

WATER JET PROCESSING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a water jet processing apparatus for processing a workpiece by jetting pressurized liquid.

Description of the Related Art

In dividing a plate-like workpiece typified by a package substrate formed by sealing device chips disposed on a substrate with a sealing member (mold resin) composed of a resin, and a semiconductor wafer formed with a plurality of devices thereon, a cutting apparatus mounted with a ring-shaped cutting blade is mainly used. The cutting blade is rotated to cut in a workpiece held on a chuck table provided in the cutting apparatus, thereby cutting and dividing the workpiece.

In a case in which the workpiece contains a metal, when the workpiece is cut with the cutting blade, the metal comes in contact with the cutting blade to be elongated, resulting in generation of whisker-like burrs. This burr causes degradation in quality of a chip obtained by division of the workpiece. Accordingly, generation of burrs is required to be suppressed as much

as possible when dividing a workpiece. In order to suppress generation of burrs, a technique of dividing a workpiece by use of a water jet processing apparatus has been proposed. This water jet processing apparatus performs processing such as removing part of a workpiece by jetting water pressurized with a pump toward the workpiece. Japanese Patent Laid-Open No. 2004-130401 and Japanese Patent Laid-Open No. 2012-109327 disclose a technique of dividing a package substrate into a plurality of chips by jetting high-pressure water to the package substrate along each street (division line) formed thereon. Further, a technique of removing burrs generated due to cutting processing with water jet while using a cutting blade for cutting a workpiece has been proposed. Japanese Patent Laid-Open No. 2016-157722 discloses a processing apparatus in which a burr removing nozzle is provided at a position adjacent to a cutting blade and jets high-pressure water toward each cut groove formed by cutting a workpiece with the cutting blade to thereby remove burrs.

SUMMARY OF THE INVENTION

The water jet processing apparatus has a jetting nozzle for jetting high-pressure water toward a workpiece

from a jetting port mounted thereto. A shape and a diameter of the jetting port of this jetting nozzle is set depending on various processing conditions such as a size in processing region, a shape of the processing region, a material of the workpiece, and the like. Accordingly, as the processing condition varies, it is required to replace the jetting nozzle by an appropriate one. Replacement of the jetting nozzle is carried out by an operator who operates the water jet processing apparatus. In a case in which the operator incorrectly selects a jetting nozzle to be mounted and mounts the wrong nozzle to the water jet processing apparatus, processing on the workpiece is performed by the incorrect jetting nozzle, so that the workpiece is not properly processed, thereby causing a defective product. To cope with this problem, it is preferred to check whether or not an appropriate jetting nozzle is mounted to the water jet processing apparatus after carrying out the replacement of the jetting nozzle to thereby prevent processing by the incorrect jetting nozzle. However, the jetting nozzle is mounted inside the water jet processing apparatus in which a large number of components are disposed in a complicated manner. For this reason, once the jetting nozzle is mounted to the water jet processing

apparatus, it is difficult to check the type of jetting nozzle, a diameter of the jetting port thereof, and the like.

The present invention has been made in view of this problem, and it is therefore an object of the present invention to provide a water jet processing apparatus capable of identifying a jetting nozzle which is mounted, even after the jetting nozzle has been mounted to the water jet processing apparatus.

In accordance with an aspect of the present invention, there is provided a water jet processing apparatus including a jetting unit detachably mounted with a jetting nozzle jetting pressurized liquid to a workpiece held on a chuck table for holding the workpiece thereon, a moving unit causing the jetting nozzle to move relatively with respect to the chuck table, and a nozzle determination section determining a diameter or an area of the jetting nozzle, in which the jetting unit has a pump pressurizing the liquid in response to a rotational speed of a motor, and the nozzle determination section includes a motor rotational speed storing section in which rotational speeds of the motor necessary to jet the liquid from a jetting port of the jetting nozzle at a predetermined pressure are stored by diameter or area of

the jetting port of the jetting nozzle, a determination section referring to information stored in the motor rotational speed storing section and then determining, from the rotational speed of the motor at the time of jetting the liquid at a predetermined pressure from the jetting nozzle, the diameter or the area of the jetting port of the jetting nozzle from which the liquid has been jetted, and a notification section providing a determination result of the determination section.

Preferably, the nozzle determination section further includes a nozzle type storing section in which types of a plurality of jetting nozzles are stored by diameter or area of the jetting port of the jetting nozzle. The determination section refers to information stored in the nozzle type storing section to further determine the type of jetting nozzle according to the diameter or the area of the jetting port of the jetting nozzle determined from the rotational speed of the motor, and the notification section provides the type of jetting nozzle determined by the determination section. Also, preferably, the water jet processing apparatus further includes a cutting unit cutting the workpiece held on the chuck table with a cutting blade. Moreover, preferably, the pump is a plunger pump, and the rotational speed of

the motor at the time of jetting the liquid at a predetermined pressure from the jetting nozzle is a rotational speed of the motor specified by a signal input to an inverter connected to the motor, or a rotational speed of the motor detected by an encoder connected to the motor.

