

PROCESSING METHOD AND CUTTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a processing method and a cutting apparatus that execute step cutting of a package substrate by two kinds of blades with different thicknesses and form a chip (package) with a side surface in which a stair-shaped cutout part is formed.

Description of the Related Art

In association with size reduction of electrical equipment in recent years, size reduction has been advancing also in the package size, and the electrode area of the package substrate has been becoming smaller. Thus, a package referred to as a wettable flank is widely employed in order to strengthen bonding to a mounting board and in order to enhance visibility of the bonding state.

The wettable flank package is formed as follows. Planned dividing lines of a package substrate are half-cut by a blade, and side surfaces of electrodes to the middle position in the thickness direction are exposed in the cutting surface. Thereafter, plating is executed for

the electrodes. Subsequently, full cutting is executed by a blade with a smaller width than the half-cut groove (for example, refer to Japanese Patent Laid-open No. 2020-161615).

In the wettable flank package, wettability of solder is improved by making a cut in the electrode side surfaces and executing plating. Moreover, through forming a stair-shaped cutout part in the side surfaces, solder supplied to the cutout part at the time of mounting forms a bulge referred to as a fillet like the skirts of Mount Fuji. Due to this, the bonding state of the solder can be visually recognized from the upper surface and the side surface, and therefore an appearance inspection by a camera is enabled.

SUMMARY OF THE INVENTION

On the other hand, in the cutting blade, an R-shape is formed at the tip in association with wear. Therefore, if cutting is continued without changing the cutting-in depth in a state in which the R-shape is formed at the tip of the blade for half cutting, the depth of the cutout part formed in the chip (package) side surface changes.

The change in the depth of the cutout part causes a

problem that the fillet that is the solder connecting part exposed in the package side surface is not formed to a sufficient height from the mounting board at the time of mounting, and thus the possibility of lowering of the reliability of inspection and connection failure are caused.

Thus, an object of the present invention is to provide a processing method and a cutting apparatus that can suppress lowering of the reliability of a chip and connection failure.

In accordance with an aspect of the present invention, there is provided a processing method for forming a chip with a side surface in which a stair-shaped cutout part is formed by executing full cutting by a second blade with a thinner blade thickness than a first blade after executing, by the first blade, half cutting for a package substrate in which multiple planned dividing lines that intersect are set. The processing method includes a half cutting step of causing the first blade to cut into the package substrate and cutting the package substrate by the first blade along the planned dividing line to form a first cut groove and form an uncut residual part under the first cut groove, a full cutting step of cutting the uncut residual part along the

first cut groove by the second blade thinner than the first blade after the half cutting step is executed, and a tip shape check step of checking a tip shape of the first blade. In the half cutting step, the first blade is caused to cut into the package substrate to a cutting-in depth that allows the depth of the cutout part to become a predetermined depth on the basis of the tip shape of the first blade checked in the tip shape check step and the blade thickness of the second blade.

Preferably, in the tip shape check step, a cut mark is formed in an upper surface of the package substrate by the first blade, and the tip shape of the first blade is checked on the basis of the cut mark.

Preferably, the processing method further includes a planarization step of correcting and planarizing a tip of the first blade at a predetermined timing.

In accordance with another aspect of the present invention, there is provided a cutting apparatus that forms a chip with a side surface in which a stair-shaped cutout part is formed by executing full cutting by a second blade with a thinner blade thickness than a first blade after executing, by the first blade, half cutting for a package substrate in which multiple planned dividing lines that intersect are set. The cutting

apparatus includes a table that holds the package substrate and a first cutting unit having the first blade that cuts the package substrate along the planned dividing line to form a first cut groove and form an uncut residual part under the first cut groove. The cutting apparatus also includes a second cutting unit having the second blade that cuts the uncut residual part along the first cut groove and is thinner than the first blade, an imaging unit that images a cut mark formed through causing the first blade to cut into a cutting target object, and a control unit that controls the respective constituent elements. The control unit includes an estimating section that estimates a tip shape of the first blade on the basis of an image obtained through imaging by the imaging unit and a calculating section that calculates a cutting-in depth of the first blade with which the depth of the cutout part becomes a predetermined depth on the basis of the tip shape of the first blade estimated by the estimating section and the blade thickness of the second blade.

According to the present invention, an effect that lowering of the reliability of the chip and connection failure can be suppressed is provided.

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 configuration example of a cutting apparatus according to an embodiment;

FIG. 2 is a plan view of a package substrate that is a processing target of a processing method and the cutting apparatus according to the embodiment;

FIG. 3 is a side view of the package substrate illustrated in FIG. 2;

FIG. 4 is a plan view of the back surface side of the package substrate illustrated in FIG. 2;

FIG. 5 is a perspective view of a package chip obtained by dividing the package substrate illustrated in FIG. 2;

FIG. 6 is a front view illustrating a first cutting unit, a second cutting unit, and so forth of the cutting apparatus illustrated in FIG. 1;

FIG. 7 is a flowchart illustrating the flow of the processing method according to the embodiment;

FIG. 8 is a sectional view schematically illustrating a half cutting step in the processing method illustrated in FIG. 7;

FIG. 9 is a sectional view schematically illustrating a full cutting step in the processing method illustrated in FIG. 7;

FIG. 10 is a sectional view schematically illustrating a state before a first blade of the cutting apparatus illustrated in FIG. 1 wears out;

FIG. 11 is a sectional view schematically illustrating a state in which the first blade illustrated in FIG. 10 has worn out;

FIG. 12 is a sectional view schematically illustrating a state in which the first blade illustrated in FIG. 11 has additionally worn out;

FIG. 13 is a partially sectional side view schematically illustrating a state in which the cutting edge of the first blade is caused to cut into an outer circumferential surplus region of a base substrate of the package substrate in a tip shape check step in the processing method illustrated in FIG. 7;

