

PROCESSING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a processing apparatus including an image capturing unit for capturing an image of a workpiece held on a holding unit, to detect a region of the workpiece to be processed.

Description of the Related Art

Wafers with a plurality of devices such as integrated circuits (ICs) and large-scale integrated (LSI) circuits formed in respective areas demarcated on their face side by a plurality of intersecting projected dicing lines are divided into individual device chips by a dicing apparatus or a laser processing apparatus. The device chips will be used in electric appliances such as mobile phones and personal computers.

A dicing apparatus includes at least a chuck table for holding a wafer thereon, a cutting unit having a rotatable cutting blade for cutting the wafer held on the chuck table, a feed mechanism for processing-feeding the chuck table and the cutting unit relatively to each other, an image capturing unit for capturing an image of the wafer held on the chuck table and detecting a region

of the wafer to be processed on the basis of the captured image, and a display unit for displaying the image captured by the image capturing unit. The dicing apparatus can divide the wafer highly accurately into individual device chips on the basis of the captured image (see, for example, JP 2005-166991A).

A laser processing apparatus is realized by replacing the cutting unit referred to above with a laser beam applying unit, with other structural details being basically identical to those of the dicing apparatus. The laser processing apparatus thus constructed is capable of processing a wafer highly accurately with a laser beam (see, for example, JP 2016-146403A).

The present applicant has developed and proposed a processing apparatus including a chuck table in the form of a transparent plate for holding a wafer thereon and a lower image capturing unit disposed below the chuck table and used for capturing an image of the wafer on the chuck table, in which a face side of the wafer is placed on the chuck table and a region of the wafer to be processed is detected on the basis of an image of the face side of the wafer that has been captured by the lower image capturing unit (see JP 2021-052144A).

SUMMARY OF THE INVENTION

In the processing apparatus including the lower image capturing unit disclosed in JP 2021-052144A, a wafer that is held on the chuck table with its face side oriented upwardly is processed in sometimes. To deal with such a wafer, the processing apparatus needs to include an upper image capturing unit disposed above the chuck table and used for capturing an image of the upwardly oriented face side of the wafer. In other words, depending on whether the wafer on the chuck table has its face side facing upwardly or downwardly, the upper image capturing unit or the lower image capturing unit is used to capture an image of the face side of the wafer, and a region of the wafer to be processed is detected on the basis of the captured image.

The lower image capturing unit disclosed in JP 2021-052144A captures an image of the wafer from below the chuck table through a dicing tape affixed to the wafer and the transparent plate as the chuck table. The dicing tape and the transparent plate tend to create a widely different imaging environment for the lower image capturing unit in contrast to the upper image capturing unit. The different imaging environments for the upper and lower image capturing units are liable to make the

respective images captured by the upper and lower image capturing units largely different in image quality from each other. When the captured images of different image qualities are displayed on a display unit, they are likely to cause a feeling of unease and strangeness even if they represent the same region of the wafer. Another problem is that the data of key patterns used for an alignment step carried out before the wafer is processed cannot be shared between the images captured by the upper and lower image capturing units.

In accordance with an aspect of the present invention, there is provided a processing apparatus that includes a holding unit for holding a workpiece thereon, a processing unit for processing the workpiece held on the holding unit, a feed mechanism for processing-feeding the holding unit and the processing unit relatively to each other, an image capturing assembly for capturing an image of the workpiece held on the holding unit, a display unit for displaying the image captured by the image capturing assembly, and a controller having a storage section. The holding unit includes a transparent plate having an upper surface for holding the workpiece thereon and a frame supporting the transparent plate thereon. The image capturing assembly includes an upper

image capturing unit that can be positioned above the transparent plate and a lower image capturing unit that can be positioned below the transparent plate, so that the upper image capturing unit and the lower image capturing unit can be positioned in vertically sandwiching relation to the transparent plate. The storage section of the controller stores therein a corrective function for correcting brightness levels of brightness gradations of a first image of the workpiece captured by the lower image capturing unit positioned below the transparent plate. The controller corrects the brightness levels of the brightness gradations of the first image of the workpiece captured by the lower image capturing unit positioned below the transparent plate, according to the corrective function, to make the first image similar in image quality to a second image of the workpiece captured by the upper image capturing unit positioned above the transparent plate.

