

CUTTING BLADE STATE DETECTING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a cutting blade state detecting method for detecting a state of a cutting blade mounted to a cutting apparatus.

Description of the Related Art

A cutting blade to be used in a cutting apparatus may undergo generation of chipping or a through-hole in a tool edge or on a radial-directionally inner side as compared to the tool edge, due to a load during processing or collision of a scattered chip. When processing of a workpiece is conducted in such a state of the tip edge, chipping or cracking at a level more than expected would be generated; in view of this, a blade damage detector has been developed, and the cutting blade is constantly monitored (see, for example, Japanese Patent Laid-open No. 2001-298001). The blade damage detector described in Japanese Patent Laid-open No. 2001-298001 generally detects chipping in the tool edge of the cutting edge.

SUMMARY OF THE INVENTION

The cutting blade may undergo formation of a through-hole on a radial-directionally inner side as compared to the tool edge of the cutting edge due to collision of a chip. The through-hole thus generated also causes chipping or cracking. However, the blade damage detector described in Japanese Patent Laid-open No. 2001-298001 examines only chipping in the tool edge of the cutting edge, so that a through-hole may be overlooked.

Accordingly, it is an object of the present invention to provide a cutting blade state detecting method which makes it possible to detect a through hole formed in a cutting edge, in addition to chipping.

In accordance with an aspect of the present invention, there is provided a cutting blade state detecting method for detecting a state of a cutting edge of a cutting blade, in a cutting apparatus including a chuck table that holds a workpiece, a cutting unit in which the cutting blade having a cutting edge at a periphery thereof is mounted to a spindle and which cuts the workpiece held on the chuck table with the cutting blade, a tool edge examination unit including an entering section where the cutting edge of the cutting blade enters and a light emitting section and a light receiving section disposed opposite to each other with the entering

section therebetween, and a moving unit that relatively moves the tool edge examination unit and the cutting unit in a radial direction of the cutting blade. The tool edge examination unit further includes a photoelectric conversion section that converts an amount of pulsed light received by the light receiving section into voltage, and a voltage recording section that records the voltage converted by the photoelectric conversion section on a pulse basis. The cutting blade state detecting method includes a voltage recording step in which the moving unit is moved while rotating the cutting blade, and variation in the voltage during when the light receiving section is moved from a position where the cutting edge does not shield the pulsed light to be received by the light receiving section to a position where the cutting edge enters the entering section by a predetermined amount is recorded, and a determining step of determining a state of the cutting edge from the variation in the voltage recorded in the voltage recording step. In the determining step, it is determined that chipping is absent in the cutting edge in a case where an increase in the voltage of equal to or more than a predetermined value is absent, it is determined that chipping has been generated at a tip end

of the cutting edge in a case where a periodical and temporary increase in the voltage is generated from immediately after the shielding of the pulsed light by the cutting edge is started, and it is determined that a through-hole has been formed on a radial-directionally inner side as compared to an outer peripheral edge of the cutting edge in a case where a periodical and temporary increase in the voltage is generated after a state in which generation of a periodical and temporary increase in the voltage is absent has continued from immediately after the shielding of the pulsed light by the cutting edge is started.

Preferably, the moving unit includes a cutting-in feeding unit that moves the cutting unit or a light emitting section-light receiving section moving unit that moves together the light emitting section and the light receiving section.

The present invention produces an effect that it is possible to detect a through-hole formed in a cutting edge, in addition to chipping.

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 some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a configuration example of a cutting apparatus for carrying out a cutting blade state detecting method according to a first embodiment;

FIG. 2 is a perspective view depicting a major part of a cutting unit of the cutting apparatus illustrated in FIG. 1 and a unit main body of a tool edge examination unit;

FIG. 3 is a diagram schematically depicting a configuration of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1;

FIG. 4 is a side view schematically depicting pulsed light emitted by a light emitting section of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1 and a cutting blade;

FIG. 5 is a diagram depicting a value of a voltage converted by a photoelectric conversion section from an amount of pulsed light of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1;

FIG. 6 is a schematic diagram for explaining a position of detecting a state of a tool edge of a cutting edge of the cutting blade of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1;

FIG. 7 is a diagram schematically depicting a configuration of a second tool edge examination unit of the cutting apparatus illustrated in FIG. 1;

FIG. 8 is a flow chart depicting a flow of the cutting blade state detecting method according to the first embodiment;

FIG. 9 is a diagram depicting an example of variation in voltage value at the time of determining that chipping is generated in the cutting edge, in a determining step of the cutting blade state detecting method illustrated in FIG. 8;

FIG. 10 is a diagram depicting an example of variation in voltage value at the time of determining that a through-hole is generated in the cutting edge, in the determining step of the cutting blade state detecting method illustrated in FIG. 8; and

FIG. 11 is a diagram schematically depicting a configuration of a second tool edge examination unit of a cutting apparatus for carrying out a cutting blade state detecting method according to a second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described in detail below referring to the drawings. The present invention is not to be limited by the contents described in the following embodiments. In addition, the components described below include those which can be easily conceived of by a person skilled in the art and those which are substantially the same. Further, the configurations described below can be combined as required. Besides, various kinds of omission, replacement or modification of the configuration can be made in such ranges as not to depart from the gist of the present invention.

<First Embodiment>

A cutting blade state detecting method according to a first embodiment of the present invention will be described based on the drawings. The cutting blade state detecting method according to the first embodiment is carried out in a cutting apparatus 1 illustrated in FIG. 1. First, a configuration of the cutting apparatus 1 will be described. FIG. 1 is a perspective view depicting a configuration example of the cutting apparatus for carrying out the cutting blade state detecting method

according to the first embodiment. FIG. 2 is a perspective view depicting a major part of a cutting unit of the cutting apparatus illustrated in FIG. 1 and a unit main body of a tool edge examination unit.

In the first embodiment, a workpiece 200 as an object to be processed by the cutting apparatus 1 illustrated in FIG. 1 is a wafer such as a disk-shaped semiconductor wafer or optical device wafer using silicon, gallium arsenide, silicon carbide (SiC), sapphire, or the like as a base material. The workpiece 200 is formed with devices 203 in regions partitioned in a grid pattern by a plurality of division lines 202 formed in a grid pattern in a front surface 201 thereof.

