

GRINDING METHOD OF WORKPIECE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a grinding method of a workpiece.

Description of the Related Art

For the realization of compact and lightweight device chips, there are increasing situations where a wafer with devices such as integrated circuits arranged on a side of a front surface thereof is processed thin. A wafer is ground thin, for example, by the wafer being held on the side of the front surface thereof on a chuck table, both a grinding wheel, on which grinding stones that contain abrasive grits therein are fixed, and the chuck table being rotated, and the grinding stones being pressed against a side of a back surface of the wafer while fluid (grinding fluid) such as pure water is supplied.

Described specifically, the grinding wheel is first disposed above the chuck table on which the wafer is held. The grinding wheel is next lowered at high speed toward the chuck table. When the grinding wheel approaches a position that has a predetermined

distance from the chuck table, the lowering speed of the grinding wheel is changed to low speed, followed by initiation of grinding of the wafer. It is to be noted that shortly after the change of the lowering speed to the low speed, there is a duration called "air cutting" in which the grinding wheel moves down at the low speed and idles with the grinding stones not in contact with the wafer (see, for example, Japanese Patent Laid-open No. 2014-24145).

SUMMARY OF THE INVENTION

According to the above-mentioned method, the lowering grinding wheel does not hit the wafer at high speed owing to the existence of the duration of air cutting in which the grinding wheel moves down at the low speed and idles. On the other hand, the grinding of the wafer does not proceed at all in the duration of air cutting in which the grinding wheel moves down at the low speed. A reduction in the duration of this air cutting is hence believed to shorten the time required for grinding such wafers and thereby make improvements in productivity.

A timing at which the lowering speed of the grinding wheel is changed to the low speed (in other

words, the timing of initiation of air cutting in which the grinding wheel moves down at the low speed) is determined according to a thickness of the wafer (the height of an upper surface of the wafer) as measured, for example, by a contact height gauge. With this method, however, there is no choice but to change the lowering speed of the grinding wheel at a height position set with a certain degree of margin in view of the measurement accuracy or the like of the height gauge, thereby failing to achieve any sufficient reduction in the duration of air cutting in which the grinding wheel moves down at the low speed and idles.

The present invention therefore has as an object thereof the provision of a grinding method of a workpiece that, compared with the related art, can make a reduction in the duration of air cutting in which a grinding wheel moves down at low speed and idles.

In accordance with an aspect of the present invention, there is provided a grinding method of a workpiece, including a holding step of holding the workpiece on a holding surface of a chuck table, a disposing step of disposing a grinding wheel that is

mounted on a distal end of a spindle and includes grinding stones aligned in an annular array, above the chuck table, a first moving step of, while forming a film with a flowing grinding fluid on an upper surface of the workpiece, with the grinding wheel kept rotating but the chuck table not rotating, moving the chuck table and the grinding wheel relative to each other at a first speed such that the chuck table and the grinding wheel are caused to approach each other to reach a first distance, and a second moving step of, after the first moving step, with the chuck table and grinding wheel each kept rotating, moving the chuck table and the grinding wheel relative to each other at a second speed such that the chuck table and the grinding wheel are caused to approach each other to reach a second distance smaller than a thickness of the workpiece. The first moving step is ended using as the first distance a distance between the chuck table and the grinding wheel at a time point when a load on rotation of the grinding wheel has varied beyond a threshold through contact between the rotating grinding wheel and the film of the grinding fluid flowing on the upper surface of the workpiece.

In the aspect of the present invention, the

second speed may preferably be smaller than the first speed. In the aspect of the present invention, the grinding method may preferably further include, after the first moving step but before the second moving step, a separation step of moving the chuck table and the grinding wheel relative to each other such that the chuck table and the grinding wheel are separated from each other. In the aspect of the present invention, the grinding method may preferably further include, after the disposing step but before the first moving step, a priming moving step of moving the chuck table and the grinding wheel relative to each other at a priming speed greater than the first speed such that the chuck table and the grinding wheel are caused to approach each other to reach a first-moving-step initiation distance greater than the first distance.

