

DIVIDING METHOD OF WORKPIECE, DETECTION METHOD OF DIMENSIONS OF CHIPS, AND CUTTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a dividing method of a workpiece by which the workpiece is divided into plural chips, a detection method of dimensions of chips by which dimensions of the chips are detected, and a cutting apparatus that can detect dimensions of the chips.

Description of the Related Art

A package substrate such as a quad flat non-lead (QFN) package substrate is formed by covering plural device chips arranged on a base substrate by a sealing material composed of a resin (mold resin). By dividing this package substrate along planned dividing lines (streets), plural chips (package devices) each including device chips are obtained. For the dividing of the workpiece typified by the above-described package substrate, for example, a cutting apparatus including a chuck table that holds the workpiece and a cutting unit to which a circular-ring-shaped cutting blade that cuts the workpiece is mounted is used (for example, refer to Japanese Patent Laid-Open No. 2017-50309). By rotating

the cutting blade and causing the cutting blade to cut into the workpiece in the state in which the workpiece is held by the chuck table, the workpiece is cut to be divided into plural chips.

SUMMARY OF THE INVENTION

After the workpiece is divided into the plural chips, work of checking whether or not desired chips have been obtained is executed. For example, dimensions of the chips (size of the whole of the chip, the position of an electrode which the chip has, and so forth) obtained by the dividing of the workpiece are measured. In addition, the process capability index is calculated based on actual dimensions of the chips. Then, evaluation of the chips is executed based on the actual dimensions of the chips and the process capability index.

The measurement of dimensions of the chips is executed by an evaluator of the chips with use of a microscope, for example. In this case, the evaluator needs to execute work of position alignment between the microscope and the chip, measurement of dimensions of the chip, recording of the measured dimensions of the chip, and so forth for each chip individually. For this reason, in the case of executing evaluation of a particularly

large number of chips, enormous time and labor are spent in the evaluation of the chips.

The present invention is made in view of such a problem and intends to provide a dividing method of a workpiece, a detection method of dimensions of chips, and a cutting apparatus that enable easy detection of dimensions of chips.

In accordance with an aspect of the present invention, there is provided a dividing method of a workpiece by which the workpiece is divided into a plurality of chips and actual dimensions of the chips are detected by a cutting apparatus. The cutting apparatus includes holding means that holds the workpiece having electrodes in each of a plurality of regions marked out by a plurality of planned dividing lines that intersect each other and cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted. The cutting apparatus includes also imaging means that images the workpiece and control means that controls the holding means and the cutting means. The dividing method includes a dividing step of cutting the workpiece by the cutting blade along the planned dividing lines to divide the workpiece into the plurality of chips, an image acquisition step of imaging the chips by the

imaging means and acquiring an image of the chips, and a detection step of detecting the actual dimensions of the chips by the control means based on the image.

Preferably, the dividing method of a workpiece further includes a calculation step of calculating a value that indicates a degree of variation in the actual dimensions of the chips by the control means. Furthermore, preferably, the workpiece is divided in a state of being held by the holding means in the dividing step, and the workpiece is imaged in a state of being held by the holding means in the image acquisition step.

In accordance with another aspect of the present invention, there is provided a detection method of dimensions of chips by which a workpiece is divided into a plurality of chips and actual dimensions of the chips are detected by a cutting apparatus. The cutting apparatus includes holding means that holds the workpiece having electrodes in each of a plurality of regions marked out by a plurality of planned dividing lines that intersects each other and cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted. The cutting apparatus includes also imaging means that images the workpiece and control means that controls the holding means and the cutting means.

The detection method includes a dividing step of cutting the workpiece by the cutting blade along the planned dividing lines to divide the workpiece into the plurality of chips, an image acquisition step of imaging the chips by the imaging means and acquiring an image of the chips, and a detection step of detecting the actual dimensions of the chips by the control means based on the image.

Preferably, the detection method of dimensions of chips further includes a calculation step of calculating a value that indicates a degree of variation in the actual dimensions of the chips by the control means. Furthermore, preferably, the workpiece is divided in a state of being held by the holding means in the dividing step, and the workpiece is imaged in a state of being held by the holding means in the image acquisition step.

In accordance with another aspect of the present invention, there is provided a cutting apparatus including holding means that holds a workpiece, cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted, imaging means that images the workpiece, and control means that controls the holding means and the cutting means. The imaging means images the workpiece divided into a plurality of chips by the cutting blade and acquires an image of the chips, and

the control means includes a detecting section that detects actual dimensions of the chips based on the image.

Preferably, the control means further includes a storing section that stores reference values of dimensions of the chips set in advance and a calculating section that calculates a value that indicates a degree of variation in the actual dimensions of the chips based on the actual dimensions of the chips and the reference values. Furthermore, preferably, the cutting apparatus further includes display means that displays the value calculated in the calculating section.

The cutting apparatus according to the aspect of the present invention includes the imaging means that images the workpiece divided into the plural chips and the control means that detects the actual dimensions of the chips based on an image of the chips acquired by imaging. Due to this, automatic measurement of dimensions of the chips by the cutting apparatus is enabled and detection of the dimensions of the chips is simplified.

