

CUTTING BLADE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an annular cutting blade used at a time of cutting a workpiece.

Description of the Related Art

In the case of dividing various kinds of plate-shaped workpieces such as semiconductor wafers, resin package substrates, ceramic substrates, and glass substrates into a plurality of chips or in the case of forming the workpiece with a groove or grooves, use is made of a cutting blade including a cutting edge containing abrasive grains fixed by a bond. As the cutting blade, for example, an annular hubless blade (or washer blade) which does not have a base member and in which the blade as a whole is formed of a cutting edge is used. The hubless blade is an annular blade which has a circular outer periphery and has a through-hole (specifically, a round hole) formed in a central portion of a disk such as to be concentric with the outer peripheral circle. The hubless blade is mounted to a mount by using the through-hole.

The mount includes a cylindrical boss section, and

a flange section formed on an outer peripheral side of the boss section. In the case of mounting the hubless blade onto the mount, the boss section is inserted into the through-hole of the hubless blade, and one surface of the hubless blade is put into contact with the flange section. Then, an annular presser nut is put into contact with the other surface of the hubless blade, and the hubless blade is sandwiched between the flange section and the presser nut. Thereafter, an annular fixing nut is disposed on an opposite side of the presser nut from the hubless blade, and the fixing nut is fixed to a tip portion of the boss section. As a result, the hubless blade is fixed to the mount in the state of being sandwiched between the flange section and the presser nut.

A tip end portion of a cylindrical spindle is fixed to a part of the mount by a bolt or the like. A rotational drive source such as a motor is connected to the other end portion of the spindle, and the spindle serves as a rotational shaft of the mount. When cutting a workpiece by the hubless blade, the spindle is rotated by the rotational drive source, whereby the hubless blade is rotated at high speed. Then, the hubless blade being rotated at high speed is made to cut into the workpiece,

to cut the workpiece.

Incidentally, when cutting is conducted in a state in which a misregistration amount between a rotational center of the spindle and a center of the outer peripheral circle of the hubless blade is comparatively large, the cutting is conducted by only a part of an outer peripheral portion of the hubless blade, so that chipping or clacking is liable to occur in the workpiece. Note that, for easy insertion of the boss section into the through-hole of the hubless blade, a diameter of the through-hole is set larger than an outside diameter of the boss section (an allowance width is provided), and, for reducing the aforementioned misregistration amount, the allowance width is generally set to a small size (for example, 10 μm to 20 μm). As a result, when the hubless blade is mounted to the mount, the misregistration amount between the rotational center of the spindle and the center of the outer peripheral circle of the hubless blade is reduced.

However, as a result of the reduction in the allowance width, a play amount of the through-hole is reduced, and it becomes comparatively difficult to insert the boss section into the through-hole. For example, in the case where the workmanship of the operator is low or

in the case where the mount has a flaw, the cutting blade may be damaged when the boss section is inserted into the through-hole. On the other hand, when the diameter of the through-hole is set sufficiently larger than the outside diameter of the boss section, the boss section can easily be inserted into the through-hole, but, as described above, the misregistration amount between the rotational center of the spindle and the center of the outer peripheral circle of the hubless blade becomes comparatively large. Therefore, if cutting is conducted in this state, chipping or clacking is liable to occur in the workpiece. In order to avoid this, it is necessary to reshape the outer peripheral portion according to the misregistration amount (namely, truing) and to process the hubless blade in such a manner that the outer peripheral portion becomes a perfect circle with reference to the rotational center of the spindle (to perform what is generally called generation of roundness) each time the hubless blade is mounted to the mount (see, for example, Japanese Patent Laid-Open No. 2013-233613).

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above-mentioned problems. It is an

object of the present invention to secure both setting the size of a through-hole to such a size as to allow easy insertion of a boss section, and omission of truing for generation of roundness each time a blade is mounted to a mount.

In accordance with an aspect of the present invention, there is provided an annular cutting blade having a through-hole and used at a time of cutting a workpiece, the cutting blade including a mark section indicative of an orientation of the cutting blade when a cylindrical boss section provided in a mount fixed to one end portion of a spindle is inserted into the through-hole of the cutting blade. An inner periphery of the cutting blade corresponding to an edge of the through-hole includes a positioning region where a length from a center of an outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is equal to a radius of the boss section, and an allowance region which is located in a region different from the positioning region and where the length from the center of the outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is longer than the radius of the boss section. When the cutting blade is disposed on the boss section by inserting the boss section into

the through-hole while the mark section is adjusted to a predetermined orientation, a distance between a rotational center of the boss section and the center of the outer peripheral circle of the cutting blade is equal to or less than a predetermined length.