With use of a phenomenon that the load on the rotation of the grinding wheel substantially varies if the rotating grinding wheel comes close to the workpiece in a state in which it is in contact with the film of the grinding fluid flowing on the upper surface of the workpiece, the grinding method according to the aspect of the present invention for the workpiece ends the first moving step at the time

point when the load on the rotation of the grinding wheel has varied beyond the threshold. Compared with the related art which uses, for example, the measurement value of the height gauge, the grinding method according to the aspect of the present invention can initiate the second moving step from a state in which the grinding wheel and the workpiece have approached each other to reach the first distance. Compared with the related art, a reduction can thus be made in the duration of air cutting in which the grinding of the workpiece does not proceed in the second moving step where the grinding wheel moves down at low speed.

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 cross-sectional view schematically illustrating a grinding apparatus;

FIG. 2 is a cross-sectional view schematically illustrating how a grinding wheel is disposed above a chuck table on which a workpiece is held;

FIG. 3 is a cross-sectional view illustrating how the chuck table and the grinding wheel move relative to each other to approach each other and reach a first-moving-step initiation distance;

FIG. 4 is a cross-sectional view illustrating how the chuck table and the grinding wheel move relative to each other to approach each other and reach a first distance;

FIG. 5 is a graph illustrating a relation between the time elapsed in a state in which the chuck table and the grinding wheel are moving relative to each other and the electric current flowing through a rotary drive source that rotates the grinding wheel; and

FIG. 6 is a cross-sectional view illustrating how the chuck table and the grinding wheel move relative to each other to approach each other and reach a second distance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the attached drawings, a

description will hereinafter be made with regard to an embodiment of the present invention. FIG. 1 is a cross-sectional view schematically illustrating a grinding apparatus 2 for use in a grinding method according to this embodiment for a workpiece. As illustrated in FIG. 1, the grinding apparatus 2 includes a chuck table 4 configured to enable holding of a disk-shaped workpiece 11 (see FIG. 2).

The chuck table 4 includes a disk-shaped (short cylindrical) frame body 6 formed using, for example, ceramics or the like. On a side of an upper surface of the frame body 6, a recessed portion 6a is formed having a circular opening on an upper end thereof. Fixed in this recessed portion 6a is a porous holding plate 8 formed in a disk shape with ceramics or the like.

The holding plate 8 has an upper surface 8a, which is configured to have a shape corresponding, for example, to a circular conical surface and which functions as a holding surface that holds the workpiece 11. It is to be noted that the shape of the upper surface 8a of the holding plate 8 is exaggerated in FIG. 1, but in reality, a difference in height (height difference) between a center of the upper

surface 8a, the center corresponding to the apex of a circular cone, and an outer peripheral edge of the upper surface 8a is 10 μm to 30 μm or so.

The holding plate 8 is connected on a side of a lower surface thereof to a suction source (not illustrated) such as an ejector via a flow channel 6b disposed inside the frame body 6 and a valve and other connecting means (not illustrated) arranged outside the frame body 6. The workpiece 11 is thus sucked by the chuck table 4 if the workpiece 11 is brought into contact with the upper surface 8a of the holding plate 8 and the valve is opened to allow a negative pressure to act from the suction source. Accordingly, the workpiece 11 is held by the chuck table 4.

To a lower portion of the frame body 6, a rotary drive source (not illustrated) such as a motor is connected. The chuck table 4 is rotated about an axis of rotation along a vertical direction, for example, by power generated by the rotary drive source, such that the center of the upper surface 8a of the holding plate 8 acts as a center of rotation. Further, the frame body 6 is supported, for example, by a chuck table moving mechanism (not illustrated) of the ball screw type, and the chuck table 4 is moved,

for example, along a horizontal direction by power generated from the chuck table moving mechanism.

