

HOLDING TABLE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a holding table for use with a wafer processing method for processing a wafer having a device area and an annular reinforcing portion formed around the device area, wherein the annular reinforcing portion is removed from the wafer.

Description of the Related Art

A plurality of devices such as ICs and LSIs are formed on the front side of a wafer. The wafer thus having the devices is divided into the individual devices by using a dicing apparatus or the like. These devices are incorporated in various electronic equipment and widely used. To reduce the size and weight of electronic equipment, the thickness of the wafer is reduced to 50 μm to 100 μm , for example. However, such a thin wafer is reduced in rigidity and causes a warpage, so that the wafer is hard to handle and there is a possibility of damage to the wafer during transportation of the wafer. To cope with this problem, there has been proposed a method for increasing the rigidity of a wafer, wherein the wafer has a device area where a plurality of devices are formed and a peripheral marginal area surrounding the device area on the front side of the wafer, and the back side of the device area is ground to form an annular reinforcing portion corresponding to the peripheral marginal area (see Japanese Patent Laid-open No. 2007-19461, for example).

There has also been proposed a method of removing the annular reinforcing portion from the wafer before dividing the wafer along division

lines (see Japanese Patent Laid-open No. 2012-23175, for example). In the method described in Japanese Patent Laid-open No. 2012-23175, a boundary portion between the device area and the annular reinforcing portion (the peripheral marginal area) is cut by a cutting blade to thereby separate the annular reinforcing portion from the device area of the wafer. After thus removing the annular reinforcing portion from the wafer, the wafer now having only the device area is cut along the division lines from the front side of the wafer by using the cutting blade, thereby dividing the wafer into the individual devices.

SUMMARY OF THE INVENTION

In the method described in Japanese Patent Laid-open No. 2012-23175, however, the thinner the wafer in the device area, the larger the step between the device area and the annular reinforcing portion. With an increase in height of this step, the edge projection amount of the cutting blade must be set larger than the usual amount by the height of the step, so as to avoid the contact between a blade hub and the annular reinforcing portion. However, when the wafer is cut in the condition where the edge projection amount of the cutting blade is large, an excessive load is applied to the cutting blade, causing a possibility of meander and breakage of the cutting blade. Increasing the thickness of the cutting blade may be considered to prevent such meander and breakage of the cutting blade. However, in this case, the width of a cut groove formed by the cutting blade is increased by an amount corresponding to the increase of the thickness of the cutting blade, causing a problem such that the device area is reduced.

In particular, the diameter of the wafer is intended to increase in recent years, so as to increase a chip size and productivity. Increasing the diameter of the wafer causes an increase in thickness of the wafer. Accordingly, it is assumed that the height of the step due to the annular reinforcing portion may be increased by reducing the thickness of the wafer in the device area. As a result, the edge projection amount of the cutting blade is further increased to cause a difficulty in properly removing the annular reinforcing portion from the wafer.

It is therefore an object of the present invention to provide a holding table for use with a wafer processing method which can process a wafer having a device area and an annular reinforcing portion formed around the device area, wherein the annular reinforcing portion can be stably removed from the wafer without reducing the device area.

In accordance with an aspect of the present invention, there is provided a holding table for holding a wafer having a device area where a plurality of devices are formed and a peripheral marginal area surrounding said device area on a front side of said wafer, said wafer further having an annular reinforcing portion formed on a back side of said peripheral marginal area; said holding table having an upper surface formed with an annular escape groove for allowing the escape of a laser beam, said annular escape groove being formed so as to correspond to a boundary portion between the device area and the annular reinforcing portion of said wafer held on the upper surface of said holding table, a bottom of said escape groove being tapered and formed with fine asperities for scattering said laser beam.

With this configuration, the laser beam is applied to the wafer

along the boundary portion between the device area and the annular reinforcing portion (the peripheral marginal area), thereby separating the annular reinforcing portion from the device area of the wafer. When applying the laser beam, since the tapered bottom of the annular escape groove is formed with fine asperities, reflected light of the laser beam reflected from the bottom of the escape groove may not return to a laser source and intensity of the reflected light is decreased to thereby preventing the laser source from being damaged.