FIG. 14 is a plan view of the outer circumferential

surplus region of the base substrate of the package substrate in which a cut mark is formed in the tip shape check step in the processing method illustrated in FIG. 7;

FIG. 15 is a diagram illustrating an image obtained through imaging of the cut mark by an imaging unit in the tip shape check step in the processing method illustrated in FIG. 7;

FIG. 16 is a diagram illustrating an image of the tip of the cutting edge of the first blade generated through reducing the length of the image illustrated in FIG. 15 in the tip shape check step in the processing method illustrated in FIG. 7;

FIG. 17 is a sectional view of the tip of the cutting edge of the first blade that forms the cut mark illustrated in FIG. 14;

FIG. 18 is a longitudinal sectional view parallel to the longitudinal direction of the cut mark illustrated in FIG. 14;

FIG. 19 is a sectional view schematically illustrating a calculated cutting-in depth and so forth in the tip shape check step in the processing method illustrated in FIG. 7;

FIG. 20 is a partially sectional side view

schematically illustrating a state in which the cutting edge of the first blade is caused to cut into the outer circumferential surplus region of the base substrate of the package substrate in the tip shape check step in a processing method according to a modification example of the embodiment; and

FIG. 21 is a plan view of the outer circumferential surplus region of the base substrate of the package substrate in which a cut mark is formed in the tip shape check step in the processing method according to the modification example of the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described in detail below with reference to the drawings. The present invention is not limited by contents described in the following embodiment. Furthermore, what can be easily envisaged by those skilled in the art and what are substantially the same are included in constituent elements described below. Moreover, configurations described below can be combined as appropriate. In addition, various kinds of omission, replacement, or change of a configuration can be carried out without departing from the gist of the present

invention.

A processing method and a cutting apparatus 1 according to the embodiment of the present invention will be described on the basis of drawings. FIG. 1 is a perspective view illustrating a configuration example of the cutting apparatus according to the embodiment. FIG. 2 is a plan view of a package substrate that is a processing target of the processing method and the cutting apparatus according to the embodiment. FIG. 3 is a side view of the package substrate illustrated in FIG. 2. FIG. 4 is a plan view of the back surface side of the package substrate illustrated in FIG. 2. FIG. 5 is a perspective view of a package chip obtained by dividing the package substrate illustrated in FIG. 2. FIG. 6 is a front view illustrating a first cutting unit, a second cutting unit, and so forth of the cutting apparatus illustrated in FIG. 1.

The cutting apparatus illustrated in FIG. 1 according to the embodiment is a processing apparatus that executes cutting processing for a package substrate 200 that is the substrate illustrated in FIG. 2, FIG. 3, and FIG. 4 and divides the package substrate 200 into individual package chips 201 (equivalent to the chip) illustrated in FIG. 5 to form the package chips 201.

(Package Substrate)

In the package substrate 200 that is a processing target of the cutting apparatus 1 according to the embodiment, the planar shape is formed into a rectangular flat plate shape as illustrated in FIG. 2. The package substrate 200 includes a base substrate 202 with a rectangular flat plate shape and has a device region 204 and an outer circumferential surplus region 205 that surrounds the device region 204 in a front surface 203 of the base substrate 202. The front surface 203 of the base substrate 202 is equivalent to the upper surface of the package substrate 200. The base substrate 202 is composed of metal such as a metal containing copper (i.e. copper alloy).

In the device region 204, multiple planned dividing lines 206 that intersect each other are set. The planned dividing lines 206 in one direction in the multiple planned dividing lines 206 that intersect each other extend in the direction parallel to the longitudinal direction of the base substrate 202 and the planned dividing lines 206 in the other direction extend in the direction that is orthogonal to the longitudinal direction of the base substrate 202 and is parallel to the width direction of the base substrate 202. Device

chips 208 are disposed in regions 207 marked out by these multiple planned dividing lines 206 that intersect each other. The planned dividing lines 206 are configured to penetrate the base substrate 202. The regions 207 are configured by one part of the base substrate 202, and the device chips 208 are disposed on the side of a back surface 210 (illustrated in FIG. 4 and so forth) on the back side of the front surface 203. In the respective planned dividing lines 206, electrodes 209 for connecting the package chip 201 to a wiring board or the like are disposed.

The electrodes 209 are configured by one part of the base substrate 202. In the embodiment, each of the electrodes 209 is disposed at the center of the planned dividing line 206 in the width direction and is formed into a straight line shape in the direction orthogonal to each planned dividing line 206. The electrodes 209 are connected to the device chip 208 by wires or the like that are not illustrated in the diagram.

In the embodiment, multiple (in the embodiment, three) device regions 204 are disposed at intervals in the longitudinal direction of the base substrate 202. The outer circumferential surplus region 205 is a region in which the device chip 208 is not disposed, and is

configured by the base substrate 202 and surrounds the whole circumference of each device region 204. In addition, the outer circumferential surplus region 205 couples the device regions 204 adjacent to each other.

Furthermore, as illustrated in FIG. 3 and FIG. 4, the package substrate 200 includes a sealing resin 211 that seals (covers) the side of the back surface 210 of each device region 204. The sealing resin 211 is composed of a thermoplastic resin and seals (covers) the device chips 208 disposed on the back surface 210 of the regions 207 of the base substrate 202 and the wires. In addition, the inside of the planned dividing lines 206 is filled with the sealing resin 211. The sealing resin 211 seals (covers) the whole of each device region 204 on the side of the back surface 210 of the base substrate 202. On the side of the front surface 203 of the base substrate 202, the sealing resin 211 seals the inside of the planned dividing lines 206 in a state in which the regions 207 in which the device chips 208 are disposed and the electrodes 209 are exposed.