Above the chuck table 4, a grinding unit 10 is disposed. The grinding unit 10 includes a cylindrical spindle housing (not illustrated). This spindle housing is supported, for example, by a grinding unit moving mechanism (not illustrated) of the ball screw type, and the grinding unit 10 is moved along the vertical direction by power generated from the grinding unit moving mechanism.

In a space inside the spindle housing, a column-shaped spindle 12 is accommodated. Further, a disk-shaped mount 14 is fixed on a lower end portion of the spindle 12. In an outer edge portion of the mount 14, a plurality of holes (not illustrated) are formed extending through the mount 14 in a thickness direction thereof. In each hole, a bolt (not illustrated) or the like is inserted.

On a lower surface of the mount 14, a disk-shaped grinding wheel 16 of a substantially equal diameter as the mount 14 is mounted by bolts or the like. The grinding wheel 16 is thus mounted on the lower end portion of the spindle 12 via the mount 14, etc. The grinding wheel 16 includes a disk-shaped

wheel base 18 formed using such metal as stainless steel or aluminum. In an outer edge portion of an upper surface of the wheel base 18, screw holes are disposed such that the above-mentioned bolts or the like are inserted therein.

In an annular region on a lower surface of the wheel base 18, a plurality of grinding stones 20 are fixed along a peripheral direction of the wheel base 18. The grinding stones 20 are thus aligned in an annular array on the lower surface of the wheel base 18. Each grinding stone 20 has a structure in which abrasive grits of diamond material or the like are dispersed in a binder such as resin, and is suited for grinding the workpiece 11.

To a side of an upper end of the spindle 12, a rotary drive source (not illustrated) such as a motor is connected. The grinding wheel 16 is rotated about an axis of rotation along the vertical direction, for example, by power generated from the rotary drive source so that the point of intersection between the grinding wheel 16 and an axial center of the spindle 12 (in other words, a center of the grinding wheel 16) acts as a center of rotation. It is to be noted that in general, the axis of rotation of the grinding wheel

16 is slightly tilted with respect to the axis of rotation of the chuck table 4.

Disposed right below the grinding wheel 16 is a nozzle 22 configured to enable supply of a grinding fluid 21 (see FIG. 2) to the workpiece 11 held on the chuck table 4. As the grinding fluid 21, pure water is used, for example. It is to be noted that instead of or in addition to the nozzle 22, a supply port configured to enable supply of the grinding fluid 21 to the workpiece 11 may be disposed inside the grinding wheel 16.

To the individual components of the above-mentioned grinding apparatus 2, a control unit (not illustrated) is connected. The control unit is configured by a computer that includes, for example, a processor, a storage device, and an input device, and controls operations or the like of the individual components of the above-mentioned grinding apparatus 2 such that the workpiece 11 is appropriately ground.

The processor is typically a central processing unit (CPU), and performs various kinds of processing required to control the above-mentioned components. The storage device includes, for example, a primary storage device such as a dynamic random

access memory (DRAM) and an auxiliary storage device such as a hard disk drive or flash memory.

The input device is, for example, a touch panel, and also serves as an output device (specifically, display device). It is to be noted that a keyboard, a mouse, and/or the like may be adopted as the input device. Functions of the control unit configured as described above are realized by operation of the processor in accordance with software stored in the storage device.

In this embodiment, some or all of the steps required for the grinding of the workpiece 11 are executed under control by the control unit of the grinding apparatus 2. However, some or all of the steps are not necessarily required to be executed under control by the control unit. For example, some or all of the steps may be executed under control by an operator.

In the grinding method according to this embodiment, first, the disk-shaped workpiece 11 is held on the holding surface of the chuck table 4 (holding step), and the grinding wheel 16 is disposed above the chuck table 4 (disposing step). FIG. 2 is a cross-sectional view schematically illustrating how

the grinding wheel 16 is disposed above the chuck table 4 on which the disk-shaped workpiece 11 is held.

