

CUTTING BLADE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a cutting blade for use in cutting a workpiece.

Description of the Related Art

A plurality of device chips with devices included separately in the respective device chips is manufactured by dividing and singulating a wafer on which the devices are formed. Further, a package substrate is obtained by mounting the plurality of device chips on a predetermined substrate and packaging the mounted device chips with an encapsulant (molding resin) made of resin. A plurality of package devices with the packaged device chips included separately in the respective package devices is then manufactured by dividing and singulating the package substrate. Device chips and package devices are incorporated in various kinds of electronic equipment such as mobile phones and personal computers.

For dividing a workpiece such as the above-described wafer or package substrate, a cutting apparatus is used. The cutting apparatus includes a chuck table that holds the workpiece thereon, and a cutting unit that

applies cutting processing to the workpiece, and an annular cutting blade is mounted on the cutting unit to cut the workpiece. By rotating the cutting blade and allowing the cutting blade to cut in the workpiece held on the chuck table, the workpiece is cut and divided.

As the cutting blade to be mounted on the cutting apparatus, a hub-type cutting blade (hub blade) or a washer-type cutting blade (washer blade) is used. The hub blade is a cutting blade in which an annular hub and an annular cutting blade formed along an outer peripheral edge of the hub are integrated. On the other hand, the washer blade is a cutting blade configured of an annular cutting blade alone. When cutting a workpiece, an appropriate blade is selected according to the material, processing conditions, and the like of the workpiece.

The cutting unit of the cutting apparatus includes a spindle that functions as a rotating shaft, and a mount fixed on a distal end portion of the spindle, and the cutting blade is mounted on the mount. Described specifically, the hub blade is mounted on the mount such that a support shaft (boss portion) for the mount is inserted in an opening formed in the hub and the cutting blade. On the other hand, the washer blade is held between the mount and a fixing member called a

"detachable flange," whereby the washer blade is mounted on the mount.

The hub blade and the washer blade are different in construction, shape, dimensions, and the like, and are also different in the mounting method on the mount. When replacing, for example, the hub blade, which is mounted on the cutting unit, with the washer blade, a need also arises for work to replace a hub blade mount with a washer blade mount. Blade replacement work therefore requires labor and time.

A method has hence been proposed to simplify the replacement work of a cutting blade by using a cutting blade (hubbed blade) in which a washer blade is integrated with an annular hub (see JP 2012-135833A). Use of this hubbed blade enables to mount a washer blade on a hub blade mount, and hence obviates the replacement work of the mount.

SUMMARY OF THE INVENTION

The above-described hubbed blade is manufactured by joining the annular hub and the annular blade (washer blade) together. Described specifically, the hub and the blade which is greater in outer diameter than the hub are separately and independently formed, and are then bonded

together between first surfaces thereof via an adhesive. As a consequence, the hub and the blade are joined together with the blade protruding at an outer peripheral portion thereof from an outer peripheral edge of the hub, thereby obtaining a cutting blade (hubbed blade) that can cut a workpiece with the outer peripheral portion of the blade.

Depending on the materials of the hub and the blade and the material of the adhesive, however, the joining between the hub and the blade may not be provided with a sufficient strength. If a workpiece is cut using a hubbed blade of such a quality, the blade may come off and separate from the hub by loads applied to the outer peripheral portion of the blade, thereby possibly causing a processing failure, breakage of the blade, and/or the like.

With the foregoing problem in view, the present invention has as an object thereof the provision of a cutting blade that can provide an improved joining strength between a hub and a blade.

In accordance with an aspect of the present invention, there is provided a cutting blade including an annular hub, and an annular blade. The hub and the blade are joined together between first surfaces thereof via an

adhesive. The blade has a first region including an outer peripheral edge of the blade, and a second region inside the first region. The first region has first recessed portions existing in the first surface of the blade. The second region has, in the first surface of the blade, second recessed portions having a greater width than that of the first recessed portions existing in the first surface. The adhesive is in contact with the second region of the blade.

Preferably, the second recessed portions may have a width of 20 μm or greater and 100 μm or smaller. Also preferably, the hub may include, on the first surface thereof, a region in which recessed portions are formed, and the adhesive may be also in contact with the region of the hub. Also preferably, the blade may include abrasive grits, and a bonding material fixing the abrasive grits, and the bonding material may be a resin bond, a metal bond, or a vitrified bond.