Preferably, the mark section is provided in such a manner as to cut out the cutting blade from the inner periphery of the cutting blade toward an outer periphery of the cutting blade.

In addition, preferably, the cutting blade further includes a weight adjusting section for adjusting a deviation in weight balance generated due to misregistration between the center of the outer peripheral circle of the cutting blade and a center of a circle of the inner periphery of the cutting blade.

Besides, preferably, the weight adjusting section is a cutout section provided in such a manner as to cut out the cutting blade from the inner periphery of the cutting blade toward the outer periphery of the cutting blade.

The cutting blade according to the described aspect of the present invention includes the mark section indicative of the orientation of the cutting blade when the cylindrical boss section provided in the mount is

inserted into the through-hole of the cutting blade. The inner periphery of the cutting blade corresponding to the edge of the through-hole includes the positioning region and the allowance region. In the positioning region, the length from the center of the outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is equal to the radius of the boss section. On the other hand, the allowance region is located in a region different from the positioning region, and, in the allowance region, the length from the center of the outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is longer than the radius of the boss section. Therefore, when the boss section is inserted into the through-hole by adjusting the mark section to a predetermined orientation, the boss section can easily be inserted into the through-hole.

Further, when the cutting blade is disposed on the boss section by inserting the boss section into the through-hole while the mark section is adjusted to a predetermined orientation, a distance between the rotational center of the boss section and the center of the outer peripheral circle of the cutting blade is equal to or less than a predetermined length. For example, when the cutting blade is disposed on the boss section by

inserting the boss section into the through-hole while the mark section is adjusted to a predetermined orientation, the rotational center of the boss section and the center of the outer peripheral circle of the cutting blade coincide with each other. In this way, when the cutting blade is disposed on the boss section by inserting the boss section into the through-hole while the mark section is adjusted to the predetermined orientation, the outer peripheral circle of the cutting blade can be regarded as a perfect circle with reference to the rotational center of the spindle, and, therefore, reshaping of the cutting blade for generation of roundness (namely, truing) can be omitted.

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 partially sectional side view of a cutting apparatus;

FIG. 2 is an exploded perspective view of a cutting unit;

FIG. 3 is a partially sectional side view of the cutting unit;

FIG. 4A is a front view of a mount fixed to a tip portion of a spindle and the like;

FIG. 4B is a diagram depicting one side of a cutting blade;

FIG. 4C is a diagram depicting a state in which a first boss section is inserted into a through-hole;

FIG. 5A is a front view of a cutting blade according to a second embodiment;

FIG. 5B is a front view of a cutting blade according to a third embodiment; and

FIG. 6 is a front view of a cutting blade according to a fourth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment according to a mode of the present invention will be described referring to the attached drawings. FIG. 1 is a partially sectional side view of a cutting apparatus 2. First, a workpiece 11 cut by use of the cutting apparatus 2 and the like will be described. The workpiece 11 in the present embodiment is

a disk-shaped wafer formed of a semiconductor material such as silicon (Si), silicon carbide (SiC), and gallium nitride (GaN). Note that the workpiece 11 is not limited to the disk-shaped wafer and may be a rectangular substrate such as a resin package substrate, a ceramic substrate, and a glass substrate.

A plurality of streets (not illustrated) is set in a grid pattern on a front surface 11a side of the workpiece 11 in the present embodiment, and a device (not illustrated) is formed in each of regions partitioned by the plurality of streets. A circular dicing tape 13 formed of a resin and having a diameter larger than a diameter of the workpiece 11 is adhered to a back surface 11b side of the workpiece 11. The dicing tape 13 has, for example, a laminated structure of a base material layer and a pressure sensitive adhesive layer (glue layer).