The water jet processing apparatus according to one aspect of the present invention includes the nozzle determination section identifying the jetting nozzle mounted to the water jet processing apparatus on the basis of a rotational speed of the motor connected to the pump which pressurizes liquid. Accordingly, it is possible to check whether or not an appropriate jetting nozzle is mounted to the water jet processing apparatus, so that generation of a processing defect caused by processing of the workpiece with an incorrect jetting nozzle can be prevented.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view illustrating a water jet processing apparatus;

FIG. 2A is a perspective view illustrating a frame unit;

FIG. 2B is an enlarged perspective view illustrating a workpiece;

FIG. 3 is a partial cross-sectional side view illustrating a water jet unit;

FIG. 4A is a front elevational view illustrating a jetting nozzle;

FIG. 4B is a front elevational view illustrating another jetting nozzle;

FIG. 5 is a graph indicating a relation between a pressure of liquid jetted from the jetting nozzle and a rotational speed of a motor;

FIG. 6 is a perspective view illustrating an external appearance of the water jet processing apparatus;

FIG. 7 is a partial cross-sectional front view illustrating a manner in which the workpiece is processed by a cutting unit; and

FIG. 8 is a partial cross-sectional front view

illustrating a manner in which the workpiece is processed by the water jet unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment will be described below with reference to the attached drawings. FIG. 1 is a perspective view illustrating a water jet processing apparatus 2 according to the preferred embodiment. The water jet processing apparatus 2 cuts a workpiece with a cutting blade and jets pressurized liquid to the workpiece to process the workpiece. Note that some of a configuration of the water jet processing apparatus 2 are represented by blocks in FIG. 1.

The water jet processing apparatus 2 includes a base 4 supporting each component constituting the water jet processing apparatus 2. The base 4 has an opening 4a formed at a front corner portion thereof, and a cassette support base 6 moving up and down by an elevating mechanism (not illustrated) is provided in the opening 4a. The cassette support base 6 has a cassette 8 mounted on an upper surface thereof, the cassette 8 accommodating a plurality of workpieces. Note that, in FIG. 1, an outline of the cassette 8 only is illustrated for convenience of explanation.

The workpiece is accommodated into the cassette 8 in a state of being supported by an annular frame. FIG. 2A is a perspective view illustrating a frame unit 21 in which a workpiece 11 is supported by an annular frame 19. The workpiece 11 is a package substrate including a plate-like substrate 13 formed into a rectangular shape in a plan view, and a plurality of device chips (not illustrated) disposed on a front surface 13a side of the substrate 13. A resin layer (mold resin) 15 sealing the plurality of device chips is formed on the front surface 13a side of the substrate 13. A description will be given regarding a case in which the workpiece 11 is a package substrate, by way of example. However, the type of workpiece 11 is not limited to this. For example, the workpiece 11 may be a semiconductor wafer having devices such as integrated circuits (ICs) formed on the front surface thereof, for example. A circular adhesive tape 17 has such a diameter capable of covering an entire back surface 13b of the substrate 13 and is attached to the back surface 13b of the substrate 13. The annular frame 19 is attached to an outer periphery of the adhesive tape 17, and the back surface 13b side of the substrate 13 is attached to a center portion of the adhesive tape 17. Accordingly, the frame unit 21 is formed from the

workpiece 11, the adhesive tape 17, and the annular frame 19. In this frame unit 21, the workpiece 11 is supported by the annular frame 19 in a state in which the resin layer 15 is exposed upward. However, the resin layer 15 may be attached to the adhesive tape 17 such that the back surface 13b side of the substrate 13 is exposed upward.

FIG. 2B is an enlarged perspective view illustrating the workpiece 11. The workpiece 11 is divided into a plurality of separate regions along a plurality of streets (division lines) 23 arrayed in a grid pattern so as to cross one another. The workpiece 11 is divided into individual package devices along the streets 23, so that the plurality of package devices each having a device chip therein are obtained. Also, on a front surface 15a side of the resin layer 15, a plurality of recesses (cavities) 15b in an elliptical shape in a plan view are formed along the streets 23. The recess 15b is disposed such that a major axis direction thereof extends along a direction perpendicular to a lengthwise direction of the street 23 and has a depth smaller than a thickness of the resin layer 15.

Inside the resin layer 15, a metal (electrode) is disposed being connected to each device chip covered with

the resin layer 15. When the recess 15b is formed on the front surface 15a side of the resin layer 15, the metal is exposed from an inner wall and a bottom surface of the recess 15b. The exposed metal functions as an electrode for connecting the individual package devices to each terminal formed on a mounting board when the workpiece 11 is divided into the plurality of device packages and each package device is to be mounted to the mounting board.

On a lateral side of the cassette support base 6 illustrated in FIG. 1, a rectangular opening 4b is formed such that a longitudinal direction thereof extends along an X-axis direction (front-back direction or processing feed direction). Inside the opening 4b, a ball screw type X-axis moving mechanism 10, a table cover 12, and a dust-proof and drip-proof cover 14 for covering an upper portion of the ball screw type X-axis moving mechanism 10 are disposed. The ball screw type X-axis moving mechanism 10 includes an X-axis moving table (not illustrated) covered with the table cover 12, causing the X-axis moving table to move in the X-axis direction. At a position close to the lateral side of the cassette support base 6, a temporary setting mechanism 16 for temporarily setting the workpiece 11 is provided. The temporary setting mechanism 16 includes a pair of guide

rails 16a and 16b moving closer to and apart from each other while keeping a state parallel to a Y-axis direction (right and left direction or indexing direction), for example. When the workpiece 11 is transferred from the cassette 8 to the temporary setting mechanism 16, the pair of guide rails 16a and 16b moves closer to each other in the X-axis direction so as to hold the opposite ends of the frame unit 21 in which the workpiece 11 is supported by the annular frame 19, therebetween, thereby aligning the workpiece 11 at a predetermined position.