In the cutting blade according to the aspect of the present invention, the second region of the blade has, in the first surface thereof, the second recessed portions having the greater width than that of the first recessed portions existing in the first surface in the first region, and the adhesive is in contact with the second

region of the blade. Owing to these features, an increased area of contact is provided between the blade and the adhesive, whereby an improved joining strength can be provided between the hub and the blade.

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 an exploded perspective view depicting a cutting blade according to an embodiment of the present invention;

FIG. 2A is a plan view depicting a blade of the cutting blade of FIG. 1;

FIG. 2B is an enlarged fragmentary cross-sectional view depicting a first region of the blade of FIG. 2A;

FIG. 2C is an enlarged fragmentary cross-sectional view depicting a second region of the blade of FIG. 2A;

FIG. 3A is a perspective view depicting the cutting blade of FIG. 1;

FIG. 3B is a cross-sectional view depicting the cutting blade of FIG. 1;

FIG. 4 is an enlarged fragmentary cross-sectional view depicting the cutting blade of FIG. 1 with a hub and the blade joined together via an adhesive;

FIG. 5A is a plan view depicting a modification of the blade of the cutting blade of FIG. 1, the blade including a plurality of second recessed portions (slits) formed in a concentric pattern;

FIG. 5B is a plan view depicting another modification of the blade of the cutting blade of FIG. 1, the blade including a plurality of radially formed second recessed portions (slits);

FIG. 6A is a plan view depicting a modification of the hub of the cutting blade of FIG. 1, the hub including a recessed-projected region (dimpled region);

FIG. 6B is an enlarged fragmentary cross-sectional view depicting the recessed-projected region (dimpled region) of the hub of FIG. 6A;

FIG. 7 is an enlarged fragmentary cross-sectional view depicting a cutting blade in which the hub of FIGS. 6A and 6B, which includes the recessed-projected region (dimpled region), and the blade of FIGS. 1 to 4 are joined together via the adhesive;

FIG. 8 is an exploded perspective view depicting a cutting blade which is similar to the cutting blade of FIG. 1 and includes another modification of the hub of the cutting blade of FIG. 1 that includes recessed portions in a shape of a groove;

FIG. 9 is a cross-sectional view depicting the cutting blade of FIG. 8 which has the hub including the recessed portions in the shape of the groove;

FIG. 10 is a perspective view depicting a cutting apparatus on which the cutting blade of the present invention, specifically, the cutting blade of FIG. 1 is mounted; and

FIG. 11 is a perspective view depicting a cutting unit of the cutting apparatus of FIG. 10, the cutting blade of FIG. 1 being mounted on the cutting unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the attached drawings, an embodiment of the present invention will hereinafter be described. A description will first be made about a configuration example of a cutting blade 2 according to the present embodiment. FIG. 1 is an exploded perspective view depicting the cutting blade 2. The cutting blade 2 includes an annular hub 4 and an annular blade 6, and is

a hubbed blade formed by integrating the hub 4 and the blade 6 together.

The hub 4 is made, for example, of a metal such as an aluminum alloy, and includes a first surface (front surface) 4a and a second surface (back surface) 4b, which are substantially parallel to each other, and an outer peripheral edge (outer peripheral surface) 4c. At a central portion of the hub 4, a cylindrical opening 4d is formed extending through the hub 4 in a thickness direction from the first surface 4a to the second surface 4b.

The blade 6 is a washer blade formed in an annular shape, and contains abrasive grits made of diamond, cubic boron nitride (CBN), or the like and a bonding material fixing the abrasive grits. As the bonding material, a resin bond, a metal bond, or a vitrified bond is used, for example. The material and grit size of the abrasive grits and the material and the like of the bonding material, both contained in the blade 6, can be selected as needed according to the specification of the cutting blade 2. A description will hereinafter be made primarily assuming a case in which the blade 6 is a blade (resin bond blade) in which abrasive grits are fixed with a resin bond.

The blade 6 includes a first surface (front surface) 6a and a second surface (back surface) 6b, which are substantially parallel to each other, and an outer peripheral edge (outer peripheral surface) 6c extending to the first surface 6a and the second surface 6b. At a central portion of the blade 6, a cylindrical opening 6d is formed extending through the blade 6 in a thickness direction from the first surface 6a to the second surface 6b. The opening 6d defines a side surface (inner peripheral surface) of the blade 6 which is exposed inside the opening 6d.