Preferably, the corrective function is a conversion formula for performing gamma correction. Preferably, the controller has an adjusting capability for adjusting a range of brightness gradations of the corrective function.

The processing apparatus according to the aspect of

the present invention is effective to make the first image captured by the lower image capturing unit similar in image quality to the second image captured by the upper image capturing unit, thereby solving the problem of first and second images causing a feeling of unease and strangeness. The processing apparatus also allows the data of key patterns, which are to be used in image processing in an alignment step, to be shared between the first and second images.

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 dicing apparatus as a processing apparatus according to an embodiment of the present invention;

FIG. 2 is an exploded perspective view of a holding unit of the dicing apparatus illustrated in FIG. 1;

FIG. 3 is an exploded perspective view of an

assembly including a wafer as a workpiece to be processed by the dicing apparatus illustrated in FIG. 1;

FIG. 4 is a perspective view illustrating the manner in which an image of the wafer held on the holding unit is captured;

FIG. 5 is a front elevational view illustrating an image to be corrected that is captured by a lower image capturing unit and an image that has been corrected by a function;

FIGS. 6A through 6E are conceptual diagrams illustrating examples of different functions for correcting the image captured by the lower image capturing unit; and

FIG. 7 is a perspective view of a cutting unit of the processing apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A processing apparatus according to a preferred embodiment of the present invention will be described in detail below with reference to the accompanying drawings. FIG. 1 illustrates in perspective a dicing apparatus 1 as the processing apparatus according to the present embodiment. The dicing apparatus 1 will be described in reference to a three-dimensional coordinate system having

an X-axis, a Y-axis, and a Z-axis that are perpendicular to each other. Directions along the X-axis will be referred to as "X-axis directions" that extend horizontally, directions along the Y-axis will be referred to as "Y-axis directions" that extend horizontally, and directions along the Z-axis will be referred to as "Z-axis directions" that extend vertically. As illustrated in FIG. 1, the dicing apparatus 1 includes a holding unit 20 for holding a workpiece thereon, an image capturing assembly 30 for capturing an image of the workpiece held on the holding unit 20, a cutting unit 40 provided as processing means for processing the workpiece held on the holding unit 20, an X-axis feed mechanism 50 for processing-feeding the holding unit 20 and the cutting unit 40 relatively to each other in the X-axis directions, i.e., along the X-axis, indicated by an arrow X in FIG. 1, and a display unit 60 for displaying the image captured by the image capturing assembly 30.

The dicing apparatus 1 also includes a Y-axis feed mechanism 70 for indexing-feeding the cutting unit 40 in the Y-axis directions, i.e., along the Y-axis, that are indicated by an arrow Y in FIG. 1 and are perpendicular to the X-axis directions.

The holding unit 20 includes a rectangular X-axis movable plate 21 movably mounted on a base 2 for movement along the X-axis directions, a support base 22 having a channel-shaped cross section fixed to an upper surface of the X-axis movable plate 21, a circular transparent plate 23 having an upper surface 23a for holding the workpiece thereon, a hollow cylindrical frame 24 rotatable about its vertical central axis and supporting the transparent plate 23 on an upper surface thereof, and a plurality of clamps 25 disposed around the transparent plate 23 and used for clamping an annular frame, to be described later, that supports the workpiece. The clamps 25 are disposed between the transparent plate 23 and the frame 24 and are angularly spaced at regular intervals circumferentially around the transparent plate 23.

The X-axis feed mechanism 50 operates by converting rotary motion of an electric motor 51 through a ball screw 52 to linear motion and transmitting the linear motion to the X-axis movable plate 21 to move the X-axis movable plate 21 and the support base 22 in one of the X-axis directions or the other along a pair of X-axis guide rails 2A on the base 2.

The cutting unit 40 is disposed in a rear position over the base 2 adjacent in one of the Y-axis directions

to an area where the holding unit 20 is movable in the X-axis directions. The cutting unit 40 includes a spindle unit 41. The spindle unit 41 includes an annular cutting blade 43 that is fixed to a distal end of a rotatable spindle 42 extending along the Y-axis and that has a cutting edge on an outer circumferential portion thereof, and a blade cover 44 that surrounds and protects the cutting blade 43. The blade cover 44 has cutting fluid supply means 45 that is adjacent to the cutting blade 43 and that ejects a cutting fluid introduced through the blade cover 44 to a position where the cutting blade 43 cuts the workpiece held on the upper surface 23a of the transparent plate 23. The spindle unit 41 houses a rotary actuator such as an electric motor, not illustrated, in an end portion thereof remote from the cutting blade 43. The rotary actuator is connected to the proximal end of the spindle 42. When energized, the rotary actuator rotates the spindle 42 about its horizontal central axis, rotating the cutting blade 43 about its central axis.

