

PROCESSING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a processing apparatus that is used in calculation of the center position of one surface of a wafer with a circular plate shape and executes predetermined processing for an outer circumferential part of the wafer.

Description of the Related Art

The following processing method is known (for example, refer to Japanese Patent Laid-open No. 2007-19461). In a circular plate-shaped wafer having, on the front surface side, a device region in which a plurality of devices are formed and an outer circumferential surplus region that surrounds the device region, a region on the back surface side corresponding to the device region is ground to form a circular recessed part. In addition, a ring-shaped reinforcing part is left in a region corresponding to the outer circumferential surplus region. Thereafter, the wafer is divided in units of device. In the case of dividing the wafer in units of device by the processing method, in general, the ring-shaped reinforcing part needs to be removed first.

Hence, there have been proposed processing apparatuses that identify the center position of the front surface of a wafer and then cut and remove the ring-shaped reinforcing part with high accuracy in reference to this center position (for example, refer to Japanese Patent Laid-open No. 2014-60224 and Japanese Patent Laid-open No. 2020-43186).

In the processing apparatus described in Japanese Patent Laid-open No. 2020-43186, in order to identify the center position of the front surface of a wafer, a holding table in which a circular truncated cone is disposed on the bottom part side relative to a holding surface and whose diameter is smaller than that of the wafer is used. The circular truncated cone has, as the side surface, an annular inclined surface that is inclined by 45 degrees with respect to the horizontal plane and functions as a mirror surface. A light source such as a light emitting diode (LED) is disposed on a lateral side of the circular truncated cone. A camera is disposed above the inclined surface and light emitted from the light source is reflected to the upper side by the inclined surface and is imaged by the camera.

For calculating the center position of the front surface of the wafer by using this circular truncated

cone, first, the recessed part that is formed by grinding and corresponds to the device region is fitted to the holding table and the wafer is held under suction by the holding table. At this time, an outer circumferential part of the wafer sticks out to the outside of the holding table. Next, the side surface of the circular truncated cone is irradiated with light from a lateral side, the outer circumferential part of the wafer is irradiated with reflected light from the inclined surface, and the outer circumferential part is imaged by the above-described camera. In particular, three different places in the outer circumferential part of the wafer are imaged by the camera by rotation of the holding table.

The center position (coordinates) in the holding surface of the holding table is known, and hence, the center position (center coordinates) of the front surface of the wafer can be calculated in reference to the positions (coordinates) of three points at the edge obtained by imaging the three places in the outer circumferential part. However, among the types of wafers, there are ones with various outer diameters such as 6 inches (approximately 150 mm), 8 inches (approximately 200 mm), and 12 inches (approximately 300

mm). The diameter of the circular recessed part formed on the back surface side of the wafer differs depending on the diameter of the wafer.

SUMMARY OF THE INVENTION

Consequently, for holding under suction the recessed part of the wafer having various diameters, the holding table having a diameter according to the diameter of the wafer is necessary. Hence, in the optical system using the circular truncated cone, there is a problem that the circular truncated cone with a different size is required depending on the outer diameter of the holding table and time and labor for replacement is accordingly generated. The present invention is made in view of such a problem and intends to provide an optical system that can irradiate an outer circumferential part of a wafer held under suction by a holding table with light and can be used even for the holding table with a different diameter.

In accordance with an aspect of the present invention, there is provided a processing apparatus that is used in calculation of a center position of one surface of a wafer with a circular plate shape and executes predetermined processing for an outer

circumferential part of the wafer. The processing apparatus includes a holding unit that holds the wafer, a processing unit that processes the wafer, and an imaging unit that images the outer circumferential part of the wafer held by the holding unit. The holding unit has a holding table with a circular plate shape for holding under suction the wafer, a rotating shaft that is coupled to the holding table and is for rotating the holding table, and a drive part that rotates the rotating shaft. The imaging unit has a camera part, a light emitting unit that is disposed on the lower side relative to the camera part and includes a light source, and at least three reflecting units that are each fixed to the rotating shaft and are disposed at an outer circumferential part of the holding table in such a manner as to be separate from each other along a circumferential direction of the holding table, each have a pair of inclined surfaces opposed, and each allow light from the light source to be output upward through the pair of inclined surfaces. By adjustment of a position of each reflecting unit in the imaging unit, the outer circumferential part of the wafer that has a larger diameter than the holding table and sticks out to the outside of the holding table in a radial direction when being held under suction by the

holding table is irradiated with the light from the light source sequentially from each reflecting unit, and at least three places in the outer circumferential part of the wafer are imaged by the imaging unit.

Preferably, the at least three reflecting units include at least three first reflecting units each capable of irradiating, with the light from the light source, an outer circumferential part of a first wafer that sticks out to outside of a first holding table having a first diameter in the radial direction of the first holding table, when being held under suction by the first holding table, and has a diameter larger than the first diameter, when the first holding table is used as the holding table for the holding unit, and at least three second reflecting units each capable of irradiating, with the light from the light source, an outer circumferential part of a second wafer that sticks out to outside of a second holding table having a second diameter larger than the first diameter in the radial direction of the second holding table, when being held under suction by the second holding table, and has a diameter larger than the second diameter, when the second holding table is used as the holding table for the holding unit instead of the first holding table.

Moreover, preferably, the holding unit further has a circular annular auxiliary table disposed at the outer circumferential part of the holding table, and the auxiliary table includes through-holes for irradiating the outer circumferential part of the wafer with light reflected by each reflecting unit.

Further, preferably, the pair of inclined surfaces of each reflecting unit include a first mirror surface and a second mirror surface that are inclined by 45 degrees with respect to a flat surface orthogonal to the longitudinal direction of the reflecting unit in which the pair of inclined surfaces are disposed to cause the light from the light source to be output upward.