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 illustrating a cutting apparatus;

FIG. 2A is a plan view illustrating a workpiece;

FIG. 2B is a bottom view illustrating the workpiece;

FIG. 2C is an enlarged plan view illustrating the workpiece;

FIG. 3 is a plan view illustrating the workpiece supported by a ring-shaped frame;

FIG. 4 is a partial sectional side view illustrating the workpiece held by a chuck table;

FIG. 5 is an enlarged plan view illustrating the workpiece after dividing; and

FIG. 6 is a schematic diagram illustrating a configuration example of an imaging unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described below with reference to the accompanying drawings. First, a configuration example of a cutting

apparatus according to the present embodiment will be described. FIG. 1 is a perspective view illustrating a cutting apparatus 2. The cutting apparatus 2 includes a base 4 that supports the respective constituent elements that configure the cutting apparatus 2. An opening 4a is formed at a corner part on a front side of the base 4 and a cassette support pedestal 6 that rises and lowers by a lifting mechanism (not illustrated) is disposed inside the opening 4a. Furthermore, on the cassette support pedestal 6, a cassette 8 in which plural workpieces 11 (see FIG. 2A and FIG. 2B) cut by the cutting apparatus 2 can be housed is disposed. In FIG. 1, only the contour of the cassette 8 is illustrated for convenience of explanation.

FIG. 2A is a plan view illustrating the workpiece 11 and FIG. 2B is a bottom view illustrating the workpiece 11. In the present embodiment, the case in which the workpiece 11 is a package substrate will be described. For example, as the workpiece 11, a package substrate such as a chip size package (CSP) substrate or QFN package substrate is used as the workpiece 11.

The workpiece 11 includes a plate-shaped base substrate 13 that has a front surface 13a and a back surface 13b and is formed into a rectangular shape in

plan view. The base substrate 13 is formed by using a metal such as 42 alloy (alloy of iron and nickel) or copper, for example. However, there is no limit to the material, shape, structure, size, and so forth of the base substrate 13. On the side of the back surface 13b of the base substrate 13, plural device chips (not illustrated) including devices formed of an integrated circuit (IC), a large-scale integration (LSI), or the like are disposed. These device chips are covered by a resin layer (mold resin) 15 formed on the side of the back surface 13b of the base substrate 13 and are sealed. There is no limit to the kind, quantity, shape, structure, size, arrangement, and so forth of the device chips.

As illustrated in FIG. 2A, the workpiece 11 is segmented into plural device regions 11a by plural planned dividing lines (streets) 17 arranged in a lattice manner to intersect each other. The device chips formed on the side of the back surface 13b of the base substrate 13 are each disposed in the device region 11a. Each device region 11a is separated by dividing the workpiece 11 along the planned dividing lines 17, so that plural chips (package devices) each including the device chip sealed by the resin are obtained.

FIG. 2C is an enlarged plan view illustrating the

workpiece 11. The workpiece 11 includes plural electrodes 19 formed on a front surfaces of the device regions 11a. The electrodes 19 are formed into a spherical shape, for example, and are arranged to be exposed on the side of the front surface 13a of the base substrate 13. In FIG. 2C, an example in which the electrodes 19 on two rows are arranged along the outer circumferential edge (contour) of the device region 11a is illustrated. For example, the electrodes 19 are connected to the device chip disposed on the side of the back surface 13b of the base substrate 13 through metal wires (not illustrated) or the like. The electrodes 19 function as connecting electrodes when the chips are mounted on another mounting board or the like after the workpiece 11 is divided into the plural chips.

Although the case in which the workpiece 11 is a package substrate is described here, there is no limit to the kind, material, shape, structure, size, and so forth of the workpiece 11. For example, the workpiece 11 may be a semiconductor wafer on which a device such as an IC or an LSI is formed in each of plural regions marked out by plural planned dividing lines that intersect each other, or the like. Furthermore, this device may include an electrode exposed on a surface.

When the workpiece 11 is cut by the cutting

apparatus 2 (see FIG. 1), the workpiece 11 is supported by a ring-shaped frame. FIG. 3 is a plan view illustrating the workpiece 11 supported by a ring-shaped frame 23. To a back surface side (side of the resin layer 15 (see FIG. 2B)) of the workpiece 11, a circular tape 21 having a diameter that allows covering of the whole of the workpiece 11 is stuck. The tape 21 is a flexible film obtained by forming a rubber-based or acrylic adhesion layer (glue layer) on a base composed of a resin such as polyolefin, polyvinyl chloride, or polyethylene terephthalate. The ring-shaped frame 23 is stuck to an outer circumferential part of the tape 21. The frame 23 has a circular opening 23a having a diameter that allows housing of the workpiece 11. The workpiece 11 is supported by the frame 23 with the intermediary of the tape 21 in the state of being disposed inside the opening 23a in such a manner that the front surface side (side of the front surface 13a of the base substrate 13) is exposed upward.