On an upper surface of the X-axis moving table, a chuck table 18 for holding the workpiece 11 under suction is provided so as to be exposed from the table cover 12. The chuck table 18 is coupled with a rotational driving source (not illustrated) such as a motor and rotates around a rotational axis substantially parallel to a Z-axis direction (vertical direction). Moreover, the chuck table 18 moves in the X-axis direction together with the X-axis moving table and the table cover 12 by the X-axis moving mechanism 10. An upper surface of the chuck table 18 constitutes a holding surface 18a for holding the workpiece 11 under suction thereon. The holding surface 18a is formed substantially in parallel with respect to

the X-axis direction and the Y-axis direction and connected to a suction source (not illustrated) such as an ejector through a suction passage (not illustrated) provided inside the chuck table 18.

Four clamps 20 for fixing the annular frame 19 (see FIG. 2A) which supports the workpiece 11 from four sides are provided on a periphery of the chuck table 18 at respective positions corresponding to the four sides. In addition, in a region adjacent to the opening 4b, a transfer unit (not illustrated) for transferring the workpiece 11 onto the chuck table 18 or the like is disposed.

On an upper side of the chuck table 18, a cutting unit 22 which cuts the workpiece 11 with an annular cutting blade, and a water jet unit 24 which jets pressurized liquid to the workpiece 11 are provided. In addition, on an upper surface of the base 4, a gate type support structure 26 for supporting the cutting unit 22 and the water jet unit 24 is disposed so as to stride across the opening 4b. On a front upper portion of the gate type support structure 26, a moving unit 28a which moves the cutting unit 22 in the Y-axis direction and the Z-axis direction, and a moving unit 28b which moves the water jet unit 24 in the Y-axis direction and the Z-axis

direction are provided.

The moving units 28a and 28b include Y-axis moving plates 32a and 32b, respectively. Each of the Y-axis moving plates 32a and 32b is mounted to a pair of Y-axis guide rails 30 disposed along the Y-axis direction on a front surface of the support structure 26 in a slidable manner. A back surface side (rear surface side) of the Y-axis moving plate 32a has a nut (not illustrated) provided therein, and a Y-axis ball screw 34a provided so as to extend in a direction substantially parallel to the pair of Y-axis guide rails 30 is screwed into the nut. Similarly, a back surface side (rear surface side) of the Y-axis moving plate 32b has a nut (not illustrated) provided therein, and a Y-axis ball screw 34b provided so as to extend in a direction substantially parallel to the pair of Y-axis guide rails 30 is screwed into the nut. Each of the Y-axis ball screws 34a and 34b has a Y-axis pulsed motor 36 coupled to one end thereof. The Y-axis ball screw 34a is rotated by the Y-axis pulsed motor 36 connected thereto, so that the Y-axis moving plate 32a moves in the Y-axis direction along the Y-axis guide rails 30. Similarly, the Y-axis ball screw 34b is rotated by the Y-axis pulsed motor 36 connected thereto, so that the Y-axis moving plate 32b moves in the Y-axis direction

along the Y-axis guide rails 30.

On a front surface side of the Y-axis moving plate 32a, a pair of Z-axis guide rails 38a is provided in the Z-axis direction, and on a front surface side of the Y-axis moving plate 32b, a pair of Z-axis guide rails 38b is provided in the Z-axis direction. Moreover, a Z-axis moving plate 40a is slidably mounted on the pair of Z-axis guide rails 38a, and a Z-axis moving plate 40b is slidably mounted on the pair of Z-axis guide rails 38b. On a back surface (rear) side of the Z-axis moving plate 40a, a nut (not illustrated) is provided, and the nut has a Z-axis ball screw 42a screwed therein, the Z-axis ball screw 42a being provided so as to extend in a direction substantially parallel to the Z-axis guide rails 38a. A Z-axis pulsed motor 44 is coupled to one end of the Z-axis ball screw 42a, and the Z-axis ball screw 42a is rotated by the Z-axis pulsed motor 44, so that the Z-axis moving plate 40a moves in the Z-axis direction along the Z-axis guide rails 38a. On a back surface (rear) side of the Z-axis moving plate 40b, a nut (not illustrated) is provided, and the nut has a Z-axis ball screw 42b screwed therein, the Z-axis ball screw 42b being provided so as to extend in a direction substantially parallel to the Z-axis guide rails 38b. A Z-axis pulsed motor 44 is coupled

to one end of the Z-axis ball screw 42b, and the Z-axis ball screw 42b is rotated by the Z-axis pulsed motor 44, so that the Z-axis moving plate 40b moves in the Z-axis direction along the Z-axis guide rails 38b.

The cutting unit 22 is provided on a lower portion of the Z-axis moving plate 40a. An imaging unit (camera) 46a is provided at a position adjacent to the cutting unit 22, and the imaging unit 46a images the workpiece 11 and the like held under suction on the chuck table 18. Moreover, the water jet unit 24 is provided on a lower portion of the Z-axis moving plate 40b. An imaging unit (camera) 46b is provided at a position adjacent to the water jet unit 24, and the imaging unit 46b images the workpiece 11 and the like held under suction on the chuck table 18. The moving unit 28a controls a position of the cutting unit 22 in each of the Y-axis direction and the Z-axis direction and a position of the imaging unit 46a in each of the Y-axis direction and the Z-axis direction. Similarly, the moving unit 28b controls a position of the water jet unit 24 in each of the Y-axis direction and the Z-axis direction and a position of the imaging unit 46b in each of the Y-axis direction and the Z-axis direction. In other words, the position of the cutting unit 22 and the position of the water jet unit 24 are controlled

independently of each other.