The holding unit of the processing apparatus according to the aspect of the present invention has at least three reflecting units that are each fixed to the rotating shaft of the holding table and are disposed at the outer circumferential part of the holding table in such a manner as to be separate from each other along the circumferential direction of the holding table. Each reflecting unit has the pair of inclined surfaces opposed and allows the light incident on the reflecting unit from the light source to be output upward through this pair of inclined surfaces. The outer circumferential part of the

wafer held by the holding unit is imaged by the imaging unit. For example, when the first holding table having the first diameter is mounted in the holding unit and the first wafer is held under suction by the first holding table, the coordinates of three points at the edge of the first wafer are identified by imaging the outer circumferential part of the first wafer by the three reflecting units.

In contrast, when a holding table having a diameter larger than the first diameter is mounted in the holding unit and a wafer with a larger diameter than the first wafer is held under suction by this holding table, the coordinates of three points at the edge of the wafer with the larger diameter are identified without use of the reflecting units. As described above, in the case of using the holding tables different in size, coordinates at the outer circumferential edges of the wafers different in diameter can each be identified by mere selection of whether or not to use at least three reflecting units. Hence, it is possible to provide an optical system that can be used even for the holding tables with the different diameters. Moreover, time and labor required for replacement of the circular truncated cone can also be eliminated compared with the case in

which a dedicated circular truncated cone corresponding to the diameter of the holding table is mounted for each of the holding tables different in size.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a laser processing apparatus;

FIG. 2A is a perspective view of a front surface side of a wafer unit;

FIG. 2B is a perspective view of a back surface side of a wafer;

FIG. 3 is an enlarged perspective view of a holding unit;

FIG. 4 is a partially sectional side view of the holding unit;

FIG. 5 is a partially sectional side view illustrating the state in which an outer circumferential

part of the wafer is imaged;

FIG. 6 is a partially sectional side view illustrating the state in which an outer circumferential part of a wafer with a larger diameter is imaged;

FIG. 7A is a top view of the holding unit in which a chuck table having a first diameter is mounted in a second embodiment;

FIG. 7B is a top view of the holding unit in which a chuck table having a second diameter is mounted in the second embodiment;

FIG. 8 is a partially sectional side view illustrating a reflecting unit according to a third embodiment;

FIG. 9 is an enlarged view of the holding unit according to a modification example;

FIG. 10 is a partially sectional side view illustrating the state in which the outer circumferential part of the wafer is imaged; and

FIG. 11 is a partially sectional side view illustrating the state in which the outer circumferential part of the wafer with the larger diameter is imaged.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments according to one aspect of the

present invention will be described with reference to the accompanying drawings. FIG. 1 is a perspective view illustrating a configuration example of a laser processing apparatus (processing apparatus) 2. The laser processing apparatus 2 includes a base 4 that supports the respective structures. The base 4 includes a base part 6 with a rectangular parallelepiped shape and a wall part 8 extending upward at the rear end of the base part 6. A chuck table (first holding table) 10 with a circular plate shape is disposed over the base part 6. The chuck table 10 holds under suction a circular plate-shaped wafer (first wafer) 11 that becomes a processing target.

Here, the wafer 11 will be described with reference to FIG. 2A and FIG. 2B. The wafer 11 has a single-crystal substrate formed of a semiconductor material such as silicon. However, the single-crystal substrate is not limited to silicon and may be formed of a compound semiconductor such as silicon carbide (SiC) or gallium nitride (GaN) or may be formed of another material. As illustrated in FIG. 2A, a plurality of planned dividing lines 13 are set in a lattice manner on the side of a front surface (one surface) 11a of the wafer 11. A device 15 is formed in each of rectangular

regions marked out by the plurality of planned dividing lines 13. For example, the device 15 is an integrated circuit (IC), micro electro mechanical systems (MEMS), LED, or the like. However, there is no particular limitation on the kind, size, quantity, arrangement, and so forth of the device 15.

In a radial direction of the wafer 11, an annular outer circumferential surplus region 19 is present outside a device region 17 that is located on the central part side and in which the plurality of devices 15 are formed. The outer circumferential surplus region 19 is a substantially flat region in which the device 15 is not formed. In FIG. 2A, a boundary 17a between the device region 17 and the outer circumferential surplus region 19 is illustrated by a dashed line for convenience. However, the boundary 17a is not indicated on the actual wafer 11. A notch 11c indicating the crystal orientation of the single-crystal substrate is formed at an outer circumferential part of the wafer 11.

As illustrated in FIG. 2B, a circular recessed part 21 is formed on the side of a back surface 11b of the wafer 11 by grinding of a circular region corresponding to the device region 17 on the side of the back surface 11b. For example, the wafer 11 in the

device region 17 is thinned to a thickness of approximately 50 μm . Outside the circular recessed part 21, an annular projecting part 23 is formed to surround the circular recessed part 21. The annular projecting part 23 is a region that is not ground and remains at the time of the formation of the circular recessed part 21 and is an annular region corresponding to the outer circumferential surplus region 19.

The diameter of the wafer 11 is 8 inches (approximately 200 mm), for example. The annular projecting part 23 has the thickness of the wafer 11 that has not yet been ground. The thickness of the annular projecting part 23 is approximately 725 μm , for example. This thickness is defined as appropriate depending on the diameter of the wafer 11. Further, the width of the annular projecting part 23 in the radial direction of the wafer 11 is approximately 3.0 mm, for example. The annular projecting part 23 functions as a reinforcing part of the wafer 11 in which the circular recessed part 21 is formed. Providing the annular projecting part 23 makes it possible to prevent breakage and so forth at the time of conveyance of the wafer 11 compared with the case in which the side of the back surface 11b is evenly thinned without the annular projecting part 23 being

provided.