FIG. 2A is a plan view depicting the blade 6 of the cutting blade 2 of FIG. 1. The blade 6 has a first region 8 including the outer peripheral edge 6c of the blade 6, and a second region 10 inside the first region 8. For example, the first region 8 is an annular region which is located along the outer peripheral edge 6c and which has a predetermined width (length in a radial direction of the blade 6), and is equivalent to an outer peripheral portion of the blade 6. Further, the second region 10 is, for example, an annular region which is located inside the first region 8 in the radial direction of the blade 6 and outside the opening 6d in the radial direction of the blade 6 and which has a predetermined width (length in

the radial direction of the blade 6). The second region 10 has an outer diameter set, for example, to substantially the same as an outer diameter of the hub 4 (the diameter of the outer peripheral edge 4c, see FIG. 1).

The first surface 6a of the blade 6 is a planar surface formed substantially flat. However, the first surface 6a of the blade 6 may reflect fine recesses and projections existing on a surface of the bonding material of the blade 6, and also fine machining marks (scars) and the like formed in a forming step of the blade 6. In other words, fine recesses and projections may be formed on the first surface 6a of the blade 6, so that the first surface 6a of the blade 6 may not be a complete planar surface.

FIG. 2B is an enlarged fragmentary cross-sectional view depicting the first region 8 of the blade 6 of FIG. 2A. As depicted in FIG. 2B, undeliberately formed first recesses 8a (first recessed portions) may exist in the first surface 6a in the first region 8. However, the first recesses 8a are minute relative to the thickness of the blade 6, and practically do not affect the strength of the blade 6. In the second region 10 of the blade 6, on the other hand, recesses and projections are

deliberately formed. As will be described subsequently herein, the second region 10 is equivalent to a region with which an adhesive comes into contact to join the hub 4 and the blade 6 together. The formation of such recesses and projections in the second region 10 can therefore provide an increased area of contact between the blade 6 and the adhesive, thereby enabling to improve the adhesive strength of the adhesive to the blade 6.

FIG. 2C is an enlarged fragmentary cross-sectional view depicting the second region 10 of the blade 6 of FIG. 2A. In the first surface 6a in the second region 10, a plurality of second recesses 10a (specifically, dimples; second recessed portions) is formed. The second recesses 10a are greater than the first recesses 8a (see FIG. 2B) existing in the first surface 6a in the first region 8. The second recesses 10a are formed over the entirety of the second region 10. The second recesses 10a may be uniform or random in dimensions. Further, the second recesses 10a may be formed in a periodic pattern at predetermined intervals, or may be formed at random intervals.

The second recesses 10a are formed, for example, by applying laser processing to the first surface 6a in the second region 10. Described specifically, with a focal

point of a pulsed laser beam positioned at the first surface 6a in the second region 10, the blade 6 is moved relative to the pulsed laser beam at a predetermined speed along a direction parallel to the first surface 6a of the blade 6, and is hence scanned with the pulsed laser beam. As a consequence, the second recesses 10a are formed in a periodic pattern at predetermined intervals. However, no limitation is imposed on the forming method of the second recesses 10a. For example, the second recesses 10a can also be formed by fracturing processing which physically fractures the surface of the blade 6. Examples of the fracturing processing include sand blasting processing which blows an abrasive material against the blade 6, water jet processing which ejects a pressurized liquid such as water against the blade 6, and the like. As a further alternative, the second recesses 10a may also be formed by applying a chemical treatment (wet etching or the like) to the blade 6.

The second recesses 10a have a width W greater than that of the fine first recesses 8a (see FIG. 2B) existing without deliberation in the first surface 6a of the blade 6. The second recesses 10a have a width W that is, for example, twice or greater than the width of the first recesses 8a. Described specifically, the fine first

recesses 8a existing in the first region 8 often has a width of 10 μm or smaller, and the second recesses 10a have a width W set, for example, at 20 μm or greater and 100 μm or smaller. It is to be noted that all the second recesses 10a are not required to have a width greater than the width of the first recesses 8a. In other words, the widths W of the second recesses 10a are required to have an average value greater than the average value of the widths of the first recesses 8a. On the other hand, the second recesses 10a have a depth D equal to or greater than that of the first recesses 8a, preferably. For example, the depth D of the second recesses 10a is 5 μm or greater and 10 μm or smaller, and is greater than the depth of the first recesses 8a. Further, the first surface 6a in the second region 10 has a surface roughness which is preferably equal to or greater than the surface roughness of the first surface 6a in the first region 8. For example, the surface roughness (Ra) of the first surface 6a in the second region 10 is greater than the surface roughness (Ra) of the first surface 6a in the first region 8.

