

PROCESSING APPARATUS AND METHOD OF PROCESSING WAFER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a processing apparatus for processing a wafer having an outer circumferential ridge formed on a reverse side thereof by a circular recess defined in the reverse side of the wafer, and a method of processing a wafer using the processing apparatus.

Description of the Related Art

In a step of growing a metal film on a reverse side of a thinned wafer according to a step of processing a semiconductor wafer, there is concern that the wafer may be damaged for lack of enough mechanical strength of the wafer. To prevent the wafer from being damaged, there is known a technology where when the reverse side of the wafer is ground, an outer circumferential excess area thereof is not ground, but left as thick as the original wafer, leaving an outer circumferential ridge that acts as a stiffening portion.

For dicing the wafer into individual chips after the metal film has been grown on the wafer, since the wafer needs to be cut with its face side facing up, the

wafer is held on a holding table that is complementary in shape to the circular recess in the reverse side of the wafer that is surrounded by the outer circumferential ridge. JP 2010-016146A, for example, discloses a projected-type holding table having a disk-shaped porous suction region for fitting into the circular recess.

JP 2007-019379A reveals a technology where an area of a reverse side of a wafer that corresponds to a device zone is ground to form a circular recess therein, leaving an outer circumferential ridge, and after the device zone or reverse side of the wafer whose reverse side has been ground is additionally processed, the outer circumferential ridge is removed from the additionally processed wafer.

SUMMARY OF THE INVENTION

The width of the outer circumferential ridge that as the stiffening portion differs from wafer pattern to wafer pattern, i.e., from chip size to chip size or from device zone size to device zone size. With the projected-type holding table configuration according to JP 2010-016146A, it is necessary to fabricate holding tables for use with different wafers whose outer circumferential ridges have different widths, and it is burdensome and

tedious to manage those holding tables. Changing holding tables on a processing apparatus is time consuming and reduces the uptime of the processing apparatus.

The projected-type holding table may not be used if the wafer is cut while its reverse side is being exposed upwardly. However, the proposal is problematic in that since an image of the face side of the wafer cannot be captured by an infrared (IR) camera if a metal film is grown on the reverse side of the wafer, streets on the face side of the wafer cannot be detected and an alignment process cannot be performed on the wafer.

In view of the above problems, it may be proposed to grow no metal film on the upper end of the outer circumferential ridge and to capture an image of this area with an IR camera to detect streets. However, as the pattern accuracy on the outer circumferential portion is so low that it would be difficult to perform a highly accurate alignment process, the proposed solution would hardly be adopted.

After the outer circumferential ridge has been removed to planarize the reverse side of the wafer as disclosed in JP 2007-019379A, the wafer may be diced with the face side of the wafer oriented upwardly. This process dispenses with the use of a projected-type

holding table. However, it is necessary to affix a tape to the reverse side of the wafer in order to allow the exposed face side of the wafer to be processed. Since the outer circumferential ridge as the stiffening portion of the thinned wafer has been removed and hence the mechanical strength of the wafer has been reduced, the wafer may possibly run the risk of becoming damaged at the time the tape is affixed to the reverse side of the wafer.

It is therefore an object of the present invention to provide a processing apparatus and a method of processing a wafer having a circular recess and an outer circumferential ridge on a reverse side thereof, for allowing the wafer to be divided into individual device chips without dislodging the wafer from a holding table.

In accordance with an aspect of the present invention, there is provided a processing apparatus for processing a wafer having a face side including a device zone where a plurality of devices are formed in respective areas demarcated by a plurality of crossing streets and a reverse side including a recess defined therein that corresponds to the device zone and an outer circumferential ridge on the reverse side that surrounds the recess. The processing apparatus includes a rotatable

holding table having a holder made of a transparent material and holding the face side of the wafer, a lower image capturing camera for capturing an image of the face side of the wafer held on the holding table through the holder, a cutting mechanism including a first cutting unit having a first cutting blade for cutting the outer circumferential ridge on the reverse side of the wafer to reduce a height of the outer circumferential ridge, and a second cutting unit having a second cutting blade for cutting the wafer along the streets on the face side of the wafer whose image has been captured by the lower image capturing camera, and a moving mechanism for moving the holding table and the cutting mechanism relatively to each other.