As the annular reinforcing portion can be separated from the device area without using a cutting blade, so that it is unnecessary to consider the edge projection amount and the thickness of the cutting blade as in the case of using the cutting blade. Further, since the wafer is processed by applying the laser beam, a processing area can be minimized to thereby eliminate the problem that the device area is reduced. Further, even in the case that the thickness of the wafer is increased with an increase in diameter of the wafer, the annular reinforcing portion can be stably removed.

The holding table of the present invention is to be used when grinding a back side of the wafer corresponding to the device area to thereby form the annular reinforcing portion including the peripheral marginal area, and deleting the annular reinforcing portion by applying the laser beam having an absorption wavelength to the wafer toward the boundary portion.

According to the present invention, the laser beam is applied to the wafer along the boundary portion between the device area and the annular reinforcing portion, thereby separating the annular reinforcing

portion from the device area, so that the annular reinforcing portion can be stably removed from the wafer without reducing the device area.

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 laser processing apparatus;

FIGS. 2A and 2B are views for illustrating a holding table;

FIG. 3 is a sectional side view for illustrating a wafer attaching step;

FIG. 4 is a sectional side view for illustrating an alignment step;

FIGS. 5A to 5C are views for illustrating an annular reinforcing portion separating step;

FIG. 6 is a sectional side view for illustrating an annular reinforcing portion removing step;

FIG. 7 is a sectional side view for illustrating a device area supporting step;

FIG. 8 is a sectional side view for illustrating a dividing step; and

FIGS. 9A and 9B are schematic sectional views for illustrating an escape groove formed on the holding table.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

There will now be described a wafer processing method according

to a preferred embodiment of the present invention with reference to the attached drawings. The wafer processing method according to this preferred embodiment is performed to a so-called TAIKO wafer formed by grinding the back side of an original wafer except its peripheral portion, and this method is a method of removing the peripheral portion of such a TAIKO wafer. FIG. 1 is a perspective view of a laser processing apparatus for use in the wafer processing method according to this preferred embodiment. The configuration of a laser processing apparatus for use in the wafer processing method according to the present invention is not limited to that shown in FIG. 1, but any configuration capable of processing the wafer as in this preferred embodiment may be adopted.

As shown in FIG. 1, the laser processing apparatus denoted by reference numeral 1 includes laser beam applying means 2 for applying a laser beam to a wafer W held on a holding table 5, wherein the laser beam applying means 2 and the holding table 5 are relatively moved to process the wafer W. The wafer W is a substantially disk-shaped member having a front side 80 and a back side 81. A plurality of crossing division lines 82 are formed on the front side 80 of the wafer W to thereby define a plurality of separate regions (see FIG. 8). In these separate regions defined by the division lines 82, a plurality of devices are respectively formed on the front side 80 in the central area of the wafer W. That is, the front side 80 of the wafer W is composed of a device area 83 where the plural devices are formed and a peripheral marginal area 84 surrounding the device area 83 (see FIG. 2B).

As shown in FIGS. 1 and 2B, a circular recess is formed by

grinding on the back side 81 of the wafer W in a central area corresponding to the device area 83, and an annular projecting portion as a reinforcing portion 85 is formed on the back side 81 of the wafer W in a peripheral area corresponding to the peripheral marginal area 84. Accordingly, only the central area of the wafer W is reduced in thickness, and the rigidity of the wafer W is improved by the annular reinforcing portion 85. As a result, the device area 83 of the wafer W is reduced in thickness, and the warpage of the wafer W is suppressed by the annular reinforcing portion 85 to thereby prevent damage to the wafer W during transportation. The wafer W may be a semiconductor wafer formed of silicon, gallium arsenide, etc. or may be an optical device wafer formed of ceramic, glass, sapphire, etc.