As described above, the blade 6 with the second recesses 10a formed in the second region 10 is joined to the hub 4. Described specifically, the adhesive is first

applied to the first surface 6a in the second region 10 of the blade 6. As depicted in FIG. 1, the first surface 4a of the hub 4 and the first surface 6a of the blade 6 are then brought into a face-to-face relation, and are bonded together via the adhesive. As a consequence, the hub 4 and the blade 6 are joined and integrated together, so that the cutting blade 2 is formed. It is to be noted that the adhesive may also be applied to a region of the first surface 4a of the hub 4, the region corresponding to the second region 10 of the blade 6.

FIG. 3A is a perspective view depicting the cutting blade 2 of FIG. 1, and FIG. 3B is a cross-sectional view depicting the cutting blade 2 of FIG. 1. The hub 4 and the blade 6 are bonded together such that their center positions coincide each other, and are concentrically arranged. The blade 6 has an outer diameter (the outer peripheral edge 6c has a diameter) greater than the outer diameter of the hub 4 (the diameter of the outer peripheral edge 4c). The outer peripheral portion of the blade 6 therefore protrudes from the outer peripheral edge 4c of the hub 4 outwardly in a radial direction of the hub 4 when the hub 4 and the blade 6 are bonded together. Further, the blade 6 has an inner diameter (the opening 6d has a diameter) equal to or greater than an

inner diameter of the hub 4 (the diameter of the opening 4d). Therefore, the opening 4d of the hub 4 is in an exposed state without being covered by the blade 6.

FIG. 4 is an enlarged fragmentary cross-sectional view depicting the cutting blade 2 of FIG. 1 with the hub 4 and the blade 6 joined together via an adhesive 12. It is to be noted that depiction of the first recesses 8a (see FIG. 2B) existing in the first region 8 of the blade 6 is omitted in FIG. 4 because the first recesses 8a are fine. The hub 4 and the blade 6 are bonded together via the adhesive 12 applied to the first surface 4a of the hub 4 or the first surface 6a of the blade 6. No limitation is imposed on the material of the adhesive 12, and an epoxy resin-based adhesive can be used, for example. The adhesive 12 is held between the hub 4 and the blade 6, and is brought into contact with the first surface 4a of the hub 4 and the first surface 6a in the second region 10 of the blade 6.

When the adhesive 12 comes into contact with the first surface 6a in the second region 10 of the blade 6, the adhesive 12 enters and fills up the second recesses 10a. As a result, the adhesive 12 comes into contact with the entirety of inner walls of the second recesses 10a. The formation of the second recesses 10a in the first

surface 6a of the blade 6 therefore provides an increased area of contact between the blade 6 and the adhesive 12 compared with a case in which the first surface 6a is a planar surface. Owing to the increased area of contact, the adhesive strength of the adhesive 12 to the blade 6 can be improved. It is to be noted that, even if the adhesive 12 also enters the first recesses 8a (see FIG. 2B) existing without deliberation in the first surface 6a of the blade 6, no substantial change occurs in the area of contact between the blade 6 and the adhesive 12 because the first recesses 8a are fine. Further, the first recesses 8a are small in width, so that the adhesive 12 is hard to enter the first recesses 8a and may not fill the first recesses 8a. On the other hand, the width W of the second recesses 10a is greater than that of the first recesses 8a. Therefore, the adhesive 12 readily enters and fills the second recesses 10a, and is assured to come into contact with the inner walls of the second recesses 10a.

The area of contact between the blade 6 and the adhesive 12 increases, as the second recesses 10a become deeper and the surface roughness of the first surface 6a in the second region 10 becomes greater. If the depth D of the second recesses 10a is excessively large relative

to the width W of the second recesses 10a, however, the blade 6 is reduced in strength, and therefore becomes prone to breakage. Therefore, the depth D of the second recesses 10a is preferably one-third or smaller than the width W of the second recesses 10a, with one-tenth or smaller being more preferred.

In the cutting blade 2 according to the present embodiment as described above, the first surface 6a in the second region 10 of the blade 6 is provided with the second recesses 10a greater in width than the first recesses 8a existing in the first surface 6a in the first region 8, and the adhesive 12 comes into contact with the second region 10 of the blade 6. As a consequence, the area of contact between the blade 6 and the adhesive 12 is increased, thereby enabling to improve the joining strength between the blade 6 and the adhesive 12.