Preferably, the processing apparatus further includes an upper image capturing camera for capturing the reverse side of the wafer held on the holding table.

In accordance with another aspect of the present invention, there is provided a method of processing a wafer, including a wafer preparing step of preparing a wafer having a face side including a device zone where a plurality of devices are formed in respective areas demarcated by a plurality of crossing streets and a reverse side including a recess defined therein that

corresponds to the device zone and an outer circumferential ridge on the reverse side that surrounds the recess, a protective member placing step of placing a transparent protective member on the face side of the wafer, a holding step of holding the face side of the wafer on a holding table having a holder made of a transparent material, with the transparent protective member interposed between the holding table and the wafer, a first cutting step of causing a tip end of a first cutting blade into the outer circumferential ridge of the wafer held on the holding table, to a height short of a bottom surface of the recess to cut the outer circumferential ridge, thereby reducing a height of the outer circumferential ridge, after the first cutting step, a street detecting step of capturing an image of the face side of the wafer with a lower image capturing camera disposed below the holding table through the transparent holder and the transparent protective member, thereby detecting one of the streets, and a second cutting step of cutting the wafer along the street detected in the street detecting step, with a second cutting blade.

According to the present invention, the wafer with the recess in the reverse side thereof and the outer circumferential ridge on the reverse side thereof can be

divided into individual device chips without dislodging the wafer from the holding table. Therefore, the wafer is prevented from suffering possible damage that would otherwise occur upon dislodging the wafer from the holding table.

Furthermore, since the outer circumferential ridge has been processed by the first cutting blade and a thickness of the outer circumferential ridge has been greatly reduced, it is not necessary to feed the cutting edge of the second cutting blade by an excessively large distance, but the cutting edge of the second cutting blade may be fed by a proper distance to cut the wafer. Therefore, the second cutting blade is prevented from cracking or wobbling.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a processing

apparatus according to an embodiment of the present invention;

FIG. 2 is an exploded perspective view of a support box and a holding table;

FIG. 3A is a perspective view of the support box and the holding table mounted on the support box;

FIG. 3B is a perspective view of a lower image capturing camera and a support structure therefor;

FIG. 4 is a view illustrating a positional relation between the holding table and the lower image capturing camera;

FIG. 5A is a perspective view of a wafer as an example of workpiece, illustrating a face side thereof;

FIG. 5B is a perspective view of the wafer, illustrating a reverse side thereof;

FIG. 6A is a perspective view of the wafer to which a protective member is to be affixed;

FIG. 6B is a perspective view of a wafer unit;

FIG. 7A is a side elevational view, partly in cross section, illustrating a first cutting step for removing an outer circumferential ridge from the wafer with a first cutting blade;

FIG. 7B is a cross-sectional view of the wafer from which the outer circumferential ridge has been removed;

FIG. 8A is a cross-sectional view illustrating a manner in which an image of the face side of the wafer is captured through a holding pad; and

FIG. 8B is a cross-sectional view illustrating a manner in which the wafer is cut by a second cutting unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described in detail below with reference to the accompanying drawings. FIG. 1 illustrates in perspective a processing apparatus 2 according to the present embodiment. As illustrated in FIG. 1, the processing apparatus 2 is constructed as a cutting apparatus of the facing dual spindle type in which two cutting blades are disposed opposite each other.

The processing apparatus 2 includes a base 4 on which a holding table 27 is reciprocally movable in X-axis directions, i.e., horizontal directions, by a moving mechanism 23 (see FIG. 3A). A water cover 14 is disposed around the holding table 27 that is movably coupled to the base 4 by a bellows 16. A cassette rest table 21 for placing thereon a cassette 20 that houses workpieces, to be described later, therein is disposed on a front corner of the base 4.

