 3 by an abrasive waterjet 2. Rinse-and-dry stage D receives plurality of package products 3 from cut stage C for rinsing and drying package products 3.

Cutting apparatus 100 includes delivery means (not shown) such as a pusher, grip feed, pickup, and the like to supply encapsulated body 1 from carry stage A to
15 prestage B. Cutting apparatus 100 also includes a delivery mechanism 4 such as a pusher, grip feed, pickup, and the like to carry encapsulated body 1 from prestage B to cut stage C, and to carry plurality of package products 3 from cut stage C to rinse-and-dry stage D. In the present embodiment, a mechanical chuck type pickup means is provided as delivery mechanism 4.

20 Each of the delivery means (not shown) and delivery mechanism 4 can move left and right (X-axis direction), i.e. in the horizontal direction in Fig. 1, as well as in a direction perpendicular to the drawing sheet of Fig. 1, i.e. vertical direction (Z-axis direction).

In other words the delivery means (not shown) can move encapsulated body 1
25 from carry stage A to prestage B. In addition, delivery mechanism 4 can move encapsulated body 1 from prestage B to cut stage C, and also move plurality of package products 3 from cut stage C to rinse-and-dry stage D.

As shown in Fig. 1, cutting apparatus 100 has carry stage A, prestage B, cut

stage C, and rinse-and-dry stage D arranged substantially linear so that a process other than predetermined steps can be completed during the transfer of encapsulated body 1 and package products 3 along one straight line (X-axis direction). By the arrangement of carry stage A, prestage B, cut stage C, and rinse-and-dry stage D, the transfer time of encapsulated body 1 and package products 3 can be shortened.

The arrangement of the four stages set forth above is not limited to that set forth above, and any arrangement may be employed as long as the object of the present invention is accomplished. The same delivery mechanism 4 may be used to move encapsulated body 1 during the delivery from carry stage A to rinse-and-dry stage D. Furthermore, the transfer of encapsulated body 1 between the stages may be realized by a plurality of independent delivery mechanisms. In this case, conveyer rail 5 may differ for each delivery mechanism 4.

In the usage of cutting apparatus 100, first the delivery means (not shown) carries encapsulated body 1 from carry stage A to prestage B. Then, encapsulated body 1 is moved from prestage B to cut stage C by delivery mechanism 4 along conveyer rail 5. Then, at cut stage C, encapsulated body 1 is cut to be divided into a plurality of package products 3.

Cutting apparatus 100 further includes a product inspection stage and storage stage not shown. The product inspection stage is directed to inspecting a plurality of package products 3 subsequent to completion of the rinsing and drying step carried out at rinse-and-dry stage D. The storage stage includes a final product tray (not shown) for receiving and storing a plurality of package products 3 transferred from the product inspection stage.

In the present embodiment, encapsulated body 1 includes, as shown in Figs. 2 and 4, a substrate 1a, a plurality of electronic components mounted on one main surface of substrate 1a, and a resin mold 1b encapsulating the plurality of electronic components all together in resin.

In Fig. 5, cutting lines 7 are marked in the X direction and Y direction at the

other surface of encapsulated body 1, i.e. the non-mount face 6 where electronic components 6 are not placed, corresponding to the location and number of the plurality of electronic components. Encapsulated body 1 is cut along each of the two cutting lines (7x and 7y) to be divided into a plurality of package products 3.

5 In Fig. 5, cutting line 7x in the X direction includes a curve and straight line whereas a cutting line 7y in the Y direction includes only a straight line. Cutting line 7 at the corner where cutting line 7x in the X direction and cutting line 7y in the Y direction intersect corresponds to a curve. In other words, cutting lines 7 (7x and 7y) employed in the present embodiment differ from conventional cutting lines constituted
10 of only a group of straight lines extending along two orthogonal directions.

 Encapsulated body 1 is the object of cutting, and includes a substrate 1a such as a lead frame, printed circuit board or the like, and a resin mold 1b. Each of the plurality of regions partitioned by a plurality of cutting lines 7x and a plurality of cutting lines 7y corresponds to one package product 3 of an electronic component that is the
15 completed product.

 In the cutting operation of encapsulated body 1, cutting is first carried out along the shorter side direction (X direction) of substrate 1a shown in Fig. 5. Then, encapsulated body 1 is cut along cutting line 7 in succession to the short side direction in one continuous stroke.

20 For example, three package products 3 adjacent to the aforementioned one short side are cut. Then, the next three package products 3 adjacent to the aforementioned three package products 3 are cut in one continuous stroke, likewise the previous three package products 3. Eventually, one encapsulated body 1 is divided into 18 package products 3.