The tape 21 may be stuck to a front surface side of the workpiece 11. In this case, the workpiece 11 is supported by the frame 23 in the state in which the back surface side (side of the resin layer 15) is exposed upward. Furthermore, plural workpieces 11 may be stuck to

the tape 21. In this case, the frame 23 having the opening 23a having a diameter that allows housing of the plural workpieces 11 is used. Furthermore, the workpiece 11 does not necessarily need to be supported by the frame 23. When the frame 23 is not used, for example, a rectangular tape formed into substantially the same shape and size as the workpiece 11 is stuck to the front surface side or back surface side of the workpiece 11.

The workpiece 11 supported by the frame 23 is housed in the cassette 8 illustrated in FIG. 1. Then, the cassette 8 in which the plural workpieces 11 are housed is disposed on the cassette support pedestal 6.

A rectangular opening 4b whose longitudinal direction is along an X-axis direction (processing feed direction, front-rear direction) is formed on a lateral side of the cassette support pedestal 6. Inside the opening 4b, an X-axis movement mechanism 10 of a ball screw system and a dust-proof drip-proof cover 12 that covers an upper side of the X-axis movement mechanism 10 are disposed. The X-axis movement mechanism 10 includes an X-axis moving table 10a and moves the X-axis moving table 10a along the X-axis direction. Furthermore, a temporary placement mechanism 14 for temporarily placing the workpiece 11 is disposed to overlap with the opening

4b on the lateral side of the cassette support pedestal 6. The temporary placement mechanism 14 includes a pair of guide rails 14a and 14b that gets close to and separated from each other while keeping the state of being substantially parallel to a Y-axis direction (indexing feed direction, left-right direction). The guide rails 14a and 14b sandwich the workpiece 11 along the X-axis direction and adjust it to a predetermined position.

A chuck table (holding table, holding means) 16 that holds the workpiece 11 is disposed on the X-axis moving table 10a. The chuck table 16 is coupled to a rotational drive source (not illustrated) such as a motor and this rotational drive source rotates the chuck table 16 around a rotation axis substantially parallel to a Z-axis direction (vertical direction, upward-downward direction). Furthermore, the chuck table 16 moves along the X-axis direction by the X-axis movement mechanism 10. An upper surface of the chuck table 16 configures a holding surface 16a that holds the workpiece 11. The holding surface 16a is formed substantially in parallel to the X-axis direction and the Y-axis direction and is connected to a suction source (not illustrated) such as an ejector through a suction path (not illustrated) disposed inside the chuck table 16. Moreover, four clamps

18 that grip and fix the ring-shaped frame 23 (see FIG. 3) that supports the workpiece 11 are disposed around the chuck table 16.

A conveyance mechanism (not illustrated) that conveys the workpiece 11 housed in the cassette 8 to the chuck table 16 is disposed near the opening 4b. The workpiece 11 is conveyed by the conveyance mechanism and is disposed on the holding surface 16a of the chuck table 16 in such a manner that the front surface side (side of the front surface 13a of the base substrate 13 (see FIG. 3)) is exposed upward, for example.

On an upper surface of the base 4, a gate-shaped support structure 20 is disposed to straddle the opening 4b. The support structure 20 supports two sets of cutting units (cutting means) 22 that execute cutting processing for the workpiece 11 held by the chuck table 16. Furthermore, two sets of movement mechanisms 24 that move the cutting units 22 in the Y-axis direction and the Z-axis direction are mounted to an upper part of the front surface (face surface) side of the support structure 20.

The movement mechanisms 24 are each mounted to a pair of Y-axis guide rails 26 disposed along the Y-axis direction on the front surface side of the support structure 20. Specifically, the movement mechanism 24

includes a Y-axis moving plate 28 and the Y-axis moving plate 28 is attached to the Y-axis guide rails 26 slidably along the Y-axis guide rails 26. A nut part (not illustrated) is disposed on a rear surface (back surface) side of the Y-axis moving plate 28 and a Y-axis ball screw 30 disposed substantially in parallel to the Y-axis guide rails 26 is screwed to this nut part. Furthermore, a Y-axis pulse motor 32 is coupled to one end part of the Y-axis ball screw 30. When the Y-axis ball screw 30 is rotated by the Y-axis pulse motor 32, the Y-axis moving plate 28 moves in the Y-axis direction along the Y-axis guide rails 26.

A pair of Z-axis guide rails 34 disposed along the Z-axis direction is set on a front surface (face surface) side of the Y-axis moving plate 28. A Z-axis moving plate 36 is attached to the Z-axis guide rails 34 slidably along the Z-axis guide rails 34. A nut part (not illustrated) is disposed on a rear surface (back surface) side of the Z-axis moving plate 36 and a Z-axis ball screw 38 disposed substantially in parallel to the Z-axis guide rails 34 is screwed to this nut part. Furthermore, a Z-axis pulse motor 40 is coupled to one end part of the Z-axis ball screw 38. When the Z-axis ball screw 38 is rotated by the Z-axis pulse motor 40, the Z-axis moving

plate 36 moves in the Z-axis direction along the Z-axis guide rails 34.