In addition, the workpiece 200 of the present invention may be a so-called TAIKO (registered trademark) wafer which is thinned in a central portion and is formed with a thicker part at a peripheral portion, or may be, other than a wafer, a resin package substrate such as a rectangular quad flat no leaded (QFN) package substrate having a plurality of devices sealed with a resin, a ceramic substrate, a ferrite substrate, a substrate including at least one of nickel and iron, a glass substrate, or the like. In the first embodiment, the workpiece 200 is supported by an annular frame 205, with

its back surface 204 adhered to an adhesive tape 206 having the annular frame 205 mounted to a peripheral edge of the adhesive tape 206.

(Cutting Apparatus)

The cutting apparatus 1 illustrated in FIG. 1 is a processing apparatus for holding the workpiece 200 by a chuck table 10 and cutting the workpiece 200 along division lines 202 by a cutting blade 21. As depicted in FIG. 1, the cutting apparatus 1 includes the chuck table 10 that suction holds the workpiece 200 by a holding surface 11, a cutting unit 20 that cuts the workpiece 200 held on the chuck table 10 by the cutting blade 21, an imaging unit 30 that images the workpiece 200 held on the chuck table 10, and a tool edge examination unit 40.

In addition, as illustrated in FIG. 1, the cutting apparatus 1 includes a moving unit 50 that relatively moves the chuck table 10 and the cutting unit 20. The moving unit 50 includes at least an X-axis moving unit 51 as a processing feeding unit that puts the chuck table 10 into processing feeding in an X-axis direction parallel to a horizontal direction, a Y-axis moving unit 52 as an indexing feeding unit that puts the cutting unit 20 into indexing feeding in a Y-axis direction parallel to a horizontal direction and orthogonal to the X-axis

direction, a Z-axis moving unit 53 as a cutting-in feeding unit that puts the cutting unit 20 into cutting-in feeding in a Z-axis direction orthogonal to both the X-axis direction and the Y-axis direction and parallel to the vertical direction, and a rotational moving unit 54 that rotates the chuck table 10 around an axis parallel to the Z-axis direction.

The X-axis moving unit 51 moves the moving plate 12 supporting the chuck table 10 and the rotational moving unit 54 in the X-axis direction which is the processing feeding direction, thereby to put the chuck table 10 and the cutting unit 20 into relative processing feeding in the X-axis direction. The Y-axis moving unit 52 moves the cutting unit 20 in the Y-axis direction which is the indexing feeding direction, thereby to put the chuck table 10 and the cutting unit 20 into relative indexing feeding in the Y-axis direction. The Z-axis moving unit 53 moves the cutting unit 20 in the Z-axis direction which is the cutting-in direction, thereby to put the chuck table 10 and the cutting unit 20 into relative cutting-in feeding in the Z-axis direction. The rotational moving unit 54 is disposed on the moving plate 12. Note that the Z-axis direction corresponds to a radial direction of the cutting blade 21.

The X-axis moving unit 51, the Y-axis moving unit 52, and the Z-axis moving unit 53 include a known ball screw provided to be rotatable around an axis, a known motor that rotates the ball screw around the axis, and known guide rails that support the chuck table 10 or the cutting unit 20 movably in the X-axis direction, the Y-axis direction, or the Z-axis direction. In addition, the Z-axis moving unit 53 is for moving the cutting unit 20 in the Z-axis direction, and is a moving unit as described in the claim for relatively moving a light emitting section 45 and a light receiving section 46 of the tool edge examination unit 40 and the cutting unit 20 in the Z-axis direction.

The chuck table 10 is disc-shaped, and its holding surface 11 for holding the workpiece 200 is formed from a porous ceramic or the like. In addition, the chuck table 10 is provided to be movable in the X-axis direction, with the moving plate 12 provided to be movable, by the X-axis moving unit 51, between a processing region under the cutting unit 20 and a carrying-in/out region which is spaced from the lower side of the cutting unit 20 and at which the workpiece 200 is carried in and out. The chuck table 10 is provided to be rotatable around an axis parallel to the Z-axis direction by the rotational moving

unit 54. The chuck table 10 is connected to a vacuum suction source (not illustrated), and by being sucked by the vacuum suction source, suction holds the workpiece 200 mounted on the holding surface 11. In the first embodiment, the chuck table 10 suction holds the back surface 204 side of the workpiece 200 through the adhesive tape 206. In addition, as depicted in FIG. 1, a plurality of clamp sections 13 for clamping the annular frame 205 are provided in the periphery of the chuck table 10.

The cutting unit 20 is cutting means in which the cutting blade 21 is mounted to a spindle 23 and which is for cutting the workpiece 200 held by the chuck table 10. As illustrated in FIG. 1, the cutting apparatus 1 is a so-called facing dual type cutting apparatus which includes two cutting units 20, namely, which is a two-spindle dicing saw.

The cutting units 20 are each provided to be movable in the Y-axis direction by the Y-axis moving unit 52 relatively to the workpiece 200 held by the chuck table 10, and are each provided to be movable in the Z-axis direction by the Z-axis moving unit 53. As depicted in FIG. 1, the cutting units 20 are each provided on a support frame 3 erected from an apparatus main body 2,

through the Y-axis moving unit 52 and the Z-axis moving unit 53 and the like. The cutting units 20 are configured such that the cutting blade 21 can be positioned at a freely selected position on the holding surface 11 of the chuck table 10 by the Y-axis moving unit 52 and the Z-axis moving unit 53.

As illustrated in FIG. 2, the cutting unit 20 includes the cutting blade 21, a spindle housing 22 provided to be movable in the Y-axis direction and the Z-axis direction by the Y-axis moving unit 52 and the Z-axis moving unit 53, the spindle 23 which is provided in the spindle housing 22 to be rotatable around an axis, which is rotated by a motor (not illustrated) and which has the cutting blade 21 mounted to a tip end thereof, and a blade cover 24 fixed to a tip end surface of the spindle housing 22.

The cutting blade 21 is a substantially ring-shaped extremely thin grindstone. In the first embodiment, as depicted in FIG. 2, the cutting blade 21 is a so-called hub blade which includes an annular circular base 211, and an annular cutting edge 212 for cutting the workpiece 200 and disposed at a peripheral edge of the circular base 211. The cutting edge 212 includes abrasive grains of diamond, cubic boron nitride (CBN), or the like and a

bond material (binder) such as a metal or a resin, and is formed in a predetermined thickness. The cutting edge 212 of the cutting blade 21 is worn when cutting the workpiece 200. Note that, in the present invention, the cutting blade 21 may be a so-called washer blade which includes only the cutting edge 212.