A portal-shaped column 24 is erected on the base 4. A pair of guide rails 26 extending in Y-axis directions, i.e., horizontal directions, perpendicular to the X-axis directions is fixed to the column 24. A first Y-axis movable block 28 is movably mounted on the guide rails 26 for movement therealong in the Y-axis directions. The first Y-axis movable block 28 is guided by the guide rails 26 when the first Y-axis movable block 28 is moved by a first Y-axis moving mechanism 34 that includes a ball screw 30 and a stepping motor, not illustrated.

A pair of guide rails 36 extending in Z-axis directions, i.e., vertical directions, perpendicular to the X-axis directions and the Y-axis directions is fixed to the first Y-axis movable block 28. A first Z-axis movable block 38 is movably mounted on the guide rails 36 for movement therealong in the Z-axis directions. The first Z-axis movable block 38 is guided by the guide rails 36 when the first Z-axis movable block 38 is moved by a first Z-axis moving mechanism 44 that includes a ball screw 40 and a stepping motor 42.

A first cutting unit 46 and an upper image capturing camera 52 are mounted on the first Z-axis movable block 38. As illustrated in FIG. 7A, the first cutting unit 46 includes a spindle 48 rotatable about its

central axis by an electric motor, not illustrated, and a first cutting blade 50 detachably mounted on a distal end of the spindle 48.

A second Y-axis movable block 28a is movably mounted on the guide rails 26 for movement therealong in the Y-axis directions. The second Y-axis movable block 28a is guided by the guide rails 26 when the second Y-axis movable block 28a is moved by a second Y-axis moving mechanism 34a that includes a ball screw 30a and a stepping motor 32a.

A pair of guide rails 36a extending in Z-axis directions perpendicular to the X-axis directions and the Y-axis directions is fixed to the second Y-axis movable block 28a. A second Z-axis movable block 38a is movably mounted on the guide rails 36a for movement therealong in the Z-axis directions. The second Z-axis movable block 38a is guided by the guide rails 36a when the second Z-axis movable block 38a is moved by a second Z-axis moving mechanism 44a that includes a ball screw 40a and a stepping motor 42a.

A second cutting unit 46a is mounted on the second Z-axis movable block 38a. The second cutting unit 46a includes a spindle rotatable about its central axis by an electric motor, not illustrated, and a second cutting

blade, not illustrated, detachably mounted on the distal end of the spindle.

A spinner cleaning unit 54 having a spinner table 56 is mounted in the base 4. The spinner cleaning unit 54 cleans a workpiece that has been cut while the workpiece is held under suction on the spinner table 56 and is being rotated by the spinner table 56. After the workpiece is cleaned, it is dried by being spun by the spinner table 56.

FIG. 2 illustrates a configuration of the holding table 27 in exploded perspective. As illustrated in FIG. 2, the holding table 27 includes an annular support member 62 and a disk-shaped holding pad 74. The annular support member 62 has a fitting boss 64, a belt pulley 66 that is larger in diameter than the fitting boss 64, an annular housing 68 that is substantially equal in diameter to the fitting boss 64, a through region 65 extending axially through the annular support member 62, and an inner circumferential surface 65a that defines the through region 65.

The annular housing 68 has an inside diameter that is substantially identical to the outside diameter of the holding pad 74. The annular housing 68 has an annular support 70 formed on an inner bottom of the annular

housing 68 for supporting the holding pad 74.

The holding pad 74 is made of a transparent material such as quartz glass, borosilicate glass, sapphire, calcium fluoride, lithium fluoride, or magnesium fluoride. The holding pad 74 has a number of pores 76 that are open in a holder 74a on its surface. The term "transparent" of the transparent material refers to transmitting, but not absorbing or dispersing, light having wavelengths that are at least part of visible light. The transparent material should be able to allow an outer circumferential ridge detecting step and a street detecting step, to be described later, to be carried out, and may be colored. The pores 76 are disposed on a circumferential portion of the holder 74a as illustrated in FIG. 2, but not limited to such a layout. The pores 76 may be disposed all over the entire surface of the holder 74a, for example.

Each of the pores 76 is held in fluid communication with a suction groove 78a (see FIG. 4) defined in the holding pad 74. The annular support 70 of the annular support member 62 has a fluid communication channel 72 defined therein that is held in fluid communication with the suction groove 78a in the holding pad 74. The fluid communication channel 72 is connected to a suction source

80.