The cutting unit 22 is fixed to a lower part of the Z-axis moving plate 36. The cutting unit 22 includes a spindle (not illustrated) that is disposed substantially in parallel to the Y-axis direction and has a circular cylindrical shape. A cutting blade 42 that cuts the workpiece 11 and has a circular ring shape is mounted on one end part (tip part) of the spindle. The cutting blade 42 is formed by fixing abrasive grains composed of diamond, cubic boron nitride (CBN), or the like by a bond material composed of a metal, ceramic, resin, or the like, for example. Furthermore, a rotational drive source (not illustrated) such as a motor that rotates the spindle is coupled to the other end side (base end part) of the spindle. When the spindle is rotated by the rotational drive source in the state in which the cutting blade 42 is mounted to a tip part of the spindle, the cutting blade 42 rotates by power transmitted from the rotational drive source via the spindle.

An imaging unit (imaging means) 44 that images the workpiece 11 or the like is disposed at a position adjacent to the cutting unit 22. When the Y-axis moving plate 28 is moved in the Y-axis direction by the movement

mechanism 24, the cutting unit 22 and the imaging unit 44 move along the Y-axis direction. Furthermore, when the Z-axis moving plate 36 is moved in the Z-axis direction by the movement mechanism 24, the cutting unit 22 and the imaging unit 44 move along the Z-axis direction. Based on an image of the workpiece 11 acquired by the imaging unit 44, position alignment between the chuck table 16 that holds the workpiece 11 and the cutting unit 22 is executed.

An opening 4c is formed at a position on an opposite side to the opening 4a across the opening 4b. A cleaning unit 46 that cleans the workpiece 11 is disposed inside the opening 4c. The workpiece 11 processed by the cutting unit 22 is conveyed from on the chuck table 16 to the cleaning unit 46 by the conveyance mechanism (not illustrated) and is cleaned. Then, the workpiece 11 after the cleaning is housed in the cassette 8 by the conveyance mechanism.

Furthermore, in the cutting apparatus 2, a display part (display means) 48 that displays various kinds of information relating to processing of the workpiece 11 is disposed. The display part 48 is formed of a monitor of a touch panel system serving as a user interface, for example. In this case, an operator of the cutting

apparatus 2 can input information on processing conditions and so forth to this monitor.

Moreover, the respective constituent elements that configure the cutting apparatus 2 (the X-axis movement mechanism 10, the temporary placement mechanism 14, the chuck table 16, the cutting unit 22, the movement mechanism 24, the imaging unit 44, the cleaning unit 46, and so forth) are connected to a control part (control means) 60 disposed in the cutting apparatus 2. The control part 80 is formed of a computer or the like, for example, and controls operation of each constituent element.

By the above-described cutting apparatus 2, the workpiece 11 is cut along the planned dividing lines 17 (see FIG. 3) and is divided into plural chips. Furthermore, dimensions of the chips obtained by the dividing of the workpiece 11 are detected by the cutting apparatus 2. A specific example of a dividing method of a workpiece and a detection method of dimensions of chips by use of the cutting apparatus 2 will be described below.

First, the workpiece 11 housed in the cassette 8 is conveyed to the temporary placement mechanism 14 by the conveyance mechanism (not illustrated). Then, after position alignment of the workpiece 11 is executed by the

temporary placement mechanism 14, the workpiece 11 is conveyed onto the holding surface 16a of the chuck table 16 and is held by the chuck table 16. FIG. 4 is a partial sectional side view illustrating the workpiece 11 held by the chuck table 16. The workpiece 11 is disposed on the chuck table 16 in such a manner that the front surface side (side of the front surface 13a of the base substrate 13) is exposed upward and the back surface side (side of the resin layer 15) is opposed to the holding surface 16a, for example. Furthermore, the frame 23 that supports the workpiece 11 is fixed by the clamps 18. When a negative pressure of the suction source is caused to act on the holding surface 16a in this state, the workpiece 11 is sucked and held by the chuck table 16 with the intermediary of the tape 21.

Next, the chuck table 16 is rotated and a length direction of one planned dividing line 17 (see FIG. 3) is aligned with the X-axis direction. Furthermore, a height of the cutting unit 22 is adjusted in such a manner that a lower end of the cutting blade 42 is disposed on a lower side relative to the back surface of the workpiece 11 (upper surface of the tape 21) and on an upper side relative to the holding surface 16a (lower surface of the tape 21). Moreover, a position of the cutting unit 22 in

the Y-axis direction is adjusted in such a manner that the cutting blade 42 is disposed on an extension line of the one planned dividing line 17. Then, while the cutting blade 42 is rotated, the chuck table 16 is moved along the X-axis direction. Thereby, the chuck table 16 and the cutting unit 22 are relatively moved along the planned dividing line 17 and the cutting blade 42 cuts into the workpiece 11. As a result, the workpiece 11 is cut along the planned dividing line 17 and is divided.

Thereafter, the same procedure is repeated and the workpiece 11 is cut along all planned dividing lines 17. Thereby, the device regions 11a (see FIG. 3) of the workpiece 11 are diced into individual pieces and the workpiece 11 is divided into plural chips (dividing step). FIG. 5 is an enlarged plan view illustrating the workpiece 11 after the dividing. The workpiece 11 is divided into plural chips (package devices) 25 each including the plural electrodes 19. Furthermore, in the regions cut by the cutting blade 42 in the workpiece 11, kerfs (cut ends) 11b that reach the back surface of the workpiece 11 from the front surface are formed. A width of the kerf 11b corresponds to a thickness of the cutting blade 42 (see FIG. 4). In FIG. 5, the regions in which the kerfs 11b are formed are given hatching.