After the circular recessed part 21 is formed on the side of the back surface 11b, a circular tape 25 with a larger diameter than the wafer 11 is stuck to the side of the back surface 11b of the wafer 11. The tape 25 is formed of resin that is substantially transparent to at least light in the visible light band. For example, the tape 25 has a layer-stacking structure with an adhesive layer (glue layer) formed of resin having adhesiveness, such as an ultraviolet-curable resin, and a base layer formed of resin. The side of the back surface 11b of the wafer 11 is stuck to a central part of the tape 25 in such a manner that the tape 25 follows the shape of the circular recessed part 21.

One surface of an annular frame 27 formed of metal is stuck to an outer circumferential part of the tape 25. In this manner, a wafer unit 29 in which the wafer 11 is supported by the annular frame 27 through the tape 25 is formed. FIG. 2A is a perspective view of the side of the front surface 11a of the wafer unit 29. FIG. 2B is a perspective view of the side of the back surface 11b of the wafer 11 in which the tape 25 and the annular frame 27 are omitted. The wafer unit 29 is held under suction by the chuck table 10.

FIG. 3 is an enlarged perspective view of a holding unit 12 of the first embodiment including the chuck table 10. FIG. 4 is a partially sectional side view of the holding unit 12. As illustrated in FIG. 4, the chuck table 10 has a circular plate-shaped frame body 14a formed of non-porous ceramic. A recessed part with a circular plate shape is formed on the upper surface side of the frame body 14a. A porous plate 14b formed of a porous ceramic is fixed to this recessed part. Grooves and holes for transmitting a negative pressure to the porous plate 14b are formed in a bottom part of the recessed part.

When a negative pressure is caused to act from a suction source 16 such as an ejector, the negative pressure is transmitted to the upper surface of the porous plate 14b through the grooves and the holes of the frame body 14a and so forth. The upper surfaces of the frame body 14a and the porous plate 14b function as a holding surface 10a that holds under suction the wafer unit 29. The wafer 11 is disposed over the chuck table 10 in such a manner that the circular recessed part 21 is fitted to an upper part of the chuck table 10 including the holding surface 10a, with the interposition of the tape 25. A lower part of the chuck table 10 is

attachably/detachably fixed to a table base 18 with a circular plate shape.

As the chuck table 10, one with a proper size is selected according to the size of the wafer 11 to be held under suction (more specifically, diameter of the circular recessed part 21 of the wafer 11) and is mounted on the table base 18. An upper part of a rotating shaft 20 with a circular column shape is coupled to a lower part of the table base 18. Part of the rotating shaft 20 corresponds to a rotor of a motor electrically driven and is supported by an X-axis direction moving plate 40 to be described later, with the interposition of a bearing (not illustrated). A circular cylindrical drive part 22 for rotating the rotating shaft 20 is disposed around the rotating shaft 20.

The drive part 22 corresponds to a stator of the motor electrically driven. The rotating shaft 20 and the drive part 22 configure a direct-current motor. However, the rotating shaft 20 and the drive part 22 may be another kind of motor such as an alternating-current motor. When power is supplied to the drive part 22, the chuck table 10 coupled to the rotating shaft 20 with the interposition of the table base 18 rotates around a center 20a of the rotating shaft 20. A rotation angle

sensor (not illustrated) such as a rotary encoder for detecting the rotation angle of the chuck table 10 is disposed on the drive part 22.

At an outer circumferential part of the chuck table 10, a plurality of clamp units 24 that each clamp the annular frame 27 are disposed at substantially equal intervals along the circumferential direction of the chuck table 10. A base end part of each clamp unit 24 is fixed to the table base 18. The chuck table 10, the table base 18, the rotating shaft 20, the drive part 22, the four clamp units 24, and so forth configure the holding unit 12. The chuck table 10 is replaced as appropriate according to the diameter of the wafer 11 to be held under suction. At the outer circumferential part of the table base 18, four reflecting units (first reflecting units) 26 are disposed at substantially equal intervals in such a manner as to be separate from each other along the circumferential direction of the chuck table 10. A base end part of each reflecting unit 26 is fixed to the rotating shaft 20 with the interposition of the table base 18, at a different position from the clamp units 24.

Here, the reflecting unit 26 will be described in detail with reference to FIG. 5. The reflecting unit 26

has an arm part 28 that is made of metal and protrudes with a longitudinal direction 28a extending along the radial direction of the table base 18. Each arm part 28 is disposed at the outer circumferential part of the chuck table 10 in such a manner as to protrude outward relative to the outer circumference of the chuck table 10. A first reflecting block 30 that has a large thickness in a Z-axis direction compared with the arm part 28 and is made of metal is disposed at a tip part of the arm part 28 in the longitudinal direction 28a. The outside side surface of the first reflecting block 30 in the longitudinal direction 28a is a perpendicular flat surface 30a orthogonal to the longitudinal direction 28a (flat surface orthogonal to the longitudinal direction 28a).

In contrast, the inside side surface of the first reflecting block 30 in the longitudinal direction 28a is a flat surface (inclined surface 30b) inclined by a predetermined angle with respect to the perpendicular flat surface 30a. The inclined surface 30b of the present embodiment is inclined by 45 degrees with respect to the perpendicular flat surface 30a in such a manner that the lower end part thereof is located outside relative to the upper end part in the longitudinal

direction 28a. The inclined surface 30b includes a first mirror surface 30c formed by execution of mirror surface finish processing. The first mirror surface 30c may be provided by a mirror being fixed to the inclined surface 30b instead of the mirror surface finish processing being executed.