The cutting unit 40 is supported on a vertical support wall 47a of a cutting unit support structure 47. A pair of Y-axis guide rails 2B extending parallel to the Y-axis directions are disposed on the base 2. The cutting unit support structure 47 includes a horizontal support

floor 47b on which the vertical support wall 47a is erected. The horizontal support floor 47b is slidably mounted on the Y-axis guide rails 2B for sliding movement along the Y-axis directions. The cutting unit support structure 47 is movable along the Y-axis directions by the Y-axis feed mechanism 70. The Y-axis feed mechanism 70 operates by converting rotary motion of an electric motor 71 through a ball screw 72 to linear motion and transmitting the linear motion to the horizontal support floor 47b of the cutting unit support structure 47 to move the cutting unit support structure 47 in one of the Y-axis directions or the other along the Y-axis guide rails 2B on the base 2.

A pair of Z-axis guide rails 48, partly indicated by the broken lines, extending parallel to the Z-axis directions, i.e., along the Z-axis, indicated by an arrow Z are disposed on a side surface of the vertical support wall 47a. A Z-axis movable base 46 that supports the spindle unit 41 is slidably mounted on the Z-axis guide rails 48 for sliding movement along the Z-axis directions. An electric motor 49 is mounted on an upper end of the vertical support wall 47a. Rotary motion of the electric motor 49 is converted into linear motion by a ball screw, not illustrated, and the linear motion is

transmitted to the Z-axis movable base 46. When the electric motor 49 is energized to rotate in one direction or the other, the Z-axis movable base 46 and hence the spindle unit 41 are moved in one of the Z-axis directions or the other.

The image capturing assembly 30 includes an upper image capturing unit 31 that can be positioned above the upper surface 23a of the transparent plate 23 and a lower image capturing unit 32 that can be positioned below a lower surface of the transparent plate 23 that is opposite the upper surface 23a, so that the upper image capturing unit 31 and the lower image capturing unit 32 can be positioned in vertically sandwiching relation to the transparent plate 23. The upper image capturing unit 31 includes an upper extension arm 33 extending from the spindle unit 41 and an upper camera 34 disposed on a distal end of the upper extension arm 33 and facing downwardly. The lower image capturing unit 32 includes a lower extension arm 35 fixedly mounted on the horizontal support floor 47b of the cutting unit support structure 47 and extending along the Y-axis directions and a lower camera 36 disposed on a distal end of the lower extension arm 35 and facing upwardly. The upper camera 34 and the lower camera 36 are identical in structure and function

to each other. Although the spindle unit 41 with the upper camera 34 fixedly supported thereon is vertically movable along the Z-axis guide rails 48 by the electric motor 49 and the upper camera 34 and the lower camera 36 are thus vertically movable relatively to each other, the upper camera 34 and the lower camera 36 are always kept in vertical alignment with each other such that their X and Y coordinates in a horizontal coordinate system defined by the X-axis and the Y-axis remain identical to each other. Therefore, when the support base 22 is moved along the X-axis to position the transparent plate 23 directly below the upper camera 34, the lower camera 36 is positioned within the channel-shaped support base 22 below the lower surface of the transparent plate 23 that is opposite the upper surface 23a while being kept in vertical alignment with the upper camera 34. As a result, the upper camera 34 and the lower camera 36 can capture an image of the workpiece held on the transparent plate 23 at identical X and Y coordinates. Before the dicing apparatus 1 dices the workpiece on the transparent plate 23, the image capturing assembly 30 captures an image of the workpiece. The captured image will be processed for an alignment step to be performed to detect a region of the workpiece to be processed, i.e., cut, by the cutting

unit 40, as described below.