After the dividing of the workpiece 11, work of checking whether or not the chips 25 with desired dimensions have been obtained is executed. Specifically, dimensions of the chips 25 (size of the whole of the chip 25, the position of the electrode 19 which the chip 25 has, and so forth) obtained by the dividing of the workpiece 11 are measured and evaluation of the chips 25 is executed based on actual dimensions of the chips 25. When actual dimensions of the chips 25 are detected, first, an image of the chips 25 is acquired by imaging the chips 25 by the imaging unit 44 (see FIG. 1) (image acquisition step). In the image acquisition step, the imaging is executed in the state in which the workpiece 11 is held by the chuck table 16.

FIG. 6 is a schematic diagram illustrating a configuration example of the imaging unit 44. The imaging unit 44 includes a casing 60 in which the respective constituent elements that configure the imaging unit 44 are housed. A partition wall 62 that partitions an inside of the casing 60 and an outside is disposed at a tip part (lower end part) of the casing 60. The partition wall 62 is disposed on an upper side relative to a lower end 60a of the casing 60. The partition wall 62 has an opening part that vertically penetrates the partition wall 62 and

a light transmissive part 64 formed of a transparent member is disposed in this opening part. Furthermore, an objective lens 66 disposed on the upper side of the partition wall 62 is housed in the casing 60.

A space 68 surrounded by the tip part of the casing 60 and the partition wall 62 is connected to a water source 72 through a water supply port 60b formed in the casing 60 and a valve 70. At a time of imaging of the workpiece 11, the imaging unit 44 is positioned in such a manner that a distance between the lower end 60a of the casing 60 and the front surface of the workpiece 11 becomes approximately 0.5 to 1 mm, for example. Furthermore, water is supplied from the water source 72 to the space 68 via the valve 70 and the water supply port 60b at a predetermined flow rate and the space 68 is filled with the water.

Moreover, the imaging unit 44 includes a strobe light source 74 that executes irradiation with strobe light. As the strobe light source 74, a xenon flash lamp is used, for example. Part of the strobe light emitted from the strobe light source 74 is reflected by a beam splitter 76 disposed inside the casing 60 and is applied to the workpiece 11 held by the chuck table 16 via the objective lens 66 and the light transmissive part 64. A

camera 78 that images the workpiece 11 irradiated with the strobe light is disposed on the optical axis of the objective lens 66. For example, the camera 78 is configured by using a charge-coupled device (CCD) image sensor.

The strobe light source 74 and the camera 78 are connected to the control part 80 and operation thereof is controlled by the control part 80. Furthermore, the control part 80 synchronizes irradiation with the strobe light from the strobe light source 74 with imaging by the camera 78. Thereby, the upper surface side of the workpiece 11 (chips 25) is imaged by the imaging unit 44 and an image of the workpiece 11 (chips 25) is acquired.

When cutting processing is executed for the workpiece 11 (see FIG. 4), a foreign matter such as dust generated due to the cutting (cutting dust) adheres to the workpiece 11 in some cases. For this reason, when the workpiece 11 is imaged by the imaging unit 44 subsequently to the dividing step, it is preferable to supply water from the water source 72 to the space 68 and wash away the foreign matter that adheres to the workpiece 11. This can prevent the imaging of the workpiece 11 from being inhibited by the foreign matter. However, water does not necessarily need to be supplied

to the space 68 when the workpiece 11 is imaged by the imaging unit 44. For example, if a step of cleaning the workpiece 11 (cleaning step) is separately executed after dividing of the workpiece 11 and before imaging of the workpiece 11, no foreign matter adheres to the workpiece 11 at the time of imaging of the workpiece 11. In this case, the supply of water from the water source 72 to the space 68 can be omitted.

Furthermore, imaging of the workpiece 11 may be executed while the workpiece 11 and the imaging unit 44 are relatively moved. For example, while the chuck table 16 that holds the workpiece 11 is moved relative to the imaging unit 44, irradiation with strobe light from the strobe light source 74 and imaging by the camera 78 are synchronized and the workpiece 11 is imaged by the imaging unit 44 plural times consecutively. This can execute cutting and imaging of the workpiece 11 concurrently.

The image (taken image) acquired by the imaging by the imaging unit 44 is output to the control part 80 (see FIG. 1). Then, based on the taken image, actual dimensions of the chips 25 are detected by the control part 80 (detection step). As illustrated in FIG. 1, the control part 80 includes a detecting section 82 that

detects actual dimensions of the chips 25. For example, the detecting section 82 measures dimensions of the chips 25 by executing image processing of edge detection, pattern matching, and so forth for the taken image. As examples of the measured dimensions of the chip 25, the size of the whole of the chip 25, the position of the electrode 19 which the chip 25 has, and so forth are cited.