A through-hole 28b with an inverted quadrangular frustum shape is formed at a base end part of the arm part 28. At least part of the through-hole 28b is located outside relative to the outer circumference of the holding surface 10a in the longitudinal direction 28a and is located directly under an outer circumferential part 11d of the wafer 11 held under suction by the holding surface 10a. A second reflecting block 34 that has a large thickness in the Z-axis direction compared with the arm part 28 and is made of metal is disposed on the lower surface side of the base end part of the arm part 28. An opening 34a is formed at a tip part of the second reflecting block 34 in the longitudinal direction 28a.

At a part of the second reflecting block 34 on the side of the table base 18 relative to the opening 34a, a flat surface (inclined surface 34b) that is located directly under the through-hole 28b and is

disposed to be opposed to the inclined surface 30b in the longitudinal direction 28a is disposed. The inclined surface 34b is inclined in the same direction as the inclined surface 30b by a predetermined angle with respect to the perpendicular flat surface 30a. The inclined surface 34b of the present embodiment is inclined in the same direction as the inclined surface 30b by 45 degrees with respect to the perpendicular flat surface 30a. Moreover, the inclined surface 34b includes a second mirror surface 34c formed by execution of mirror surface finish processing. The second mirror surface 34c may be provided by a mirror being fixed to the inclined surface 34b instead of the mirror surface finish processing being executed.

When the rotating shaft 20 is rotated, the chuck table 10, the table base 18, the arm parts 28, and so forth integrally rotate. A light emitting unit 32 including a light source 32a such as an LED is disposed directly under a region corresponding to one place on a circular annular region formed by the locus of the inclined surface 30b of the first reflecting block 30. Light 32b emitted from the light emitting unit 32 sequentially goes through the first mirror surface 30c and the second mirror surface 34c (that is, pair of

inclined surfaces 30b and 34b) and the through-hole 28b and is output upward from the through-hole 28b. This light 32b is used when the outer circumferential part 11d (particularly, outer circumferential edge 11e) of the wafer 11 held under suction by the holding surface 10a is imaged by a camera part 64 to be described later.

In the present embodiment, the case in which the four reflecting units 26 are disposed on the holding unit 12 has been described. However, it suffices to dispose at least three reflecting units 26 on the holding unit 12 to image at least three places in the outer circumferential part 11d of the wafer 11. The four (at least three) reflecting units 26, the light emitting unit 32, the camera part 64, and so forth configure an imaging unit 36 (that is, optical system).

Here, with reference to FIG. 1 again, other constituent elements of the laser processing apparatus 2 will be described. The above-described drive part 22 is supported by the X-axis direction moving plate 40 with a rectangular shape. The above-described light emitting unit 32 is fixed to one place in four corners of the X-axis direction moving plate 40. The X-axis direction moving plate 40 is supported in a slidable manner by a pair of X-axis guide rails 42 disposed substantially in

parallel to an X-axis direction. A nut part (not illustrated) is disposed on the lower surface side of the X-axis direction moving plate 40 and a screw shaft 44 having a longitudinal part disposed along the X-axis direction is coupled in a rotatable manner to this nut part with the interposition of a plurality of balls (not illustrated).

A drive source 46 such as a stepping motor is coupled to one end part of the screw shaft 44. When the screw shaft 44 is rotated by the drive source 46, the X-axis direction moving plate 40 moves along the X-axis direction. The X-axis direction moving plate 40, the pair of X-axis guide rails 42, the nut part, the screw shaft 44, the drive source 46, and so forth configure an X-axis direction movement unit 48 of a ball screw system. The pair of X-axis guide rails 42 are fixed to the upper surface of a Y-axis direction moving plate 50. The Y-axis direction moving plate 50 is supported in a slidable manner by a pair of Y-axis guide rails 52 that are disposed substantially in parallel to a Y-axis direction and are fixed to the upper surface of the base part 6.

A nut part (not illustrated) is disposed on the lower surface side of the Y-axis direction moving plate 50, and a screw shaft 54 having a longitudinal part

disposed along the Y-axis direction is coupled in a rotatable manner to this nut part with the interposition of a plurality of balls (not illustrated). A drive source 56 such as a stepping motor is coupled to one end part of the screw shaft 54. When the screw shaft 54 is rotated by the drive source 56, the Y-axis direction moving plate 50 moves along the Y-axis direction. The Y-axis direction moving plate 50, the pair of Y-axis guide rails 52, the nut part, the screw shaft 54, the drive source 56, and so forth configure a Y-axis direction movement unit 58 of a ball screw system.

A base end part of a cantilever-shaped arm 60 is fixed to the front side surface of the wall part 8 in such a manner that the arm 60 protrudes to the upper side of the holding unit 12 along the Y-axis direction. Part of a laser processing unit (processing unit) 62 that processes the wafer 11 or the like is disposed on the arm 60. The laser processing unit 62 has a laser oscillator (not illustrated) including a rod-shaped laser medium formed of neodymium-doped yttrium aluminum garnet crystal (Nd:YAG), neodymium-doped yttrium orthovanadate (Nd:YVO₄), or the like. A pulsed laser beam emitted from the laser oscillator is output toward the holding surface 10a through a substantially circular cylindrical light

collector 62a disposed at a tip part of the arm 60 and above the holding unit 12.

The laser beam with which irradiation is executed from the light collector 62a has such a wavelength as to be absorbed by the wafer 11 (for example, 355 nm). When the chuck table 10 is rotated in the state in which the focal point of the laser beam focused by the light collector 62a is positioned to the boundary 17a of the wafer 11, the annular projecting part 23 can be split off from the wafer 11 by ablation processing. In this way, the laser processing unit 62 is used when laser processing (predetermined processing) is executed for the outer circumferential part 11d of the wafer 11. The camera part 64 is disposed on the arm 60 in addition to the laser processing unit 62.