The spindle 23 rotates the cutting blade 21 by being rotated around an axis by a motor. The blade cover 24 covers at least the upper side of the cutting blade 21. The blade cover 24 is fixed to a tip end surface of the spindle housing 22. In addition, the blade cover 24 is provided with a shower nozzle 25 and a pair of blade nozzles 26. The shower nozzle 25 faces a tool edge of the cutting edge 212 of the cutting blade 21 in the X-axis direction, and supplies cutting water to the tool edge of the cutting edge 212 of the cutting blade 21 during cutting. The blade nozzles 26 extend in parallel to the X-axis direction and are disposed with a spacing therebetween in the Y-axis direction. The blade nozzles 26 have a lower end of the cutting edge 212 of the cutting blade 21 positioned between themselves, and supplies cutting water to the lower end of the cutting edge 212 of the cutting blade 21 during cutting. Note that the axes of the cutting blade 21 and the spindle 23

of the cutting unit 20 are set parallel to the Y-axis direction.

The imaging unit 30 is fixed to the cutting unit 20 on one side so as to be moved as one body with the cutting unit 20 on the one side. The imaging unit 30 includes an imaging element for imaging a region to be divided, the region of the workpiece 200 before cutting that is held by the chuck table 10. The imaging element is, for example, a charge-coupled device (CCD) imaging element or a complementary MOS (CMOS) imaging element. The imaging unit 30 images the workpiece 200 held by the chuck table 10, to obtain an image for, for example, performing alignment between the workpiece 200 and the cutting blade 21, and outputs the obtained image to a control unit 100 of the tool edge examination unit 40.

In addition, the cutting apparatus 1 includes an X-axis direction position detection unit (not illustrated) for detecting the position of the chuck table 10 in the X-axis direction, a Y-axis direction position detection unit (not illustrated) for detecting the position of the cutting unit 20 in the Y-axis direction, and a Z-axis direction position detection unit for detecting the position of the cutting unit 20 in the Z-axis direction. The X-axis direction position detection unit and the Y-

axis direction position detection unit can include a linear scale parallel to the X-axis direction or the Y-axis direction, and a reading head. The Z-axis direction position detection unit detects the position of the cutting unit 20 in the Z-axis direction by pulses of a motor. The X-axis direction position detection unit, the Y-axis direction position detection unit and the Z-axis direction position detection unit output to the control unit 100 the position of the chuck table 10 in the X-axis direction and the position of the lower end of the cutting edge 212 of the cutting blade 21 of the cutting unit 20 in the Y-axis direction or the Z-axis direction.

Note that, in the first embodiment, the positions of the chuck table 10 and the cutting unit 20 of the cutting apparatus 1 in the X-axis direction and those in the Y-axis direction and the Z-axis direction are determined based on reference positions (not illustrated) which are preliminarily determined. In addition, in the first embodiment, the reference position in the Z-axis direction for the cutting unit 20 is a position where the holding surface 11 of the chuck table 10 and the lower end of the cutting edge 212 of the cutting blade 21 are positioned on the same plane.

(Tool Edge Examination Unit)

Next, the tool edge examination unit will be described. FIG. 3 is a diagram schematically depicting a configuration of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1. FIG. 4 is a side view schematically depicting pulsed light emitted by the light emitting section of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1 and the cutting blade. FIG. 5 is a diagram depicting a voltage value of a voltage converted by the photoelectric conversion section from a light amount of the pulsed light of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1. FIG. 6 is a diagram for explaining a position for detecting the tool edge state of the cutting edge of the cutting blade of the tool edge examination unit of the cutting apparatus illustrated in FIG. 1.

The tool edge examination unit 40 is a unit for detecting the state of the tool edge of the cutting edge 212 of the cutting blade 21 for cutting the workpiece 200. As the state of the tool edge, the tool edge examination unit 40 detects the presence or absence of chipping of a part from the peripheral edge of the cutting edge 212 and the presence or absence of a through-hole 213 (depicted in FIG. 4 and the like)

penetrating the radial-directionally inner side as compared to the peripheral edge of the cutting edge 212. The chipping and the through-hole 213 may be generated during the manufacture of the cutting blade 21 or during cutting. The through-hole 213 is generated by collision of a part of the workpiece 200 cut during cutting, and has an inside diameter of the order of 40 μm , for example. The tool edge examination unit 40 includes a unit main body 41 depicted in FIGS. 2 and 3.

In the first embodiment, the unit main body 41 is attached to an inner surface of a water case 60 which is provided in the periphery of the chuck table 10 and which has a drain port (not illustrated) for receiving and draining cutting water containing cutting swarf generated by cutting the workpiece 200 by the cutting unit 20.

The unit main body 41 includes a pair of leg sections 42 erected in the Z-axis direction and a connection section 43. The pair of leg sections 42 are disposed with a spacing therebetween in the Y-axis direction. The spacing between the pair of leg sections 42 is larger than the thickness of the cutting edge 212 of the cutting blade 21. Accordingly, the pair of leg sections 42 are provided therebetween with an entering section 44 where the cutting edge 212 of the cutting

blade 21 enters. In other words, the tool edge examination unit 40 includes the entering section 44. The pair of leg sections 42 are disposed so as to clamp the cutting edge 212 of the cutting blade 21 therebetween when the cutting edge 212 of the cutting blade 21 is inserted therebetween. The connection section 43 connects lower end portions of the pair of leg sections 42, and extends in a horizontal direction in parallel to the Y-axis direction.

In addition, the unit main body 41 includes the light emitting section 45 and the light receiving section 46 on opposite sides of the entering section 44 in the Y-axis direction. The light emitting section 45 is provided at the leg section 42 on one side of the pair of leg sections 42. The light emitting section 45 includes an optical fiber 48 that is connected to a light source 47, propagates pulsed light (depicted in FIG. 4 and hereinafter referred to as the pulsed light 300) from the light source 47, and emits the light toward the leg section 42 on the other side, namely, the light receiving section 46. In the first embodiment, the outside diameter of the optical fiber 48 of the light emitting section 45 is, for example, 0.3 to 5 mm, and a spot diameter of the pulsed light 300 is, for example, 0.3 to 5 mm. In

addition, the light emitting section 45 emits the pulsed light 300 at a predetermined frequency.