Through cutting of the center of each planned dividing line 206 of each device region 204 in the width direction and halving of the electrodes 209, the package substrate 200 is divided into the individual package

chips 201 illustrated in FIG. 5. As above, the package substrate 200 that is a processing target of the processing method and the cutting apparatus 1 according to the embodiment is a quad flat non-leaded package (QFN) substrate in which the electrodes 209 composed of metal are disposed on the planned dividing lines 206 to be cut by a cutting blade 21. Although the package substrate 200 is a QFN substrate in which the electrodes 209 are disposed on the planned dividing lines 206 in the embodiment, the package substrate 200 is not limited thereto and may be a chip scale packaging (CSP) substrate. Furthermore, in the embodiment, the package chip 201 obtained by dividing from the package substrate 200 is a small chip with such a size that the lengths of the respective sides are approximately 1 mm × 1 mm, that is, with a small chip size.

Moreover, in the embodiment, in the package substrate 200, as illustrated in FIG. 2, marks 212 for alignment that indicate the cutting position in the planned dividing line 206 at the time of cutting processing are disposed at both end parts of the planned dividing lines 206 of the front surface 203 of the base substrate 202. In the embodiment, the marks 212 for alignment are disposed at positions that line up with the

center of each planned dividing line 206 in the width direction.

As illustrated in FIG. 5, the package chip 201 manufactured through dividing the package substrate 200 includes the region 207 of the base substrate 202, the device chip 208 disposed on the back surface 210 of the region 207, the electrodes 209, and the sealing resin 211. The sealing resin 211 seals the device chip 208 and so forth in a state in which the front surface 203 of the region 207 and the electrodes 209 are exposed.

Furthermore, in the embodiment, a stair-shaped cutout part 214 is formed in each side surface 213 in the package chip 201. The cutout part 214 includes a second side surface 213-1 that is flat in the direction that is parallel to the side surface 213 and is orthogonal to both the front surface 203 and the back surface 210 and is on the side of the front surface 203 and a flat surface 213-2 continuous with the second side surface 213-1 and the side surface 213. The flat surface 213-2 is formed flatly along both the front surface 203 and the back surface 210. In the region in which the electrodes 209 are formed, the cutout part 214 is formed only in the electrodes 209 and is not formed in the sealing resin 211. A depth 215 of the cutout part 214 is set to a

predetermined depth 219 that is smaller than the thickness of the electrodes 209 and is set in advance at a design stage or the like.

Moreover, the package chip 201 includes a plated layer that is composed of metal and is not illustrated in the diagram on the surfaces of the electrodes 209. The plated layer is what improves the wettability of solder that fixes the package chip 201 to a mounting board with respect to the electrode 209. The package chip 201 is mounted on the mounting board through fixing of the electrodes 209 to metal parts that are not illustrated in the diagram on the mounting board by the solder.

(Cutting Apparatus)

The cutting apparatus 1 according to the embodiment is a processing apparatus that holds the package substrate 200 on a table 10 and executes cutting processing along the multiple planned dividing lines 206. In the embodiment, the cutting apparatus 1 is a processing apparatus (what is called a jig dicer) that directly holds the package substrate 200 to which a dicing tape is not stuck on the table 10 and executes what is called full cutting of the package substrate 200 to divide it into the package chips 201.

As illustrated in FIG. 1, the cutting apparatus 1

includes the table 10 that sucks and holds the package substrate 200 by a holding surface 11, a sub-chuck table 15, cutting units 20 that execute cutting processing of the package substrate 200 held by the table 10, an imaging unit 30 that photographs the package substrate 200 held by the table 10, and a control unit 100. The cutting apparatus 1 is a dicing saw including two cutting units 20, i.e. 2-spindle type dicing saw, and is a cutting apparatus of what is called the facing dual type dicing saw as illustrated in FIG. 1 and FIG. 6.

Furthermore, the cutting apparatus 1 includes a movement unit 40 that relatively moves the table 10 and the cutting unit 20 as illustrated in FIG. 1. The movement unit 40 includes an X-axis movement unit 41, a Y-axis movement unit 42, a Z-axis movement unit 43, and a rotational movement unit 44.

The X-axis movement unit 41 is what moves the table 10 and the rotational movement unit 44 in an X-axis direction that is a processing feed direction and is parallel to the horizontal direction to thereby relatively move the cutting unit 20 and the table 10 along the X-axis direction. The Y-axis movement unit 42 is what moves the cutting unit 20 in a Y-axis direction that is an indexing feed direction and is parallel to the

horizontal direction and is orthogonal to the X-axis direction to thereby relatively move the cutting unit 20 and the table 10 along the Y-axis direction.

The Z-axis movement unit 43 is what moves the cutting unit 20 in a Z-axis direction that is a cutting-in feed direction and is orthogonal to both the X-axis direction and the Y-axis direction to thereby relatively move the cutting unit 20 and the table 10 along the Z-axis direction. The rotational movement unit 44 is disposed to be supported by the X-axis movement unit 41 and support the table 10 and be movable in the X-axis direction together with the table 10. The rotational movement unit 44 rotates the table 10 around the axial center parallel to the Z-axis direction.

The X-axis movement unit 41, the Y-axis movement unit 42, and the Z-axis movement unit 43 include a well-known ball screw disposed rotatably around the axial center, a well-known motor that rotates the ball screw around the axial center, and well-known guide rails that support the table 10 or the cutting unit 20 movably in the X-axis direction, the Y-axis direction, or the Z-axis direction. Furthermore, the rotational movement unit 44 includes a motor that rotates the table 10 around the axial center.

The table 10 sucks and holds the package substrate 200 by the holding surface 11 that is the upper surface. The table 10 is rotated around the axial center parallel to the Z-axis direction by the rotational movement unit 44. The table 10 is moved in the X-axis direction together with the rotational movement unit 44 by the X-axis movement unit 41.