A support tape T1 is attached to the front side 80 of the wafer W, and an annular frame F1 having a central opening is attached to the peripheral portion of the support tape T1. The wafer W is carried to the laser processing apparatus 1 in the condition where the wafer W is supported through the support tape T1 to the annular frame F1. As shown in FIG. 2B, a boundary portion 86 is formed between the device area 83 and the peripheral marginal area 84, so that a step due to the annular reinforcing portion 85 is formed in the boundary portion 86. In the case of mechanical dicing using a cutting blade, a blade hub may interfere with the annular reinforcing portion 85, causing a difficulty in performing a proper operation. From this point of view, this preferred embodiment employs laser ablation to remove the annular reinforcing portion 85 from the wafer W.

As shown in FIG. 1, the laser processing apparatus 1 has a

rectangular base 11. There is provided on the upper surface of the base 11 a holding table moving mechanism 4 for moving the holding table 5 in the X direction extending along an X axis shown in FIG. 1 and in the Y direction extending along a Y axis shown in FIG. 1. The holding table moving mechanism 4 includes a pair of parallel guide rails 41 provided on the upper surface of the base 11 so as to extend in the X direction and a motor-driven X table 42 slidably supported to the guide rails 41. The holding table moving mechanism 4 further includes a pair of parallel guide rails 43 provided on the upper surface of the X table 42 so as to extend in the Y direction and a motor-driven Y table 44 slidably supported to the guide rails 43.

Nut portions (not shown) are formed on the lower surfaces of the X table 42 and the Y table 44, and ball screws 45 and 46 are threadedly engaged with these nut portions of the X table 42 and the Y table 44, respectively. Drive motors 47 and 48 are connected to the end portions of the ball screws 45 and 46, respectively. Accordingly, when the ball screws 45 and 46 are rotationally driven by the drive motors 47 and 48, respectively, the holding table 5 is moved in the X direction and the Y direction along the guide rails 41 and 43, respectively. A θ table 49 is provided on the upper surface of the Y table 44 so as to be rotatable about a Z axis shown in FIG. 1. The holding table 5 for holding the wafer W is provided on the upper surface of the θ table 49.

The holding table 5 is a circular member formed of a metal material such as stainless steel. The holding table 5 has an upper surface functioning as a holding surface 51 for holding the wafer W thereon. The holding surface 51 is formed with a plurality of suction

grooves 57 and 58 (see FIG. 2A), wherein a vacuum is produced in the suction grooves 57 and 58 to hold the wafer W on the holding surface 51 under suction. Further, four air-driven clamps 60 are provided on the outer circumference of the holding table 5. The four clamps 60 function to fix the annular frame F1 supporting the wafer W through the support tape T1 in the condition where the wafer W is held on the holding surface 51 under suction. A wall portion 12 stands from the base 11 at its rear end behind the holding table 5. An arm portion 13 projects from the front surface of the wall portion 12. The laser beam applying means 2 is supported to the arm portion 13 so as to be opposed to the holding table 5.

The laser beam applying means 2 has a processing head 21 provided at the front end of the arm portion 13. Optical components constituting the laser beam applying means 2 are provided in the arm portion 13 and the processing head 21. More specifically, a laser oscillator (not shown) is provided in the arm portion 13, and the processing head 21 includes a focusing lens (not shown) for focusing a laser beam oscillated from the laser oscillator to the wafer W held on the holding table 5, thereby processing the wafer W. In this case, the laser beam has an absorption wavelength to the wafer W, and the focal point of the laser beam is adjusted by the optical components so that the laser beam is focused inside the support tape T1 attached to the front side 80 of the wafer W (the lower surface as viewed in FIG. 2B). By the application of the laser beam to the wafer W, ablation occurs in the wafer W together with the support tape T1.

The ablation is a phenomenon such that when the intensity of a

laser beam applied to a solid surface becomes greater than or equal to a predetermined processing threshold, the energy of the laser beam is converted into electronic, thermal, photochemical, and mechanical energy, so that neutral atoms, molecules, positive and negative ions, radicals, clusters, electrons, and light are explosively emitted to cause etching of the solid surface.

Referring back to FIG. 1, imaging means 3 for imaging a peripheral edge 90 of the wafer W (see FIG. 2B) is provided adjacent to the laser beam applying means 2. The imaging means 3 functions to apply imaging light to the peripheral edge 90 of the wafer W and receive reflected light therefrom, thereby imaging the peripheral edge 90 of the wafer W. Further, arbitrary three points on the peripheral edge 90 of the wafer W are imaged by the imaging means 3, and the resultant images are subjected to image processing to detect the coordinates of the three points on the peripheral edge 90. According to the coordinates of the three points on the peripheral edge 90, the center of the wafer W is calculated and alignment is then performed on the basis of the center of the wafer W calculated above.