When the holding pad 74 is placed on the annular support 70 of the annular support member 62 and the fitting boss 64 of the annular support member 62 is fitted in a circular opening 15a in a support box 15, the holding table 27 is rotatably mounted on the support box 15 as illustrated in FIG. 3A.

The support box 15 has a joint plate 15b on which an electric motor 17 is mounted. A belt 29 is trained around a pulley 17a coupled to the output shaft of the electric motor 17 and the belt pulley 66 of the annular support member 62. When the electric motor 17 is energized, the holding table 27 is rotated thereby through the belt 29.

The electric motor 17 is constructed as a stepping motor, for example. When the electric motor 17 is energized by given pulses in an alignment process, the holding table 27 is turned through a predetermined angle of θ , streets, i.e., projected dicing lines, 13 of a wafer 10 illustrated in FIG. 5A that is placed on the holding table 27 are aligned with a certain direction.

The support box 15 includes an upper plate 15c with a plurality of, four in the present embodiment, support bases 15d disposed thereon. The support bases 15d support

on their upper surfaces an annular frame to be described later.

As illustrated in FIG. 3A, the support box 15 is slidably placed on a pair of guide rails 31 fixed in place and extending in the X-axis directions. The support box 15 is movable in the X-axis directions a moving mechanism 23 while being guided along the guide rails 31. The moving mechanism 23 includes a ball screw 23a disposed between and extending parallel to the guide rails 31 and a stepping motor 23b coupled to an end of the ball screw 23a.

As illustrated in FIG. 3A, the ball screw 23a is threaded through an internally threaded member, not illustrated, mounted on a lower surface of a lower plate 15e of the support box 15. When the stepping motor 23b is energized, it rotates the ball screw 23a about its own central axis, moving the support box 15 in one of the X-axis directions.

As illustrated in FIG. 3A, a lower image capturing camera 82 for capturing an image of a workpiece such as a semiconductor wafer held on the holding table 27 from below the holding pad 74 is disposed near the support box 15 of the holding table 27.

As illustrated in FIG. 3A, the lower image

capturing camera 82 is mounted on a column 96 erected on a Y-axis movable block 83. The Y-axis movable block 83 is slidably placed on a pair of guide rails 81 fixed in position and extending in the Y-axis directions. The Y-axis movable block 83 is movable in the Y-axis directions by actuating means 85. The actuating means 85 includes a ball screw 85a disposed between and extending parallel to the guide rails 81 and a stepping motor 85b coupled to an end of the ball screw 85a.

As illustrated in FIG. 3A, the ball screw 85a is threaded through an internally threaded member, not illustrated, mounted on a lower surface of the Y-axis movable block 83. When the stepping motor 85b is energized, it rotates the ball screw 85a about its own central axis, moving the Y-axis movable block 83 in one of the Y-axis directions.

As illustrated in FIG. 3B, the lower image capturing camera 82 has a camera unit 84 including a low-magnification camera 86 and a high-magnification camera 88. Two illuminating apparatuses 90 and 92 are attached to a side surface of the camera unit 84 for illuminating an area whose image is to be captured by the camera unit 84.

As illustrated in FIG. 3B, the camera unit 84 is

supported on a support plate 94 having a proximal end fixed to a Z-axis movable block 98. A column 96 is erected on the Y-axis movable block 83. Z-axis moving means 104 including a ball screw 100 and a stepping motor 102 coupled to an end of the ball screw 100 is mounted on the column 96. The Z-axis movable block 98 is slidably mounted on a pair of guide rails 106 fixed to the column 96 and extending in the Z-axis directions. When the stepping motor 102 is energized, it rotates the ball screw 100 about its own central axis, moving the Z-axis movable block 98 and hence the camera unit 84 in one of the Z-axis directions.

As illustrated in FIG. 4, the support box 15 is of a channel shape as viewed in side elevation, including the upper plate 15c and the lower plate 15e that are joined to each other the joint plate 15b. The support box 15 has an opening 15g defined between the upper plate 15c and the lower plate 15e remotely from the joint plate 15b. The opening 15g allows the lower image capturing camera 82 to enter below the upper plate 15c.