The light receiving section 46 is provided at the leg section 42 on the other side, receives the pulsed light 300 emitted from the light emitting section 45, and outputs the received pulsed light 300 to the control unit 100.

Besides, as illustrated in FIGS. 1 and 3, the tool edge examination unit 40 includes the control unit 100 which is a computing unit, in addition to the aforementioned unit main body 41. The control unit 100 includes a photoelectric conversion section 101, a voltage recording section 102, a determining section 103, and a control section 104.

The photoelectric conversion section 101 converts the light amount of the pulsed light 300 received by the light receiving section 46 into a voltage. The photoelectric conversion section 101 converts into a voltage value of voltage according to the light amount of the pulsed light 300 inputted from the light receiving section 46. Note that, in the first embodiment, the light amount of the pulsed light 300 received by the light receiving section 46 and the voltage value of the voltage converted by the photoelectric conversion section 101 are

proportional to each other.

Note that, as the cutting blade 21 is lowered along the Z-axis direction and enters the depth of the entering section 44, an amount 301 (indicated by dotted line in FIG. 4) by which the pulsed light 300 emitted from the light emitting section 45 and received by the light receiving section 46 is shielded by the cutting blade 21 increases. Then, the voltage value of the voltage converted by the photoelectric conversion section 101 is gradually reduced, as depicted in FIG. 5.

Note that, in FIG. 5, the axis of abscissas represents the time elapsed from the start of lowering of the cutting blade 21, and the axis of ordinates represents the voltage value of the voltage converted by the photoelectric conversion section 101. In addition, in the first embodiment, in FIG. 5, the voltage value when the pulsed light 300 is received by the photoelectric conversion section 101 in an amount of 100% (when a reception rate of the pulsed light 300 is 100%) is indicated as 100%, and the voltage value when the pulsed light 300 is received by the photoelectric conversion section 101 in an amount of 0% (when the reception rate of the pulsed light 300 is 0%) is indicated as 0%.

The voltage recording section 102 records the

voltage converted by the photoelectric conversion section 101 on a pulse basis. In the first embodiment, the voltage recording section 102 records the voltage value of the voltage converted by the photoelectric conversion section 101, in one-to-one correspondence with the time when the pulsed light 300 is inputted to the photoelectric conversion section 101.

The determining section 103 determines the state of the tool edge of the cutting edge 212 of the cutting blade 21 inserted into the entering section 44, or the presence or absence of chipping and the through-hole 213, from variation in the voltage value of the voltage recorded by the voltage recording section 102.

The control section 104 controls each component of the cutting unit 20 and the tool edge examination unit 40, to cause the tool edge examination unit 40 to perform an operation of detecting the state of the tool edge of the cutting edge 212 of the cutting blade 21. In the operation of detecting the state of the tool edge, the control section 104 positions the position of the cutting blade 21 relative to the unit main body 41 of the tool edge examination unit 40 at a position where the reception rate of the pulsed light 300 received by the light receiving section 46, or the voltage value

converted by the photoelectric conversion section 101, is 100%, and then positions the relative position sequentially at each of positions where the reception rate, or the voltage value, is 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, or 0%, which are each the value lowered by a predetermined value of 10% at a time from 100%.

The control section 104 causes the tool edge examination unit 40 to perform the operation of detecting the state of the tool edge when the position of the cutting blade 21 relative to the unit main body 41 of the tool edge examination unit 40 is at each of the positions where the reception rate of the pulsed light 300 received by the light receiving section 46, or the voltage value converted by the photoelectric conversion section, is 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, or 0%. In the operation of detecting the state of the tool edge, the control section 104, in a state of rotation at a predetermined rotational speed by the spindle 23, emits the pulsed light 300 at a predetermined frequency from the light receiving section 45, receives the pulsed light 300 by the light receiving section 46, converts the pulsed light 300 into a voltage by the photoelectric conversion section 101, and records the voltage in the

voltage recording section 102.

Note that each of the positions where the voltage value converted by the photoelectric conversion section 101 is 100%, 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, or 0% is each of the positions where the lower end of the cutting edge 212 of the cutting blade 21 is positioned at each of the positions indicated by horizontal lines in FIG. 6. Particularly, in the first embodiment, the position where the voltage value converted by the photoelectric conversion section 101 is 100% is a position where the pulsed light 300 to be received by the light receiving section 46 is not shielded by the cutting edge 212 at all, and is a starting position for starting the detection of the state of the tool edge in the method of detecting the state of the cutting blade 21.

In the first embodiment, the position where the voltage value converted by the photoelectric conversion section 101 is 0% is, for example, a position where the lower end of the cutting edge 212 of the cutting blade 21 is equal to or lower than a position which is on the same plane as the lower end of the pulsed light 300. The position where the voltage value converted by the photoelectric conversion section 101 is 0% is a position where the pulsed light 300 to be received by the light

receiving section 46 is perfectly shielded by the cutting edge 212, and is a finishing position for finishing the detection of the state of the tool edge in the method of detecting the state of the cutting blade 21. In addition, in the first embodiment, each of the positions where the voltage value converted by the photoelectric conversion section 101 is 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, or 0%, or which are each a value lowered by a predetermined value at a time from 100%, is a detection position for detecting the state of the tool edge in the method of detecting the state of the cutting blade 21. Note that, in the present invention, the predetermined value is not limited to 10%. Besides, in the first embodiment, the position where the voltage value converted by the photoelectric conversion section 101 is 90% is a position immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started.

Note that the control section 104 sets a combination of the frequency of light emission of the pulsed light 300 and the rotational speed of the cutting blade 21 in such a manner that the pulsed light 300 is not always applied at the same angle to the cutting blade 21, namely, that the pulsed light 300 is not applied to the same position of the cutting edge 212 of the cutting

blade 21. That the pulsed light 300 is not applied to the same position of the cutting edge 212 of the cutting blade 21 means that the positions where the pulsed light 300 is applied to the cutting edge 212 of the cutting blade 21 are deviated in the circumferential direction, that the whole parts of the positions where the pulsed light 300 is applied to the cutting edge 212 of the cutting blade 21 do not overlap with each other, and that parts of the positions where the pulsed light 300 is applied to the cutting edge 212 of the cutting blade 21 may overlap with each other.