After performing this alignment, the processing head 21 is positioned directly above the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84) of the wafer W held on the holding table 5 in the laser processing apparatus 1 (see FIG. 5A). The laser beam is applied from the processing head 21 toward the wafer W, and the holding table 5 is rotated to thereby cut the wafer W together with the support tape T1. Accordingly, the annular reinforcing portion 85 and the annular frame

F1 are separated from the wafer W. Thereafter, the annular reinforcing portion 85 supported through the support tape T1 to the annular frame F1 is removed together with the annular frame F1 from the holding table 5. Thus, the annular reinforcing portion 85 is removed from the wafer W (see FIG. 6).

The holding table 5 according to this preferred embodiment will now be described in more detail with reference to FIGS. 2A and 2B. FIG. 2A is a perspective view of the holding table 5, and FIG. 2B is a sectional view of the holding table 5. In FIG. 2B, the wafer W held on the holding table 5 is shown by a phantom line.

As shown in FIGS. 2A and 2B, the upper surface of the holding table 5 is formed with an annular escape groove 53 for allowing the escape of the laser beam in performing the ablation. The escape groove 53 is formed along the outer circumference of the holding table 5 so as to correspond to the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84) of the wafer W held on the holding table 5. The central area of the upper surface of the holding table 5 on the radial inside of the escape groove 53 is formed as the holding surface 51 for holding the wafer W. The holding surface 51 is formed so as to correspond to the device area 83 of the wafer W. As described above, the holding surface 51 has the plural suction grooves 57 and 58. More specifically, the grooves 57 are formed as a pair of crossing suction grooves intersecting at right angles to each other at the center of the holding table 5, and the grooves 58 are formed as a plurality of concentric ring grooves about the intersection of the crossing suction grooves 57.

The crossing suction grooves 57 and the ring suction grooves 58 are in communication with each other, and they are connected through a suction passage 59 formed in the holding table 5 to a vacuum source (not shown). Accordingly, a vacuum is produced in the suction grooves 57 and 58 to thereby hold the wafer W through the support tape T1 on the holding surface 51 under suction. Further, a peripheral area 52 of the upper surface of the holding table 5 on the radial outside of the escape groove 53 is flush with the holding surface 51 and functions to support the support tape T1 projecting radially outward from the wafer W. Accordingly, the support tape T1 is kept in a horizontal condition between the holding surface 51 and the peripheral area 52, so that it is possible to prevent that the support tape T1 may be deformed (downward) into the escape groove 53 to cause a deviation of a laser beam applying position.

A bottom 54 of the escape groove 53 is inclined so that the depth of the escape groove 53 increases toward the center of the holding table 5. That is, the bottom 54 is a tapering surface and it is formed with fine asperities for scattering the laser beam. These fine asperities may be formed by sand blasting or the like. Accordingly, the laser beam is irregularly reflected from the bottom 54, and the resultant reflected light travels away from the laser source (the processing head 21). Further, the intensity of the reflected light from the bottom 54 is reduced, so that damage to the laser beam by the reflected light can be suppressed. Further, as will be hereinafter described in detail, the imaging light applied from the imaging means 3 (see FIG. 4) is also reflected from the bottom 54 in performing the alignment, and the resultant reflected light

travels away from the imaging means 3. Further, the intensity of the reflected light from the bottom 54 in this case is also reduced. Accordingly, the contrast in the image of the peripheral edge 90 of the wafer W as obtained by the imaging means 3 can be increased.