The dicing apparatus 1 includes a controller 100. The controller 100 includes a computer including a central processing unit (CPU) for performing arithmetic processing operations according to control programs, a read only memory (ROM) for storing the control programs and other data, a read/write random access memory (RAM) for temporarily storing images captured by the image capturing assembly 30 and results of the arithmetic processing operations performed by the CPU, an input interface, and an output interface. Structural details of these parts of the controller 100 are omitted from illustration as they are well known in the art. The controller 100 controls operation of the various components of the dicing apparatus 1. The controller 100 also stores information including images captured by the image capturing assembly 30, corrects the image quality of those images, and detects a region of the workpiece to be processed by way of pattern matching or the like on the basis of the images whose image quality has been corrected.

The support base 22, the transparent plate 23, and the frame 24 of the holding unit 20 will be described in greater detail below with reference to FIG. 2.

FIG. 2 illustrates in exploded perspective the various components of the holding unit 20. As illustrated in FIG. 2, a ring-shaped slide member 22b is disposed on an upper surface 22a of the support base 22. The slide member 22b has an annular suction groove 22d defined in an upper surface thereof and extending along an outer circumferential portion thereof and a suction hole 22c defined in its bottom and fluidly connected to a suction pump, not illustrated. A circular tubular frame 22e is erected coaxially centrally on the slide member 22b radially inwardly of the suction groove 22d. The frame 24 that supports the transparent plate 23 has a substantially hollow cylindrical shape with a space 24a defined therein and includes an annular bottom 24b. The slide member 22b and the frame 24 are put together by inserting the tubular frame 22e upwardly into the space 24a in the frame 24 until the bottom 24b is placed on the slide member 22b. The frame 24 has a driven ring gear 24c disposed on the outer circumferential surface of a lower portion thereof. The driven ring gear 24c is operatively held in mesh with a gear on a rotation transmitting member 26 mounted on the upper surface 22a of the support base 22 for transmitting rotation of an electric motor, not illustrated, to the frame 24. The frame 24 that has

an inner side surface defining the space 24a has an inside diameter slightly larger than the outside diameter of the tubular frame 22e. The frame 24 has a downwardly protruding annular ridge, not illustrated, disposed on the bottom 24b and having a small height. The annular ridge is complementary in shape to the suction groove 22d in the slide member 22b. The slide member 22b has an upper surface coated with fluorocarbon polymers to allow the frame 24 placed thereon to rotate smoothly when the rotation of the electric motor is transmitted from the rotation transmitting member 26 to the driven ring gear 24c. The frame 24 has a fluid communication hole 24d extending vertically therethrough. The suction hole 22c is fluidly connected to a space defined in the suction groove 23d beneath the bottom 24b of the frame 24. A negative pressure produced by the suction pump, not illustrated, is transmitted through the suction hole 22c and the fluid communication hole 24d to the upper surface of the frame 24.

As illustrated in FIG. 2, the transparent plate 23 is placed on the upper surface of the frame 24. The transparent plate 23 has an upper surface 23a for supporting the workpiece, or specifically a circular wafer 10 illustrated in FIG. 3, thereon. The transparent

plate 23 is made of a transparent material such as acrylic resin, for example. However, the transparent material is not limited to acrylic resin and may be glass or the like. The transparent plate 23 has an annular suction groove 23b defined in the upper surface 23a along an outer circumferential edge thereof and a suction hole 23c defined in its bottom and fluidly connected to the fluid communication hole 24d in the frame 24. The suction groove 23d is slightly larger in diameter than the wafer 10. The wafer 10 placed on the transparent plate 23 is secured thereto by a transparent circular adhesive tape T (see FIG. 3) affixed to the wafer 10 and supporting the wafer 10 under the negative pressure transmitted from the fluid communication hole 24d through the suction hole 23c to a lower surface of the tape T around the wafer 10.

FIG. 3 illustrates in exploded perspective an assembly including the wafer 10 as the workpiece to be processed by the dicing apparatus 1 according to the present embodiment. As illustrated in an upper section of FIG. 3, the wafer 10 has a plurality of devices 12 formed in respective areas demarcated on a face side 10a of the wafer 10, which is illustrated as facing upwardly, by a grid of projected dicing lines 14. As illustrated in a middle section of FIG. 3, the wafer 10 is turned upside