For example, in the first embodiment, in a case where the outside diameter of the cutting edge 212 of the cutting blade 21 is 55.6 mm, the length of the outer circumference of the cutting edge 212 is 174.6725515 mm, and the rotational speed of the cutting blade 21 is 60,000 rpm, and with the frequency of light emission of the pulsed light 300 being 250 kHz and with the sampling frequency of the pulsed light 300 of the light receiving section 46 being 0.004 ms, the spacing between the centers of the positions where the pulsed light 300 is applied to an outer edge of the cutting edge 212 of the cutting blade 21 may be set to 0.698690206 mm.

In addition, the control section 104 of the control

unit 100 controls each component of the cutting apparatus 1 to cause the cutting apparatus 1 to perform a processing operation on the workpiece 200. Note that the control unit 100 is a computer that includes a computing unit having a microprocessor such as a central processing unit (CPU), a storage unit having a memory such as a read only memory (ROM) or a random access memory (RAM), and an input-output interface unit. The computing unit of the control unit 100 performs computing processing according to a computer program stored in the storage unit, and outputs control signals for controlling the cutting apparatus 1 and the tool edge examination unit 40 to each component of the cutting apparatus 1 and the tool edge examination unit 40 through the input-output interface unit.

The control unit 100 is connected to a display unit 110 including, for example, a liquid crystal display for displaying the state of a processing operation and images and the like, an input unit (not illustrated) used when the operator registers processing contents information and the like, and an alarm unit 120 that gives an alarm to the operator. The input unit includes at least one of a touch panel provided at the display unit 110 and an external input device such as a keyboard. The alarm unit

120 gives an alarm to the operator by issuing at least one of a sound or light.

In addition, the tool edge examination unit 40 is used also for determining a reference position in the Z-axis direction for the cutting unit 20. The control unit 100 preliminarily stores as a reference voltage 400 (depicted in FIG. 5) a voltage value of a voltage converted by the photoelectric conversion section 101 when the cutting unit 20 is positioned at a reference position in the Z-axis direction. The tool edge examination unit 40 detects, and stores, the result of detection by the Z-axis direction position detection unit when the cutting blade 21 is gradually lowered and gradually inserted toward the depth of the entering section 44, the light receiving section 46 receives the pulsed light 300 from the light emitting section 45, and the voltage value of the voltage converted by the photoelectric conversion section 101 becomes a reference voltage 400, as a reference position in the Z-axis direction for the cutting unit 20. The control section 104 of the control unit 100 performs cutting by utilizing the reference position in the Z-axis direction for the cutting unit 20 detected by the tool edge examination unit 40.

Note that the timing at which the cutting apparatus 1 detects the reference position in the Z-axis direction for the cutting unit 20 by use of the tool edge examination unit 40 is, for example, each time one sheet of workpiece 200 is cut, or each time a predetermined number of workpieces 200 is cut, and is stored in the storage unit of the control unit 100 as part of the processing contents information.

In addition, the aforementioned cutting apparatus 1 includes a second tool edge examination unit 70 depicted in FIG. 7. FIG. 7 is a diagram schematically depicting a configuration of the second tool edge examination unit of the cutting apparatus illustrated in FIG. 1. The second tool edge examination unit 70 is a unit for detecting the state of the tool edge of the cutting edge 212 of the cutting blade 21 during cutting. As the state of the tool edge, the second tool edge examination unit 70 detects the presence or absence of chipping of a part from an outer edge of the cutting edge 212.

As illustrated in FIG. 7, the second tool edge examination unit 70 includes a unit main body 71, and includes the photoelectric conversion section 101 and the voltage recording section 102 and the determining section 103 of the tool edge examination unit 40. In the first

embodiment, the unit main body 71 is provided on the blade cover 24. The unit main body 71 includes a pair of leg sections 72 which are erected in the Z-axis direction, which are spaced from each other in the Y-axis direction, and which have the cutting edge 212 of the cutting blade 21 positioned therebetween, and a connection section 73 connecting upper end portions of the pair of leg sections 72. A part between the pair of leg sections 72 is an entering section 74 where the cutting edge 212 of the cutting blade 21 enters. The second tool edge examination unit 70 includes the entering section 74.

In addition, the unit main body 71 includes a light emitting section 75 provided at the leg section 72 on one side of the pair of leg sections 72, and a light receiving section 76 provided at the leg section 72 on the other side. The light emitting section 75 includes an optical fiber 78 which is connected to a light source 77, transmits pulsed light emitted by the light source 77, and emits the light toward the leg section 72 on the other side, namely, toward the light receiving section 76. In the first embodiment, the outside diameter of the optical fiber 78 of the light emitting section 75 is, for example, 0.3 to 5 mm, and the light receiving section 76

receives the pulsed light emitted from the light emitting section 75 and outputs the received light to the photoelectric conversion section 101 of the control unit 100.

The photoelectric conversion section 101 converts the light amount of the pulsed light received by the light receiving section 76 into a voltage. The photoelectric conversion section 101 converts the light amount of the pulsed light 300 inputted from the light receiving section 76 into a voltage of a voltage value according to the light amount. Note that, in the first embodiment, the light amount of the pulsed light 300 received by the light receiving section 76 and the voltage value of the voltage converted by the photoelectric conversion section 101 are proportional to each other.

Note that, when chipping is generated in the cutting edge 212 of the cutting blade 21 during cutting, the light amount of the pulsed light emitted from the light emitting section 75 and received by the light receiving section 76 increases as compared to before the generation of chipping.

The voltage recording section 102 stores the voltage converted by the photoelectric conversion section

101 on a pulse basis. In the first embodiment, the voltage recording section 102 records the voltage value of the voltage converted by the photoelectric conversion section 101, in one-to-one correspondence with the time when the pulsed light is inputted to the photoelectric conversion section 101.

The determining section 103 determines the state of the tool edge of the cutting edge 212 of the cutting blade 21, namely, the presence or absence of generation of chipping, from variation in the voltage value of the voltage recorded by the voltage recording section 102. The determining section 103 determines whether or not the voltage value recorded by the voltage recording section 102 during cutting is increased more than a preset increase rate attendant on blade wear and periodically, and, when it is determined that the voltage value is increased more than the increase rate and periodically, the determining section 103 determines that chipping has been generated in the cutting edge 212 of the cutting blade 21.