25 Cut stage C includes a reciprocating fixing table 50, as shown in Fig. 1. Fixing table 50 includes a fix position 51 where encapsulated body 1 is secured, and a cut position 52 where encapsulated body 1 is cut. Cut stage C also includes a reciprocating transfer means (not shown) that moves back and forth between fix position

51 and cut position 52. The reciprocating transfer means moves encapsulated body 1 from fix position 51 to cut position 52.

An alignment position 53 is provided between fix position 51 and cut position 52. Alignment position 53 is directed to registration of cutting lines 7 (7x and 7y) marked on non-mount face 6 of encapsulated body 1.

Fixing table 50 can reciprocate between fix position 51 and cut position 52 with encapsulated body 1 or package product 3 secured.

Furthermore, cutting apparatus 100 includes a transfer mechanism 12, as shown in Fig. 1. Transfer mechanism 12 moves image pickup means such as a CCD (Charge Coupled Device) camera 11 for alignment of nozzle 10 and encapsulated body 1 back and forth between cut position 52 and alignment position 53 in a two dimensional plane (X-axis direction and Y-axis direction).

According to the detailed structure of fixing table 50, which will be described afterwards, encapsulated body 1 that is the cutting target is held by suction and the like against fixing table 50.

In the cutting apparatus of the present embodiment, abrasive waterjet 2 is sprayed out at high pressure from nozzle 10, whereby encapsulated body 1 is cut.

In the cutting method of encapsulated body 1 employing cutting apparatus 100 of the present embodiment, cut stage C moves encapsulated body 1 on prestage 5 to fix position 51 using delivery means, and attaches encapsulated body 1 to fixing table 50 located at fix position 51.

Then, fixing table 50 is moved by the reciprocating transfer means. In association, encapsulated body 1 is moved together with fixing table 50 to alignment position 53. Substantially at the same time, cutting apparatus 100 moves CCD camera 11 located above alignment position 53 in the horizontal direction by means of transfer mechanism 12. Then, cutting apparatus 100 executes alignment of encapsulated body 1 taking advantage of the image data obtained from CCD camera 11.

Then, encapsulated body 1 is moved from alignment position 53 to cut position

52 by the reciprocating transfer means. Substantially at the same time, cutting apparatus 100 moves nozzle 10 located above cut position 52 in the horizontal direction by means of transfer mechanism 12. Accordingly, encapsulated body 1 is cut along cutting lines 7 (7x and 7y) marked on non-mount face 6 to be divided into a plurality of package products 3.

Each of the plurality of package products 3 is moved from cut position 52 to fix position 51 by the reciprocating transfer means in the state attached to fixing table 50. The regions of encapsulated body 1 other than plurality of package products 3 are dropped towards a dust box (not shown) located beneath cut position 52. In other words, the unwanted regions of encapsulated body 1 are removed away from fixing table 50. A removal mechanism (not shown) to remove the unwanted regions from encapsulated body 1 is provided at nozzle 10. The unwanted regions of encapsulated body 1 may be removed by the removal mechanism that is moved by delivery mechanism 12.

Next, the plurality of package products 3 are transferred to fix position 51 to be secured at fixing plate 50, and then moved from cut stage C to rinse-and-dry stage D along conveyer rail 5 by delivery mechanism 4.

The operation of each constituent element of cutting apparatus 100 set forth above is under control of a control unit (not shown) provided in cutting apparatus 100. This control unit provides control of carry stage A, prestage B, cut stage C and rinse-and-dry stage D, as well as abrasive waterjet 2 sprayed out from nozzle 10 to effect control of cutting encapsulated body 1 along respective cutting lines 7 (7x and 7y) in two crossing directions including a curvilinear section.

Cut stage C includes the constituent elements set forth below as the components of a system for spraying out water containing abrasive grains at high pressure. These constituent elements include a high-pressure pump to pressurize water supplied from an air water source, a switch valve connected to the high-pressure pump, a first tank connected to the switch valve via a first flow-in side water system pipe, a second tank

connected to the switch valve via a second flow-in side water system pipe, and a first flow-out side water system pipe and a second flow-out side water system connected to the first tank and second tank, respectively. These constituent elements are depicted as pump unit 8 in Fig. 8.

5 As shown in Fig. 1, nozzle system pipe 9 is connected to the region where the first flow-out side water system pipe and second flow-out side water system pipe are connected. A cutting nozzle 10 is connected to nozzle system pipe 9. The first and second tanks are both substantially filled with water containing abrasive grains.