In a region on an opposite side of the opening 4a across the opening 4b, an opening 4c is formed. A cleaning unit 48 for cleaning the workpiece 11 is disposed inside the opening 4c, and the workpiece 11 is cleaned by the cleaning unit 48 after having been subjected to a predetermined processing on the chuck table 18.

An annular cutting blade (not illustrated) mounted on the cutting unit 22 is rotated to cut in the workpiece 11, so that cutting processing of the workpiece 11 can be carried out. More specifically, the cutting unit 22 includes a spindle having an axis in a direction substantially parallel to the holding surface 18a of the chuck table 18, and the annular cutting blade is mounted on a tip portion of the spindle. The cutting blade is formed by an electroformed grindstone to which diamond abrasive grains, for example, are fixed by nickel plating. The spindle is coupled with a rotational driving source such as a motor, and the cutting blade mounted to the spindle is rotated by a force transmitted from the rotational driving source. The cutting blade is thus rotated to cut in the workpiece 11 held on the chuck table 18, and then, the workpiece 11 and the cutting

blade are moved relatively along the X-axis direction (processing feed direction), so that the workpiece 11 is cut. In addition, pressurized liquid is jetted toward the workpiece 11 from the water jet unit 24, thereby achieving processing such as removal of part of the workpiece 11 and removal of metal burrs formed in the workpiece 11. Note that the removal of burrs by use of the water jet unit 24 will be described later.

FIG. 3 is a partial cross-sectional side view illustrating the water jet unit 24. The water jet unit 24 has a detachable jetting nozzle 50 mounted thereto, the jetting nozzle 50 jetting pressurized liquid 52 downward. The jetting nozzle 50 is connected to a pump unit 60 (see FIG. 1) which pressurizes liquid to be supplied, and the pressurized liquid supplied from the pump unit 60 is jetted toward the workpiece 11 from a jetting port 50a of the jetting nozzle 50, so that the workpiece 11 is processed. Moreover, the water jet unit 24 includes a cover 54 covering a lower portion of the jetting nozzle 50. The cover 54 is formed into a hemispherical hollow shape (bowl-like shape) inside and has an opening 54a in a region (top portion) positioned at a center of the cover 54 in a plan view. This opening 54a has the jetting nozzle 50 inserted therein, and the cover 54 is mounted

to the jetting nozzle 50 thus inserted in such a manner that a ring-shaped edge 54b of the cover 54 faces the holding surface 18a of the chuck table 18.

As illustrated in FIG. 3, when the liquid 52 is jetted from the jetting nozzle 50 to process the workpiece 11, the cover 54 is positioned so as to cover the processed region of the workpiece 11. As a result, dispersion of a mist and processing dust generated by the processing are prevented by the cover 54. Note that a shape of the cover 54 can be appropriately modified as long as the dispersion of the mist and the processing dust can be prevented. For example, the cover 54 may be formed in a hollow conical shape inside. In addition, the cover 54 has an opening 54c formed at a position different from the opening 54a, and the opening 54c is connected to one end of a tube 56 provided outside the cover 54. The other end of the tube 56 is connected to a suction source (not illustrated), and a mist and processing dust generated inside the cover 54 due to processing of the workpiece 11 are sucked and removed through the tube 56. Note that a position of the jetting nozzle 50 can be controlled by the moving unit 28b illustrated in FIG. 1. Control of the moving unit 28b causes the jetting nozzle 50 to relatively move with

respective to the chuck table 18.

As illustrated in FIG. 1, the water jet unit 24 is connected to the pump unit 60. The pump unit 60 pressurizes liquid such as water to be supplied to the jetting nozzle 50 of the water jet unit 24. Note that the pump unit 60 is connected to the controller 80, and the controller 80 controls operation of the pump unit 60.

The pump unit 60 includes a pump 62 which pressurizes liquid. The pump 62 is connected with a liquid supplying source 72 including a tank and the like, and liquid such as water supplied from the liquid supplying source 72 is pressurized by the pump 62. Note that the pump 62 is connected with the liquid supplying source 72 through a flow rate control unit 64, and the flow rate control unit 64 controls a flow rate of the liquid supplied from the liquid supplying source 72 to the pump 62. The flow rate control unit 64 is connected to the controller 80, and the controller 80 controls operation of the flow rate control unit 64. More specifically, the controller 80 includes a flow rate control section 82 connected to the flow rate control unit 64. The flow rate control section 82 controls operation of the flow rate control unit 64 in such a way that liquid is supplied at a predetermined flow rate from

the liquid supplying source 72 to the pump 62. Moreover, the flow rate control unit 64 can control whether or not liquid is supplied from the liquid supplying source 72 to the pump 62.

In addition, the pump 62 is connected to a motor 66 and controls pressure of liquid supplied from the flow rate control unit 64 in response to a rotational speed of the motor 66. In this manner, an example of the pump 62 which pressurizes liquid supplied from the flow rate control unit 64 in response to a rotational speed of the motor 66 may include a plunger pump. In addition, an inverter 68 is connected to the motor 66 and controls the rotational speed of the motor 66 in accordance with a signal input from the controller 80. More specifically, the controller 80 includes a pressurization control section 84 connected to the inverter 68, and the pressurization control section 84 outputs a signal specifying a rotational speed (frequency) of the motor 66 to the inverter 68. When this signal is input to the inverter 68, the inverter 68 rotates the motor 66 at a rotational speed (command frequency) specified by the pressurization control section 84. Then, in response to the rotational speed of the motor 66 controlled by the inverter 68, the pump 62 pressurizes the liquid supplied

from the flow rate control unit 64 to a predetermined pressure. As a result, the liquid with the predetermined pressure is supplied to the jetting nozzle 50 (see FIG. 3) of the water jet unit 24, and accordingly, the liquid 52 is jetted from the jetting port 50a toward the workpiece 11. Further, the motor 66 has an encoder 70 connected thereto, the encoder 70 detecting the rotational speed of the motor 66. The rotational speed of the motor 66 detected by the encoder 70 is output to the controller 80.