The control section 104 controls each component of the second tool edge examination unit 70, to cause the second tool edge examination unit 70 to perform an operation of detecting the state of the tool edge of the

cutting edge 212 of the cutting blade 21. In the first embodiment, when the determining section 103 determines that chipping has been generated in the cutting edge 212 of the cutting blade 21, the control section 104 stops cutting, and operates the alarm unit 120 to give an alarm to the operator. When the determining section 103 determines that the voltage value is not increased more than the increase rate and periodically, the determining section 103 determines that chipping has not been generated in the cutting edge 212 of the cutting blade 21, and continues cutting. Note that the functions of the photoelectric conversion section 101, the determining section 103 and the control section 104 mentioned above are achieved by a process in which the computing unit of the control unit 100 executes a computer program stored in the storage unit. The function of the voltage recording section 102 is realized by the storage unit of the control unit 100.

The cutting apparatus 1 configured as aforementioned starts a processing operation when the operator or the like registers processing contents information in the control unit 100, the workpiece 200 is placed on the holding surface 11 of the chuck table 10 in the carrying-in/out region through the adhesive tape 206,

and the control unit 100 accepts an instruction to start the processing operation from the operator or the like. When the processing operation is started, the cutting apparatus 1 suction holds the workpiece 200 on the holding surface 11 through the adhesive tape 206, clamps the annular frame 205 by the clamp sections 13, rotates the spindle 23 around an axis, and supplies cutting water from the nozzles 25 and 26. The cutting apparatus 1 moves the chuck table 10 from the carrying-in/out region toward the processing region to a position below the imaging unit 30 by the moving unit 50, images the workpiece 200 suction held on the chuck table 10 by the imaging unit 30, and performs alignment.

The cutting apparatus 1 performs cutting by causing the cutting blade 21 to cut into the division line 202 of the workpiece 200 until reaching the adhesive tape 206 while relatively moving the cutting blade 21 and the workpiece 200 along the division line 202. When all the division lines 202 of the workpiece 200 have been cut, the cutting apparatus 1 moves the chuck table 10 from the processing region toward the carrying-in/out region.

The cutting apparatus 1 stops movement of the chuck table 10 in the carrying-in/out region, stops suction holding of the workpiece 200 by the chuck table 10,

releases the clamping by the clamp sections 13, and finishes the processing operation.

(Cutting Blade State Detecting Method)

The cutting blade state detecting method according to the first embodiment is a method of detecting the state of the tool edge of the cutting edge 212 of the cutting blade 21, namely, the presence or absence of generation of chipping and the presence or absence of generation of the through-hole 213, in the cutting apparatus 1 configured as aforementioned. FIG. 8 is a flow chart depicting the flow of the cutting blade state detecting method according to the first embodiment. FIG. 9 is a diagram depicting an example of variation in voltage value when it is determined that chipping has been generated in the cutting edge, in the determining step of the cutting blade state detecting method depicted in FIG. 8. FIG. 10 is a diagram depicting an example of variation in voltage value when it is determined that a through-hole has been generated in the cutting edge, in the determining step of the cutting blade state detecting method depicted in FIG. 8.

The cutting blade state detecting method (hereinafter referred to the state detecting method) according to the first embodiment is carried out, for

example, at a timing of each time one sheet of workpiece 200 is cut, or each time a predetermined number of workpieces 200 is cut, or the like. The timing for performing the state detecting method is stored in the storage unit of the control unit 100 as part of processing contents information. In the first embodiment, the cutting apparatus 1, after performing the state detecting method and determining that both the generation of chipping and the generation of the through-hole 213 are absent, detects a reference position in the Z-axis direction for the cutting unit 20 by use of the tool edge examination unit 40; in the present invention, the timing for performing the state detecting method and the detecting timing of the reference position are not limited to the timings described in the first embodiment.

As depicted in FIG. 8, the state detecting method includes a starting position setting step ST1, a voltage recording step ST2, and a determining step ST3. The starting position setting step ST1 is a step of positioning the lower end of the cutting edge 212 of the cutting blade 21 at a starting position. In the starting position setting step ST1, the control section 104 of the control unit 100 controls the motor of the cutting unit 20 to rotate the spindle 23, and, without supplying

cutting water from the nozzles 25 and 26, controls the moving unit 50 to position the lower end of the cutting edge 212 of the cutting blade 21 of the cutting unit 20 at a position directly above the entering section 44 of the tool edge examination unit 40. In the starting position setting step ST1, the control section 104 of the control unit 100 emits pulsed light 300 at a predetermined frequency from the light source 47, emits the pulsed light 300 from the light emitting section 45 toward the light receiving section 46, and controls the Z-axis moving unit 53 to lower the cutting unit 20, thereby inserting the cutting edge 212 of the cutting blade 21 into the entering section 44.

In the starting position setting step ST1, the control section 104 of the control unit 100 controls the Z-axis moving unit 53 based on the voltage value of the voltage obtained through reception of light by the light receiving section 46 and conversion by the photoelectric conversion section 101, to position the cutting unit 20 at the starting position, and stops movement of the cutting unit 20 in the Z-axis direction.

The voltage recording step ST2 is a step in which the Z-axis moving unit 53 is driven while rotating the cutting blade 21, and variation in the voltage value

while the cutting edge 212 is moved from the starting position where the cutting edge 212 does not shield the pulsed light 300 to be received by the light receiving section 46 to a position where the cutting edge 212 enters the entering section by a predetermined amount is recorded. In the first embodiment, in the voltage recording step ST2, the control section 104 of the control unit 100 controls the Z-axis moving unit 53 to lower the cutting unit 20 while rotating the cutting blade 21, thereby inserting the cutting blade 21 toward the depth of the entering section 44. In the first embodiment, in the voltage recording step ST2, the control section 104 of the control unit 100 controls the Z-axis moving unit 53 based on the voltage value obtained through reception of light by the light receiving section 46 and conversion by the photoelectric conversion section 101, to position the cutting blade 21 at a position where the voltage value is 90%, namely, where the voltage value is lowered by a predetermined value of 10% from the starting position, and stops movement of the cutting unit 20 in the Z-axis direction. In the voltage recording step ST2, the voltage recording section 102 of the control unit 100 records the voltage value of the voltage obtained through reception of light by the light

receiving section 46 and conversion by the photoelectric conversion section 101.