Described specifically, as illustrated in FIG. 2, the workpiece 11 is placed on the chuck table 4 such that the workpiece 11 remains, at a lower surface 11a thereof, in contact with the upper surface 8a of the holding plate 8. The valve is next opened, so that the negative pressure generated at the suction source acts on the upper surface 8a of the holding plate 8. As a consequence, the workpiece 11 is sucked on the side of the lower surface 11a thereof to the upper surface 8a of the holding plate 8, whereby the workpiece 11 is held on the chuck table 4 in a state in which its upper surface 11b is exposed.

After the workpiece 11 has been held on the holding surface of the chuck table 4, the grinding wheel 16 is disposed above the chuck table 4. Described specifically, as illustrated in FIG. 2, the chuck table moving mechanism moves the chuck table 4 to a position below the grinding wheel 16 under control by the control unit such that an extension in the vertical direction of the axis of rotation of the grinding wheel 16 passes, for example, an outer peripheral edge portion of the workpiece 11 held on

the holding surface of the chuck table 4. In other words, the grinding wheel 16 with the grinding stones 20 aligned in the annular array thereon is disposed above the chuck table 4 on which the workpiece 11 is held, such that the grinding stones 20 and the workpiece 11 partly overlap with each other as viewed in a top view.

The grinding fluid 21 is supplied from the nozzle 22 onto the upper surface 11b of the workpiece 11, for example, after the grinding wheel 16 has been disposed above the chuck table 4. It is to be noted that, although in this embodiment, the grinding wheel 16 is disposed above the chuck table 4 after the workpiece 11 has been held on the holding surface of the chuck table 4, the workpiece 11 may be held on the holding surface of the chuck table 4 after the grinding wheel 16 has been disposed above the chuck table 4.

After the grinding wheel 16 has been disposed above the chuck table 4 subsequent to the holding of the workpiece 11 on the holding surface of the chuck table 4, the chuck table 4 and the grinding wheel 16 are moved relative to each other at a predetermined priming speed, so that they are caused to approach

each other to reach a predetermined initiation distance (first-moving-step initiation distance) D_0 (priming moving step). FIG. 3 is a cross-sectional view illustrating how the chuck table 4 and the grinding wheel 16 move relative to each other to approach each other and reach the initiation distance (first-moving-step initiation distance) D_0 .

Described specifically, as illustrated in FIG. 3, the grinding unit moving mechanism lowers the grinding unit 10 to a height position of the initiation distance D_0 from the chuck table 4 under control by the control unit. The priming speed for the lowering of the grinding unit 10 is set as desired, typically in a range of 1 mm/s to 100 mm/s. However, the priming speed is not limited to falling within this range.

If the chuck table 4 and the grinding wheel 16 approach each other to reach the predetermined initiation distance D_0 , for example, the lowering of the grinding unit 10 at the priming speed, in other words, the relative movement between the chuck table 4 and the grinding wheel 16, is ended. Here, as the initiation distance D_0 , a value obtained by adding 10 μm to 50 μm to a thickness of the workpiece 11 is set

typically. However, the initiation distance D0 is not limited to falling within this range.

The relative movement that causes the chuck table 4 and the grinding wheel 16 to approach each other to reach the initiation distance D0 is performed typically without rotation of the chuck table 4 and grinding wheel 16. In this case, the rotation of the grinding wheel 16 is initiated after the chuck table 4 and the grinding wheel 16 have approached each other to reach the initiation distance D0. The speed of rotation (rpm) of the grinding wheel 16 is set as desired, typically in a range of 1000 rpm to 6000 rpm. It is to be noted that the relative movement between the chuck table 4 and the grinding wheel 16 may be performed with the grinding wheel 16 kept rotating.