When the pressurized liquid 52 is jetted from the water jet unit 24 to the workpiece 11, liquid is first supplied at a predetermined flow rate from the liquid supplying source 72 through the flow rate control unit 64 to the pump 62, while at the same time, the rotational speed of the motor 66 is controlled by the inverter 68. Then, the pump 62 pressurizes the supplied liquid to a pressure corresponding to the rotational speed of the motor 66. Note that the rotational speed of the motor 66 is detected by the encoder 70 to be output to the controller 80. Then, the liquid which has been pressurized to the predetermined pressure by the pump 62 is supplied to the water jet unit 24. In this manner, the water jet unit 24 and the pump unit 60 constitutes a unit

(jetting unit) which pressurizes the liquid supplied from the liquid supplying source 72 and jets the pressurized liquid to the workpiece 11 held on the chuck table 18.

Note that the components such as the elevating mechanism which moves up and down the cassette support base 6 in the vertical direction, the X-axis moving mechanism 10, the chuck table 18, the transfer unit (not illustrated), the cutting unit 22, the moving units 28a and 28b, the imaging units 46a and 46b, and the cleaning unit 48 are also connected to the controller 80, and operations of the respective components are controlled by the controller 80.

When the workpiece 11 is processed by the water jet unit 24, a shape and a diameter of the jetting port 50a of the jetting nozzle 50 may be required to be changed depending on processing conditions (a size of a processing region, a shape of the processing condition, a material of the workpiece 11, and the like), in some cases. In this case, an operator replaces the jetting nozzle 50. However, in a case in which the operator incorrectly selects a jetting nozzle 50 to be mounted and mounts the wrong nozzle 50 to the water jet unit 24, the workpiece 11 is processed by the improper jetting nozzle 50, causing a processing defect to be generated. The

water jet processing apparatus 2 according to the present embodiment includes the nozzle determination section 90 which discriminates a type of jetting nozzle 50 mounted to the water jet unit 24. After the jetting nozzle 50 is replaced, the nozzle determination section 90 checks the type of jetting nozzle 50 mounted to the water jet unit 24, so that generation of a processing defect caused by processing of the workpiece 11 with an incorrect jetting nozzle 50 can be prevented.

The type of jetting nozzle 50 can be distinguished by diameter or area of the jetting port 50a of the jetting nozzle 50, for example. FIG. 4A is a front elevational view illustrating a jetting nozzle 100 which is an example of the jetting nozzle 50. FIG. 4B is a front elevational view illustrating a jetting nozzle 102 which is another example of the jetting nozzle 50. The jetting nozzle 100 and the jetting nozzle 102 are different in diameter of the jetting port from each other. The jetting nozzle 100 includes a circular jetting port 100a from which liquid is jetted, and the jetting port 100a is connected to the pump unit 60 (see FIG. 1) through a flow passage 100b formed inside the jetting nozzle 100. Similarly, the jetting nozzle 102 includes a circular jetting port 102a from which liquid is jetted,

and the jetting port 102a is connected to the pump unit 60 (see FIG. 1) through a flow passage 102b formed inside the jetting nozzle 102. A diameter of the jetting port 102a of the jetting nozzle 102 is larger than a diameter of the jetting port 100a of the jetting nozzle 100. More specifically, the jetting port 100a is formed into a circular shape having a diameter $\phi 1 = 0.25$ mm. The jetting port 102a is formed into a circular shape having a diameter $\phi 2 = 0.30$ mm.

A pressure of the liquid jetted from the jetting nozzle is decided by how much the liquid is pressurized by the pump 62 provided in the pump unit 60, and pressurization by the pump 62 is controlled by the rotational speed of the motor 66. In other words, in order to jet the liquid having a predetermined pressure from the jetting nozzle, it is required to rotate the motor 66 at a predetermined rotational speed corresponding to the predetermined pressure. However, a relation between the pressure of the liquid jetted from the jetting nozzle and the rotational speed of the motor 66 is different according to the type of jetting nozzle. FIG. 5 is a graph indicating a relation between the pressure of the liquid jetted from the jetting nozzle and the rotational speed (frequency) of the motor 66 in each

case of using the jetting nozzle 100 provided with the jetting port 100a having a diameter $\phi 1 = 0.25$ mm and the jetting nozzle 102 provided with the jetting port 102a having a diameter $\phi 2 = 0.30$ mm. FIG. 5 indicates the rotational speed of the motor 66 necessary to jet the liquid from the jetting nozzle at a predetermined pressure (in the range of 0 to 70 MPa). As indicated in FIG. 5, the relation between the pressure of the liquid jetted from the jetting nozzle and the rotational speed of the motor 66 is different according to the diameter of the jetting port of the jetting nozzle. Accordingly, the relation between the pressure of the liquid jetted from the jetting nozzle and the rotational speed of the motor 66 is recorded in advance for each diameter of the jetting ports 100a and 102a. Thereafter, when the jetting nozzle is replaced, the liquid is jetted from the replaced jetting nozzle at a predetermined pressure. By detecting the rotational speed of the motor 66 at this time, the diameter of the jetting nozzle can be identified according to the rotational speed thus detected, and the type of jetting nozzle which is mounted can be determined. As a modification, the type of jetting nozzle may be determined by a parameter other than the diameter of the jetting nozzle. For example, the relation

between the pressure of the liquid jetted from the jetting nozzle and the rotational speed of the motor 66 for each area of the jetting ports 100a and 102a is recorded in advance, the area of the jetting port of the jetting nozzle is identified to thereby determine the type of jetting nozzle as well.