In the table 10, the holding surface 11 is segmented into multiple regions by clearance grooves 12 that the cutting blade 21 enters at the time of cutting processing and a suction hole 13 for sucking the package substrate 200 and the package chip 201 is opened in each of the regions marked out by the clearance grooves 12 in the holding surface 11. The clearance grooves 12 are made at positions corresponding to the planned dividing lines 206 (positions that overlap with the planned dividing lines 206 of the package substrate 200 held by the holding surface 11) and are formed recessedly from the holding surface 11.

The suction holes 13 are made at positions corresponding to the package chips 201 (that is, positions that overlap with the package chips 201 of the package substrate 200 held by the holding surface 11) and are opened in the respective regions of the holding

surface 11. In the embodiment, the suction holes 13 correspond to the package chips 201 in a one-to-one relationship. The suction holes 13 are connected to a suction source through a suction path that is not illustrated in the diagram.

On the table 10, the side of the sealing resin 211 of the package substrate 200 is placed on the holding surface 11. Through suction of the suction holes 13 by the suction source, the table 10 sucks and holds the package substrate 200 and the package chips 201 on the holding surface 11. In the embodiment, the table 10 is what is called a jig table that directly sucks and holds the package substrate 200 to which a dicing tape is not stuck on the holding surface 11. However, in the present invention, the table 10 is not limited to the jig table.

The sub-chuck table 15 is disposed at a position adjacent to the table 10 and sucks and holds a dressing board 250 by a holding surface 16. The dressing board 250 is used for flat dressing in which, when being cut by the cutting blade 21, the dressing board 250 causes the tip of the cutting edge of the cutting blade 21 to wear out and makes the tip of the cutting edge be flat along the axial center direction of the cutting unit 20.

The sub-chuck table 15 is moved in the X-axis

direction by the X-axis movement unit 41 together with the table 10 and the rotational movement unit 44. The sub-chuck table 15 rotates around the axial center together with the table 10 by the rotational movement unit 44.

The cutting units 20 are processing units that include the cutting blade 21 mounted on a spindle 23 and cut the package substrate 200 held by the table 10. The cutting units 20 are each disposed to be capable of moving in the Y-axis direction by the Y-axis movement unit 42 and moving in the Z-axis direction by the Z-axis movement unit 43 relative to the package substrate 200 held by the table 10. As illustrated in FIG. 1, the cutting units 20 are disposed on a support frame 3 erected from an apparatus main body 2 with the interposition of the Y-axis movement unit 42, the Z-axis movement unit 43, and so forth. The cutting units 20 can position the cutting blade 21 to an optional position on the holding surface 11 of the table 10 by the Y-axis movement unit 42 and the Z-axis movement unit 43.

The cutting units 20 have the cutting blade 21, a spindle housing 22 disposed to be capable of moving in the Y-axis direction and the Z-axis direction by the Y-axis movement unit 42 and the Z-axis movement unit 43,

the spindle 23 that is disposed in the spindle housing 22 rotatably around the axial center and has a tip on which the cutting blade 21 is mounted, a spindle motor that rotates the spindle 23 around the axial center and is not illustrated in the diagram, and a cutting water nozzle 24 that supplies cutting water to the cutting blade 21.

The cutting blades 21 are very-thin cutting abrasive stones having a substantially ring shape. The cutting blades 21 are each fixed to the tip of the spindle 23. In the embodiment, the cutting blades 21 are what are called hub blades including a circular base with a circular annular shape and a circular annular cutting edge that is disposed on the outer circumferential edge of the circular base and cuts the package substrate 200. The cutting edge is composed of abrasive grains of silicon carbide (SiC), alumina, diamond, cubic boron nitride (CBN), or the like and a bond (binding agent) that is composed of metal, resin, or the like and fixes the abrasive grains, and is formed into a predetermined thickness. In the present invention, the cutting blades 21 may be what are called washer blades composed only of a cutting edge.

Hereinafter, one of the two cutting units 20 will be referred to as the first cutting unit 20 (denoted by

numeral 20-1) and the other will be referred to as the second cutting unit 20 (denoted by numeral 20-2). Furthermore, hereinafter, as illustrated in FIG. 6, the cutting blade 21 of the first cutting unit 20-1 will be referred to as the first blade 21 (denoted by numeral 21-1) and the cutting blade 21 of the second cutting unit 20-2 will be referred to as the second blade 21 (denoted by numeral 21-2). Moreover, a blade thickness 25-2 of the cutting edge of the second blade 21-2 of the second cutting unit 20-2 is thinner than a blade thickness 25-1 of the cutting edge of the first blade 21-1 of the first cutting unit 20-1. Furthermore, in the embodiment, when the blades 21-1 and 21-2 repeat cutting of the package substrate 200, the cutting edges thereof gradually wear out from the tip side and are formed into a curved surface (R-shape) through removal of the corners.

The imaging unit 30 is fixed to the first cutting unit 20-1 so as to move integrally with the first cutting unit 20-1. The imaging unit 30 includes an imaging element that photographs a region to be divided in the package substrate 200 held by the table 10 before cutting. The imaging element is a charge-coupled device (CCD) imaging element or complementary metal oxide semiconductor (CMOS) imaging element, for example. The

imaging unit 30 photographs the package substrate 200 held by the table 10 and obtains an image for performing alignment to execute position adjustment between the package substrate 200 and the cutting blade 21, and so forth, to output the obtained image to the control unit 100.

Moreover, the cutting apparatus 1 includes an X-axis direction position detecting unit that is for detecting the position of the table 10 in the X-axis direction and is not illustrated in the diagram, a Y-axis direction position detecting unit that is for detecting the position of the cutting units 20-1 and 20-2 in the Y-axis direction and is not illustrated in the diagram, and a Z-axis direction position detecting unit for detecting the position of the cutting units 20-1 and 20-2 in the Z-axis direction. The X-axis direction position detecting unit and the Y-axis direction position detecting unit can be configured by a linear scale parallel to the X-axis direction or the Y-axis direction and a reading head. The Z-axis direction position detecting unit detects the position of the cutting units 20-1 and 20-2 in the Z-axis direction by the pulse of a motor. The X-axis direction position detecting unit, the Y-axis direction position detecting unit, and the Z-axis direction position

detecting unit output, to the control unit 100, the position of the table 10 in the X-axis direction and the position of the lower ends of the cutting edges of the cutting units 20-1 and 20-2 in the Y-axis direction or the Z-axis direction.