The base material layer is formed of a resin such as a polyolefin (PO), and a pressure sensitive adhesive layer formed of a pressure sensitive adhesive resin such as an ultraviolet (UV) curing resin is formed on the whole part or a part of a surface of the base material layer. The back surface 11b side of the workpiece 11 is adhered to a substantially central portion of the dicing tape 13, and one surface of an annular frame 15 formed of

a metal is adhered to an outer peripheral portion of the dicing tape 13. Note that the dicing tape 13 is not limited to the laminated structure of the base material layer and the pressure sensitive adhesive layer. For example, the dicing tape 13 may have only the base material layer. In this case, the base material layer is thermocompression bonded to the workpiece 11 or the like, whereby the dicing tape 13 is adhered to the workpiece 11 or the like.

The cutting apparatus 2 has a disk-shaped chuck table 4 that holds under suction the workpiece 11 or the like. The chuck table 4 has a frame body formed of a metal or the like. A flow path (not illustrated) of a predetermined shape is provided inside the frame body, and one end of the flow path is connected to a suction source (not illustrated) such as an ejector. A recess including a disk-shaped space is formed on an upper surface side of the frame body. A disk-shaped porous plate (not illustrated) is fixed to the recess. An upper surface of the porous plate is exposed on the upper side of the chuck table 4, and a lower surface of the porous plate is connected to the other end of the flow path in the frame body.

When the suction source is operated, a negative

pressure is generated at the upper surface of the porous plate, so that the upper surface of the chuck table 4 functions as a holding surface 4a that holds under suction an object placed on the upper surface. Note that a plurality of clamp units 6 for fixing the frame 15 is provided at an outer peripheral portion of the chuck table 4. A θ table (not illustrated) for rotating the chuck table 4 around a predetermined rotational axis is provided under the chuck table 4. In addition, an X-axis moving mechanism (not illustrated) for moving the chuck table 4 or the like in a processing feeding direction (X-axis direction) is provided under the θ table.

A cutting unit 10 has a cylindrical spindle 14. The spindle 14 is disposed in such a manner that its height direction is along a Y-axis direction. An annular cutting blade (hubless blade) 18 is mounted to a tip portion of the spindle 14 through a mount 16 or the like, and a rotational drive source such as a motor is connected to the other end side of the spindle 14. In the case of cutting the workpiece 11 by the cutting unit 10, first, the back surface 11b side (namely, the dicing tape 13) of the workpiece 11 is held by the holding surface 4a such that the front surface 11a is exposed, and the frame 15 is fixed by the plurality of clamp units 6.

Next, the front surface 11a side of the workpiece 11 is imaged by a camera unit (not illustrated) having an imaging element or the like. Based on an image obtained by the imaging, a region to be cut (namely, the street) is detected. Then, the cutting blade 18 is positioned on an extension line of one of the streets. Thereafter, the cutting blade 18 is rotated with a rotational axis of the spindle 14 as a center, and a lower end of the cutting blade 18 is positioned between the back surface 11b of the workpiece 11 and the holding surface 4a. Then, the chuck table 4 is moved in the X-axis direction relative to the workpiece 11 by the X-axis moving mechanism. As a result, the workpiece 11 is cut along the X-axis direction.

After the workpiece 11 is cut along one of the streets, the cutting unit 10 is moved along the Y-axis direction (indexing feeding direction), and the cutting blade 18 is positioned on an extension line of other street adjacent in the Y-axis direction to the one of the streets. Then, the workpiece 11 is cut along the other street. Similarly, the workpiece 11 is cut along the remaining streets. Note that the X-axis direction and the Y-axis direction are orthogonal to each other on a plane perpendicular to the vertical direction (Z-axis

direction).

Next, the configuration of the cutting unit 10 will be described in detail using FIGS. 2, 3, 4A, 4B, and 4C. FIG. 2 is an exploded perspective view of the cutting unit 10, and FIG. 3 is a partially sectional side view of the cutting unit 10. The cutting unit 10 has a tubular spindle housing 12. A part of the aforementioned spindle 14 is accommodated in the spindle housing 12 in a rotatable manner. A tip portion of the spindle 14 is formed with a tapped hole 14a having a predetermined depth along the height direction of the spindle 14. The tapped hole 14a is substantially cylindrical in shape, and the center axis of the tapped hole 14a coincides with the rotational axis of the spindle 14.