It is to be noted that no limitation is imposed on the shape of the second recesses 10a (see FIG. 2C) formed in the second region 10 of the blade 6. For example, the second recesses 10a may be formed in a polygonal prism shape or a cylindrical shape, or may be formed in a polygonal pyramidal shape or a conical shape such that the second recesses 10a have a greater width toward the first surface 6a. Further, the second recesses 10a may be

continuously formed in the shape of a plurality of lines (strips) in the second region 10 of the blade 6.

FIG. 5A is a plan view depicting a blade 66 as a modification of the blade 6 of the cutting blade 2 of FIG. 1, the blade 66 including a plurality of slits 60a (second recessed portions) formed in a concentric pattern. Further, FIG. 5B is a plan view depicting a blade 76 as another modification of the blade 6 of the cutting blade 2 of FIG. 1, the blade 76 including a plurality of slits 70a (second recessed portions) formed radially. It is to be noted that, in FIGS. 5A and 5B, a position corresponding to the outer peripheral edge 4c of the hub 4 (see FIG. 1) is indicated by a circle of broken line.

As depicted in FIG. 5A, the slits 60a are formed in a first surface 66a in a second region 60. The slits 60a have different diameters, respectively, and are formed in concentric circles about a common center. It is to be noted that no limitations are imposed on the number and intervals of the slits 60a. FIG. 5A also depicts an outer peripheral edge (outer peripheral surface) 66c, an opening 66d, and a first region 68 of the blade 66. As depicted in FIG. 5B, on the other hand, the slits 70a are formed in straight lines on a first surface 76a in a

second region 70. The slits 70a are formed extending from an opening 76d toward an outer peripheral edge 76c along a radial direction of the blade 76, and are arranged at substantially equal intervals along a peripheral direction of the blade 76. It is to be noted that no limitations are imposed on the number and intervals of the slits 70a. Dimensions of the slits 60a and 70a are set similar to those of the second recesses (specifically, the dimples) 10a (see FIG. 2C). Therefore, the slits 60a and 70a are greater in width than the first recesses 8a (see FIG. 2B). FIG. 5B also depicts a first region 78.

Recesses and projections may also be formed on the hub 4 in addition to the blade 6. FIG. 6A is a plan view depicting a hub 84 as a modification of the hub 4 of the cutting blade 2 of FIG. 1, the hub 84 including a region with recesses and projections formed therein (specifically, a dimpled region; recessed-projected region) 84A. The dimpled region 84A is an annular region of the hub 84, where the hub 84 is joined with the blade 6. In a first surface 84a in the dimpled region 84A, the projections and recesses are formed deliberately. FIG. 6A also depicts an outer peripheral edge (outer peripheral surface) 84c and an opening 84d. FIG. 6B is an enlarged

fragmentary cross-sectional view depicting the dimpled region 84A of the hub 84. In the first surface 84a in the dimpled region 84A, a plurality of recesses (specifically, dimples; recessed portions) 84B is formed over the entirety of the dimpled region 84A. The recesses 84B are similar in dimensions, shape, forming method, and the like to the second recesses 10a (see FIG. 2C) formed in the blade 6.

FIG. 7 is an enlarged fragmentary cross-sectional view depicting a cutting blade 2A in which the hub 84 of FIGS. 6A and 6B, which includes the recesses 84B, and the blade 6 of FIGS. 1 to 4, which includes the second recesses 10a, are joined together via the adhesive 12. When the hub 84 and the blade 6 are bonded together via the adhesive 12, the adhesive 12 comes into contact with the first surface 84a in the dimpled region 84A of the hub 84 and the first surface 6a in the second region 10 of the blade 6. The adhesive 12 then enters and fills up the recesses 84B and the second recesses 10a. If the recesses 84B are formed in the first surface 84a of the hub 84 as described above, an increased area of contact is provided between the hub 84 and the adhesive 12 compared with a case in which the first surface 84a is a planar surface. Owing to the increased area of contact,

the adhesive strength of the adhesive 12 to the hub 84 can be improved.

Further, the construction of the hub 4 can be changed as needed insofar as the blade 6 can be supported by the hub 4. FIG. 8 is an exploded perspective view depicting a cutting blade 2B which is similar to the cutting blade 2 of FIG. 1 and includes a hub 94 as another modification of the hub 4 of FIG. 1 that includes recessed portions, which are to be filled with the adhesive, in a shape of a groove 94f.