A method of processing a wafer according to the present embodiment using the processing apparatus 2 thus constructed will be described below. The method of processing a wafer includes various steps to be described

below.

<Wafer preparing step>

First, a disk-shaped wafer 10 as an example of workpiece to be processed as illustrated in FIGS. 5A and 5B is prepared.

FIG. 5A illustrates in perspective a face side 10a of the wafer 10. A plurality of devices 11 are arranged in a grid pattern on the face side 10a and disposed in a device zone including respective areas demarcated by the streets 13. When the wafer 10 is divided by cutting or the like along the streets 13, the wafer 10 is separated into individual device chips including the respective devices 11.

FIG. 5B illustrates in perspective a reverse side 10b of the wafer 10. The reverse side 10b includes a circular recess 18 concentric with the disk-shaped wafer 10 and an outer circumferential ridge 19 surrounding the circular recess 18. The circular recess 18 is defined in a portion of the reverse side 10b that corresponds to the device zone of the face side 10a where the devices 11 are formed. In some applications, metal films may be formed on respective surfaces of the recess 18 and the outer circumferential ridge 19.

<Protective member placing step>

As illustrated in FIG. 6A, a transparent tape T as a protective member for protecting the devices is affixed to the face side 10a of the wafer 10, and, as illustrated in FIG. 6B, an outer circumferential portion of the transparent tape T is affixed to an annular frame F, thereby making up a wafer unit 8. The "transparent" of the transparent tape T refers to transmitting, but not absorbing or dispersing, light having wavelengths that are at least part of visible light. The transparent material should be able to allow the outer circumferential ridge detecting step and the street detecting step, to be described later, to be carried out, and may be colored. The protective member may be an extensible and contractible tape of resin or a hard plate of glass, resin, or the like.

The tape T includes a base member having a thickness ranging from 10 to 200 μm and made of vinyl chloride, polyethylene terephthalate (PET), polyimide (PI), or the like and a glue layer of acryl or rubber.

<Holding step>

Then, as illustrated in FIG. 4, the wafer unit 8 is placed on the holding table 27 such that the wafer 10 is held on the holding table 27 with the tape T interposed therebetween. Specifically, the tape T of the wafer unit

8 is placed on the holding pad 74 of the holding table 27, and the suction source 80 starts to produce a negative pressure that acts through the pores 76 on the tape T, attracting the face side 10a of the tape T under suction. At this time, the annular frame F of the wafer unit 8 is placed on the frame support bases 15d.

<Outer circumferential ridge detecting step>

Then, as illustrated in FIG. 4, the upper image capturing camera 52 detects the position of the outer circumferential ridge 19 of the wafer 10. Specifically, an image captured by the upper image capturing camera 52 is analyzed to detect an outer circumferential edge of the outer circumferential ridge 19, i.e., an outer circumferential edge of the wafer 10. A width W of the outer circumferential ridge 19, i.e., the width thereof in radial directions of the wafer 10, and a diameter of the wafer 10 has been recognized by the processing apparatus 2 as attribute information of the wafer 10 with respect to each of types of wafers to be processed.

Instead of detecting the position of the outer circumferential edge of the outer circumferential ridge 19 from the image captured by the upper image capturing camera 52 (see FIG. 4), the lower image capturing camera 82 may capture an image of the wafer 10 from below, and

the captured image may be analyzed to detect the position of an outer circumferential edge of the outer circumferential ridge 19, i.e., an outer circumferential edge of the wafer 10. According to such a modification, the capturing of images by the upper image capturing camera 52 may be omitted, or the upper image capturing camera 52 itself may be omitted depending on the apparatus configuration.

<First cutting step>

Next, as illustrated in FIG. 7A, the first cutting blade 50 of the first cutting unit 46 is positioned over the outer circumferential ridge 19 and is caused to cut into the outer circumferential ridge 19 to remove the outer circumferential ridge 19 by cutting.