A mount 16 is disposed at a tip portion of the spindle 14. The mount 16 has a cylindrical first boss section (boss section) 16a which is inserted in a through-hole 18a of the cutting blade 18. On the outside of the first boss section 16a, a flange section 16b is provided concentrically such as to surround the outside of the first boss section 16a. The flange section 16b has an annular surface 16c which makes contact with one surface of the cutting blade 18 in the case where the cutting blade 18 is disposed on an outer peripheral

portion of the first boss section 16a. The annular surface 16c is located between one end and the other end in a lengthwise direction of the cylindrical first boss section 16a.

On one end side of the first boss section 16a, a cylindrical second boss section 16d smaller in diameter than the first boss section 16a is formed concentrically with the first boss section 16a. The cylindrical second boss section 16d is formed in the inside thereof with a mounting hole 16e corresponding to the shape on the tip side of the spindle 14. On the other end side of the first boss section 16a, a cylindrical third boss section 16f is formed concentrically with the first boss section 16a. An outside diameter of the third boss section 16f is smaller than the outside diameter of the first boss section 16a and is substantially equal to an outside diameter of the second boss section 16d.

A male screw 16g is formed in a partial region located on the side opposite to the first boss section 16a, of the outside surface of the third boss section 16f. In addition, an attaching hole 16h is formed on the inside of the third boss section 16f and the first boss section 16a. The attaching hole 16h is formed concentrically with the third boss section 16f and the

first boss section 16a. The attaching hole 16h is connected to the mounting hole 16e, and the attaching hole 16h and the mounting hole 16e form a through-hole. The attaching hole 16h has a cylindrical first space formed mainly in the inside of the third boss section 16f.

The attaching hole 16h further has a cylindrical second space which is formed mainly in the inside of the first boss section 16a and has a diameter smaller than a diameter of the first space. Note that the center axes of the first and second spaces coincide with the center axis of the mounting hole 16e. Due to the difference between the diameters of the first and second spaces, a stepped part 16i is formed inside the attaching hole 16h. A washer 20 having an outside diameter larger than an inside diameter of the stepped part 16i is disposed at the stepped part 16i. A shaft portion of a bolt 22 having a head portion of a diameter larger than an inside diameter of the washer 20 is inserted in the washer 20.

When the shaft portion of the bolt 22 is fastened to the tapped hole 14a of the spindle 14 in a state in which the spindle 14 is mounted to the mounting hole 16e, the mount 16 is fixed to a tip portion (one end portion) of the spindle 14 by the head portion of the bolt 22 and

the washer 20. In this instance, the center axis of the cylindrical first boss section 16a coincides with a rotational center 14b of the spindle 14. FIG. 4A is a front view of the mount 16 fixed to a tip portion of the spindle 14 and the like. An outer peripheral circle of the first boss section 16a in a plane orthogonal to the center axis of the first boss section 16a has a predetermined outside diameter ($2r_1$).

Referring again to FIGS. 2 and 3, the third boss section 16f is inserted in an annular presser flange section 24. The presser flange section 24 has an annular surface 24a. The annular surface 24a is the same in outside diameter and the inside diameter as the annular surface 16c of the flange section 16b and faces the annular surface 16c in the case where the third boss section 16f is inserted in the presser flange section 24. When the third boss section 16f is inserted in the presser flange section 24 in a state in which the cutting blade 18 is set on an outer peripheral portion of the first boss section 16a, a male screw 16g located at a tip portion of the third boss section 16f is exposed from the presser flange section 24. An annular fixing nut 26 formed with a female screw 26a at an inside surface thereof is fastened to the thus exposed male screw 16g.

As a result, the cutting blade 18 is fixed to a tip portion of the spindle 14 in the state of being sandwiched between the annular surface 16c of the mount 16 and the annular surface 24a of the presser flange section 24.

Next, the structure of the cutting blade 18 will be described more in detail. The cutting blade 18 is an annular hubless blade (namely, washer blade) in which diamond abrasive grains are dispersed in a resin bond or a metal bond. It is to be noted, however, that the cutting blade 18 may be a hubless blade which is formed by an electroforming method and which contains abrasive grains dispersed in a bond of a metal such as nickel. FIG. 4B is a diagram depicting one surface side of the cutting blade 18. An outer peripheral circle of the cutting blade 18 has a radius r_2 (for example, 28.0 mm) larger than the radius r_1 of the first boss section 16a. On the other hand, an inner peripheral circle (namely, the edge of the through-hole 18a) of the cutting blade 18 has a radius r_3 (for example, 20.1 mm) larger than the radius r_1 and smaller than the radius r_2 .