On a first surface (front surface) 94a of the hub 94 depicted in FIG. 8, a raised portion 94e is disposed extending from the first surface 94a. For example, the raised portion 94e is formed in an annular shape concentrically with an opening 94d, and is arranged in a region outside the opening 94d in a radial direction of the hub 94 such that the raised portion 94e surrounds the opening 94d. In the first surface 94a of the hub 94, the groove 94f is also disposed. For example, the groove 94f is formed in an annular shape concentrically with the opening 94d and raised portion 94e, and is arranged in a region outside the raised portion 94e in the radial direction of the hub 94 such that the groove 94f surrounds the opening 94d and raised portion 94e. In

addition, a support surface 94g is also arranged on an outer peripheral portion of the hub 94. The support surface 94g is a planar surface substantially in parallel to the first surface 94a, and is formed in an annular shape along an outer peripheral edge 94c of the hub 94. For example, the support surface 94g is formed in an annular shape concentrically with the opening 94d, the raised portion 94e, and the groove 94f, and is arranged such that the support surface 94g surrounds the opening 94d, the raised portion 94e, and the groove 94f.

FIG. 9 is a cross-sectional view depicting the cutting blade 2B of FIG. 8 which has the hub 94 including the recessed portions in the shape of the groove 94f. The groove 94f includes a bottom surface 94h substantially parallel to the first surface 94a and the support surface 94g, a side surface (radially inner side wall) 94i located on a side of a center of the hub 94, and another side surface (radially outer side wall) 94j located on a side of the outer peripheral edge 94c of the hub 94. For example, the side surface 94i is formed substantially vertical to the bottom surface 94h, while the side surface 94j is formed to incline to the bottom surface 94h. Described specifically, the side surface 94j is formed with a diameter increasing from the bottom surface

94h toward the support surface 94g, and an end portion of the side surface 94j on a side of the support surface 94g is disposed on the side of the outer peripheral edge 94c of the hub 94 relative to an end portion of the side surface 94j on a side of the bottom surface 94h.

The adhesive 12 is applied in the groove 94f. Described specifically, the adhesive 12 is filled in the groove 94f such that the adhesive 12 reaches the same plane as the support surface 94g. When the first surface 94a of the hub 94 and the first surface 6a of the blade 6 are bonded together in this state, the raised portion 94e of the hub 94 is inserted into the opening 6d of the blade 6, and at the same time, the first surface 6a of the blade 6 is brought into contact with the support surface 94g. As a consequence, the blade 6 is supported by the raised portion 94e and the support surface 94g. In addition, the adhesive 12 filled in the groove 94f comes into contact with the first surface 6a of the blade 6, whereby the hub 94 and the blade 6 are bonded together via the adhesive 12.

The raised portion 94e of the hub 94 has an outer peripheral surface which is formed to correspond to the opening 6d of the blade 6. For example, the raised portion 94e is formed such that the outer peripheral

surface has a diameter substantially equal to that of the opening 6d and a shape substantially matching that of a contour of the opening 6d. When the raised portion 94e is inserted into the opening 6d, the hub 94 and the blade 6 are hence disposed in a predetermined positional relation. In other words, the alignment between the hub 94 and the blade 6 is automatically performed. In each of the bottom surface 94h, the side surface 94i, and the side surface 94j of the groove 94f, a plurality of recesses similar to the recesses 84B (see FIG. 6B) may be formed. Owing to these recesses, an increased area of contact is provided between the hub 94 and the adhesive 12, whereby the adhesive 12 can be provided with an improved joining strength to the hub 94. FIGS. 8 and 9 also depict a second surface (back surface) 94b of the hub 94.

The cutting blade according to the present invention, for example, the cutting blade 2 of FIG. 1 is mounted on a cutting apparatus, and is used in cutting a workpiece. A description will hereinafter be made about a configuration example of the cutting apparatus that cuts the workpiece with use of the cutting blade 2. FIG. 10 is a perspective view depicting a cutting apparatus 20 on which the cutting blade 2 of FIG. 1 is mounted for

cutting a workpiece 11. In FIG. 10, an X-axis direction (processing feed direction, first horizontal direction, front-rear direction) and a Y-axis direction (indexing feed direction, second horizontal direction, left-right direction) are orthogonal to each other. Further, a Z-axis direction (vertical direction, up-down direction, height direction) is orthogonal to the X-axis direction and Y-axis direction.