The determining step ST3 is a step of determining the state of the cutting edge 212, from variation in the voltage value of the voltage recorded in the voltage recording step ST2. In the first embodiment, in the determining step ST3, the determining section 103 of the control unit 100 determines whether or not an increase in voltage of equal to or more than a predetermined value 500 (depicted in FIGS. 9 and 10) is absent, in variation of the voltage recorded by the voltage recording section 102 in the voltage recording step ST2 immediately before. In the determining step ST3, in a case where an increase in voltage of equal to or more than the predetermined value 500 (depicted in FIGS. 9 and 10) is absent, in variation in the voltage recorded by the voltage recording section 102 in the voltage recording step ST2 immediately before, the determining section 103 of the control unit 100 determines that chipping is absent in the cutting edge 212, and determines that abnormality is absent in the cutting edge 212 of the cutting blade 21.

In addition, in the determining step ST3, in a case where a periodical and temporary increase in voltage value of equal to or more than the predetermined value

500 has been generated, as depicted in FIG. 9, in variation of the voltage recorded by the voltage recording section 102 in the voltage recording step ST2 immediately before, the determining section 103 of the control unit 100 determines that chipping has been generated at a tip end of the cutting edge 212, and determines that abnormality is present in the cutting edge 212 of the cutting blade 21. In this way, in the determining step ST3, in a case where a periodical and temporary increase in voltage value has been generated from the position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started, the determining section 103 of the control unit 100 determines that chipping has been generated at the tip end of the cutting edge 212. In the determining step ST3, the control section 104 of the control unit 100 records the result of determination by the determining section 103 in the storage unit.

The control section 104 of the control unit 100 determines whether or not abnormality has been present in the determining step ST3 (step ST4). Upon determining that abnormality has been present in the determining step ST3 (step ST4: Yes), the control section 104 of the

control unit 100 operates the alarm unit 120 to give an alarm to the operator (step ST5), and finishes the state detecting method.

Upon determining that abnormality has been absent in the determining step ST3 (step ST4: No), the control section 104 of the control unit 100 determines whether or not the cutting blade 21 of the cutting unit 20 is located at the finishing position (the position where the voltage value is 0%) (step ST6), based on the voltage value of the voltage obtained through reception of light by the light receiving section 46 and conversion by the photoelectric conversion section 101.

Upon determining that the cutting blade 21 of the cutting unit 20 is located at the finishing position (the position where the voltage value is 0%) (step ST6: Yes), the control section 104 of the control unit 100 finishes the state detecting method, whereas, upon determining that the cutting blade 21 of the cutting unit 20 is not located at the finishing position (the position where the voltage value is 0%) (step ST6: No), the control returns to the voltage recording step ST2.

In the voltage recording step ST2 to which the control has returned, the control section 104 of the control unit 100 controls the Z-axis moving unit 53 to

lower the cutting unit 20, positions the cutting blade 21 at the position at which the voltage value is 80% and which is the detecting position where the voltage value is lowered by a predetermined value of 10% from the position where the voltage value is 90%, based on the voltage value of the voltage obtained through reception of light by the light receiving section 46 and conversion by the photoelectric conversion section 101, and stops movement of the cutting unit 20 in the Z-axis direction. In the voltage recording step ST2, the voltage recording section 102 of the control unit 100 records the voltage value of the voltage obtained through reception of light by the light receiving section 46 and conversion by the photoelectric conversion section 101, and the control proceeds to the determining step ST3.

In the determining step ST3, in a case where an increase in voltage of equal to or more than a predetermined value 500 (depicted in FIGS. 9 and 10) is absent, in variation of the voltage recorded by the voltage recording section 102 in the voltage recording step ST2 immediately before, the determining section 103 of the control unit 100 determines that the through-hole 213 is absent, and determines that abnormality is absent in the cutting edge 212 of the cutting blade 21.

In addition, in the determining step ST3, in a case where a periodical and temporary increase in voltage value of equal to or more than the predetermined value 500 is generated, as depicted in FIG. 10, in variation in the voltage recorded by the voltage recording section 102 in the voltage recording step ST2 immediately before, the determining section 103 of the control unit 100 determines that the through-hole 213 has been generated on a radial-directionally inner side as compared to the outer peripheral edge of the cutting edge 212, and determines that abnormality is present in the cutting edge 212 of the cutting blade 21. In this way, in the determining step ST3, in a case where a periodical and temporary increase in voltage value has been generated at one of the detecting positions where the voltage value is less than 90%, after a state in which generation of a periodical and temporary increase in voltage value is absent has continued from the position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started, the determining section 103 of the control unit 100 determines that the through-hole 213 has been generated on a radial-directionally inner side as compared to an outer peripheral edge of the cutting edge 212, and

determines that abnormality is present in the cutting edge 212 of the cutting blade 21. In the determining step ST3, the control section 104 of the control unit 100 records the result of determination by the determining section 103 in the storage unit, and proceeds to step ST4.

In this way, the state detecting method repeats the voltage recording step ST2, the determining step ST3, the step ST4, and the step ST6, by moving the cutting blade 21 of the cutting unit 20 and the tool edge examination unit 40 in the Z-axis direction from the starting position toward the finishing position, to sequentially position the cutting blade 21 at detecting positions where the voltage value is lowered by a predetermined amount at a time, and until it is determined in the determining step ST3 that chipping or the through-hole 213 has been generated in the cutting edge 212. In addition, in a case where it is not determined in the determining step ST3 that chipping or the through-hole 213 has been generated in the cutting edge 212, the state detecting method moves the cutting blade 21 of the cutting unit 20 and the tool edge examination unit 40 from the starting position toward the finishing position, to sequentially position the cutting blade 21 at the

detecting positions where the voltage value is lowered by a predetermined amount at a time, and determines the state of the tool edge.

As has been described above, in the determining step ST3, of the state detecting method according to the first embodiment, in a case where a periodical and temporary increase in voltage value has been generated from the position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started, the determining section 103 of the control unit 100 determines that chipping has been generated at the tip end of the cutting edge 212. In addition, in the determining step ST3, in the state detecting method according to the first embodiment, in a case where a periodical and temporary increase in voltage value has been generated at one of the detecting positions where the voltage value is less than 90%, after a state in which generation of a periodical and temporary increase in voltage value is absent has continued from the position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started, the determining section 103 of the control unit 100 determines that the through-hole 213 has been generated

on a radial-directionally inner side as compared to an outer peripheral edge of the cutting edge 212. As a result, the state detecting method according to the first embodiment produces an effect that it is possible to detect the through-hole 213 formed in the cutting edge 212, in addition to chipping.