down, so that a reverse side 10b thereof faces upwardly and the face side 10a faces downwardly. As illustrated in a lower section of FIG. 3, a frame F has a circular opening defined centrally therein. The inverted wafer 10 is positioned in the circular opening in the annular frame F and affixed centrally to the tape T that has an outer circumferential portion to which the annular frame F is affixed. The wafer 10, the tape T, and the frame F are thus integrally assembled. The tape T may be a tape having a surface coated with a glue or a thermal pressure bonding tape that develops adhesion when heated. The thermal pressure bonding tape should preferably be selected from a polyolefin-based sheet or a polyester-based sheet. For affixing the thermal pressure bonding tape to the wafer 10, a heating roller with built-in heating means, not illustrated, is used to heat the thermal pressure bonding tape. According to the present embodiment, as illustrated in FIG. 3, the face side 10a of the wafer 10 faces downwardly with the reverse side 10b facing upwardly and is affixed to the tape T that is affixed to the frame F. Then, the wafer 10 thus supported on the frame F by the tape T is processed by the dicing apparatus 1. Alternatively, the reverse side 10b of the wafer 10 may face downwardly with the face side 10a

facing upwardly and may be affixed to the tape T that is affixed to the frame F. Then, the wafer 10 thus supported on the frame F by the tape T may be processed by the dicing apparatus 1.

The dicing apparatus 1 according to the present embodiment is generally of the structure described above. Operation of the dicing apparatus 1, especially operation of the image capturing assembly 30 and the controller 100, will be described below.

The assembly of the wafer 10 supported on the annular frame F by the tape T is placed on the transparent plate 23 such that the tape T with the face side 10a of the wafer 10 affixed thereto is held on the upper surface 23a of the transparent plate 23. Then, the suction pump, not illustrated, is actuated to generate and transmit a negative pressure through the suction hole 23c into the suction groove 23b in the transparent plate 23, attracting the tape T around the wafer 10 toward the suction groove 23b. Then, as illustrated in FIG. 4, the annular frame F is clamped by the clamps 25.

After the wafer 10 has been held on the transparent plate 23, the X-axis feed mechanism 50 is actuated to move the support base 22 in one of the X-axis directions and position the wafer 10 directly above the lower camera

36 of the lower image capturing unit 32, as illustrated in FIG. 4. The, the lower camera 36 below the wafer 10 captures an image of the face side 10a of the wafer 10 through the transparent plate 23 and the tape T, and transmits image data of the captured image to the controller 100. When the image data is sent to the controller 100, the controller 100 controls the display unit 60 to display an image D1 of a captured region of the wafer 10, as illustrated in a left section of FIG. 5. The displayed image D1 includes projected dicing lines 14 on the face side 10a, devices 12, and patterns P1', P2', and P3' as candidates for key patterns to be used in an alignment step.

The image D1 displayed on the display unit 60 in the left section of FIG. 5 is an image that has been captured by the lower camera 36 through the transparent plate 23 and the tape T and that has not been corrected at all. Since the image D1 has been captured through the transparent plate 23 and the tape T, its brightness is largely different from the brightness of an image of the face side 10a of the wafer 10 that would directly be captured by the upper camera 34 that is structurally and functionally identical to the lower camera 36. The image D1 displayed on the display unit 60 in the left section

of FIG. 5 is indicated by the broken lines for illustrative purposes. The image quality representing the brightness of the image D1 depends on the material and transparency of the transparent plate 23 and the tape T.

As illustrated in FIG. 5, the controller 100 corrects a brightness gradation x , i.e., a pixel value, of each of the pixels included in the image D1 captured by the lower camera 36, according to a function 110 ($y = f(x)$) stored in the controller 100, and outputs the corrected image as an image D2 illustrated in a right section of FIG. 5. The brightness gradation x in the function 110 is established in a gradation range of 0 to 255, i.e., as one of 256 gradations, and corrected according to the function 110 and converted or normalized into a brightness level y in a brightness range of 0 to 100. A specific example of the function 110 used to correct the image D1 will be described below.

FIGS. 6A through 6C illustrate examples of different exponential functions as conversion formulas for performing gamma correction, as the function 110 for correcting the image D1 captured by the lower image capturing unit 32.

FIG. 6A illustrates an equation:

$$y = a \cdot (x/255)^\gamma \quad (a = 100, \gamma = 1) \dots (1)$$

used as the function 110. The controller 100 corrects a brightness gradation x (represented on the horizontal axis) of each pixel of the image D1 into a brightness level y (represented on the vertical axis) according to the equation (1). As can be seen from FIG. 6A, the equation (1) merely normalizes the pixel value of each of the 256 gradations into a brightness in the brightness range of 0 to 100 with a coefficient a . Providing the transparent plate 23 and the tape T have a high level of transparency, the controller 100 outputs an image D2 that is identical to the image D1.