In FIG. 5, examples of the measured dimensions of the chip 25 are illustrated. L_1 and L_2 are values that indicate the size of the whole of the chip 25. Specifically, L_1 is a length of the chip 25 in a first direction (longitudinal direction of the workpiece 11, left-right direction in the plane of paper) illustrated by arrow A and L_2 is a length of the chip 25 in a second direction (short direction of the workpiece 11, upward-downward direction in the plane of paper) illustrated by arrow B. The first direction and the second direction are perpendicular to each other. L_1 and L_2 are each equivalent to a distance from one end of the chip 25 to the other end. Furthermore, L_3 and L_4 are values that indicate the position of the electrode 19 which the chip 25 has and a position of the kerf 11b. Specifically, L_3 is a distance from the kerf 11b (outer circumferential

edge of the chip 25) along the first direction (arrow A) to one electrode 19 disposed at the position closest to the kerf 11b. Furthermore, L_4 is a distance from the kerf 11b (outer circumferential edge of the chip 25) along the second direction (arrow B) to one electrode 19 disposed at the position closest to the kerf 11b. In FIG. 5, L_3 and L_4 are set based on four electrodes 19 formed at the positions closest to four corners of the chip 25.

The detecting section 82 (see FIG. 1) detects L_1 and L_2 by executing edge detection processing for the taken image, for example. Specifically, the detecting section 82 identifies coordinates of the boundary between the chip 25 and the kerf 11b (outer circumferential edge of the chip 25, end part of the kerf 11b) based on the contrast level of the taken image. Then, the detecting section 82 calculates L_1 and L_2 from a difference between the coordinates of two boundaries opposed to each other across the chip 25.

Furthermore, the detecting section 82 detects L_3 and L_4 by executing pattern matching processing for the taken image, for example. Specifically, the detecting section 82 acquires an image of the chip 25 in which the electrodes 19 are represented (image for reference) in advance and compares the taken image acquired by the

imaging unit 44 and the image for reference. Then, the detecting section 82 identifies coordinates of the electrode 19 based on a positional relationship between the chuck table 16 (workpiece 11) and the imaging unit 44 when the position of the electrode 19 represented in the taken image corresponds with the position of the electrode 19 represented in the image for reference. Thereafter, the detecting section 82 calculates a difference between the coordinates of the outer circumferential edge of the chip 25 and coordinates of the electrode 19. Thereby, L_3 and L_4 are calculated. There is no limit to the detection method of L_1 , L_2 , L_3 , and L_4 and the detecting section 82 may detect L_1 , L_2 , L_3 , and L_4 by using another method.

Furthermore, the taken image acquired by the imaging unit 44 may be an image of the whole of the workpiece 11 or may be an image of part of the workpiece 11. In particular, the accuracy of detection of actual dimensions of the chip 25 can be improved by acquiring an enlarged image of the chip 25 by the imaging unit 44. Furthermore, the vicinities of the four corners of one chip 25 may be each individually imaged and actual dimensions of the chip 25 may be detected based on plural taken images obtained by this. Moreover, the control part

80 may generate an image of the whole of the workpiece 11 by synthesizing plural taken images that represent part of the workpiece 11. In this case, the detecting section 82 may detect actual dimensions of the chip 25 by using the generated synthesized image. In addition, the detecting section 82 may detect actual dimensions of all chips 25 obtained by dividing of the workpiece 11 or may detect actual dimensions of part of the chips 25.

Actual dimensions of the chip 25 detected by the detecting section 82 can be displayed on the display part 48 (see FIG. 1), for example. In this case, the control part 80 controls the display part 48 and causes the display part 48 to display the actual dimensions of the chip 25. Thereby, the operator of the cutting apparatus 2 is informed of the actual dimensions of the chip 25.

As described above, in the cutting apparatus 2 according to the present embodiment, the detection of actual dimensions of the chips 25 is executed by the control part 80. Thus, work of manually measuring dimensions of the chips 25 by the evaluator of the chips 25 with use of a microscope and so forth can be omitted and the evaluation step of the chips 25 is simplified.

The control part 80 may calculate a value that indicates a degree of variation in actual dimensions of

the chips 25 (variation value) in addition to the detection of the actual dimensions of the chips 25 (calculation step). As examples of the variation value, a variance of the actual dimensions, a standard deviation of the actual dimensions, a process capability index (C_p , C_{pk} , or the like), and so forth are cited.

As illustrated in FIG. 1, the control part 80 includes a calculating section 84 that calculates the variation value of actual dimensions of the chips 25 and a storing section 86 that stores a program and various kinds of parameters used for processing by the calculating section 84, and so forth. In the storing section 86, actual dimensions of the chips 25 detected by the detecting section 82, reference values of dimensions of the chips 25, the program for calculating the variation value of the actual dimensions of the chips 25, and so forth are stored. The reference values of dimensions of the chips 25 are standard values of the dimensions of the chips 25, for example, and allowable values (upper-limit value and lower-limit value) or the like of actual dimensions of the chips 25 are stored in the storing section 86 as the reference values. Furthermore, the calculating section 84 calculates the variance or standard deviation of the actual dimensions

of the chips 25 based on the actual dimensions of the chips 25 detected by the detecting section 82. Moreover, the calculating section 84 calculates the process capability index (C_p , C_{pk} , or the like) of the chips 25 based on the actual dimensions of the chips 25 and the reference values (upper-limit value and lower-limit value) stored in the storing section 86. When the variation value of the actual dimensions of the chips 25 is calculated by the calculating section 84, the control part 80 displays this variation value on the display part 48. Thereby, the operator of the cutting apparatus 2 is informed of the degree of variation in the actual dimensions of the chips 25. At this time, the display part 48 may display the reference values (upper-limit value and lower-limit value) of the actual dimensions of the chips 25 in addition to the variation value.