Further, as mentioned above, the relative movement that causes the chuck table 4 and the grinding wheel 16 to approach each other to reach the initiation distance D0 is performed while the nozzle 22 is supplying the grinding fluid 21 onto the upper surface 11b of the workpiece 11. Owing to the supply of the grinding fluid 21 from the nozzle 22, a film is formed with the flowing grinding fluid 21 on the upper surface 11b of the workpiece 11.

The supply amount of the grinding fluid 21 is set such that the film of the grinding fluid 21 has a thickness of 300 μm to 1000 μm , for example, in a region where the grinding stones 20 and the workpiece 11 come into contact with each other when grinding. The grinding stones 20 of the grinding wheel 16 thus come into contact with the film of the grinding fluid 21 when the chuck table 4 and the grinding wheel 16 are caused to approach each other to reach the initiation distance D_0 .

However, the supply amount of the grinding fluid 21 is not limited to the range in which the film of the grinding fluid 21 has the thickness of 300 μm to 1000 μm . The supply amount of the grinding fluid 21 may be set, for example, in a range in which the grinding stones 20 do not come into contact with the film of the grinding fluid 21 in the state in which the chuck table 4 and the grinding wheel 16 have been caused to approach each other to reach the initiation distance D_0 .

Furthermore, the relative movement between the chuck table 4 and the grinding wheel 16 may be performed without the supply of the grinding fluid 21 by the nozzle 22 onto the upper surface 11b of the

workpiece 11. If this is the case, the supply of the grinding fluid 21 by the nozzle 22 is initiated after the chuck table 4 and the grinding wheel 16 have approached each other to reach the initiation distance D0.

After the chuck table 4 and the grinding wheel 16 have approached each other to reach the initiation distance D0, with the chuck table 4 not rotating but the grinding wheel 16 rotating, the chuck table 4 and the grinding wheel 16 move relative to each other at a predetermined first speed to approach each other and reach a first distance D1 (first moving step). FIG. 4 is a cross-sectional view illustrating how the chuck table 4 and the grinding wheel 16 move relative to each other to approach each other and reach the first distance D1.

Described specifically, as illustrated in FIG. 4, the grinding unit moving mechanism lowers the grinding unit 10 to a height position of the first distance D1 from the chuck table 4 under control by the control unit. If the workpiece 11 is subjected to coarse grinding, the first speed for the lowering of the grinding unit 10 is set as desired, for example, in a range of 5 $\mu\text{m/s}$ to 80 $\mu\text{m/s}$. If the workpiece 11

is subjected to finish grinding, on the other hand, the first speed is set in a range of 1 $\mu\text{m/s}$ to 10 $\mu\text{m/s}$ as desired. However, the first speed is not limited to falling within these ranges.

As mentioned above, the relative movement that causes the chuck table 4 and the grinding wheel 16 to approach each other to reach the first distance D1 is performed while the nozzle 22 is supplying the grinding fluid 21 onto the upper surface 11b of the workpiece 11. Owing to the supply of the grinding fluid 21 from the nozzle 22, a film is formed with the flowing grinding fluid 21 on the upper surface 11b of the workpiece 11.

If the distance between the upper surface 11b of the workpiece 11 and the grinding stones 20 then becomes sufficiently small with the grinding stones 20 kept in contact with the film of the grinding fluid 21, a load on rotation of the grinding wheel 16 increases significantly. This phenomenon is presumably attributable to greater effect of the viscosity of the grinding fluid 21 as the workpiece 11 and the grinding stones 20 approach each other. In this embodiment, the above-mentioned increase in the load on rotation is used in the control of the

relative movement between the chuck table 4 and the grinding wheel 16.

Described specifically, at a time point of detection of an increase in the load on the rotation of the grinding wheel 16, the control unit ends the lowering of the grinding wheel 16 at the first speed by the grinding unit moving mechanism. In other words, the relative movement at the first speed between the chuck table 4 and the grinding wheel 16 is ended using as the first distance D1 the distance between the chuck table 4 and the grinding wheel 16 at the time point of the detection of an increase in the load.