10 Although pump unit 8 is shown installed outside of cut stage C (cutting apparatus 100), pump unit 8 may be installed in cut stage C (cutting apparatus 100) instead.

 The abrasive grains in pump unit 8 include silicon carbide (SiC), alumina (Al_2O_3), garnet, or the like, and has a grain size of approximately 10 μm to 100 μm . The specific gravity of these abrasive grains is greater than 1. Therefore, in a normal state,
15 each of the first and second tanks includes a high ratio region where there are precipitated abrasive grains at a high ratio, and a low ratio region composed mainly of water.

 In the present embodiment, "ratio" implies "the ratio of abrasive grains to the water containing abrasive grains. Furthermore, in the present embodiment, the first
20 tank and second tank "substantially filled" with water containing abrasive grains implies the case where the tank is completely filled with the water containing abrasive grains, and also the case where there is a slight amount of bubbles or space remaining in the tank. As will be described afterwards, the first tank and the second tank preferably have the same volume since the first tank and second tank are used in a switching
25 manner.

 Cutting apparatus 100 further includes the constituent elements set forth below as the components of the system supplying abrasive grains to the first tank and second tank at pump unit 8. The constituent elements include an abrasive grain system tank

storing water containing abrasive grains at a high ratio (hereinafter, referred to as "high ratio water"), and a pump for pumping out the high ratio water from the abrasive grain system tank by supplying pressurized water to the abrasive grain system tank.

5 Further, the system includes an abrasive grain supply pipe for supplying the high ratio water pumped out from the abrasive grain system tank to the first tank and second tank, a first abrasive grain supply valve provided at a region of the abrasive grain supply pipe linking to the first tank, and a second abrasive grain supply valve provided at a region of the abrasive grain supply pipe linking to the second tank.

10 The system further includes a return pipe for returning the water overflowing from the first and second tanks to the abrasive grain system tank when the high ratio water is supplied, a first return valve provided at a region of the return pipe linking to the first tank, and a second return valve provided at a region of the return pipe linking to the second tank. The system also has a water injection valve to supply externally applied water to the abrasive grain supply pipe.

15 In the system of supplying abrasive grains to the first and second tanks, each of the first and second tanks is substantially filled with water containing abrasive grains constantly.

20 Cutting apparatus 100 includes the constituent elements set forth below as the system of maintaining appropriately the ratio of the abrasive grains in the first tank and the second tank. The system includes first and second sensors each formed of a load cell secured to the bottom of the first tank and the second tank.

25 This system also includes a control unit (controller). The control unit receives a signal from the first and second sensors to calculate the weight of water containing abrasive grains in each of the first and second tanks based on the received signal. The control unit controls, as necessary, the valves, pump, and the like provided at cutting apparatus 100. Although the control unit controls pump unit 8, each of the constituent elements of the entire cutting apparatus 100 including the control unit is under control of a control unit (not shown).

The cutting nozzle 10 includes a holder, a pole secured in the holder, a support fitted into the tip of the pole in the holder, a connector fitted integrally within the support, and a nozzle tip. A flow channel of a predetermined diameter is provided at the pole. The connector is formed with a funnel shape cavity, in communication with
5 the flow channel and having a tapered end.

The nozzle tip is formed with a small-diameter flow channel having a predetermined diameter in communication with the outside space. The tip end of the nozzle tip protrudes by a predetermined amount from the tip end of both the support and holder. The leading end of the small-diameter flow channel has a squirt hole.

10 The holder, pole, support, connector, and nozzle chip are formed of, for example, stainless steel, ceramics, or the like. A wear-resistant coat is applied at the inner wall of the small-diameter flow channel at the nozzle chip. This wear-resistant coat is formed by the well known method such as plasma CVD (Chemical Vapor Deposition).

The region of the member where the small-diameter flow channel is formed, i.e.
15 the nozzle chip itself, may be formed of a wear-resistant material such as sintered diamond. In this case, the degree of abrasion of the inner wall of the small-diameter flow channel is reduced since the inner wall of the small-diameter flow channel is formed of an anti-wear material.

Fixing table 50 will be described with reference to Figs. 1-3 hereinafter. Fixing
20 table 50 is the characteristic feature of cutting apparatus 100 of the present embodiment.