The workpiece 11 is, for example, a disc-shaped wafer made of a semiconductor such as silicon, and its front surface is defined into a plurality of rectangular or square regions by a plurality of streets (scribe lines) arranged in a grid pattern such that the streets intersect. In the regions of the workpiece 11 defined by the streets, devices such as integrated circuits (ICs), large scale integration (LSI) circuits, light emitting devices (LEDs), or micro electro mechanical systems (MEMSs) are formed, respectively. By dividing the workpiece 11 along the streets with the cutting apparatus 20, a plurality of device chips is manufactured including the devices, respectively. No limitations are imposed on the material, shape, structure, size, and the like of the workpiece 11. For example, the workpiece 11 may be a substrate (wafer) made of a semiconductor other than

silicon (GaAs, InP, GaN, SiC, or the like), sapphire, glass (quartz glass, borosilicate glass, or the like), ceramics, resin, or the like. As an alternative, the workpiece 11 may be a package substrate such as a chip size package (CSP) substrate or a quad flat non-leaded package (QFN) substrate.

The cutting apparatus 20 includes a bed 22 which supports or accommodates individual elements that make up the cutting apparatus 20. Above the bed 22, a cover 24 is disposed covering the bed 22 on a side of a top wall thereof. Inside the cover 24, there is formed a space (processing chamber) in which processing of the workpiece 11 is to be performed. In the processing chamber, a cutting unit 26 is disposed to cut the workpiece 11. To the cutting unit 26, ball screw type moving mechanisms (not depicted) are connected. These moving mechanisms move the cutting unit 26 along the Y-axis direction, and also lifts up or down the cutting unit 26 along the Z-axis direction. The cutting blade 2 is mounted on the cutting unit 26.

Below the cutting unit 26, a chuck table (holding table) 28 is disposed to hold the workpiece 11. The chuck table 28 has an upper surface which is a planar surface substantially parallel to the X-axis direction and the Y-

axis direction, and makes up a holding surface 28a on which the workpiece 11 is to be held. The holding surface 28a is connected to a suction source (not depicted) such as an ejector via a flow path (not depicted) formed inside the chuck table 28, a valve (not depicted), and the like. When a negative pressure is applied from the suction source to the holding surface 28a with the workpiece 11 placed on the holding surface 28a, the workpiece 11 is held under suction on the chuck table 28. To the chuck table 28, a further ball screw type moving mechanism (not depicted) is connected. This moving mechanism moves the chuck table 28 along the X-axis direction. To the chuck table 28, a rotary drive source (not depicted) such as a motor is also connected. This rotary drive source rotates the chuck table 28 about an axis of rotation which is substantially parallel to the Z-axis direction.

In a front corner section of the bed 22, a cassette elevator 30 is disposed. The cassette elevator 30 is configured to be movable up and down along the Z-axis direction. On the cassette elevator 30, a cassette 32 in which a plurality of workpieces 11 can be accommodated is mounted. The cassette elevator 30 adjusts the height (the position in the Z-axis direction) of the cassette 32 such

that unloading of each workpiece 11 from the cassette 32 and loading of each workpiece 11 into the cassette 32 can be appropriately performed. In a vicinity of the cassette elevator 30, a transfer mechanism (not depicted) is disposed to transfer each workpiece 11. For example, the transfer mechanism includes a suction pad that holds the workpiece 11 under suction, and transfers the workpiece 11 between the cassette 32 and the chuck table 28. Described specifically, the transfer mechanism unloads each unprocessed workpiece 11 from the cassette 32 and places it on the chuck table 28, and also transfers each processed workpiece 11 from the chuck table 28 and loads it into the cassette 32.

On a side of a front wall 24a of the cover 24, a display unit (display device) 34 is disposed to display various kinds of information regarding the cutting apparatus 20. The display unit 34 displays information (processing conditions, processing status, and the like) relating to the processing of the workpiece 11, an image of the workpiece 11 held on the chuck table 28, and so on. For example, the display unit 34 is configured of a touch screen. In this case, the display unit 34 functions as a user interface, so that an operator can input information such as processing conditions to the cutting

apparatus 20 through touch gestures on the display unit 34. In other words, the display unit 34 also functions as an input unit (input device) for inputting information to the cutting apparatus 20. However, the input unit may also be arranged separately and independently of the display unit 34. As such an input unit, a keyboard, a mouse, or the like can be used, for example.

Inside or outside the cutting apparatus 20, a control unit (control device) 36 is disposed to control the cutting apparatus 20. The control unit 36 is connected to the individual elements (the cutting unit 26, the chuck table 28, the cassette elevator 30, the display unit 34, and the like) that make up the cutting apparatus 20, and generates control signals for controlling operations of the individual elements. For example, the control unit 36 is configured of a computer, and includes a processing section that performs processing such as operation required for controlling the cutting apparatus 20 and a storage section that stores various kinds of information (data, programs, and so on) to be used in controlling the cutting apparatus 20. The processing unit is configured including a processor such as a central processing unit (CPU). On the other hand, the storage section is configured including memories such

as a read only memory (ROM) and a random access memory (RAM).