The magnitude of a load on rotation of the grinding wheel 16 corresponds, for example, to the magnitude of an electric current flowing through the rotary drive source that rotates the spindle 12. In this embodiment, the electric current that is flowing through the rotary drive source is hence measured in real time by an ammeter (not illustrated), and is used in the detection of the load. FIG. 5 is a graph illustrating a relation between the time t elapsed in a state in which the chuck table 4 and the grinding wheel 16 are moving relative to each other and the

electric current I flowing through the rotary drive source that rotates the grinding wheel 16. In FIG. 5, the abscissa represents the time t , and the ordinate the electric current I .

As illustrated in FIG. 5, in a state before a time t_1 in which the workpiece 11 and the grinding stones 20 are sufficiently separated from each other, the electric current I flowing through the rotary drive source that rotates the grinding wheel 16 is maintained at a value smaller than a first electric current I_1 . In a state after the time t_1 that the workpiece 11 and the grinding stones 20 have sufficiently approached each other, on the other hand, the electric current I flowing through the rotary drive source that rotates the grinding wheel 16 becomes greater than the first electric current I_1 .

If an electric current I greater than the preset first electric current I_1 is detected, the control unit then ends at this time point the lowering of the grinding wheel 16 at the first speed by the grinding unit moving mechanism. In other words, with use of, as the first distance D_1 , the distance between the chuck table 4 and the grinding wheel 16 at the time point when the load on the rotation of the

grinding wheel 16 has varied beyond a first threshold corresponding to the first electric current I_1 , the relative movement at the first speed between the chuck table 4 and the grinding wheel 16 is ended.

The first electric current I_1 is set as desired, for example, in a range of 1.05 to 1.20 times of an electric current I (typically, an average of electric currents I in any period before the time t_1) flowing through the rotary drive source that rotates the grinding wheel 16 with the workpiece 11 and the grinding stones 20 sufficiently separated from each other. However, the first electric current I_1 is not limited to falling within this range. Further, the load on the rotation of the grinding wheel 16 may be detected by any other appropriate method that does not use the electric current I flowing through the rotary drive source.

As described above, this embodiment uses the phenomenon that the load on the rotation of the grinding wheel 16 substantially varies when the rotating grinding wheel 16 comes close to the workpiece 11 in the state in which it is in contact with the film of the grinding fluid 21 flowing on the upper surface 11b of the workpiece 11. The relative

movement at the first speed between the chuck table 4 and the grinding wheel 16 is ended at the time point when the load on the rotation has varied beyond the first threshold. Different from the related art which uses a measurement value of a height gauge, the grinding wheel 16 and the workpiece 11 can be caused to approach each other by their relative movement at the first speed. Described specifically, with the grinding method of this embodiment, the first distance D1 can be realized in a range of 1 μm to 5 μm .

It is to be noted that in this embodiment, the chuck table 4 does not rotate when the chuck table 4 and the grinding wheel 16 move relative to each other at the first speed. Even if control or the like by the control unit slightly delays, for example, in relation to the first speed and the grinding stones 20 happen to contact the workpiece 11, no substantial problem arises in the grinding stones 20 and workpiece 11. If the grinding stones 20 come into contact with the workpiece 11, on the other hand, the load on the rotary drive source that rotates the chuck table 4 significantly increases, so that the rotation of the chuck table 4 can no longer be initiated appropriately.

It is hence desired that, if the grinding stones 20 come into contact with the workpiece 11, the chuck table 4 and the grinding wheel 16 then move relative to each other at a predetermined separating speed to separate from each other and reach a predetermined separation distance (separation step). Described specifically, the grinding unit moving mechanism may raise the grinding unit 10 to a height position of the separation distance from the chuck table 4 under control by the control unit.