The camera part 64 includes a substantially circular cylindrical head part 64a disposed at a tip part of the arm 60 and above the holding unit 12. A collecting lens (not illustrated) and so forth are disposed in the head part 64a. The above-described light emitting unit 32 is disposed on the lower side relative to the head part 64a. The head part 64a can also take in the light 32b reflected by the reflecting unit 26 after being emitted from the light emitting unit 32 and can

also directly take in the light 32b that has traveled from the light emitting unit 32 without going through the reflecting unit 26.

The camera part 64 includes an imaging element (not illustrated) such as a complementary metal-oxide-semiconductor (CMOS) image sensor or a charge-coupled device (CCD) image sensor. The light 32b taken in from the head part 64a is subjected to photoelectric conversion by the imaging element and is stored in a storing device (not illustrated) of the laser processing apparatus 2 as image information. The image information is displayed as an image on a touch panel 68 disposed on the front surface of a casing 66 of the laser processing apparatus 2, for example. The touch panel 68 functions as a display device that displays an image for an operator and functions also as an input device for allowing the operator to execute predetermined operation and input.

Operation of the holding unit 12, the suction source 16, the imaging unit 36, the X-axis direction movement unit 48, the Y-axis direction movement unit 58, the laser processing unit 62, the touch panel 68, and so forth is controlled by a controller 70. For example, the controller 70 is configured by a computer including a

processor (processing unit) typified by a central processing unit (CPU), a main storing device such as a dynamic random access memory (DRAM), static random access memory (SRAM), or read only memory (ROM), and an auxiliary storing device such as a flash memory, hard disk drive, or solid-state drive. Software including a predetermined program is stored in the auxiliary storing device. By causing the processing unit and so forth to operate in accordance with this software, functions of the controller 70 are implemented.

Next, with reference to FIG. 5, a procedure of calculating a center position 11a₁ (see FIG. 2A) of the front surface 11a of the wafer 11 will be described. FIG. 5 is a partially sectional side view illustrating the state in which the outer circumferential part 11d of the wafer 11 is imaged. To hold under suction the side of the back surface 11b of the wafer 11, the chuck table 10 having a first diameter 10b that is smaller than the diameter of the wafer 11 and is defined according to the diameter of the circular recessed part 21 of the wafer 11 is used.

First, the circular recessed part 21 of the wafer 11 is fitted to the upper part of the chuck table 10 with the interposition of the tape 25. Subsequently, the

annular frame 27 (not illustrated in FIG. 5) is clamped by the clamp units 24, and the side of the back surface 11b of the circular recessed part 21 is held under suction by the holding surface 10a by a negative pressure. Because the wafer 11 has a larger diameter than the first diameter 10b, the outer circumferential part 11d of the wafer 11 held under suction by the holding surface 10a sticks out to the outside of the chuck table 10 in the radial direction. In this manner, the wafer 11 is held by the holding unit 12.

Thereafter, the X-axis direction movement unit 48, the Y-axis direction movement unit 58, and the drive part 22 are operated and the position of one reflecting unit 26 is adjusted with respect to the head part 64a and the light emitting unit 32. Specifically, the rotation angle of the one reflecting unit 26 and the positions of the X-axis direction moving plate 40 and the Y-axis direction moving plate 50 are adjusted to cause the head part 64a to be located directly above the through-hole 28b of the one reflecting unit 26 and cause the light emitting unit 32 to be located directly under the inclined surface 30b of the one reflecting unit 26. Further, when the outer circumferential part 11d of the wafer 11 is irradiated with the light 32b from the first

reflecting unit 26 and the outer circumferential part 11d is imaged by the camera part 64, a first image including a region interrupted by the wafer 11 and a region that is not interrupted by the wafer 11 is obtained.

Next, a second image is obtained by rotating the rotating shaft 20 by substantially 90 degrees and irradiating the outer circumferential part 11d of the wafer 11 with the light 32b from the second reflecting unit 26 and imaging the outer circumferential part 11d by the camera part 64. Subsequently, a third image is obtained by further rotating the rotating shaft 20 by substantially 90 degrees and irradiating the outer circumferential part 11d of the wafer 11 with the light 32b from the third reflecting unit 26 and imaging the outer circumferential part 11d by the camera part 64. In this way, in the present embodiment, the irradiation with the light 32b is sequentially executed from the respective reflecting units 26, and three different places in the outer circumferential part 11d of the wafer 11 are imaged. Thereafter, predetermined image processing such as edge detection is executed by a first program stored in the controller 70.

For example, the first program obtains the coordinates of one point corresponding to the outer

circumferential edge 11e in each of the first to third images, that is, obtains the coordinates of three points in total, by executing binarization processing for the first to third images and then executing edge detection. The coordinates of the three points are each defined with a center position (coordinates) 10c (see FIG. 4) of the holding surface 10a being the origin. In general, the center position 10c of the holding surface 10a and the center position 11a₁ of the front surface 11a of the wafer 11 do not exactly correspond with each other and deviate from each other. By use of a known method described in Japanese Patent Laid-open No. 2020-43186, the center position 11a₁ of the front surface 11a can be calculated in reference to the center position 10c of the holding surface 10a and the coordinates of the three points corresponding to the outer circumferential edge 11e.

A second program to calculate the center position 11a₁ of the front surface 11a is stored in the controller 70. In the above description, the example in which three places in the outer circumferential part 11d are imaged has been explained. However, it suffices to image at least three places in the outer circumferential part 11d. For example, it is also possible to execute acquisition of the coordinates of three points corresponding to the

outer circumferential edge 11e and calculation of the center position 11a₁ by imaging four or more places and selectively using appropriate images excluding an image for which the imaging could not be successfully executed for some reason. The imaging unit 36 excluding the four reflecting units 26 is used also when an outer circumferential part 31d of a wafer (second wafer) 31 with a larger diameter than the wafer 11 is imaged.