The controller 80 illustrated in FIG. 1 includes the nozzle determination section 90 which determines the type of jetting nozzle 50 mounted to the water jet unit 24. The nozzle determination section 90 identifies the diameter or the area of the jetting port 50a on the basis of the rotational speed of the motor 66 detected when the liquid is jetted at a predetermined pressure from the jetting port 50a of the jetting nozzle 50 mounted to the water jet unit 24 to determine the type of jetting nozzle 50. More specifically, the nozzle determination section 90 includes a motor rotational speed storing section 92 and a nozzle type storing section 94. The motor rotational speed storing section 92 stores the relation between the pressure of the liquid jetted from the jetting nozzle and the rotational speed of the motor 66. The nozzle type storing section 94 stores types of jetting nozzles.

The motor rotational speed storing section 92

stores the rotational speeds of the motor 66 necessary to jet the liquid at a predetermined pressure from the jetting nozzle by diameter or area of the jetting port of the jetting nozzle. In other words, the relation between the pressure of the liquid and the rotational speed of the motor 66 indicated in FIG. 5 is stored in the motor rotational speed storing section 92. Data stored in the motor rotational speed storing section 92 is acquired by carrying out, in advance, an experiment in which liquid is jetted from each of a plurality of jetting nozzles different in diameter or area of the jetting port from one another and a pressure of the liquid and a rotational speed of the motor 66 detected at this time are recorded, for example. The nozzle type storing section 94 stores diameters or areas of the jetting ports of the plurality of jetting nozzles and types of jetting nozzles having the respective diameters or areas. As the type of jetting nozzle, a name, an identification symbol, a classification symbol, or the like of the jetting nozzle can be used, for example. In FIG. 1, the motor rotational speed storing section 92 and the nozzle type storing section 94 are provided independently; however, they may be included in a single storing section.

In addition, the nozzle determination section 90

includes a determination section 96 which determines a diameter or an area of the jetting port 50a of the jetting nozzle 50 mounted to the water jet unit 24 and the type of the jetting nozzle 50 with reference to the information stored in the motor rotational speed storing section 92 and the nozzle type storing section 94. To the determination section 96, a rotational speed (input rotational speed) of the motor 66 when the liquid is jetted at a predetermined pressure (specified pressure) from the jetting nozzle 50 mounted to the water jet unit 24 is input. This input rotational speed is input from the pressurization control section 84 to the determination section 96, for example. Note that the input rotational speed is identical to a rotational speed (command frequency) of the motor 66 specified by a signal output from the pressurization control section 84 to the inverter 68.

Note that, whether or not the liquid is jetted at a predetermined pressure (specified pressure) from the jetting nozzle 50 can be checked, for example, by measuring the pressure of the liquid pressurized by the pump 62 with a pressure measuring device. This pressure measuring device is, for example, installed in a flow passage of the liquid leading from the pump 62 to the

jetting port 50a of the jetting nozzle 50. Then, the determination section 96 discriminates the diameter or the area of the jetting nozzle 50 with reference to the information stored in the motor rotational speed storing section 92 on the basis of the input rotational speed. For example, there is considered a case in which the relation between the pressure and the rotational speed of the motor indicated in FIG. 5 is stored in the motor rotational speed storing section 92. When the type of the jetting nozzle 50 mounted to the water jet unit 24 is discriminated, the determination section 96 refers to the information stored in the motor rotational speed storing section 92 to identify which one of the two types of jetting nozzles indicated in FIG. 5 the jetting nozzle 50 mounted to the water jet unit 24 is, on the basis of the input rotational speed input from the pressurization control section 84. More specifically, regarding each of the two types of jetting nozzles indicated in FIG. 5, the rotational speed (reference rotational speed) of the motor necessary to jet the liquid supplied at a certain flow rate from the liquid supplying source 72 at a specified pressure is referred to. Then, by determining whether or not the reference rotational speed of each of the two types of jetting nozzles matches with the input

rotational speed (or whether or not a difference between the reference rotational speed of each of the two types of jetting nozzles and the input rotational speed is a certain value or lower), it is identified to which one of the two types of jetting nozzles the jetting nozzle 50 mounted to the water jet unit 24 belongs. As a result, the diameter of the jetting port 50a of the jetting nozzle 50 is determined by the determination section 96 (first determination step).

In addition, to the determination section 96, the rotational speed of the motor 66 detected by the encoder 70 connected to the motor 66 is input. The determination section 96 may determine the diameter or the area of the jetting port 50a by use of the rotational speed of the motor 66 detected by the encoder 70 in place of the rotational speed of the motor 66 output from the pressurization control section 84. In this case, the diameter or the area of the jetting port 50a is identified on the basis of an actual rotational speed of the motor 66, and input of the rotational speed of the motor 66 from the pressurization control section 84 to the determination section 96 can be omitted.