It is to be noted that contact between the workpiece 11 and the grinding stones 20 can be determined according to an increase in the load on the rotation of the grinding wheel 16. In the state of contact between the workpiece 11 and the grinding stones 20 after a time t_2 , the electric current I flowing through the rotary drive source that rotates the grinding wheel 16 becomes greater than a second electric current I_2 as illustrated in FIG. 5.

If the electric current I flowing through the rotary drive source that rotates the grinding wheel 16 becomes greater than the second current I_2 set beforehand, the control unit determines that the workpiece 11 and the grinding stones 20 have come into

contact with each other. In other words, if the load on the rotation of the grinding wheel 16 becomes greater than a second threshold corresponding to the second electric current I_2 , the control unit determines that the workpiece 11 and the grinding stones 20 have come into contact with each other.

Here, the second electric current I_2 is greater than the first electric current I_1 , and the second threshold is greater than the first threshold. The second electric current I_2 is set as desired, for example, in a range of 1.20 to 2.00 times of the electric current I (typically, an average of electric currents I in any period before the time t_1) flowing through the rotary drive source that rotates the grinding wheel 16 with the workpiece 11 and the grinding stones 20 sufficiently separated from each other. However, the second electric current I_2 is not limited to falling within this range.

Further, the determination as to whether or not the workpiece 11 and the grinding stones 20 are in contact with each other may be made by any other appropriate method that does not use the electric current I flowing through the rotary drive source. Moreover, the chuck table 4 and the grinding wheel 16

may be normally kept separated from each other irrespective of whether or not the workpiece 11 and the grinding stones 20 are in contact with each other. If this is the case, it is unnecessary to make a determination as to whether or not the workpiece 11 and the grinding stones 20 are in contact with each other.

The separating speed for the raising of the grinding unit 10 is set as desired, typically in a range of 1 $\mu\text{m/s}$ to 80 $\mu\text{m/s}$. However, the separating speed is not limited to falling within this range. The separation distance is desirably set in a range that gives a sufficiently small effect on the productivity, and is set as desired, typically in a range of 1 $\mu\text{m/s}$ to 10 $\mu\text{m/s}$. However, the separation distance is not limited to falling within this range either.

After the relative movement at the first speed between the chuck table 4 and grinding wheel 16, rotation of the chuck table 4 is initiated. If the chuck table 4 and the grinding wheel 16 are separated after the relative movement at the first speed between the chuck table 4 and grinding wheel 16, however, the rotation of the chuck table 4 is initiated after their

separation. The speed of rotation (rpm) of the chuck table 4 is set as desired, typically in a range of 100 rpm to 300 rpm.

With the chuck table 4 and the grinding wheel 16 each rotating, the chuck table 4 and the grinding wheel 16 then move relative to each other at a predetermined second speed to approach each other and reach a second distance D2 smaller than the thickness of the workpiece 11 (second moving step). The workpiece 11 is thus ground by the grinding wheel 16. FIG. 6 is a cross-sectional view illustrating how the chuck table 4 and the grinding wheel 16 move relative to each other to approach each other and reach the second distance D2.

Described specifically, as illustrated in FIG. 6, the grinding unit moving mechanism lowers the grinding unit 10 to a height position of the second distance D2 from the chuck table 4 under control by the control unit. The second speed for the lowering of the grinding unit 10 is smaller than the first speed. If the workpiece 11 is subjected to coarse grinding, for example, the second speed is set in a range of 1.0 $\mu\text{m/s}$ to 10.0 $\mu\text{m/s}$ as desired. If the workpiece 11 is subjected to finish grinding, on the

other hand, the second speed is set in a range of 0.1 $\mu\text{m/s}$ to 1.5 $\mu\text{m/s}$ as desired. However, the second speed is not limited to falling within these ranges.