Specifically, the first cutting blade 50 that is positioned above the outer circumferential ridge 19 is lowered to a first predetermined height, cutting into the outer circumferential ridge 19, and the holding table 27 is rotated about its own central axis to remove the outer circumferential ridge 19 by cutting. The holding table 27 is rotated by energizing the electric motor 17 to cause the belt 29 to rotate the holding table 27 as illustrated in FIG. 3A. The first cutting blade 50 and the holding table 27, i.e., the outer circumferential ridge 19, may

be positioned into alignment with each other by using the coordinates, determined in the above outer circumferential ridge detecting step, of the outer circumferential edge of the outer circumferential ridge 19, i.e., the outer circumferential edge of the wafer 10.

The term "first predetermined height" refers to a height where the first cutting blade 50 remains short of the reverse side 10b of the device zone of the wafer 10, i.e., a metal film 18a formed thereon in FIG. 7A, and is defined on the basis of the thickness of the wafer 10 and a depth of the recess 18.

When the outer circumferential ridge 19 has been removed, the wafer 10 appears as illustrated in FIG. 7B. On the wafer 10 illustrated in FIGS. 7A and 7B, the metal film 18a is formed on the reverse side 10b as widely as the recess 18. However, the present invention is also applicable to wafers that are free of the metal film 18a.

Instead of removing the outer circumferential ridge 19 by cutting by positionally aligning the outer circumferential ridge 19 and the first cutting blade 50 strictly with each other as described above, the outer circumferential ridge 19 may be removed as follows: First, the first cutting blade 50 is positioned at the first predetermined height. Then, the holding table 27 is

repeatedly moved in one of the X-axis directions (see FIG. 1) and the first cutting blade 50 is repeatedly indexing-fed in one of the Y-axis directions (see FIG. 1) to move the wafer 10 and the first cutting blade 50 relatively to each other for the first cutting blade 50 to fully cover the wafer 10. In this manner, the outer circumferential ridge 19 is removed fully from the wafer 10.

Alternatively, insofar as the holding table 27 is rotatable 360° about its central axis, the outer circumferential ridge removing step may not be carried out, the first cutting blade 50 may be positioned on the outer circumferential edge of the wafer 10 on the basis of the diameter of the wafer 10 and the central position of the holding table 27, and the holding table 27 may be rotated 360° about its central axis, thereby performing the first cutting step.

Further alternatively, insofar as the holding table 27 is rotatable 180° about its central axis, the outer circumferential ridge removing step may not be carried out, the first cutting blade 50 may be positioned on the outer circumferential edge of the wafer 10 at one diagonal end, the holding table 27 may be turned 180° clockwise about its central axis to remove a 180° portion of the outer circumferential ridge 19, thereafter the

first cutting blade 50 may be positioned on the outer circumferential edge of the wafer 10 at a diagonal end that is opposite the one diagonal end across the center of the wafer 10, and the holding table 27 may be turned 180° counterclockwise about its central axis to remove the remaining 180° portion of the outer circumferential ridge 19, thereby performing the first cutting step.

According to the above alternatives, the capturing of an image by the upper image capturing camera 52 or the lower image capturing camera 82 to detect the outer circumferential edge of the outer circumferential ridge 19 may be dispensed with, and the outer circumferential ridge detecting step may be omitted.

<Street detecting step>

Then, as illustrated in FIGS. 4 and 8A, the Y-axis movable block 83 is moved to position the lower image capturing camera 82 below the wafer 10, and captures an image of the face side 10a of the wafer 10, i.e., a lower surface of the wafer 10 in FIG. 8A through the holding pad 74 of the holding table 27 and the tape T, and one of the streets 13 (see FIG. 5A) of the wafer 10 is detected.

<Second cutting step>

Then, as illustrated in FIG. 8B, the wafer 10 is cut along the detected street 13 by the second cutting

blade 50a of the second cutting unit 46a.

Before the wafer 10 is cut by the second cutting blade 50a, an alignment process is carried out. Specifically, as illustrated in FIG. 3A, the electric motor 17 is energized to cause the belt 29 to turn the holding table 27 to change its angle until those streets 13 that extend parallel to each other in a first direction become parallel to the X-axis directions or the Y-axis directions. The second cutting unit 46a is moved in one of the Y-axis directions to position one of the streets 13 into alignment with the second cutting blade 50a of the second cutting unit 46a.