In the embodiment, the position in the X-axis direction and the position in the Y-axis direction and the Z-axis direction regarding the table 10 and the cutting units 20-1 and 20-2 of the cutting apparatus 1 are defined on the basis of a reference position that is defined in advance and is not illustrated in the diagram.

The control unit 100 is also what controls each of the respective constituent elements including the first cutting unit 20-1, the second cutting unit 20-2, and the imaging unit 30 of the cutting apparatus 1 and causes the cutting apparatus 1 to execute processing operation for the package substrate 200. The control unit 100 is a computer having a calculation processing device having a microprocessor like a central processing unit (CPU), a storing device having a memory like a read only memory (ROM) or a random access memory (RAM), and an input-output interface device. The calculation processing device of the control unit 100 executes calculation processing in accordance with a computer program stored

in the storing device and outputs a control signal for controlling the cutting apparatus 1 to the respective constituent elements of the cutting apparatus 1 through the input-output interface device.

The control unit 100 is connected to a display unit that displays a state of processing operation, an image, and so forth and is configured by a liquid crystal display device or the like and an input unit used when an operator registers information on the contents of processing or the like. The input unit is configured by a touch panel disposed on the display unit.

Furthermore, as illustrated in FIG. 1, the control unit 100 includes an estimating section 101, a calculating section 102, and a processing control section 103 that controls processing operation of the respective constituent elements of the cutting apparatus 1. Functions of the estimating section 101, the calculating section 102, and the processing control section 103 are implemented through execution of calculation processing by the calculation processing device in accordance with the computer program stored in the storing device.

The processing method according to the embodiment is a processing method in which the cutting apparatus 1 executes half cutting of the package substrate 200 by the

first blade 21-1 and thereafter executes full cutting by the second blade 21-2 with the thinner blade thickness 25-2 than the first blade 21-1 to thereby form the package chip 201 in which the stair-shaped cutout part 214 is formed in the side surfaces 213. That is, the processing method according to the embodiment is also the processing operation of the cutting apparatus 1. FIG. 7 is a flowchart illustrating the flow of the processing method according to the embodiment. As illustrated in FIG. 7, the processing method according to the embodiment includes a half cutting step 1002, a full cutting step 1003, a tip shape check step 1005, a planarization step 1007, and so forth.

In the cutting apparatus 1, the sealing resin 211 of the package substrate 200 is placed on the holding surface 11 of the table 10, and the dressing board 250 is placed on the holding surface 16 of the sub-chuck table 15. The cutting apparatus 1 executes the processing operation, i.e. the processing method, when the control unit 100 accepts a processing condition input from the input unit or the like and the control unit 100 accepts an instruction to start processing from an operator or the like. The processing condition includes the blade thicknesses 25-1 and 25-2 of the respective blades 21-1

and 21-2, a cutting-in depth 26 (illustrated in FIG. 8) of the first blade 21-1, the predetermined depth 219 set in advance at a design stage or the like for the depth 215 of the cutout part 214, the thickness of the electrodes 209, the kind of first blade 21-1, the kind of package substrate 200, and so forth. The cutting-in depth 26 of the processing condition is smaller than the thickness of the electrodes 209 and is the same as the predetermined depth 219 set in advance at a design stage or the like for the depth 215 of the cutout part 214.

When the processing operation is started, the cutting apparatus 1 rotates the spindles 23 of the cutting units 20-1 and 20-2, i.e. the cutting blades 21-1 and 21-2, around the axial center. In addition, the cutting apparatus 1 sucks and holds the package substrate 200 on the holding surface 11 of the table 10 and sucks and holds the dressing board 250 on the holding surface 16 of the sub-chuck table 15. Furthermore, when the processing operation is started, in the cutting apparatus 1, the processing control section 103 of the control unit 100 determines whether or not the present timing is a timing when the shape of the tip of the cutting edge of the first blade 21-1 is checked (step 1001). The timing when the shape of the tip of the cutting edge of the

first blade 21-1 is checked is specified depending on the kinds of package substrate 200 and first blade 21-1, and so forth. The cutting apparatus 1 proceeds to the half cutting step 1002 when the processing control section 103 of the control unit 100 determines that the present timing is not the timing when the shape of the tip of the cutting edge of the first blade 21-1 is checked (step 1001: No).

(Half Cutting Step)

FIG. 8 is a sectional view schematically illustrating the half cutting step in the processing method illustrated in FIG. 7. The half cutting step 1002 is a step of causing the first blade 21-1 to cut into the package substrate 200 and cutting the package substrate 200 by the first blade 21-1 along the planned dividing line 206 to form a first cut groove 216 and form an uncut residual part 217 under the first cut groove 216. That is, in the half cutting step 1002, the first blade 21-1 cuts the package substrate 200 along the planned dividing line 206 to form the first cut groove 216 and form the uncut residual part 217 under the first cut groove 216.

In the half cutting step 1002, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the movement unit 40 to move

the table 10 to the lower side of the imaging unit 30, and images the mark 212 of the package substrate 200 by the imaging unit 30 and performs alignment to execute position adjustment between the blades 21-1 and 21-2 and the planned dividing line 206. In the half cutting step 1002, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the respective constituent elements to cause the cutting edge of the first blade 21-1 to cut into the center of one planned dividing line 206 in the width direction by the cutting-in depth 26 specified in the processing condition while relatively moving the table 10 and the first blade 21-1 of the cutting unit 20-1 along the X-axis direction, the Y-axis direction, and so forth. In the half cutting step 1002, as illustrated in FIG. 8, the cutting apparatus 1 cuts the planned dividing line 206 of the package substrate 200 by the first blade 21-1 to form the first cut groove 216 in the planned dividing line 206 and form the uncut residual part 217 under the first cut groove 216.