FIG. 6B illustrates an equation:

$$y = a \cdot (x/255)^\gamma \quad (a = 100, \gamma = 2) \dots (2)$$

where the value of γ has been changed from 1 for the equation (1) to 2. The equation (2) represents a function for converting a brightness gradation x (represented on the horizontal axis) of each pixel of the image D1 into a brightness level y (represented on the vertical axis) in the brightness range of 0 to 100. As can be seen from FIG. 6B, according to the equation (2), the controller 100 outputs an image D2 where the image D1 is made darker as a whole and brighter areas with high pixel values are highlighted.

FIG. 6C illustrates an equation:

$$y = a \cdot (x/255)^\gamma \quad (a = 100, \gamma = 0.5) \dots (3)$$

where the value of γ has been changed from 1 for the equation (1) to 0.5. The equation (3) represents a function for converting a brightness gradation x (represented on the horizontal axis) of each pixel of the image D1 into a brightness level y (represented on the vertical axis) in the brightness range of 0 to 100. As can be seen from FIG. 6C, according to the equation (3), the controller 100 outputs an image D2 where the image D1 is made brighter as a whole and darker areas with low pixel values are highlighted.

The correction according to the equations (1) through (3) illustrated in FIGS. 6A through 6C is referred to as γ (gamma) correction based on an exponential function. On the basis of the above conversion formulas for performing gamma correction, the operator adjusts the value of γ by way of experimentation or the like in order to convert the image D1 captured by the lower camera 36 into the image D2 that is similar in image quality to an image of the same area of the wafer 10 that would be captured by the upper camera 34, thereby finalizing the function 110. Optimum γ values in the above conversion formulas are different depending on the material and transparency of the transparent plate 23 and

the tape T, and may be adjusted by way of experimentation or the like.

The present invention is not limited to the use of the function 110 based on the above conversion formulas for performing gamma correction, and may use other functions. For example, a function $y = f(x)$ illustrated in FIG. 6D is a function referred to as a conversion table that is used instead of the above conversion formulas to convert the image D1 captured by the lower camera 36 depending on the gradations x such that the image quality thereof will be more similar in image quality to an image that would be captured by the upper camera 34. The function $y = f(x)$ illustrated in FIG. 6D is established to highlight darker and brighter areas and keep intermediate brightness levels essentially unchanged. FIG. 6E illustrates in conceptual diagram an adjusting capability applicable to the conversion formulas illustrated in FIGS. 6A through 6D, for restricting a range of brightness gradations x to be converted by the function $y = f(x)$. More specifically, the adjusting capability allows the operator to adjust the range of brightness gradations x of a function to be corrected, which is indicated by the broken line and is a range of 0 to 255, to a limited range of 80 to 200 for

conversion into the brightness range of 0 to 100, by moving the function to be corrected in the directions indicated by arrows with a finger H of the operator, using a touch panel function of the display unit 60. The adjusting capability is able to correct the image D1 except for darker areas and brighter areas, so that areas with excessively dark gradations and excessively bright gradations where noise is considered to occur easily will not be included as brightness levels y in the image D2, resulting in preventing key patterns from being recognized in error in the alignment step.

As described above, a suitable function 110 is selected and used to convert the image D1 captured by the lower camera 36 into the image D2, converting the patterns P1', P2', and P3' (see the left section of FIG. 5) as candidates for key patterns to be used in the alignment step, into key patterns P1, P2, and P3 (see the right section of FIG. 5), respectively, that are suitable for use in the alignment step. The image displayed on the display unit 60 becomes similar to the image of the face side 10a of the wafer 10 that would be captured by the upper camera 34, and does not cause a feeling of unease and strangeness. The data of the key patterns to be used in image processing in the alignment step can thus be

shared between the image D1 of the face side 10a captured by the lower camera 36 and the image of the face side 10a captured by the upper camera 34. When the alignment step is carried out, the controller 100 can appropriately detect a region of the wafer 10 to be processed, i.e., coordinate positions of a projected dicing line 14 to be processed.