FIG. 6 is a partially sectional side view illustrating the state in which the outer circumferential part 31d of the wafer 31 with a large diameter compared with the wafer 11 is imaged. The diameter of the wafer 31 is 12 inches (approximately 300 mm), for example, and is larger than the diameter of the wafer 11 (8 inches). Also in the wafer 31, a circular recessed part 41 is formed on the side of a back surface 31b as in the wafer 11. When the side of the back surface 31b of the wafer 31 is held under suction, instead of the chuck table 10, a chuck table (second holding table) 80 having a second diameter 80b according to the diameter of the circular recessed part 41 of the wafer 31 is mounted on the table base 18. The second diameter 80b is larger than the first diameter 10b of the chuck table 10. The chuck table 80, the table base 18, the rotating shaft 20, the

drive part 22, the four clamp units 24, and so forth also configure the holding unit 12. The structure of the chuck table 80 is substantially the same as that of the chuck table 10, and hence detailed description thereof is omitted.

To image the outer circumferential part 31d of the wafer 31, first, the circular recessed part 41 of the wafer 31 is fitted to an upper part of the chuck table 80 with the interposition of the tape 25. Next, the annular frame 27 (not illustrated in FIG. 6) is clamped by the clamp units 24, and the side of the back surface 31b of the circular recessed part 41 is held under suction by a holding surface 80a by a negative pressure. Because the wafer 31 has a larger diameter than the second diameter 80b, the outer circumferential part 31d of the wafer 31 sticks out to the outside of the chuck table 80 in the radial direction when the wafer 31 is held under suction by the holding surface 80a.

After the wafer 31 is held by the holding unit 12, the X-axis direction movement unit 48 and the Y-axis direction movement unit 58 are operated, and the light emitting unit 32 is disposed directly under the head part 64a. Then, when the outer circumferential part 31d is imaged by the camera part 64, a fourth image including a

region interrupted by the wafer 31 and a region that is not interrupted by the wafer 31 is obtained. As illustrated in FIG. 6, when the outer circumferential part 31d of the wafer 31 is imaged, the outer circumferential part 31d of the wafer 31 is directly irradiated with the light 32b without the reflecting unit 26 being used. Next, a fifth image is obtained by rotating the rotating shaft 20 by substantially 90 degrees and directly irradiating the outer circumferential part 31d with the light 32b and imaging the outer circumferential part 31d by the camera part 64.

Next, a sixth image is obtained by further rotating the rotating shaft 20 by substantially 90 degrees and directly irradiating the outer circumferential part 31d of the wafer 31 with the light 32b and imaging the outer circumferential part 31d by the camera part 64. Four or more places in the outer circumferential part 31d may be imaged, of course. In this way, the outer circumferential part 31d of the wafer 31 is sequentially irradiated with the light 32b without the light 32b being caused to go through the reflecting unit 26, and three different places in the outer circumferential part 31d are imaged. Thereafter, through image processing and so forth, the center position (not

illustrated) of a front surface 31a is calculated.

As described above, in the present embodiment, in the case of using the chuck tables 10 and 80 different in size, coordinates at the outer circumferential edges 11e and 31e of the wafers 11 and 31 different in diameter can each be identified by mere selection of whether or not to use at least three reflecting units 26. Hence, it is possible to provide an optical system that can be used even for the chuck tables 10 and 80 with the different diameters. Moreover, time and labor required for replacement of the circular truncated cone can be reduced compared with the case in which a dedicated circular truncated cone corresponding to the diameter of the chuck table 10 or 80 is mounted for each of the chuck tables 10 and 80 different in size.

In the first embodiment, there has been illustrated an example in which the through-hole 28b is located inside relative to the light emitting unit 32 in the radial direction of the table base 18 when the chuck table 10 is seen in top view. However, when the inclined surfaces 30b and 34b are inclined by 45 degrees in the direction opposite to that in the example of FIG. 5, the through-hole 28b is formed directly above the inclined surface 30b, and the light emitting unit 32 is disposed

inside relative to the through-hole 28b in the radial direction of the table base 18.

(Second Embodiment)

Next, a second embodiment will be described with reference to FIG. 7A and FIG. 7B. FIG. 7A is a top view of the holding unit 12 in which the chuck table 10 having the first diameter 10b is mounted, and so forth. In FIG. 7A, the outer circumferential edge 11e of the wafer 11 whose side of the back surface 11b is held under suction by the holding surface 10a is illustrated by a one-dot chain line. As illustrated in FIG. 7A, the outer circumferential edge 11e is located directly above the through-holes 28b of four reflecting units 26. In the example illustrated in FIG. 7A, along the circumferential direction of the table base 18, four clamp units 24 are disposed at substantially equal intervals, and the four reflecting units 26 are disposed at substantially equal intervals. Moreover, four reflecting units (second reflecting units) 86 are disposed at substantially equal intervals.

The reflecting unit 86 has a base end part fixed to the rotating shaft 20 with the interposition of the table base 18, similarly to the reflecting unit 26. The reflecting unit 86 also includes the arm part 28, the

first reflecting block 30, and the second reflecting block 34, similarly to the reflecting unit 26. That is, the reflecting unit 86 also has the inclined surface 30b including the first mirror surface 30c and the inclined surface 34b including the second mirror surface 34c and can irradiate the head part 64a of the camera part 64 with the light 32b from the light emitting unit 32 by the first mirror surface 30c and the second mirror surface 34c. However, a distance A2 from the center position 10c of the holding surface 10a (that is, the center 20a (see FIG. 4) of the rotating shaft 20) to a through-hole 88 of the reflecting unit 86 in the longitudinal direction 28a is longer than a distance A1 from the center position 10c to the through-hole 28b of the reflecting unit 26 in the longitudinal direction 28a.