It is to be noted, however, that the center 18c of the inner peripheral circle is disposed with a deviation in a predetermined direction from the center 18b of the

outer peripheral circle. Note that, as depicted in FIG. 4B, in the present embodiment, a distance between the center 18b of the outer peripheral circle (namely, the center of the outside diameter) and the center 18c of the inner peripheral circle (namely, the center of the inside diameter) is made to be a deviation amount A, and a direction from the center 18b toward the center 18c is made to be a deviation direction. The deviation amount A is, for example, equal to or more than 100 μm and equal to or less than 1 mm. In an ordinary hubless blade, the through-hole is formed concentrically with an outer peripheral circle of the hubless blade. In other words, an ordinary hubless blade is not formed such that the center 18b of the outer peripheral circle and the center 18c of the inner peripheral circle are deviated by as much as 100 μm or more, as in the case of the cutting blade 18.

A predetermined mark section is formed at a predetermined position of the inner peripheral circle of the cutting blade 18. The mark section is formed in such a manner as to cut out a part of the cutting blade 18 from the inside toward the outside of the through-hole 18a. The cutout 18d in the present embodiment has an arch-shaped cutout (mark section) 18d, but the arch-shape

is not limitative and other shape may be adopted. The cutout 18d is formed, for example, in a region including the intersection of a straight line passing through the center 18b and the center 18c and the inner peripheral circle of the cutting blade 18. The cutout 18d functions as a mark section indicative of an orientation of the cutting blade 18 when the cutting blade 18 is mounted to the mount 16 by inserting the first boss section 16a into the through-hole 18a of the cutting blade 18.

For example, when the first boss section 16a is inserted into the through-hole 18a, an orientation of the cutout 18d is adjusted in such a manner that the cutout 18d is positioned at a top portion (an upper portion in the vertical direction) of the first boss section 16a. FIG. 4C is a diagram depicting a state in which the first boss section 16a has been inserted in the through-hole 18a. When the first boss section 16a is inserted into the through-hole 18a by adjusting the cutout 18d to a predetermined orientation and the cutting blade 18 is disposed on the first boss section 16a, two end portions located on the inner peripheral circle of the cutting blade 18, of an arch-shaped curve defining the cutout 18d, come into contact with a part of the first boss section 16a.

In other words, the two end portions function as a positioning region 18a₁ for making contact with the first boss section 16a. Note that a length from the two end portions to the center 18b of the outer peripheral circle is set to be equal to the radius r_1 of the outer peripheral circle of the first boss section 16a. Therefore, when the first boss section 16a is inserted into the through-hole 18a in a state in which the cutout 18d is adjusted to a predetermined orientation and the cutting blade 18 is disposed on the first boss section 16a, a distance between the center 18b of the outer peripheral circle and the rotational center 14b is equal to or less than a predetermined length. For example, the center 18b of the outer peripheral circle and the rotational center 14b coincide with each other.

Note that, in the present embodiment, the distance between the center 18b of the outer peripheral circle and the rotational center 14b is equal to or less than a predetermined length means that the distance between the center 18b and the rotational center 14b is within 10 μm , desirably within 5 μm . On the other hand, a region different from the positioning region 18a₁, of the through-hole 18a, is an allowance region 18a₂ where a length from the center 18b of the outer peripheral circle

to the inner peripheral circle of the through-hole 18a is longer than the radius r_1 of the first boss section 16a.

The allowance region 18a₂ is a region that does not make contact with the first boss section 16a when the first boss section 16a is inserted into the through-hole 18a in the state in which the cutout 18d is adjusted to the predetermined orientation and the cutting blade 18 is disposed on the first boss section 16a. Note that, as illustrated in FIG. 4C, in the present embodiment, a length of the allowance region 18a₂ on a straight line passing through the centers 18b and 18c is an allowance width B. With the allowance region 18a₂ provided, the first boss section 16a can be inserted into the through-hole 18a easily, as compared to the case where a play amount of the through-hole 18a relative to the outside diameter of the first boss section 16a is set as small as possible.