As described above, it is also possible for the cutting apparatus 2 according to the present embodiment to execute the calculation of the variation value of actual dimensions of the chips 25 by the control part 80. Due to this, work of calculating the variation value based on the actual dimensions of the chips 25 by the evaluator of the chips 25 can be omitted and the evaluation step of the chips 25 is simplified.

The detecting section 82 may further detect the position of the kerf 11b (see FIG. 5) formed in the workpiece 11 in addition to the dimensions of the chips 25. The position of the kerf 11b is detected by executing predetermined image processing (edge detection, pattern matching, or the like) for an image acquired by the imaging unit 44, for example. By detecting the position of the kerf 11b (for example, coordinates of a center or end part of the kerf 11b in the width direction) by the detecting section 82, whether or not the workpiece 11 has been cut at the desired position can be checked.

Furthermore, information on the position at which the workpiece 11 should be cut (ideal position of the kerf 11b) may be stored in the storing section 86. In this case, the detecting section 82 may calculate a difference between the ideal position of the kerf 11b and the detected position of the kerf 11b, i.e., an amount of deviation of the cut region. This amount of deviation is stored in the storing section 86. If the above-described amount of deviation is stored in the storing section 86, it becomes possible to correct the positional relationship between the workpiece 11 and the cutting blade 42 in such a manner as to cancel out this amount of deviation when the workpiece 11 is cut by the cutting

blade 42 later (see FIG. 4). This can accurately cut the workpiece 11 by the cutting blade 42.

For example, warpage occurs in the workpiece 11 in a manufacturing step thereof in some cases. Specifically, when heating treatment for curing the resin layer 15 (see FIG. 2B) is executed in manufacturing of the workpiece 11, the resin layer 15 contracts and warpage occurs in the workpiece 11 in some cases. If this warpage of the workpiece 11 occurs, the position of the planned dividing line 17 (see FIG. 2A) varies. Due to this, it becomes difficult for the workpiece 11 to be cut properly along the planned dividing line 17 and position deviation of the kerf 11b occurs more readily. Here, there is a tendency that the degree of warpage of the workpiece 11 manufactured in the same lot (same step) is substantially equal and the degree of position deviation of the kerf 11b also becomes substantially equal. For this reason, when position deviation of the kerf 11b when one workpiece 11 is divided is detected and another workpiece 11 manufactured in the same lot is divided, by correcting the position of the cut region in such a manner that this position deviation is canceled out, cutting the other workpiece 11 along the ideal position of the kerf 11b is enabled.

Specifically, first, one workpiece 11 is divided into plural chips 25. Thereafter, imaging is executed by the imaging unit 44 and the position of the kerf 11b is detected. For example, the kerf 11b formed at a center in FIG. 5 along the direction illustrated by arrow B is imaged. Then, a distance L_4 (distance L_{4a}) from one end (left end in FIG. 5) of the kerf 11b to the electrode 19 disposed at the position closest to the one end of the kerf 11b and a distance L_4 (distance L_{4b}) from the other end (right end in FIG. 5) of the kerf 11b to the electrode 19 disposed at the position closest to the other end of the kerf 11b are detected. Here, a consideration will be made about the case in which the value of ideal L_{4a} and L_{4b} is 0.4 mm and the values of detected L_{4a} and L_{4b} are 0.3 mm and 0.5 mm, respectively, for example. In this case, the amount of position deviation of the cut region in the direction (first direction) illustrated by arrow A is 0.1 mm. Furthermore, this amount of position deviation is stored in the storing section 86. Thereafter, when another workpiece 11 manufactured in the same lot is divided, cutting processing is executed in the state in which the position of the cut region is corrected to the other end side (right end in FIG. 5) of the relevant kerf 11b by the

above-described amount of position deviation (0.1 mm). Thereby, the influence of variation in the position of the planned dividing line 17 attributed to warpage of the workpiece 11 is canceled out and the workpiece 11 is properly cut.

In the above, the description is made about the case in which the amount of position detection of the cut region when one workpiece 11 is cut and the amount of correction of the cut region when another workpiece 11 is cut are set identical (0.1 mm). However, both do not necessarily need to be identical. For example, it is also possible that the value (0.05 mm) equivalent to half of the amount of position deviation of the cut region when one workpiece 11 is cut is set as the amount of correction of the cut region when another workpiece 11 is cut.

As described above, the cutting apparatus 2 according to the present embodiment includes the imaging unit 44 that images the workpiece 11 divided into plural chips 25 and the control part 80 that detects actual dimensions of the chips 25 based on an image of the chips 25 acquired by imaging. Due to this, automatic measurement of dimensions of the chips 25 by the cutting apparatus 2 is enabled and detection of the dimensions of

the chips 25 is simplified.