Fixing table 50 of cutting apparatus 100 of the present embodiment includes, as shown in Fig. 2, a mount member 54 where encapsulated body 1 and package product 3 are set, a groove 55 located below cutting line 7 (7x and 7y), and a plurality of protrusions 56 corresponding to a region other than grooves 55 for retaining
25 encapsulated body 1 and package products 3.

Fixing table 50 includes a plurality of bases 57. Each of the plurality of bases 57 is provided so as to link protrusions 56 together, substantially parallel to cutting line 7 (7x) extending along at least one of the aforementioned two directions (in this case,

the X direction). The plurality of protrusions 56 and plurality of bases 57 constitute fix-and-support member 58. Fix-and-support member 58 is set at a setting table 61. A side frame member 59 is attached to plurality of bases 57 in a detachable manner.

5 Fixing table 50 further includes a side member 60 extending substantially parallel to the longer side of rectangular fix-and-support member 58, at either side of fixing table 50, and attached to fix-and-support member 58 in a detachable manner. Fixing table 50 includes setting table 61. Setting table 61 has mount member 54, fix-and-support member 58, side frame member 59, and side member 60 attached in a detachable manner. Furthermore, setting table 61 has an opening located between fix-and-support member
10 58 and side member 60.

Fig. 2 represents an exploded state of fixing table 50. In the assembling procedure of fixing table 50, fix-and-support member 58, side frame member 59, and side member 60 are attached to setting table 61, and then mount member 54 is set on fix-and-support member 58.

15 Cutting apparatus 100 of the present embodiment may further include a container 90 in which fixing table 50 is installed in the interior cavity, and into which liquid 91 is poured into the interior cavity. In this case, fixing table 50 is preferably immersed in liquid 91 so as to avoid direct collision with abrasive waterjet 2 in container 90. Accordingly, abrasive waterjet 2 has its energy absorbed by entry into the liquid,
20 and then brought into contact with the plurality of protrusions 56 and bases 57 of fixing table 50 with the speed reduced. Therefore, the degree of abrasion of protrusions 56 and bases 57 is reduced.

In the case where protrusions 56 and bases 57 are formed of a material harder than the abrasive grains, container 90 and liquid 91 are not mandatory elements to
25 prevent wear on the plurality of protrusions and bases. Furthermore, as long as fixing table 50 is immersed in liquid 91 in container 90, formation of the plurality of protrusions 56 and bases 57 from a material harder than abrasive grains is not a mandatory issue to prevent wear on the plurality of protrusions 56 and bases 57.

However, abrasion of protrusions 56 and bases 57 can be prevented more reliably by the combination of the provision of container 90 and liquid 91 with the formation of protrusions 56 and bases 57 by a material harder than the abrasive grains.

The plurality of protrusions 56 corresponds to the plurality of package products 3. Recess 62 is provided at mount member 54 so as to correspond to each of the plurality of protrusions 56. At the center of each of plurality of recesses 62, a through hole 63 communicating with through hole 63 that extends along the longitudinal direction of protrusion 56 is formed. Each of the plurality of through holes 63 is connected to a suction mechanism (not shown) through a pipe. By the drive of the suction mechanism, a suction force shown by arrow 66 is generated at the plurality of through hole 63, whereby encapsulated body 1 or each of the plurality of package products 3 is adhered to recess 62 by suction.

At groove 55 extending along one direction among the plurality of grooves 55, for example, at groove 55 extending in the Y direction, a protection member 65 formed of an elongated plate member is provided so as to cover an upper surface 64 of base 57.

Each of the plurality of protection members 65 can be inserted and taken out from groove 55. In addition or alternatively, the region of fix-and-support member 58 where abrasive waterjet 2 may contact is formed of a material higher in hardness than the abrasive grains employed for cutting encapsulated body 1. Such a material includes, for example, single crystal diamond, single crystal sapphire, sintered diamond, sintered cubic boron nitride (cBN), or a composite material in which diamond or cBN is dispersed in cemented carbide, or a superhard material.

In the present embodiment, only a portion of fix-and-support member 58, i.e. only a portion of protrusions 56 and bases 57, is formed of a material higher in hardness than the abrasive grains in order to prevent wear caused by contact with abrasive waterjet 2. However, side frame member 59, side member 60, setting table 61 and container 90 (the outer wall member) may also be formed of a material higher in hardness than the abrasive grains. In the case where fix-and-support member 58 is

entirely formed of a material higher in hardness than the abrasive grains, protection member 65 may not be provided in groove 55.