Incidentally, in the case where the cutout 18d is not provided, a deviation in weight balance may be generated due to a misregistration between the center 18b of the outer peripheral circle of the cutting blade 18 and the center 18c of the inner peripheral circle (the circle of the inner periphery) of the cutting blade 18, namely, due to a misregistration between the center 18b

of the outer peripheral circle and the center 18c of the inner peripheral circle. However, with the cutout 18d provided, the deviation in weight balance generated in the surroundings of the center 18b can be adjusted. In other words, the cutout 18d functions as a weight adjusting section, in addition to a mark section.

Note that, in the case where the cutting blade 18 is inserted in the first boss section 16a and is fixed by sandwiching between the flange section 16b and the presser flange section 24, the cutout 18d is located on the inside (namely, on the side of the center axis of the first boss section 16a) relative to the outer peripheral edges of the annular surface 16c and the annular surface 24a. Therefore, the cutout 18d does not make contact with the workpiece 11 when the workpiece 11 is cut by the cutting blade 18, and, therefore, the cutout 18d does not directly influence the cutting.

Next, a method of manufacturing the cutting blade 18 in the present embodiment will be described below. For example, in the case where the cutting blade 18 is a hubless blade using a resin bond, a mixture of abrasive grains and a resin and the like is placed and molded in a mold having an annular space in which the center of an inner peripheral circle and the center of an outer

peripheral circle are deviated from each other by a predetermined length, whereby an annular molded body is obtained. Next, the molded body is baked to obtain a baked body. Then, a laser beam of such a wavelength as to be absorbed in the baked body is applied to a part in a vicinity of the inner periphery of the baked body, to remove a part of the inner peripheral region of the baked body. As a result, the cutting blade 18 formed with the cutout 18d is manufactured.

Next, a method of using the cutting blade 18 of the present embodiment will be described below. First, the first boss section 16a is inserted into the through-hole 18a of the cutting blade 18 in such a manner that the cutout 18d of the cutting blade 18 coincides with a top portion of the first boss section 16a, whereby the cutting blade 18 is disposed on the first boss section 16a (insertion step S10). After the insertion step S10, the first boss section 16a is inserted into the presser flange section 24, and the fixing nut 26 is fastened to the male screw 16g. As a result, the cutting blade 18 is mounted to the spindle 14 (mounting step S20).

In this instance, the center 18b of the outer peripheral circle of the cutting blade 18 coincides substantially with the rotational center 14b of the

spindle 14. Therefore, after the mounting step S20, it is unnecessary to reshape the cutting blade 18 (namely, truing) in such a manner that the outer peripheral circle of the cutting blade 18 becomes a perfect circle relative to the rotational center 14b. Thus, generation of roundness is unnecessary in the case of using the cutting blade 18, so that wear and tear of the cutting blade 18 can be restrained. It is to be noted, however, that in the case where the cutting blade 18 has not been subjected to setting, an outer peripheral portion of the cutting blade 18 may be dressed for the purpose of setting. Thereafter, as has been described referring to FIG. 1, the workpiece 11 is cut by the cutting unit 10 (first cutting step S30).

After the first cutting step S30, for example, an already partially processed workpiece 11 or other workpiece 11 may be cut by different kinds of hubless blades. In this case, the fixing nut 26 and the presser flange section 24 are sequentially detached, and the cutting blade 18 is detached from the mount 16. Then, a predetermined hubless blade is mounted to the mount 16 (replacement step S40). After the replacement step S40, an already partially processed workpiece 11 or other workpiece 11 is cut by the thus replaced predetermined

hubless blade (second cutting step S50).

Incidentally, after the second cutting step S50, the cutting blade 18 may be reused. In this case, the first boss section 16a is again inserted into the through-hole 18a of the cutting blade 18 in such a manner that the cutout 18d coincides with a top portion of the first boss section 16a, to thereby set the cutting blade 18 at the first boss section 16a (reinsertion step S60). After the reinsertion step S60, the cutting blade 18 is fixed to the spindle 14 by the presser flange section 24 and the fixing nut 26 (remounting step S70). Even after the remounting step S70, generation of roundness is unnecessary. Thus, with the cutting blade 18 used, wear and tear due to generation of roundness each time of the mounting step can be avoided, so that the life of the cutting blade 18 can be extended as compared to an ordinary hubless blade.