Details of constituent elements of the cutting apparatus 2 according to the present embodiment can be changed as appropriate. For example, it is also possible to use a jig table that holds the workpiece 11 instead of the chuck table 16 illustrated in FIG. 1. The jig table is formed into a rectangular shape in plan view corresponding to the shape of the workpiece 11, for example, and an upper surface of the jig table configures a holding surface that holds the workpiece 11. A suction hole is made in each of regions corresponding to the device regions 11a (see FIG. 2A) of the workpiece 11 in the holding surface side of the jig table. These plural suction holes are connected to a suction source through a suction path formed inside the jig table. In the state in which the workpiece 11 is disposed on the holding surface of the jig table, a negative pressure of the suction source is caused to act on the lower surface of the workpiece 11 through the suction holes. Thereby, the workpiece 11 is sucked and held by the jig table. Furthermore, in regions corresponding to the planned dividing lines 17 (see FIG. 2A) on the holding surface side of the jig table, linear grooves (clearance grooves) in which the lower end part of the cutting blade 42 (see

FIG. 4) is inserted are formed. When the workpiece 11 held by the jig table is cut by the cutting blade 42, the lower end part of the cutting blade 42 passes through the inside of this groove. Due to this, contact between the cutting blade 42 and the jig table is avoided.

After the workpiece 11 is divided into plural chips 25, the chips 25 are each held by the negative pressure of the suction source acting through the suction holes formed in the jig table. Thus, arrangement of the chips 25 is kept also after the dividing of the workpiece 11. In the case of holding the workpiece 11 by the jig table, sticking of the tape 21 to the workpiece 11 can be omitted.

Besides, structures, methods, and so forth according to the above-described embodiment can be implemented with appropriate changes without departing from the range of the object of the present invention.

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

WHAT IS CLAIMED IS:

1. A dividing method of a workpiece by which the workpiece is divided into a plurality of chips and actual dimensions of the chips are detected by a cutting apparatus including

holding means that holds the workpiece having electrodes in each of a plurality of regions marked out by a plurality of planned dividing lines that intersects each other,

cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted,

imaging means that images the workpiece, and

control means that controls the holding means and the cutting means,

the dividing method comprising:

a dividing step of cutting the workpiece by the cutting blade along the planned dividing lines to divide the workpiece into the plurality of chips;

an image acquisition step of imaging the chips by the imaging means and acquiring an image of the chips; and

a detection step of automatically detecting and calculating the actual dimensions of the chips by the control means based on the images obtained from the image acquisition step, the actual dimensions of the chips

include a size of the whole of the chip, and a position of electrode which the chip has, and a position of an outer circumferential edge of the chip; and

a calculation step of calculating a value that indicates a degree of variation in the actual dimensions of the chips by the control means.

2. The dividing method of a workpiece according to claim 1, wherein

the workpiece is divided in a state of being held by the holding means in the dividing step, and

the workpiece is imaged in a state of being held by the holding means in the image acquisition step.

3. A detection method of dimensions of chips by which a workpiece is divided into a plurality of chips and actual dimensions of the chips are detected by a cutting apparatus including

holding means that holds the workpiece having electrodes in each of a plurality of regions marked out by a plurality of planned dividing lines that intersects each other,

cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted,

imaging means that images the workpiece, and

control means that controls the holding means and the cutting means,

the detection method comprising:

a dividing step of cutting the workpiece by the cutting blade along the planned dividing lines to divide the workpiece into the plurality of chips;

an image acquisition step of imaging the chips by the imaging means and acquiring an image of the chips;

a detection step of automatically detecting and calculating the actual dimensions of the chips by the control means based on the image obtained from the image acquisition step, the actual dimensions of the chips include a size of the whole of the chip, and a position of electrode which the chip has, and a position of an outer circumferential edge of the chip; and

a calculation step of calculating a value that indicates a degree of variation in the actual dimensions of the chips by the control means.

4. The detection method of dimensions of chips according to claim 3, wherein

the workpiece is divided in a state of being held by the holding means in the dividing step, and

the workpiece is imaged in a state of being held by the holding means in the image acquisition step.

5. A cutting apparatus comprising:

holding means that holds a workpiece;

cutting means to which a cutting blade that cuts the workpiece held by the holding means is mounted;

imaging means that images the workpiece; and

control means that controls the holding means and the cutting means, wherein

the imaging means images the workpiece divided into a plurality of chips by the cutting blade and acquires an image of the chips, and

the control means includes a detecting section that automatically detects and calculates actual dimensions of the chips based on the image, the actual dimensions of the chips include a size of the whole of the chip, and a position of electrode which the chip has, and a position of an outer circumferential edge of the chip;

the control means further includes
a storing section that stores reference values of dimensions of the chips set in advance, and

a calculating section that calculates value that indicates a degree of variation in the actual dimensions of the chips based on the actual dimensions of the chip and the reference values.

6. The cutting apparatus according to claim 5, further comprising:

display means that displays the value calculated in the calculating section.