In the embodiment, in the half cutting step 1002, the cutting apparatus 1 causes the tip of the cutting edge of the first blade 21-1 to cut into the electrodes 209 by the cutting-in depth 26 to the center of each

electrode 209 in the thickness direction to form the first cut groove 216 also in the electrodes 209 in the planned dividing line 206. Because the first cut groove 216 is formed by causing the tip of the cutting edge of the first blade 21-1 to cut into the electrodes 209 to the center of the electrodes 209 in the thickness direction, the first cut groove 216 is a groove that does not divide the electrodes 209 and the package substrate 200, i.e. a half-cut groove.

In the embodiment, in the half cutting step 1002, the cutting apparatus 1 forms the first cut groove 216 in one planned dividing line 206 in the planned dividing lines 206 of the package substrate 200 sucked and held on the table 10. However, in the present invention, the first cut grooves 216 may be sequentially formed in the planned dividing lines 206 in the number specified in the processing condition or the like. In the embodiment, the cutting apparatus 1 proceeds to the full cutting step 1003 when having formed the first cut groove 216 in one planned dividing line 206 in the planned dividing lines 206 of the package substrate 200 sucked and held on the table 10 in the half cutting step 1002.

(Full Cutting Step)

FIG. 9 is a sectional view schematically

illustrating the full cutting step in the processing method illustrated in FIG. 7. The full cutting step 1003 is a step of cutting the uncut residual part 217 along the first cut groove 216 by the second blade 21-2 with the thinner blade thickness 25-2 than the first blade 21-1 after the half cutting step 1002 is executed. That is, in the full cutting step 1003, the second blade 21-2 is a cutting blade that cuts the uncut residual part 217 along the first cut groove 216 and has the thinner blade thickness 25-2 than the first blade 21-1.

In the full cutting step 1003, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the respective constituent elements to cause the cutting edge of the second blade 21-2 to cut into the uncut residual part 217 under the first cut groove 216 formed at the center of the one planned dividing line 206 in the width direction until the cutting edge reaches the clearance groove 12 while relatively moving the table 10 and the second blade 21-2 of the cutting unit 20-2 along the X-axis direction, the Y-axis direction, and so forth. In the full cutting step 1003, as illustrated in FIG. 9, the cutting apparatus 1 cuts the center of the uncut residual part 217 in the width direction under the first cut groove 216 formed in

the planned dividing line 206 of the package substrate 200 by the second blade 21-2 to form a second cut groove 218 that cuts, i.e. splits, the uncut residual part 217. In the full cutting step 1003, the cutting apparatus 1 forms the second cut groove 218 that cuts, i.e. splits, the uncut residual part 217 to divide the package substrate 200 into the package chips 201.

At this time, in the package substrate 200, i.e. the package chip 201, the cutout part 214 is formed by the first cut groove 216, and the side surface 213 is formed by the second cut groove 218. The inner surface of the first cut groove 216 becomes the second side surface 213-1. The bottom surface of the first cut groove 216 becomes the flat surface 213-2. The inner surface of the second cut groove 218 becomes the side surface 213. The depth 215 of the cutout part 214 is determined depending on the cutting-in depth 26 of the first blade 21-1.

In the embodiment, in the full cutting step 1003, the cutting apparatus 1 cuts the uncut residual part 217 under the first cut groove 216 formed in the one planned dividing line 206 in the planned dividing lines 206 of the package substrate 200 sucked and held on the table 10. However, in the present invention, the first cut grooves 216 may be sequentially formed in the planned

dividing lines 206 in the number specified in the processing condition or the like. In this case, it is desirable to cut, in the full cutting step 1003, the uncut residual part 217 under the first cut grooves 216 formed in the immediately previous half cutting step 1002. In the embodiment, the cutting apparatus 1 proceeds to a step 1004 when having cut the uncut residual part 217 under the first cut groove 216 formed in the one planned dividing line 206 in the planned dividing lines 206 of the package substrate 200 sucked and held on the table 10 in the full cutting step 1003.

In the cutting apparatus 1, the processing control section 103 of the control unit 100 determines whether or not the first cut grooves 216 have been formed in all planned dividing lines 206 of the package substrate 200 in the half cutting step 1002 and the package substrate 200 has been divided into the individual package chips 201 through cutting the uncut residual part 217 under the first cut grooves 216 in the full cutting step 1003 (step 1004). The cutting apparatus 1 returns to the step 1001 when the processing control section 103 of the control unit 100 determines that the first cut grooves 216 have not been formed in all planned dividing lines 206 of the package substrate 200 in the half cutting step 1002 or

the package substrate 200 has not been divided into the individual package chips 201 through cutting the uncut residual part 217 under the first cut grooves 216 in the full cutting step 1003 (step 1004: No).

The cutting apparatus 1 proceeds to the tip shape check step 1005 when the processing control section 103 of the control unit 100 determines that the present timing is the timing when the shape of the tip of the cutting edge of the first blade 21-1 is checked (step 1001: Yes). Here, in the first blade 21-1 of the cutting unit 20-1 of the cutting apparatus 1, before the first blade 21-1 wears out, for example, as illustrated in FIG. 8 and FIG. 10, the tip of the cutting edge is flatly formed along the axial center of the spindle 23, and a curved surface 28 (referred to also as R-shape) at the corner of the tip is small. FIG. 10 is a sectional view schematically illustrating a state before the first blade of the cutting apparatus illustrated in FIG. 1 wears out. FIG. 11 is a sectional view schematically illustrating a state in which the first blade illustrated in FIG. 10 has worn out. FIG. 12 is a sectional view schematically illustrating a state in which the first blade illustrated in FIG. 11 has additionally worn out.