It is to be noted that the relative movement at the second speed between the chuck table 4 and the grinding wheel 16 is also performed while the nozzle 22 is supplying the grinding fluid 21 onto the upper surface 11b of the workpiece 11. If the chuck table 4 and the grinding wheel 16 approach relative to each other to reach the preset second distance D2, for example, the lowering of the grinding unit 10 at the second speed, in other words, the relative movement between the chuck table 4 and the grinding wheel 16, is ended. The second distance D2 is set, for example, to have a value corresponding to any desired thickness that is required of the workpiece 11 after the grinding.

As described above, with use of the phenomenon that the load on the rotation of the grinding wheel 16 substantially varies if the rotating grinding wheel 16 comes close to the workpiece 11 in the state in which it is in contact with the film of the grinding fluid 21 flowing on the upper surface 11b of the workpiece 11, the relative movement at the first speed between

the chuck table 4 and the grinding wheel 16 (the first moving step) is ended at the time point when the load on the rotation of the grinding wheel 16 has varied beyond the first threshold. Different from the related art which uses a measurement value of a height gauge, the relative movement at the second speed between the chuck table 4 and the grinding wheel 16 (the second moving step) can hence be initiated from the state in which the grinding wheel 16 and the workpiece 11 have approached each other to reach the first distance. Compared with the above-mentioned related art, a reduction can thus be made in the duration of air cutting in which the grinding of the workpiece 11 does not proceed when the chuck table 4 and the grinding wheel 16 move relative to each other at the second speed smaller than the first speed.

If conventional air cutting, which lasts for 40 seconds (20 μm) at a speed (second speed) of 0.5 $\mu\text{m/s}$, is replaced by air cutting for 1.8 seconds (18 μm) at a speed (first speed) of 10 $\mu\text{m/s}$ and air cutting for 4 seconds (2 μm) at a speed (second speed) of 0.5 $\mu\text{m/s}$, for example, a reduction as much as 31 seconds or longer is made in the duration of air cutting even if 3 seconds are required when rotating

the chuck table 4 before the relative movement at 0.5 $\mu\text{m/s}$ (second speed) between the chuck table 4 and the grinding wheel 16.

It is to be noted that the present invention can be practiced with appropriate changes or modifications without being limited by the description of the above-mentioned embodiment. Further, the structure, manner, and the like according to the above-described embodiment can also be practiced with appropriate changes or modifications within the scope not departing from 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 grinding method of a workpiece,
comprising:

a holding step of holding the workpiece on a
holding surface of a chuck table;

a disposing step of disposing a grinding wheel
that is mounted on a distal end of a spindle and
includes grinding stones aligned in an annular array,
above the chuck table;

a first moving step of, while forming a film
with a flowing grinding fluid on an upper surface of
the workpiece, with the grinding wheel kept rotating
but the chuck table not rotating, moving the chuck
table and the grinding wheel relative to each other at
a first speed such that the chuck table and the
grinding wheel are caused to approach each other to
reach a first distance; and

a second moving step of, after the first
moving step, with the chuck table and grinding wheel
each kept rotating, moving the chuck table and the
grinding wheel relative to each other at a second
speed such that the chuck table and the grinding wheel
are caused to approach each other to reach a second
distance smaller than a thickness of the workpiece,

wherein the first moving step is ended using as the first distance a distance between the chuck table and the grinding wheel at a time point when a load on rotation of the grinding wheel has varied beyond a threshold through contact between the rotating grinding wheel and the film of the grinding fluid flowing on the upper surface of the workpiece.

2. The grinding method of a workpiece according to claim 1, wherein the second speed is smaller than the first speed.

3. The grinding method of a workpiece according to claim 1 or 2, further comprising:

after the first moving step but before the second moving step, a separation step of moving the chuck table and the grinding wheel relative to each other such that the chuck table and the grinding wheel are separated from each other.

4. The grinding method according to any one of claims 1 to 3, further comprising:

after the disposing step but before the first moving step, a priming moving step of moving the chuck table and the grinding wheel relative to each other at a priming speed greater than the first speed such that the chuck table and the grinding wheel are caused to

approach each other to reach a first-moving-step
initiation distance greater than the first distance.