Mount member 54 is disposed between encapsulated body 1 and fix-and-support member 58. The region of mount member 54 where encapsulated body 1 or plurality of package products 3 are placed is formed of a material lower in hardness than the abrasive grains in order to secure encapsulated body 1 and package products 3 reliably by suction. An elastic member such as rubber may be employed for the material of mount member 54. Mount member 54 includes a plurality of through holes 63 in communication with the plurality of through holes 63 of the plurality of protrusions 56. Each of the plurality of through holes 63 of mount member 54 takes a one-to-one correspondence with the plurality of through holes of protrusions 56.

As shown in Fig. 4, mount member 54 is cut at the region corresponding to cutting line 7 substantially at the same time as encapsulated body 1 placed on mount member 54 is cut. When encapsulated body 1 is to be further cut, encapsulated body 1 is cut in a one-stroke manner, as shown in Fig. 5, along cutting line 7.

In the present embodiment, a predetermined portion of mount member 54 is cut. The hardness of this mount member 54 is lower than that of the abrasive grains. Therefore, occurrence of a problem such as encapsulated body 1 or package products 3 falling off or blasted away from fixing table 50, or damage due to collision between package products 3, can be prevented.

According to fixing table 50 of the present embodiment, fix-and-support member 58 is formed of a material higher in hardness than the abrasive grains. Therefore, the wear on fixing table 50 where encapsulated body 1 is fixed can be prevented. Furthermore, mount member 54 is formed of a material lower in hardness than the abrasive grains. Therefore, mount member 54 can be secured reliably to fixing table 50 even in the case where encapsulated body 1 including a cutting line 7 corresponding to a curvilinear section as well as a straight section is to be cut.

The function of mount member 54, fix-and-support member 58, and protection

member 65 will be described hereinafter with reference to Fig. 4.

Encapsulated body 1 is drawn towards mount member 54 by the suction action generated in the direction indicated by arrow 66 via the plurality of through holes 63 and recesses 62. Accordingly, encapsulated body 1 is secured to fixing table 50, more specifically, to mount member 54. At this stage, resin mold 1b is in contact with mount member 54.

When encapsulated body 1 is cut along the Y-axis direction according to the cutting method employing cutting apparatus 100 of the present embodiment, abrasive waterjet 2 is sprayed out at high pressure from nozzle 10 towards groove 55 to collide against the upper surface of protection member 65, but not against upper surface 64 of base 57, as shown in Fig. 4. Accordingly, wear on fixing table 50, specifically on base 57 of fix-and-support member 58, is prevented.

When encapsulated body 1 is cut along the X-axis direction, the same fixing table 50 as that set forth above is used. At this stage, the moving direction of nozzle 10 is altered to the direction along cutting line 7x including a curvilinear section.

The flow of abrasive waterjet 2 following cutting of encapsulated body 1 will be described hereinafter. In the case where encapsulated body 1 is cut along the X-axis direction, abrasive waterjet 2 flows from groove 55 to the opening extending along the X-axis direction of setting table 61 and then to a downstream site of the opening. Therefore, collision of abrasive waterjet 2 with fixing table 50 is absolutely eliminated.

When encapsulated body 1 is cut along the Y direction, abrasive waterjet 2 collides against protection member 65. In other words, abrasive waterjet 2 does not collide against upper surface 64 of base 57.

Therefore, even in the case where the same fixing table 50 is used, encapsulated body 1 is cut without damage of fixing table 50. By virtue of the cutting method employing the cutting apparatus of the present embodiment, wear on at least fix-and-support member 58 of fixing table 50 is prevented.

In the case where a plurality of encapsulated bodies 1 are cut in succession, fix-

and-support member 58 and protection member 65 will be gradually worn away. In this case, fix-and-support member 58 and protection member 65 are to be exchanged at an appropriate time. Thus, encapsulated body 1 can be cut while preventing wear on fixing table 50.

- 5 Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the scope of the present invention being interpreted by the terms of the appended claims.

CLAIMS

1. A cutting apparatus (100) comprising:
a fixing table (50) where a position of a workpiece (1) is fixed, and
5 a nozzle (10) from which an abrasive waterjet (2) containing abrasive grains for cutting said workpiece (1) is sprayed out,
wherein said fixing table (50) comprises
a plurality of protrusions (56), each partitioned by a groove (55) so as to
correspond to a plurality of package products (3) subsequent to cutting of said
10 workpiece (1), and including a through hole (63) to draw in by suction said workpiece (1) or one of said plurality of package products (3),
a plurality of bases (57), each linking protrusions (56) together aligned along at least one direction among said plurality of protrusions (56),
a region of said plurality of protrusions (56) and said plurality of bases (57)
15 against which said abrasive waterjet (2) collides being formed of a material higher in hardness than said abrasive grains.
2. The cutting apparatus (100) according to claim 1, further comprising a
mount member (54) provided between said workpiece (1) or said plurality of package
20 products (3) and said plurality of protrusions (56), and on which said workpiece (1) or said package products (3) are placed,
said mount member (54) including a material lower in hardness than said abrasive grains.
- 25 3. A cutting apparatus (100) comprising:
a fixing table (50) where a position of a workpiece (1) is fixed, and
a nozzle (10) from which an abrasive waterjet (2) containing abrasive grains for cutting said workpiece (1) is sprayed out,