The first blade 21-1 wears out when repeatedly

executing cutting of the planned dividing line 206. Thus, for example, as illustrated in FIG. 11, the curved surface 28 at the corner of the tip of the cutting edge gradually becomes larger and a boundary 27 between the curved surface 28 and the surface flat along the axial center of the spindle 23 gradually moves toward the center of the cutting edge in the thickness direction. When the boundary 27 of the first blade 21-1 is located outside the second cut groove 218 formed by the second blade 21-2, the cutting-in depth 26 becomes equal to the depth 215 of the cutout part 214 and the cutout part 214 with the predetermined depth 219 can be formed. Furthermore, when the boundary 27 of the first blade 21-1 is located inside the second cut groove 218 formed by the second blade 21-2, the depth 215 of the cutout part 214 becomes smaller than the cutting-in depth 26, and the cutout part 214 with the depth 215 smaller than the predetermined depth 219 is formed.

Moreover, when the first blade 21-1 further wears out, for example, as illustrated in FIG. 12, the surface flat along the axial center disappears at the tip of the cutting edge and the tip is formed into a curved surface that bends protrudingly in the outer circumferential direction in some cases. In this case, the depth 215 of

the cutout part 214 becomes smaller than the cutting-in depth 26, and the cutout part 214 with the depth 215 smaller than the predetermined depth 219 is formed.

In the embodiment, the timing when the shape of the tip of the cutting edge of the first blade 21-1 is checked regarding the step 1001 is a timing before the first blade 21-1 wears out as illustrated in FIG. 12, for example, and the depth 215 of the cutout part 214 becomes smaller than the cutting-in depth 26 and is, for example, a timing before (immediately before) the above-described boundary 27 enters the inside of the second cut groove 218. In the embodiment, the timing when the shape of the tip of the cutting edge of the first blade 21-1 is checked regarding the step 1001 is specified for each kind of the package substrate 200 and the first blade 21-1, or the like, and is a timing after start of processing or after cutting of a predetermined number of planned dividing lines 206 after execution of the previous tip shape check step 1005, or the like.

(Tip Shape Check Step)

FIG. 13 is a partially sectional side view schematically illustrating a state in which the cutting edge of the first blade is caused to cut into the outer circumferential surplus region of the base substrate of

the package substrate in the tip shape check step in the processing method illustrated in FIG. 7. FIG. 14 is a plan view of the outer circumferential surplus region of the base substrate of the package substrate in which a cut mark is formed in the tip shape check step in the processing method illustrated in FIG. 7. FIG. 15 is a diagram illustrating an image obtained through imaging of the cut mark by the imaging unit in the tip shape check step in the processing method illustrated in FIG. 7. FIG. 16 is a diagram illustrating an image of the tip of the cutting edge of the first blade generated through reducing the length of the image illustrated in FIG. 15 in the tip shape check step in the processing method illustrated in FIG. 7. FIG. 17 is a sectional view of the tip of the cutting edge of the first blade that forms the cut mark illustrated in FIG. 14. FIG. 18 is a longitudinal sectional view parallel to the longitudinal direction of the cut mark illustrated in FIG. 14. FIG. 19 is a sectional view schematically illustrating a calculated cutting-in depth and so forth in the tip shape check step in the processing method illustrated in FIG. 7.

The tip shape check step 1005 is a step of checking the shape of the tip of the cutting edge of the first

blade 21-1. In the embodiment, in the tip shape check step 1005, in the cutting apparatus 1, the estimating section 101 of the control unit 100 controls the movement unit 40 and so forth, as illustrated in FIG. 13, to position the first blade 21-1 above the base substrate 202 in the outer circumferential surplus region 205 that is the cutting target object in the package substrate 200 and lower the first blade 21-1 that is rotating along the Z-axis direction and cause the tip of the cutting edge of the first blade 21-1 to cut into the base substrate 202 and thereafter raise the first blade 21-1 along the Z-axis direction.

Thereupon, the cut mark 220 illustrated in FIG. 14 is formed in the front surface 203 of the base substrate 202 in the outer circumferential surplus region 205 of the package substrate 200. In this manner, in the embodiment, in the tip shape check step 1005, the cutting apparatus 1 causes the first blade 21-1 to cut into the front surface 203 of the base substrate 202 in the outer circumferential surplus region 205 that is the cutting target object in the package substrate 200 and forms the cut mark 220 in the front surface 203 by the first blade 21-1. Furthermore, in the embodiment, in the tip shape check step 1005, the cut mark 220 is formed by what is

called the chopper cut in which the first blade 21-1 is raised and lowered with respect to the front surface 203 of the base substrate 202 in the outer circumferential surplus region 205 of the package substrate 200. The cut mark 220 is a groove that extends along the X-axis direction and is recessed from the front surface 203, and the shape of both ends 221 curves according to the shape of the tip of the cutting edge of the first blade 21-1.

Furthermore, because the cut mark 220 is formed through raising and lowering of the first blade 21-1 along the Z-axis direction, the both ends 221 of the cut mark 220 are formed into a dead end shape in such a manner that the position on the bottom surface of the cut mark 220 gradually gets closer to the front surface 203 as getting closer to one of the both ends 221. The shape of the both ends 221 of the cut mark 220 becomes equal to the shape of the tip of the cutting edge of the first blade 21-1.

In the tip shape check step 1005, in the cutting apparatus 1, the estimating section 101 of the control unit 100 controls the movement unit 40 and so forth to position the cut mark 220 to the lower side of the imaging unit 30. In the tip shape check step 1005, in the cutting apparatus 1, the estimating section 101 of the

control unit 100 causes the imaging unit 30 to image the cut mark 220 to obtain an image 300 about which one example is illustrated in FIG. 15. As above, the imaging unit 30 images the cut mark 220 formed by causing the first blade 21-1 to cut into the base substrate 202 in the outer circumferential surplus region 205 of the package substrate 200.