Next, the determination section 96 refers to the information stored in the nozzle type storing section 94

to determine the type of the jetting nozzle 50 from the diameter or the area of the jetting port 50a which has been determined in the first determination step (second determination step). For example, the nozzle type storing section 94 stores the diameters or the areas of the jetting ports of the plurality of jetting nozzles in association with the identification symbols corresponding thereto. In this case, the determination section 96 compares the diameter or the area of the jetting port 50a which has been determined in the first determination step described above with the diameters or the areas of the jetting ports of the plurality of jetting nozzles which are stored in the nozzle type storing section 94. Then, among the plurality of jetting nozzles stored in the nozzle type storing section 94, the determination section 96 identifies the jetting nozzle which matches with the diameter or the area of the jetting port 50a which has been determined in the first determination step (or the jetting nozzle which is different in diameter or area at a certain value or lower) to further identify the type (identification symbol) of the corresponding jetting nozzle. Accordingly, the type of jetting nozzle 50 mounted to the water jet unit 24 is determined. The type of jetting nozzle 50 determined by the determination

section 96 is output from the determination section 96 to a notification section 98, and the notification section 98 notifies an operator of the type of jetting nozzle 50. The notification section 98 includes a monitor provided in the water jet processing apparatus 2, for example.

FIG. 6 is a perspective view illustrating an external appearance of the water jet processing apparatus 2. As illustrated in FIG. 6, some components of the water jet processing apparatus 2 are covered with a cover 110, and a monitor 112 of touch panel type serving as a user interface is provided on a side surface side of the cover 110. Operation of the monitor 112 is controlled by the controller 80 (see FIG. 1). The type of jetting nozzle 50 which has been determined by the determination section 96 is displayed on the monitor 112. Accordingly, an operator can check the type of jetting nozzle 50 mounted to the water jet unit 24. In the foregoing description, a case in which the type of jetting nozzle 50 is displayed on the notification section 90 has been described. As a modification, the diameter or the area of the jetting port 50a of the jetting nozzle 50 may be displayed on the notification section 98. In this case, the determination section 96 outputs the information on the diameter or the area of the jetting port 50a to the notification section

98 after executing the first determination section, and then, the notification section 98 displays the diameter or the area of the jetting port 50a thereon. In a case in which the diameter or the area of the jetting port 50a is displayed on the notification section 98 in this manner, the nozzle type storing section 94 and the second determination step can be omitted. Alternatively, equipment other than the monitor 112 may be used as the notification section 98. For example, an indicating lamp 114 provided on an upper surface side of the cover 110 may notify an operator of the type of jetting nozzle 50. In this case, the type of jetting nozzle 50 is expressed by a lighting color or a lighting pattern of the indicating lamp 114. Operation of the indicating lamp 114 is controlled by the controller 80 (see FIG. 1).

As described above, the water jet processing apparatus 2 according to the present embodiment includes the nozzle determination section 90 identifying the jetting nozzle 50 mounted to the water jet unit 24 on the basis of the rotational speed of the motor 66 connected to the pump 62 which pressurizes the liquid. Accordingly, it is possible to check whether an appropriate jetting nozzle 50 is mounted to the water jet unit 24, and generation of a processing defect caused by processing of

the workpiece 11 with an incorrect jetting nozzle 50 can be prevented.

The water jet unit 24 provided in the water jet processing apparatus 2 described above may process the workpiece 11 solely or along with the cutting unit 22. In the following description, given is an example in which the workpiece 11 illustrated in FIG. 2B is processed using both the cutting unit 22 and the water jet unit 24. FIG. 7 is a partial cross-sectional front view illustrating a manner in which the workpiece 11 is processed by the cutting unit 22. The upper surface of the chuck table 18 constitutes the holding surface 18a for holding the workpiece 11 under suction thereon, and the holding surface 18a is connected to the suction source (not illustrated) through a suction passage (not illustrated) provided inside the chuck table 18. The cutting unit 22 for cutting the workpiece 11 is disposed above the chuck table 18. The cutting unit 22 includes a spindle 120 having an axis in a direction substantially parallel to the holding surface 18a, and an annular cutting blade 122 is mounted to a tip portion of the spindle 120. In addition, the spindle 120 is coupled with a rotational driving source (not illustrated) such as a motor, and the annular cutting blade 122 mounted to the

spindle 120 is rotated by a force transmitted from the rotational driving source.

In processing the workpiece 11, the workpiece 11 is first disposed on the holding surface 18a of the chuck table 18 through the adhesive tape 17, and the annular frame 19 which is attached to the outer periphery of the adhesive tape 17 to support the workpiece 11 therethrough is fixed with the clamps 20. A negative pressure generated from the suction source is applied to the holding surface 18a in this state, thereby holding the workpiece 11 under suction on the chuck table 18 through the adhesive tape 17. Next, the spindle 120 is rotated to cause the cutting blade 122 to cut into the front surface 15a side of the resin layer 15. Then, the chuck table 18 is moved in a direction (processing feed direction) substantially parallel to the holding surface 18a and substantially perpendicular to the axis of the spindle 120, whereby the workpiece 11 and the cutting blade 122 are relatively moved along the streets 23 (see FIG. 2B). As a result, the workpiece 11 has a linear cutting groove 11a formed therein along each of the streets 23. Note that the plurality of recesses 15b are formed on the front surface 15a side of the resin layer 15 along the streets 23 and the metal connected to each device chip

(not illustrated) covered with the resin layer 15 is exposed inside each of the recesses 15b. In addition, the cutting blade 122 is positioned in such a way that a lower end of the cutting blade 122 is disposed lower than the bottom surface of the recess 15b and higher than the back surface 13b of the substrate 13. Accordingly, a depth of the cutting groove 11a is greater than a depth of the recess 15b and smaller than a thickness of the workpiece 11, so that the workpiece 11 is in a state of not being fully cut.