Next, a second embodiment will be described below. FIG. 5A is a front view of a cutting blade 28 according to the second embodiment. Note that the same components as those in the first embodiment above are denoted by the same reference symbols as used above. The cutting blade 28 does not have the cutout 18d, but has a V-shaped mark (mark section) 28a indicative of an orientation of the

cutting blade 28 relative to the mount 16. A region of the inner periphery corresponding to the mark 28a functions as the aforementioned positioning region 18a₁. While the mark 28a is formed, for example, by using an ink such as a pigment ink or a dye ink, the mark 28a may be also formed by partly removing the other surface side of the cutting blade 28 and forming ruggedness on the other surface side.

In addition, the cutting blade 28 further includes a thin section (weight adjusting section) 28b. The thin section 28b is disposed on the side opposite to the aforementioned deviation direction, is a region on the outer peripheral side of the cutting blade 28 relative to the mark 28a, is not used as a cutting edge, and is formed in such a region as not to make contact with the workpiece 11. With the thin section 28b provided, the deviation in weight balance generated in the surrounding of the center 18b of the outer peripheral circle of the cutting blade 28 due to the misregistration between the center 18b of the outer peripheral circle and the center 18c of the inner peripheral circle can be adjusted. In this way, the mark 28a and the thin section 28b play the same role as the cutout 18d. Note that the thin section 28b may be provided on the other surface side of the

cutting blade 28 formed with the mark 28a or may be formed on one surface side located on the side opposite to the other surface of the cutting blade 28.

In the case where the insertion of the first boss section 16a into the cutting blade 28 is made to fix the cutting blade 28 in the state of being sandwiched between the flange section 16b and the presser flange section 24, the mark 28a and the thin section 28b are located on the inner side than the outer peripheral edges of the annular surface 16c and the annular surface 24a. Therefore, the mark 28a and the thin section 28b do not make contact with the workpiece 11, so that the mark 28a and the thin section 28b do not directly influence the cutting.

In the second embodiment, also, the center 18b of the outer peripheral circle of the cutting blade 28 can be made to coincide with the rotational center 14b of the spindle 14 by using the mark 28a. Therefore, generation of roundness is also unnecessary for the cutting blade 28, so that wear and tear of the cutting blade 28 can be restrained. Besides, also in the second embodiment, with the allowance region 18a₂ provided, the first boss section 16a can be inserted into the through-hole 18a of the cutting blade 28 easily, as compared to the case where the play amount of the through-hole 18a relative to the

outside diameter of the first boss section 16a is made as small as possible.

Next, a third embodiment will be described below. FIG. 5B is a front view of a cutting blade 38 according to the third embodiment. Note that the same components as those in the first and second embodiments above are denoted by the same reference symbols as used above. The cutting blade 38 has the aforementioned mark 28a. In addition, the cutting blade 38 has small cutouts 38a smaller in size than the aforementioned cutout 18d. In the present embodiment, two small cutouts 38a are disposed in the edge of the through-hole 18a, specifically at positions in line symmetry with respect to a straight line passing through the centers 18b and 18c.

The two small cutouts 38a are disposed on the side opposite to the aforementioned deviation direction in relation to the center 18b of the outer peripheral circle. The two small cutouts 38a function as a weight adjusting section for adjusting the deviation in weight balance generated in the surrounding of the center 18b of the outer peripheral circle of the cutting blade 28. In the case where the insertion of the first boss section 16a into the cutting blade 38 is made to fix the cutting

blade 38 in the state of being sandwiched between the flange section 16b and the presser flange section 24, the mark 28a and the small cutouts 38a are located on the inner side than the outer peripheral edges of the annular surface 16c and the annular surface 24a. Therefore, the mark 28a and the small cutouts 38a do not make contact with the workpiece 11, so that the mark 28a and the small cutouts 38a do not directly influence the cutting.

In the third embodiment, also, the center 18b of the outer peripheral circle of the cutting blade 38 can be made to coincide with the rotational center 14b of the spindle 14 by using the mark 28a. Therefore, generation of roundness is also unnecessary for the cutting blade 38, so that wear and tear of the cutting blade 38 can be restrained. Besides, also in the third embodiment, with the allowance region 18a₂ provided, the first boss section 16a can be inserted into the through-hole 18a of the cutting blade 38 easily, as compared to the case where the play amount of the through-hole 18a relative to the outside diameter of the first boss section 16a is made as small as possible.