In the wafer processing method according to this preferred embodiment, the device area 83 of the wafer W is divided into the individual devices as chips after removing the annular reinforcing portion 85 from the wafer W by using the laser processing apparatus 1 mentioned above. The wafer processing method according to this preferred embodiment will now be described in more detail with reference to FIGS. 3 to 8. FIG. 3 shows a wafer attaching step, FIG. 4 shows an alignment step, FIGS. 5A to 5C show an annular reinforcing portion separating step, FIG. 6 shows an annular reinforcing portion removing step, FIG. 7 shows a device area supporting step, and FIG. 8 shows a dividing step. FIG. 5A is a sectional side view of the wafer W held on the holding table 5 in the annular reinforcing portion separating step, FIG. 5B is an enlarged sectional view of an essential part of the wafer W shown in FIG. 5A, and FIG. 5C is a top plan view of an essential part of the wafer W shown in FIG. 5A.

As shown in FIG. 3, the wafer attaching step is first performed. In the wafer attaching step, the wafer W is positioned in the central opening of the annular frame F1, and the support tape T1 is attached to the front side 80 of the wafer W and the annular frame F1. Accordingly, the wafer W is supported through the support tape T1 to the annular frame F1 in the condition where the annular reinforcing portion 85 is oriented upward. The wafer W thus supported through the support tape

T1 to the annular frame F1 is carried to the laser processing apparatus 1 (see FIG. 1). This wafer attaching step may be manually performed by an operator or may be performed by using a tape mounter (not shown).

After performing the wafer attaching step mentioned above, the alignment step is performed as shown in FIG. 4. In the alignment step, the wafer W supported through the support tape T1 to the annular frame F1 is held on the holding surface 51 of the holding table 5 in the condition where the annular reinforcing portion 85 is oriented upward. Further, the annular frame F1 is fixed by the clamps 60. Thereafter, the imaging means 3 is positioned directly above the annular reinforcing portion 85 of the wafer W, and the peripheral edge 90 of the wafer W is imaged by the imaging means 3. At this time, the imaging light is applied from the imaging means 3 to the peripheral edge 90 and its near area, and the reflected light from the peripheral edge 90 and its near area is captured by the imaging means 3 to thereby form an image.

The annular reinforcing portion 85 has a horizontal upper surface 87 on the radial inside of the peripheral edge 90. The imaging light applied from the imaging means 3 is reflected from the upper surface 87 of the annular reinforcing portion 85 (i.e., halation occurs on the upper surface 87). On the other hand, the escape groove 53 is present on the radial outside of the peripheral edge 90, so that the imaging light applied from the imaging means 3 is transmitted through the support tape T1 and next reflected from the tapering bottom 54 of the escape groove 53. Accordingly, the reflected light from the bottom 54 is directed toward the center of the wafer W. At the same time, the reflected light from the bottom 54 is scattered because of the fine

asperities on the bottom 54. As a result, the reflected light on the radial outside of the peripheral edge 90 is hardly captured by the imaging means 3.

In the image of the peripheral edge 90 and its near area, a part of the image corresponding to the radial inside of the peripheral edge 90 is bright because the reflected light from this inside area is captured by the imaging means 3, whereas the remaining part corresponding to the radial outside of the peripheral edge 90 is dark because the reflected light from this outside area is hardly captured by the imaging means 3. Accordingly, the contrast in the image of the peripheral edge 90 and its near area is high in this preferred embodiment, so that the peripheral edge 90 can be clearly recognized. Similarly, plural points on the peripheral edge 90 of the wafer W are imaged by the imaging means 3. According to the images at these plural points, image processing is performed to detect the coordinates of these plural points. Thereafter, according to the coordinates of these plural points on the peripheral edge 90, the center of the wafer W is calculated to perform the alignment.

After performing the alignment step mentioned above, the annular reinforcing portion separating step is performed as shown in FIGS. 5A to 5C. In the annular reinforcing portion separating step, a first step is performed in such a manner that a laser processed groove 92 is formed in the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84) of the wafer W. In the first step, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 is positioned directly below the processing head 21. Further, the focal position and a spot

size 91 of the laser beam to be applied from the processing head 21 are adjusted. Thereafter, the laser beam having the predetermined spot size 91 is applied to the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 of the wafer W as shown by a dashed line in FIGS. 5B and 5C.