wherein said fixing table (50) comprises
a plurality of protrusions (56), each partitioned by a groove (55) so as to
correspond to a plurality of package products (3) subsequent to cutting of said
workpiece (1), and including a through hole (63) to draw in by suction said workpiece
5 (1) or one of said plurality of package products (3),

a plurality of bases (57), each linking protrusions (56) together aligned along at
least one direction among said plurality of protrusions (56),

said cutting apparatus (100) further comprising a container (90) in which said
fixing table (50) is placed in an interior cavity, and into which liquid (91) is poured into
10 the interior cavity,

said fixing table (50) being immersed in said liquid (91) to avoid direct collision
with said abrasive waterjet (2) in said container (90).

4. The cutting apparatus (100) according to claim 3, further comprising a
15 mount member (54) provided between said workpiece (1) or said plurality of package
products (3) and said plurality of protrusions (56), and on which said workpiece (1) or
said package products (3) are placed,

said mount member (54) including a material lower in hardness than said
abrasive grains.

AMENDED CLAIMS

[received by the International Bureau on June 20, 2007]

CLAIMS

1. (Amended) A cutting apparatus (100) comprising:
a fixing table (50) where a position of a workpiece (1) is fixed, and
5 a nozzle (10) from which an abrasive waterjet (2) containing abrasive grains for cutting said workpiece (1) is sprayed out,
wherein said fixing table (50) comprises
a plurality of protrusions (56), each partitioned by a groove (55) so as to correspond to a plurality of package products (3) subsequent to cutting of said
10 workpiece (1), and including a through hole (63) to draw in by suction said workpiece (1) or one of said plurality of package products (3),
a plurality of bases (57), each linking protrusions (56) together aligned along at least one direction among said plurality of protrusions (56), and
a plurality of protection members (65), each placed in a detachable manner on an
15 upper surface (64) of said plurality of bases (57) so as to traverse said plurality of bases (57) in plan view.
a region of said plurality of protrusions (56) and said plurality of bases (57) against which said abrasive waterjet (2) collides being formed of a material higher in hardness than said abrasive grains.
20
2. The cutting apparatus (100) according to claim 1, further comprising a mount member (54) provided between said workpiece (1) or said plurality of package products (3) and said plurality of protrusions (56), and on which said workpiece (1) or said package products (3) are placed,
25 said mount member (54) including a material lower in hardness than said abrasive grains.
3. (Amended) A cutting apparatus (100) comprising:

AMENDED CLAIMS

[received by the International Bureau on June 20, 2007]

a fixing table (50) where a position of a workpiece (1) is fixed, and
a nozzle (10) from which an abrasive waterjet (2) containing abrasive grains for
cutting said workpiece (1) is sprayed out,

wherein said fixing table (50) comprises

5 a plurality of protrusions (56), each partitioned by a groove (55) so as to
correspond to a plurality of package products (3) subsequent to cutting of said
workpiece (1), and including a through hole (63) to draw in by suction said workpiece
(1) or one of said plurality of package products (3),

10 a plurality of bases (57), each linking protrusions (56) together aligned along at
least one direction among said plurality of protrusions (56),

said cutting apparatus (100) further comprising a container (90) in which said
fixing table (50) is placed in an interior cavity, and into which liquid (91) is poured into
the interior cavity,

15 said fixing table (50) being immersed in said liquid (91) so that said abrasive
waterjet (2) does not achieve direct collision with said plurality of protrusions (56) and
said plurality of bases (57) but achieves direct collision with said workpiece (1) in said
container (90).

20 4. The cutting apparatus (100) according to claim 3, further comprising a
mount member (54) provided between said workpiece (1) or said plurality of package
products (3) and said plurality of protrusions (56), and on which said workpiece (1) or
said package products (3) are placed,

said mount member (54) including a material lower in hardness than said
abrasive grains.