Next, a fourth embodiment will be described below. FIG. 6 is a front view of a cutting blade 48 according to the fourth embodiment. Note that the same components as

those in the first, second, and third embodiments above are denoted by the same reference symbols as used above. The cutting blade 48 has two small cutouts 38a. In addition, the cutting blade 48 has a small cutout 48a smaller than the aforementioned cutout 18d, at substantially the same position as the cutout 18d. Of an arch-shaped curve defining the small cutout 48a, two end portions located on the inner peripheral circle of the cutting blade 48 function as the aforementioned positioning regions 18a₁.

Besides, the small cutout 48a functions as a mark section indicative of the orientation of the cutting blade 18 relative to the mount 16, at the time of mounting the cutting blade 48 to the mount 16, and, like the small cutouts 38a, functions also as a weight adjusting section. In the case where the insertion of the first boss section 16a into the cutting blade 48 is made to fix the cutting blade 48 in the state of being sandwiched between the flange section 16b and the presser flange section 24, the small cutouts 38a and 48a are located on the inner side than the outer peripheral edges of the annular surface 16c and the annular surface 24a. Therefore, the small cutouts 38a and 48a do not make contact with the workpiece 11, so that the small cutouts

38a and 48a do not directly influence the cutting.

In the fourth embodiment, also, the center 18b of the outer peripheral circle of the cutting blade 48 can be made to coincide with the rotational center 14b of the spindle 14, by using the small cutout 48a. Therefore, generation of roundness is also unnecessary for the cutting blade 48, so that wear and tear of the cutting blade 48 can be restrained. In addition, also in the fourth embodiment, with the allowance region 18a₂ provided, the first boss section 16a can be inserted into the through-hole 18a of the cutting blade 48 easily, as compared to the case where the play amount of the through-hole 18a relative to the outside diameter of the first boss section 16a is made as small as possible.

In addition, the structures, methods and the like according to the above embodiments can be modified as required insofar as the modifications do not depart from the scope of the object of the present invention. The mark 28a is not limited to the examples shown in FIGS. 5A and 5B. In other words, the position, size, number, shape and the like of the mark 28a are not limited, insofar as the positioning region 18a₁ in consideration of the misregistration between the center 18b of the outer peripheral circle and the center 18c of the inner

peripheral circle can be specified. Note that the mark 28a is not limited to the case of being visually confirmed by the operator, but may be read by a reading apparatus (not illustrated) including a camera or the like. In addition, the position, size, number, shape and the like of the small cutouts 38a are also limited to the examples depicted in FIGS. 5 and 6.

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. An annular cutting blade having a through-hole and used at a time of cutting a workpiece, the cutting blade comprising:

a mark section indicative of an orientation of the cutting blade when a cylindrical boss section provided in a mount fixed to one end portion of a spindle is inserted into the through-hole of the cutting blade,

wherein an inner periphery of the cutting blade corresponding to an edge of the through-hole includes

a positioning region where a length from a center of an outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is equal to a radius of the boss section, and

an allowance region which is located in a region different from the positioning region and where the length from the center of the outer peripheral circle of the cutting blade to the inner periphery of the cutting blade is longer than the radius of the boss section, and,

when the cutting blade is disposed on the boss section by inserting the boss section into the through-hole while the mark section is adjusted to a predetermined orientation, a distance between a

rotational center of the boss section and the center of the outer peripheral circle of the cutting blade is equal to or less than a predetermined length.

2. The cutting blade according to claim 1, wherein the mark section is provided in such a manner as to cut out the cutting blade from the inner periphery of the cutting blade toward an outer periphery of the cutting blade.

3. The cutting blade according to claim 1, further comprising:

a weight adjusting section for adjusting a deviation in weight balance generated due to misregistration between the center of the outer peripheral circle of the cutting blade and a center of a circle of the inner periphery of the cutting blade.

4. The cutting blade according to claim 3, wherein the weight adjusting section is a cutout section provided in such a manner as to cut out the cutting blade from the inner periphery of the cutting blade toward an outer periphery of the cutting blade.