Besides, in the state detecting method according to the first embodiment, the Z-axis moving unit 53 as a cutting-in feeding unit for moving the cutting unit 20 moves the cutting unit 20 to insert the cutting blade 21 into the entering section 44. As a result, the state detecting method according to the first embodiment produces an effect that it is possible to detect the through-hole 213 formed in the cutting edge 212, in addition to chipping, sequentially from the starting position through the detecting positions to the finishing position.

<Second Embodiment>

A cutting blade state detecting method according to a second embodiment of the present invention will be described based on the drawings. FIG. 11 is a diagram schematically depicting a configuration of a second tool edge examination unit of a cutting apparatus for carrying out the cutting blade state detecting method according to

the second embodiment. Note that, in FIG. 11, the same parts as those in the first embodiment above are denoted by the same reference symbols as used above, and descriptions thereof are omitted.

The cutting blade state detecting method according to the second embodiment is the same as in the first embodiment except that a unit main body 71 of a second tool edge examination unit 70 is provided to be movable in the Z-axis direction relative to a blade cover 24 by a light emitting section-light receiving section moving unit 80, the light emitting section-light receiving section moving unit 80 lowers the unit main body 71 of the second tool edge examination unit 70 from the starting position toward the finishing position, the second tool edge examination unit 70 emits pulsed light 300 from a light emitting section 75, records variation in the voltage value mentioned above, and determines the presence or absence of generation of chipping and the through-hole 213.

The light emitting section-light receiving section moving unit 80 is a moving unit as described in the claim that moves the light emitting section 75 and a light receiving section 76 of the unit main body 71 of the second tool edge examination unit 70 as one body in the

Z-axis direction, to thereby relatively move the light emitting section 75 and the light receiving section 76 of the second tool edge examination unit 70 and the cutting unit 20 in the Z-axis direction. As illustrated in FIG. 11, the light emitting section-light receiving section moving unit 80 includes a known ball screw 81 provided to be rotatable around an axis, a known motor 82 that rotates the ball screw 81 around the axis to lift the unit main body 71 upward and downward, and known guide rails 83 that support the unit main body 71 movably in the Z-axis direction.

In the cutting blade state detecting method according to the second embodiment, in a determining step ST3, in a case where a periodical and temporary increase in voltage value has been generated from a position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started, the determining section 103 of the control unit 100 determines that chipping has been generated at the tip end of the cutting edge 212. In addition, in the cutting blade state determining method according to the second embodiment, in the determining step ST3, in a case where a periodical and temporary increase in voltage value has been generated at one of the detecting

positions where the voltage value is less than 90%, after a state in which generation of a periodical and temporary increase in voltage value is absent from the position where the voltage value is 90% immediately after the shielding of the pulsed light 300 by the cutting edge 212 is started has continued, the determining section 103 of the control unit 100 determines that the through-hole 213 has been generated on a radial-directionally inner side as compared to the outer peripheral edge of the cutting edge 212. As a result, the cutting blade state detecting method according to the second embodiment produces an effect that it is possible to detect the through-hole 213 formed in the cutting edge 212, in addition to chipping, like in the first embodiment.

In addition, in the cutting blade state detecting method according to the second embodiment, the light emitting section-light receiving section moving unit 80 moves the unit main body 71 of the second tool edge examination unit 70, to insert the cutting blade 21 between the light emitting section 45 and the light receiving section 46. As a result, the cutting blade state detecting method according to the second embodiment produces an effect that it is possible to detect the through-hole 213 formed in the cutting edge 212, in

addition to chipping, sequentially from the starting position through the detection positions to the finishing position.

Note that the present invention is not limited to the above described embodiments. In other words, the present invention can be carried out with various modifications in such ranges as not to depart from the gist of the invention. Note that an example in which the lowering of the cutting blade 21 is stopped at the height of each % mentioned above and the amount of light received is measured to determine chipping and a through-hole has been shown in the voltage recording step ST2 in the above embodiments, and the time for which the lowering of the cutting blade 21 is stopped need only be a time enough for measurement for at least one revolution of the cutting blade 21 to be carried out, so that the time is short.

The present invention is not limited to the details of the above described preferred embodiments. 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 cutting blade state detecting method for detecting a state of a cutting edge of a cutting blade, in a cutting apparatus including a chuck table that holds a workpiece, a cutting unit in which the cutting blade having a cutting edge at a periphery thereof is mounted to a spindle and which cuts the workpiece held on the chuck table with the cutting blade, a tool edge examination unit including an entering section where the cutting edge of the cutting blade enters and a light emitting section and a light receiving section disposed opposite to each other with the entering section therebetween, and a moving unit that relatively moves the tool edge examination unit and the cutting unit in a radial direction of the cutting blade,

the tool edge examination unit further including a photoelectric conversion section that converts an amount of pulsed light received by the light receiving section into voltage, and a voltage recording section that records the voltage converted by the photoelectric conversion section on a pulse basis,

the cutting blade state detecting method comprising:

a voltage recording step in which the moving unit

is moved while rotating the cutting blade, and variation in the voltage during when the light receiving section is moved from a position where the cutting edge does not shield the pulsed light to be received by the light receiving section to a position where the cutting edge enters the entering section by a predetermined amount is recorded; and

a determining step of determining a state of the cutting edge from the variation in the voltage recorded in the voltage recording step, wherein

in the determining step,

it is determined that chipping is absent in the cutting edge in a case where an increase in the voltage of equal to or more than a predetermined value is absent,

it is determined that chipping has been generated at a tip end of the cutting edge in a case where a periodical and temporary increase in the voltage is generated from immediately after the shielding of the pulsed light by the cutting edge is started, and

it is determined that a through-hole has been formed on a radial-directionally inner side as compared to an outer peripheral edge of the cutting edge in a case where a periodical and temporary increase in the voltage is generated after a state in which generation of a

periodical and temporary increase in the voltage is absent has continued from immediately after the shielding of the pulsed light by the cutting edge is started.

2. The cutting blade state detecting method according to claim 1, wherein the moving unit includes a cutting-in feeding unit that moves the cutting unit.

3. The cutting blade state detecting method according to claim 1, wherein the moving unit includes a light emitting section-light receiving section moving unit that moves together the light emitting section and the light receiving section.