After the alignment step has been carried out, the X-axis feed mechanism 50 is actuated to move the support base 22 and hence the wafer 10 in one of the X-axis directions and position the wafer 10 directly below the cutting blade 43 of the cutting unit 40, as illustrated in FIG. 7. As described above, the cutting unit 40 includes the rotatable spindle 42 extending along the Y-axis and the annular cutting blade 43 fixed to the distal end of the rotatable spindle 42.

Before a cutting step is performed on the wafer 10, a predetermined projected dicing line 14 on the wafer 10 is aligned with the X-axis on the basis of the positional information of the predetermined projected dicing line 14 that has been detected in the alignment step, and positioned in alignment with the cutting blade 43. Then, the cutting blade 43 that is rotating at a high speed is lowered to cut into the wafer 10 from the reverse side

10b thereof along projected dicing line 14 aligned with the X-axis and the cutting blade 43, and the wafer 10 is processing-fed along the X-axis, forming a cut groove 16 in the wafer 10 along the projected dicing line 14. Then, the cutting blade 43 is indexing-fed to a position on a next projected dicing line 14 that is adjacent in one of the Y-axis directions to the projected dicing line 14 along which the cut groove 16 has been formed, and then, the cutting blade 43 is forced to cut into the wafer 10 along the next projected dicing line 14, forming a cut groove 16 in the wafer 10 along the next projected dicing line 14. The cutting step is repeated to form cut grooves 16 in the wafer 10 along all the projected dicing lines 14 extending along the X-axis. Thereafter, the rotation transmitting member 26 on the upper surface 22a of the support base 22 is rotated to turn the frame 24 and hence the wafer 10 about its central axis through 90 degrees in the direction indicated by an arrow R, aligning one of the projected dicing lines 14 that extend perpendicularly to the cut grooves 16 already formed in the wafer 10 and that have come into alignment with the X-axis, with the cutting blade 43. Then, the cutting step is repeatedly carried out on the wafer 10 along all the projected dicing lines 14 newly aligned with the X-axis. In this

manner, cut grooves 16 are formed in the wafer 10 along all the projected dicing lines 14 established on the wafer 10. After the cutting step has been performed, the wafer 10 is divided into individual device chips that include the respective devices 12. The wafer 10 is then delivered to a next step or stored into a storage cassette or the like.

The present invention is not limited to the above embodiment. According to the above embodiment, the image capturing assembly 30 is incorporated in the dicing apparatus 1. However, the cutting unit 40 may be replaced with laser beam applying means for applying a laser beam to the wafer 10, and the alignment step may be performed on the wafer 10 by using the image capturing assembly 30. Then, the laser beam applying means may apply a laser beam having a wavelength absorbable by the wafer 10 to the reverse side 16b of the wafer 10 along the projected dicing lines 14 on the wafer 10, thereby dividing the wafer 10 into individual device chips.

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

by the invention.

WHAT IS CLAIMED IS:

1. A processing apparatus comprising:

- a holding unit for holding a workpiece thereon;
- a processing unit for processing the workpiece held on the holding unit;
- a feed mechanism for processing-feeding the holding unit and the processing unit relatively to each other;
- an image capturing assembly for capturing an image of the workpiece held on the holding unit;
- a display unit for displaying the image captured by the image capturing assembly; and
- a controller having a storage section;

wherein the holding unit includes a transparent plate having an upper surface for holding the workpiece thereon and a frame supporting the transparent plate thereon,

the image capturing assembly includes an upper image capturing unit that is positioned above the transparent plate and a lower image capturing unit that is positioned below the transparent plate, so that the upper image capturing unit and the lower image capturing unit are positioned in vertically sandwiching relation to the transparent plate,

the storage section of the controller stores

therein a corrective function for correcting brightness levels of brightness gradations of a first image of the workpiece captured by the lower image capturing unit positioned below the transparent plate, and

the controller corrects the brightness levels of the brightness gradations of the first image of the workpiece captured by the lower image capturing unit positioned below the transparent plate, according to the corrective function, to make the first image similar in image quality to a second image of the workpiece captured by the upper image capturing unit positioned above the transparent plate.

2. The processing apparatus according to claim 1, wherein the corrective function is a conversion formula for performing gamma correction.

3. The processing apparatus according to claim 1, wherein the controller has an adjusting capability for adjusting a range of brightness gradations of the corrective function.