In this manner, as the workpiece 11 is cut along each of the streets 23, the metal exposed inside the recess 15b comes in contact with the cutting blade 122 to be elongated, whereby whisker-like burrs made of the elongated metal may be formed on a surface (cut surface) generated as a result of cutting the workpiece 11. When the burrs thus formed remain inside the recesses 15b, they may hinder connection between the metal exposed inside the recess 15b and another metal (connecting terminal of the mounting board, for example) in a subsequent step. Accordingly, it is preferred to remove the burrs. In view of this, after the workpiece 11 is cut with the cutting blade 122, the water jet unit 24 removes the burrs remaining inside each of the cutting grooves

11a.

FIG. 8 is a partial cross-sectional front view illustrating a manner in which the workpiece 11 is processed by the water jet unit 24. After the cutting grooves 11a are formed in the workpiece 11, as illustrated in FIG. 8, the jetting nozzle 50 included in the water jet unit 24 is positioned such that the jetting port 50a is disposed above one of the cutting grooves 11a. Then, the pump unit 60 (see FIG. 1) supplies the pressurized liquid to the water jet unit 24, so that the pressurized liquid 52 is jetted at a predetermined pressure from the jetting port 50a toward the cutting groove 11a. Accordingly, the burrs remaining inside the recess 15b is blown off by the liquid 52 thus jetted and then removed. Note that removal of the burrs by the water jet unit 24 is conducted in a state in which the workpiece 11 is not fully cut. Accordingly, it is possible to prevent a part of the workpiece 11 from falling off from the adhesive tape 17 due to the jetting of the pressurized liquid 52.

Movement of the water jet unit 24 is controlled independently of the cutting unit 22 by the moving unit 28b (see FIG. 1). Accordingly, the position at which the pressurized liquid 52 is jetted can be set freely. For

example, after one cutting groove 11a is formed by the cutting blade 122, the water jet unit 24 is moved relatively along the cutting groove 11a, and the liquid 52 is jetted to the cutting groove 11a, so that the burrs inside the cutting groove 11a can be removed. Note that a timing at which the burrs are removed is not limited to the above case. For example, after the cutting grooves 11a are formed along all the streets 23, the burrs inside the cutting grooves 11a may be removed all at once. Alternatively, while one cutting groove 11a is cut by the cutting unit 22, the burrs may be simultaneously removed by relatively moving the water jet unit 24 along another cutting groove 11a which has already been formed. In this case, cutting of the workpiece 11 and removal of the burrs can be conducted at the same time.

After the burrs have been removed by the water jet unit 24, the workpiece 11 is further cut along the streets 23 by the cutting unit 22. At this time, the cutting blade 122 is positioned in such a way that the lower end thereof is disposed lower than the back surface 13b of the substrate 13. Accordingly, the workpiece 11 is divided along the street 23. This cutting step is carried out along all of the streets 23, so that the workpiece 11 is divided into the plurality of package devices. Note

that, when the burrs are removed by the water jet unit 24, an appropriate jetting nozzle 50 is selected according to a material and a thickness of the workpiece 11, and a shape, a depth, and the like of the cutting groove 11a, to be mounted to the water jet unit 24. At this time, the nozzle determination section 90 illustrated in FIG. 1 checks whether an appropriate jetting nozzle 50 is mounted, whereby removal of the burrs can be properly conducted.

A structure, a method, or the like according to the embodiment described above can be implemented with appropriate changes without departing from the scope of the object of the present invention.

The present invention is not limited to the details of the above described preferred embodiment. The scope of the invention is defined by the appended claims and all changes and modifications as fall within the equivalence of the scope of the claims are therefore to be embraced by the invention.

WHAT IS CLAIMED IS:

1. A water jet processing apparatus comprising:
a jetting unit detachably mounted with a jetting nozzle jetting pressurized liquid to a workpiece held on a chuck table for holding the workpiece thereon;

a moving unit causing the jetting nozzle to move relatively with respect to the chuck table; and

a nozzle determination section determining a diameter or an area of the jetting nozzle,

wherein the jetting unit has a pump pressurizing the liquid in response to a rotational speed of a motor, and

the nozzle determination section includes

a motor rotational speed storing section in which rotational speeds of the motor necessary to jet the liquid from a jetting port of the jetting nozzle at a predetermined pressure are stored by diameter or area of the jetting port of the jetting nozzle,

a nozzle type storing section in which the type of the jetting nozzle is stored for each diameter or area of the jetting port of the jetting nozzle,

a determination section referring to information stored in the motor rotational speed storing section and then determining, from the rotational speed of the motor

at the time of jetting the liquid at a predetermined pressure from the jetting nozzle, the diameter or the area of the jetting port of the jetting nozzle from which the liquid has been jetted, and after that, referring to information stored in the nozzle type storing section and then further determining the type of the nozzle from the diameter or area of the jetting port of the jetting nozzle which is determined from the rotational speed of the motor, and

a notification section notifying a type of jetting nozzle determined by the determination section.

2. The water jet processing apparatus according to claim 1, further comprising:

a cutting unit cutting the workpiece held on the chuck table with a cutting blade.

3. The water jet processing apparatus according to claim 1 and 2,

wherein the pump is a plunger pump, and

the rotational speed of the motor at the time of jetting the liquid at a predetermined pressure from the jetting nozzle is a rotational speed of the motor specified by a signal input to an inverter connected to the motor, or a rotational speed of the motor detected by an encoder connected to the motor.