FIG. 11 is a perspective view depicting the cutting unit 26 of the cutting apparatus 20 of FIG. 10, the cutting blade 2 of FIG. 1 being mounted on the cutting unit 26. The cutting unit 26 includes a housing 40 formed in a hollow cylindrical shape. In the housing 40, a cylindrical spindle (rotating shaft) 42 disposed along the Y-axis direction is accommodated. The spindle 42 is exposed at a distal end portion thereof (on one end thereof) to an outside of the housing 40. To a proximal end portion (to a side of an opposite end) of the spindle 42, on the other hand, a rotary drive source (not depicted) such as a motor is connected to rotate the spindle 42.

On the distal end portion of the spindle 42, a mount 44 is fixed. The mount 44 includes a disc-shaped flange portion 46 and a cylindrical support shaft (boss portion) 48 that extends from a central portion of a surface 46a of the flange portion 46. On a side of the surface 46a of an outer peripheral portion of the flange portion 46, an annular raised portion 46b that protrudes from the surface 46a is disposed along an outer peripheral edge of the flange portion 46. The raised

portion 46b includes a distal end surface 46c on a side of a distal end thereof, and the distal end surface 46c is formed substantially parallel to the surface 46a. On an outer peripheral surface of the support shaft 48, a threaded portion 48a is formed. An annular fixture nut 50 is fastened on the support shaft 48. At a central portion of the fixture nut 50, a cylindrical opening 50a is formed extending in a thickness direction through the fixture nut 50. On a side surface (inner peripheral surface) of the fixture nut 50, the side surface being exposed inside the opening 50a, a thread groove is formed corresponding to the threaded portion 48a of the support shaft 48.

When the support shaft 48 is inserted into the opening 4d of the hub 4 of the cutting blade 2, the cutting blade 2 is mounted on the mount 44. In this state, the fixture nut 50 is fastened on the threaded portion 48a of the support shaft 48, whereby the blade 6 is held between the hub 4 and the distal end surface 46c of the raised portion 46b of the flange portion 46. As a consequence, the cutting blade 2 is fixed on the distal end portion (the mount 44) of the spindle 42. The cutting blade 2 is rotated about an axis of rotation which is substantially parallel to the Y-axis direction, by power

transmitted from the rotary drive source via the spindle 42 and the mount 44.

When the cutting blade 2 mounted on the cutting unit 26 is rotated and is allowed to cut in the workpiece 11 held on the chuck table 28 (see FIG. 10), the cutting blade 2 comes into contact with the workpiece 11 at the outer peripheral portion of the cutting blade 2, so that the workpiece 11 is cut. Because the hub 4 and the blade 6 are firmly joined together via the adhesive 12 (see FIG. 4 and so on) in the cutting blade 2 as described above, separation hardly occurs between the hub 4 and the blade 6 during the cutting of the workpiece 11. As a consequence, occurrence of a processing failure or breakage of the blade 6 is suppressed.

It is to be noted that the configurations, methods, and the like according to the above-described embodiment can be practiced with changes or modifications as needed to such extent as not departing from the scope of the object of the present invention.

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

by the invention.

WHAT IS CLAIMED IS:

1. A cutting blade comprising:
an annular hub; and
an annular blade,
wherein the hub and the blade are joined together
between first surfaces thereof via an adhesive,
the blade has a first region including an outer
peripheral edge of the blade, and a second region inside
the first region,
the first region has first recessed portions
existing in the first surface of the blade,
the second region has, in the first surface of the
blade, second recessed portions having a greater width
than that of the first recessed portions existing in the
first surface, and
the adhesive is in contact with the second region
of the blade.
2. The cutting blade according to claim 1, wherein
the second recessed portions have a width of 20 μm or
greater and 100 μm or smaller.
3. The cutting blade according to claim 1,
wherein the hub includes, on the first surface
thereof, a region in which recessed portions are formed,
and

the adhesive is also in contact with the region of the hub.

4. The cutting blade according to claim 1,
wherein the blade includes abrasive grits and a bonding material fixing the abrasive grits, and
the bonding material is a resin bond, a metal bond, or a vitrified bond.