FIG. 7B is a top view of the holding unit 12 in which the chuck table 80 having the second diameter 80b is mounted in place of the chuck table 10, and so forth. In FIG. 7B, the outer circumferential edge 31e of the wafer 31 whose side of the back surface 31b is held under suction by the holding surface 80a is illustrated by a one-dot chain line. As illustrated in FIG. 7B, the outer circumferential edge 31e of the wafer 31 is located directly above the through-holes 88 of the four

reflecting units 86. Hence, the light 32b emitted from the light emitting unit 32 goes through the pair of inclined surfaces (inclined surfaces 30b and 34b) in each reflecting unit 86, and the outer circumferential part 31d of the wafer 31 is irradiated with the light 32b.

The coordinates of three points at the outer circumferential edge 31e of the wafer 31 are each defined with a center position (coordinates) 80c of the holding surface 80a being the origin. The center position (not illustrated) of the front surface 31a of the wafer 31 is calculated in reference to the center position 80c and the coordinates of the three points corresponding to the outer circumferential edge 31e. It suffices for the imaging unit 36 to have at least three reflecting units 26 and at least three reflecting units 86 to calculate the respective center positions of the front surfaces 11a and 31a.

In the second embodiment, in the case of using the chuck tables 10 and 80 different in size, coordinates at the outer circumferential edges 11e and 31e of the wafers 11 and 31 different in diameter can each be identified by using either at least three reflecting units 26 or at least three reflecting units 86. Incidentally, in the second embodiment, description has

been made with regard to the case in which the wafer 11 whose diameter is 8 inches is imaged by use of the reflecting units 26 and the wafer 31 whose diameter is 12 inches is imaged by use of the reflecting units 86. However, the diameters of the wafers 11 and 31 are not limited to this example.

Further, in the case of processing a plurality of wafers having three different kinds of diameters, it is also possible to image an outer circumferential part of the wafer with the smallest diameter by using the reflecting units 26, image an outer circumferential part of the wafer with the intermediate diameter by using the reflecting units 86, and image an outer circumferential part of the wafer with the largest diameter without using the reflecting units 26 and 86. For example, the imaging unit 36 may be configured to image the wafer 11 whose diameter is 6 inches by using the reflecting units 26, image the wafer 31 whose diameter is 8 inches by using the reflecting units 86, and image an outer circumferential part of a wafer whose diameter is 12 inches without using the reflecting units 26 and 86.

(Third Embodiment)

Next, a third embodiment will be described with reference to FIG. 8. FIG. 8 is a partially sectional

side view illustrating a reflecting unit 90 according to the third embodiment. One reflecting unit 90 has both the through-holes 28b and 88. The second reflecting block 34 is coupled to the arm part 28 in a slidable manner along the longitudinal direction 28a. The second reflecting block 34 is positioned to cause the second mirror surface 34c to be located directly under the through-hole 28b or the through-hole 88.

The movement system of the second reflecting block 34 may be a manual movement system in which a worker manually moves the second reflecting block 34 or may be an automatic movement system in which the controller 70 controls a movement mechanism of a ball screw system to move the second reflecting block 34 to a predetermined position. By disposing at least three reflecting units 90 at different positions along the circumferential direction of the table base 18, functions of both the reflecting units 26 and 86 can be implemented in each reflecting unit 90.

(Modification Example)

Next, a modification example will be described with use of FIG. 9 to FIG. 11. Although a modification example regarding the first embodiment is illustrated in FIG. 9 to FIG. 11, this modification example can

similarly be applied also to the second and third embodiments. FIG. 9 is an enlarged view of the holding unit 12 according to the modification example. FIG. 10 is a partially sectional side view illustrating the state in which the outer circumferential part 11d of the wafer 11 is imaged. FIG. 11 is a partially sectional side view illustrating the state in which the outer circumferential part 31d of the wafer 31 with a larger diameter than the wafer 11 is imaged.

At an outer circumferential part of the frame body 14a of the chuck table 10 according to the modification example, a circular annular auxiliary table 14c having an outer diameter larger than the diameter of the chuck table 10 is disposed integrally with the frame body 14a. The upper surface of the auxiliary table 14c includes a circular annular outside upper surface 14c₁ that is substantially parallel to the X-Y plane and is substantially flat. The outside upper surface 14c₁ is present at a lower position than the holding surface 10a. The outside upper surface 14c₁ of the present embodiment is present at a position lower than the holding surface 10a by a length corresponding to the depth of the circular recessed part 21 of the wafer 11. Hence, as illustrated in FIG. 11, even when the wafer 31 with a

larger diameter than the wafer 11 is disposed over the chuck table 10, it is possible to hold under suction the wafer 31 while preventing bending of the wafer 31 by supporting the outer circumferential part 31d of the wafer 31 by the outside upper surface 14c₁.

A circular annular inside upper surface 14c₂ located inside relative to the outside upper surface 14c₁ is inclined to become lower as the position shifts from the outside toward the inside in the radial direction of the frame body 14a. Circular cylindrical through-holes 14d are formed in a region including a boundary 14c₃ between the outside upper surface 14c₁ and the inside upper surface 14c₂. As illustrated in FIG. 10, the through-hole 14d is located above the through-hole 28b of the reflecting unit 26, the light 32b reflected by the reflecting unit 26 passes through the through-hole 14d, and the outer circumferential part 11d of the wafer 11 held under suction by the holding surface 10a is irradiated with the light 32b. In contrast, in the case of imaging the outer circumferential part 31d of the wafer 31, as illustrated in FIG. 11, the outer circumferential part 31d of the wafer 31 is directly irradiated with the light 32b without the reflecting unit 26 being used.