At the same time, the holding table 5 holding the wafer W is rotated in the condition where the laser beam is applied to the wafer W. As a result, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 is cut away by the laser beam having the spot size 91 shown by the dashed line (see FIG. 5C). At this time, the laser beam penetrates the wafer W and the support tape T1 and is then reflected from the bottom 54 of the escape groove 53. The reflected light from the bottom 54 is directed toward the center of the holding table 5. Further, since the bottom 54 has the fine asperities, the reflected light from the bottom 54 is scattered and reduced in intensity. Accordingly, the reflected light from the bottom 54 is hardly returned to the processing head 21. Even if the reflected light from the bottom 54 is returned to the processing head 21, there is no possibility that the laser source (the processing head 21) may be damaged by the reflected light.

By performing the first step as mentioned above, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 is cut together with the support tape T1 to thereby form the laser processed groove 92. However, since the width of the laser processed groove 92 is small, there is a possibility that the laser processed groove 92 may be clogged with debris produced in the ablation. To cope with this problem, the first step is followed by a second step of

increasing the width of the laser processed groove 92 to separate the annular reinforcing portion 85 from the device area 83. In the second step, the processing head 21 (the laser beam applying means 2) is moved in the radial direction of the wafer W from the laser beam applying position in the first step as shown by the dashed line by a distance smaller than the predetermined spot size 91 (spot diameter) as shown in FIGS. 5B and 5C.

Thereafter, the laser beam is applied from the processing head 21 to the wafer W at the shifted position shown by a phantom line in FIGS. 5B and 5C. At the same time, the holding table 5 is rotated. As a result, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 is further cut away by the laser beam having the spot size 91 shown by the phantom line in FIG. 5C. At this time, the spot size 91 of the laser beam partially overlaps the laser processed groove 92 formed in the first step. Accordingly, the debris left in the laser processed groove 92 is removed by the laser beam, and at the same time the width of the laser processed groove 92 is slightly increased. In the case that the annular reinforcing portion 85 is not completely separated from the device area 83 even by these two steps of laser processing, the second step is performed again.

The second step is repeated until the width of the laser processed groove 92 is sufficiently increased to completely cut the wafer W and the support tape T1 along the boundary portion 86. Thusly, even when the annular reinforcing portion 85 is not separated from the device area 83 of the wafer W in the first step of the annular reinforcing portion separating step, the annular reinforcing portion 85 can be reliably

separated from the device area 83 by repeating the second step of the annular reinforcing portion separating step. For example, the spot size 91 of the laser beam in the first and second steps is set to 90 μm and the line spacing (index) corresponding to the shift amount of the laser beam between the first and second steps is set to 0.015 μm . Further, two cycles (four passes) of laser processing are performed per line in the first and second steps.

After performing the annular reinforcing portion separating step as mentioned above, the annular reinforcing portion removing step is performed as shown in FIG. 6. In the annular reinforcing portion removing step, the fixation of the annular frame F1 by the clamps 60 is canceled and transfer means 71 having suction pads 72 is positioned above the holding table 5. Thereafter, the annular frame F1 is held under suction by the suction pads 72 of the transfer means 71, and the annular reinforcing portion 85 supported through the support tape T1 to the annular frame F1 is removed from the holding table 5 by operating the transfer means 71. Accordingly, the annular reinforcing portion 85 is removed from the wafer W, and only the device area 83 of the wafer W is left on the holding table 5. Thereafter, the wafer W from which the annular reinforcing portion 85 has been removed is unloaded from the laser processing apparatus 1 (see FIG. 1).

After performing the annular reinforcing portion removing step as mentioned above, the device area supporting step is performed as shown in FIG. 7. In the device area supporting step, the wafer W from which the annular reinforcing portion 85 (see FIG. 6) has been removed is positioned in the central opening of another annular frame F2, and

another support tape T2 is attached to the back side 81 of the wafer W and the annular frame F2. Accordingly, the wafer W is supported through the support tape T2 to the annular frame F2 in the condition where the front side 80 of the wafer W is oriented upward. Further, the support tape T1 is peeled from the front side 80 of the wafer W. Thereafter, the wafer W thus supported through the support tape T2 to the annular frame F2 is loaded to a cutting apparatus 73 (see FIG. 8). This device area supporting step may be manually performed by an operator or may be performed by using a tape mounter (not shown).