After the alignment process has been carried out, the second cutting blade 50a of the second cutting unit 46a is positioned at a second predetermined height where its tip end cuts into the wafer 10. The holding table 27 is processing-fed in one of the X-axis directions (see FIG. 1) and the second cutting unit 46a is indexing-fed in one of the Y-axis directions (see FIG. 1), causing the second cutting blade 50a to cut the wafer 10 along all the streets 13 that extend in the first direction. Then, the holding table 27 is turned 90°, and the second cutting blade 50a cuts the wafer 10 along all the streets 13 that extend in a second direction perpendicular to the

first direction. By setting the second predetermined height to a height where the tip end of the second cutting blade 50a cuts into the protective member, i.e., the tape T, the wafer 10 is divided into device chips.

In the second cutting step, as illustrated in FIG. 7B, since the outer circumferential ridge 19 has been processed by the first cutting blade 50 and the thickness thereof has been greatly reduced, it is not necessary to feed the cutting edge of the second cutting blade 50a by an excessively large distance, but the cutting edge of the second cutting blade 50a may be fed by a proper distance to cut the wafer 10. Specifically, if the outer circumferential ridge 19 existed, it would be necessary for the second cutting blade 50a to cut the outer circumferential ridge 19 and also cut the wafer to the face side 10a. Therefore, it would be necessary to feed the cutting edge of the second cutting blade 50a by an unduly large distance that would tend to cause the second cutting blade 50a to crack or wobble. According to the present embodiment, these difficulties are avoided because the outer circumferential ridge 19 has been substantially removed by the first cutting blade 50. Furthermore, inasmuch as the distance that the cutting edge of the second cutting blade 50a is fed is reduced,

it is possible to select a thin cutting blade as the second cutting blade 50a for cutting the wafer 10 with higher accuracy.

In the second cutting step, the second cutting blade 50a may fully cut the wafer 10 by going fully thicknesswise through the wafer 10 or may partly cut the wafer 10 by going partly thicknesswise into the wafer 10.

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 processing apparatus for processing a wafer having a face side including a device zone where a plurality of devices are formed in respective areas demarcated by a plurality of crossing streets and a reverse side including a recess defined therein that corresponds to the device zone and an outer circumferential ridge on the reverse side that surrounds the recess, the processing apparatus comprising:

a rotatable holding table having a holder made of a transparent material and holding the face side of the wafer;

a lower image capturing camera for capturing an image of the face side of the wafer held on the holding table through the holder;

a cutting mechanism including a first cutting unit having a first cutting blade for cutting the outer circumferential ridge on the reverse side of the wafer to reduce a height of the outer circumferential ridge, and a second cutting unit having a second cutting blade for cutting the wafer along the streets on the face side of the wafer whose image has been captured by the lower image capturing camera; and

a moving mechanism for moving the holding table and

the cutting mechanism relatively to each other.

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

an upper image capturing camera for capturing the reverse side of the wafer held on the holding table.

3. A method of processing a wafer, comprising:

a wafer preparing step of preparing a wafer having a face side including a device zone where a plurality of devices are formed in respective areas demarcated by a plurality of crossing streets and a reverse side including a recess defined therein that corresponds to the device zone and an outer circumferential ridge on the reverse side that surrounds the recess;

a protective member placing step of placing a transparent protective member on the face side of the wafer;

a holding step of holding the face side of the wafer on a holding table having a holder made of a transparent material, with the transparent protective member interposed between the holding table and the wafer;

a first cutting step of causing a tip end of a first cutting blade into the outer circumferential ridge of the wafer held on the holding table, to a height short

of a bottom surface of the recess to cut the outer circumferential ridge, thereby reducing a height of the outer circumferential ridge;

after the first cutting step, a street detecting step of capturing an image of the face side of the wafer with a lower image capturing camera disposed below the holding table through the transparent holder and the transparent protective member, thereby detecting one of the streets; and

a second cutting step of cutting the wafer along the street detected in the street detecting step, with a second cutting blade.