As described above, when the chuck table 10 having the auxiliary table 14c is used, the wafer 11 can be held under suction by the chuck table 10. Moreover, the wafer 31 with a larger diameter than the wafer 11 can be held under suction by the chuck table 10 without replacement to the chuck table 80 with a larger diameter than the chuck table 10. Besides, structures, methods, and so forth according to the above-described embodiments can be carried out with appropriate changes without departing from the scope of the object of the present invention. For example, it is also possible to similarly process by the laser processing apparatus 2 the outer circumferential part 11d of the wafer 11 in which the circular recessed part 21 is not formed.

Incidentally, contents similar to the above-described embodiments can be implemented also in a cutting apparatus (processing apparatus) (not illustrated) that removes the annular projecting part 23 and so forth by executing edge trimming (that is, predetermined processing such as cutting) for the outer circumferential part 11d or 31d of the wafer 11 or 31. The cutting apparatus has a cutting unit (processing unit) instead of the laser processing unit 62. The cutting unit includes a cylindrical spindle housing

having a longitudinal part disposed in parallel to the Y-axis direction. Part of a spindle with a circular column shape is housed in a rotatable manner in the spindle housing.

A rotational drive source such as a motor is disposed near a base end part of the spindle. A tip part of the spindle protrudes from the spindle housing. A cutting blade having a circular annular cutting edge is mounted on the tip part of the spindle. Further, the head part 64a of the camera part 64 is disposed at a position adjacent to the tip part of the spindle in the X-axis direction. This head part 64a is fixed to the spindle housing.

The cutting apparatus has a cutting-in feed unit of a ball screw system that moves the spindle housing along the Z-axis direction. An indexing feed unit of a ball screw system that moves the spindle housing along the Y-axis direction is coupled to the cutting-in feed unit. The table base 18, the rotating shaft 20, and the drive part 22 are disposed under the cutting unit. The clamp units 24 and the reflecting units 26 are disposed on the table base 18 as in the above-described embodiment. One of the chuck tables 10 and 80 is mounted on the table base 18 in a replaceable manner.

The drive part 22 is supported by the X-axis direction moving plate 40. The X-axis direction moving plate 40 and so forth configure the X-axis direction movement unit (processing feed unit) 48 of a ball screw system. The light emitting unit 32 is disposed on the upper surface of the X-axis direction moving plate 40. At least three reflecting units 26, the light emitting unit 32, the camera part 64, and so forth configure the imaging unit 36.

Also in the cutting apparatus, in the case of using the chuck tables 10 and 80 different in size, coordinates in the outer circumferential parts 11d and 31d of the wafers 11 and 31 different in diameter can each be identified by mere selection of whether or not to use at least three reflecting units 26 or the like. Hence, it is possible to provide an optical system that can be used even for the chuck tables 10 and 80 with the different diameters. Moreover, time and labor required for replacement of the circular truncated cone can also be reduced compared with the case in which a dedicated circular truncated cone corresponding to the diameter of the chuck table 10 or 80 is mounted for each of the chuck tables 10 and 80 different in size. Also in the cutting apparatus, the second and third embodiments and the

modification example can be applied.

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

WHAT IS CLAIMED IS:

1. A processing apparatus that is used in calculation of a center position of one surface of a wafer with a circular plate shape and executes predetermined processing for an outer circumferential part of the wafer, the processing apparatus comprising:

a holding unit that holds the wafer;

a processing unit that processes the wafer; and

an imaging unit that images the outer circumferential part of the wafer held by the holding unit, wherein

the holding unit has

a holding table with a circular plate shape for holding under suction the wafer,

a rotating shaft that is coupled to the holding table and is for rotating the holding table, and

a drive part that rotates the rotating shaft,

the imaging unit has

a camera part,

a light emitting unit that is disposed on a lower side relative to the camera part and includes a light source, and

at least three reflecting units that are

each fixed to the rotating shaft and are disposed at an outer circumferential part of the holding table in such a manner as to be separate from each other along a circumferential direction of the holding table, each have a pair of inclined surfaces opposed, and each allow light from the light source to be output upward through the pair of inclined surfaces, and

by adjustment of a position of each reflecting unit in the imaging unit, the outer circumferential part of the wafer that has a larger diameter than the holding table and sticks out to outside of the holding table in a radial direction when being held under suction by the holding table is irradiated with the light from the light source sequentially from each reflecting unit, and at least three places in the outer circumferential part of the wafer are imaged by the imaging unit.

2. The processing apparatus according to claim 1, wherein

the at least three reflecting units include
at least three first reflecting units
each capable of irradiating, with the light from the light source, an outer circumferential part of a first wafer that sticks out to outside of a first holding table having a first diameter in a radial direction of the

first holding table, when being held under suction by the first holding table, and has a diameter larger than the first diameter, when the first holding table is used as the holding table for the holding unit, and

at least three second reflecting units each capable of irradiating, with the light from the light source, an outer circumferential part of a second wafer that sticks out to outside of a second holding table having a second diameter larger than the first diameter in a radial direction of the second holding table, when being held under suction by the second holding table, and has a diameter larger than the second diameter, when the second holding table is used as the holding table for the holding unit instead of the first holding table.

3. The processing apparatus according to claim 1 or 2, wherein

the holding unit further has a circular annular auxiliary table disposed at the outer circumferential part of the holding table, and

the auxiliary table includes through-holes for irradiating the outer circumferential part of the wafer with light reflected by each reflecting unit.

4. The processing apparatus according to any one

of claims 1 to 3, wherein

the pair of inclined surfaces of each reflecting unit include a first mirror surface and a second mirror surface that are inclined by 45 degrees with respect to a flat surface orthogonal to a longitudinal direction of the reflecting unit in which the pair of inclined surfaces are disposed to cause the light from the light source to be output upward.