After performing the device area supporting step as mentioned above, the dividing step is performed as shown in FIG. 8. In the dividing step, the wafer W is held on a holding table 74 included in the cutting apparatus 73 in the condition where the front side 80 of the wafer W is oriented upward (exposed). Thereafter, a cutting blade 75 included in the cutting apparatus 73 is set above the wafer W at a position on the radial outside of the wafer W so that the cutting blade 75 is aligned with a predetermined one of the division lines 82. Thereafter, the cutting blade 75 is lowered to such a level that the depth of cut by the cutting blade 75 reaches the middle of the thickness of the support tape T2 attached to the back side 81 of the wafer W. Thereafter, the wafer W held on the holding table 74 is fed to the cutting blade 75 being rotated at a high speed, so that the wafer W is cut along the predetermined division line 82 to thereby divide the wafer W into the individual devices as chips.

The dividing method for the wafer W in this dividing step is not especially limited. For example, the wafer W may be half cut to form a

cut groove along each division line, and the wafer W is next divided by a breaking operation. As a modification, the wafer W may be fully cut by ablation and thereby divided into the individual devices. As another modification, a modified layer may be formed inside the wafer W along each division line by an SD (Stealth Dicing) operation, and an external force may be applied to each modified layer to thereby divide the wafer W. Each modified layer is a region different from its ambient region in density, refractive index, mechanical strength, or any other physical properties in the wafer W irradiated with a laser beam, so that the strength in this region is reduced. Examples of each modified layer include a melted region, cracked region, breakdown region, and refractive index changed region. These regions may be mixed.

There will now be described the positional relation between the escape groove 53 of the holding table 5 and the annular reinforcing portion 85 of the wafer W held on the holding table 5 with reference to FIGS. 9A and 9B. FIG. 9A is an enlarged sectional view showing the escape groove 53 and its near area according to this preferred embodiment, and FIG. 9B is an enlarged sectional view similar to FIG. 9A, showing a comparison. In this comparison shown in FIG. 9B, the same parts as those shown in FIG. 9A are denoted by the same reference symbols.

As shown in FIG. 9A, the escape groove 53 according to this preferred embodiment is wider than the annular reinforcing portion 85, and it is positioned so as to correspond to the annular reinforcing portion 85. An inside surface 55 of the escape groove 53 is positioned so as to be shifted radially inward from an inside surface 88 of the annular

reinforcing portion 85 by a small distance X1. An outside surface 56 of the escape groove 53 is positioned so as to be shifted radially outward from an outside surface 89 of the annular reinforcing portion 85 by a sufficient distance X2. In this manner, the escape groove 53 according to this preferred embodiment is formed so that the inside surface 55 is radially positioned near the annular reinforcing portion 85 and the outside surface 56 is radially positioned far from the annular reinforcing portion 85.

Since the inside surface 55 of the escape groove 53 is radially positioned near the inside surface 88 of the annular reinforcing portion 85, the wafer W can be held on the holding surface 51 of the holding table 5 in a large area. Accordingly, in performing the laser processing, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84) and its near area can be stably supported on the holding surface 51, so that there is no possibility that the laser beam applying position to the boundary portion 86 may be deviated. Further, in performing the alignment, the quantity of light applied from the imaging means 3 (see FIG. 4) into the escape groove 53 is large because the outside surface 56 of the escape groove 53 is sufficiently shifted from the outside surface 89 of the annular reinforcing portion 85 in the radial direction. Accordingly, the dark area in the image obtained by the imaging means 3 becomes clear, so that the peripheral edge 90 of the wafer W can be easily recognized.

On the other hand, as shown in FIG. 9B, the escape groove 53 according to this comparison is also wider than the annular reinforcing portion 85, and it is positioned so as to correspond to the annular

reinforcing portion 85. However, the inside surface 55 of the escape groove 53 shown in FIG. 9B is positioned so as to be shifted radially inward from the inside surface 88 of the annular reinforcing portion 85 by a sufficient distance $X3$ ($X3 > X1$). Further, the outside surface 56 of the escape groove 53 is positioned so as to be shifted radially outward from the outside surface 89 of the annular reinforcing portion 85 by a small distance $X4$ ($X4 < X2$). In this manner, the escape groove 53 according to this comparison is formed so that the inside surface 55 is radially positioned far from the annular reinforcing portion 85 and the outside surface 56 is radially positioned near the annular reinforcing portion 85.

Since the inside surface 55 of the escape groove 53 is radially positioned far from the inside surface 88 of the annular reinforcing portion 85, the area of the holding surface 51 for holding the wafer W is smaller than that of the holding surface 51 shown in FIG. 9A. Accordingly, in performing the laser processing, the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84) and its near area are not stably supported on the holding surface 51, so that there is a possibility that the laser beam applying position to the boundary portion 86 may be deviated. Further, in performing the alignment, the quantity of light applied from the imaging means 3 (see FIG. 4) into the escape groove 53 is small because the outside surface 56 of the escape groove 53 is slightly shifted from the outside surface 89 of the annular reinforcing portion 85 in the radial direction. Accordingly, the dark area in the image obtained by the imaging means 3 becomes unclear, so that it is difficult to recognize the

peripheral edge 90 of the wafer W.

According to the wafer processing method in this preferred embodiment described above, the laser beam is applied to the wafer W along the boundary portion 86 between the device area 83 and the annular reinforcing portion 85 (the peripheral marginal area 84), thereby separating the annular reinforcing portion 85 from the device area 83 of the wafer W. Thereafter, the annular reinforcing portion 85 is removed from the holding table 5, thereby removing the annular reinforcing portion 85 from the wafer W. In this manner, the annular reinforcing portion 85 can be separated from the device area 83 of the wafer W without using a cutting blade. Accordingly, it is unnecessary to consider the edge projection amount and the thickness of the cutting blade as in the case of using the cutting blade. Further, since the wafer W is processed by applying the laser beam, a processing area can be minimized to thereby eliminate the problem that the device area 83 is reduced. Further, even in the case that the thickness of the wafer W is increased with an increase in diameter of the wafer W, the annular reinforcing portion 85 can be stably removed.

The present invention is not limited to the above preferred embodiment, but various modifications may be made. The size, shape, etc. of the parts in the above preferred embodiment shown in the attached drawings are merely illustrative and they may be suitably changed within the scope where the effect of the present invention can be exhibited. Further, the above preferred embodiment may be suitably modified without departing from the scope of the object of the present invention.

For example, while the escape groove 53 is formed on the upper surface of the holding table 5 in the above preferred embodiment, the escape groove 53 may not be formed on the upper surface of the holding table 5 provided that no damage to the laser source is caused by the reflection of the laser beam from the upper surface of the holding table 5.

Further, while the bottom 54 of the escape groove 53 is inclined so that the depth of the escape groove 53 is increased toward the center of the holding table 5 in the above preferred embodiment, the configuration of the bottom 54 of the escape groove 53 is not limited provided that the reflected light from the bottom 54 in performing the alignment or the laser processing does not return to the imaging means 3 or the processing head 21. For example, the bottom 54 of the escape groove 53 may be inclined so that the depth of the escape groove 53 is increased toward the outer circumference of the holding table 5.

Further, while the laser beam applying position in the first and second steps of the annular reinforcing portion separating step is indexed in the radially inward direction in the above preferred embodiment, the laser beam applying position may be indexed in the radially outward direction in the first and second steps.

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 holding table for holding a wafer having a device area where a plurality of devices are formed and a peripheral marginal area surrounding said device area on a front side of said wafer, said wafer further having an annular reinforcing portion formed on a back side of said peripheral marginal area;

said holding table having an upper surface formed with an annular escape groove for allowing the escape of a laser beam, said annular escape groove being formed so as to correspond to a boundary portion between the device area and the annular reinforcing portion of said wafer held on the upper surface of said holding table, a bottom of said escape groove being tapered and formed with fine asperities for scattering said laser beam.

2. The holding table according to claim 1, wherein said laser beam has an absorption wavelength to said wafer and is directed toward said boundary portion to delete said annular reinforcing portion.