In the tip shape check step 1005, in the cutting apparatus 1, the estimating section 101 of the control unit 100 reduces the length of at least a partial image including one end 221 of the cut mark 220 in the image 300 in such a manner that the length of at least the partial image becomes a length as viewed from a tangential direction 29 (illustrated in FIG. 18) of the tip of the cutting edge of the blade 21-1, and forms an image 400 that approximates to the tip of the cutting edge of the first blade 21-1. Specifically, the estimating section 101 of the control unit 100 divides the image 300 in the longitudinal direction of the cut mark 220 as illustrated in FIG. 15.

In the embodiment, the estimating section 101 of the control unit 100 divides the image 300 into multiple divided images 301, 302, 303, 304, ... by each length L that can be obtained by the following expression 1 from

the one end 221 of the cut mark 220. The control unit 100 stores the following expression 1 in advance. The control unit 100 obtains a length L1 (indicated by L in the expression 1) that can be obtained by the expression 1 corresponding to a value $\alpha 1$ (indicated by α in the expression 1) regarding the divided image 302 including the one end 221 of the cut mark 220. However, the value $\alpha 1$ is set to, for example, 1 μm , and R is deemed as the radius of the first blade 21-1, and d is deemed as the cutting-in depth of the cut mark 220. The divided image 302 is an image of part of the cut mark 220 including the one end 221 of the cut mark 220.

[Math. 1]

$$L = \sqrt{R^2 - (R - d)^2} - \sqrt{(R - \alpha)^2 - (R - d)^2} \quad \dots \text{Expression 1}$$

The estimating section 101 of the control unit 100 removes part of the pixels that configure the divided image 302 in such a manner that the length L (L1) of the divided image 302 becomes the value $\alpha 1$. At this time, the control unit 100 removes pixels at every equal interval according to the difference in the length between the length L (L1) and the value $\alpha 1$.

Next, the control unit 100 obtains the length L (L2) of the divided image 303 adjacent to the divided image 302 corresponding to a value $\alpha 2$ (indicated by α in

the expression 1) by using the expression 1 in such a manner that the value α_2 is set to, for example, $1\ \mu\text{m}$ and d is deemed as the cutting-in depth of the cut mark 220 and R is set to $R - \alpha_1$. The estimating section 101 of the control unit 100 removes part of the pixels that configure the divided image 303 in such a manner that the length L (L_2) of the divided image 303 becomes the value α_2 . Moreover, the control unit 100 obtains the length L (L_3) of the divided image 304 adjacent to the divided image 303 corresponding to a value α_3 (indicated by α in the expression 1) by using the expression 1 in such a manner that the value α_3 is set to, for example, $1\ \mu\text{m}$ and d is deemed as the cutting-in depth of the cut mark 220 and R is set to $R - (\alpha_1 + \alpha_2)$. The control unit 100 removes part of the pixels that configure the divided image 304 in such a manner that the length L (L_3) of the divided image 304 becomes the value α_3 .

In this manner, the estimating section 101 of the control unit 100 divides the image 300 into the divided images 301, 302, 303, ..., and 30N and obtains the lengths L_1 , L_2 , L_3 , ..., and L_N of the divided images 302, 303, 304, ..., and 30N corresponding to the respective values α_1 , α_2 , α_3 , ..., and α_N . The estimating section 101 of the control unit 100 removes part of the

pixels of all divided images 302, 303, 304, ..., and 30N to reduce the lengths to the values α_1 , α_2 , α_3 , ..., and α_N . Then, the estimating section 101 of the control unit 100 combines the reduced divided images 301, 302, 303, 304, ..., and 30N to generate the image 400 that approximates to the shape of the tip of the cutting edge of the first blade 21-1 through reducing the length of the image 300 as illustrated in FIG. 16. The shape of the cut mark 220 in the image 400 illustrated in FIG. 16 is substantially equal to the sectional shape of the tip of the cutting edge of the first blade 21-1 that has formed the cut mark 220, illustrated in FIG. 17.

In this manner, in the embodiment, in the tip shape check step 1005, the estimating section 101 of the control unit 100 checks the shape of the tip of the cutting edge of the first blade 21-1 on the basis of the image 300 of the cut mark 220 obtained through imaging by the imaging unit 30.

Next, the above-described expression 1 will be described. As illustrated in FIG. 18, the imaging unit 30 images one end 221 of the cut mark 220 from the upper side in the direction orthogonal to the front surface 203 of the base substrate 202 in the outer circumferential surplus region 205 of the package substrate 200. In FIG.

18, when the center of the first blade 21-1 when the one end 221 of the cut mark 220 is formed is defined as A, the point at which a straight line that extends in the Z-axis direction from the center A intersects the front surface 203 of the package substrate 200 is defined as B, and the one end 221 of the cut mark 220 is defined as C0, the length of a side BC0 of a triangle ABC0 can be represented by the following expression 2.

[Math. 2]

$$\sqrt{R^2 - (R - d)^2} \quad \dots \text{Expression 2}$$

In FIG. 18, when the end of the divided image 302 on the side remoter from the one end 221 of the cut mark 220 is defined as C1 and the depth of the cut mark 220 in the radial direction of the first blade 21-1 at the end C1 of the divided image 302 on the side remoter from the one end 221 of the cut mark 220 is defined as $\alpha 1$ (indicated by α in the expression 3), the length of a side BC1 of a triangle ABC1 can be represented by the following expression 3.

[Math. 3]

$$\sqrt{(R - \alpha)^2 - (R - d)^2} \quad \dots \text{Expression 3}$$

Furthermore, in FIG. 18, when the length of the divided image 302 in the longitudinal direction of the cut mark 220 is defined as L1 (indicated by L in the

expression 1), the estimating section 101 of the control unit 100 can obtain the expression 1 from the expression 2 and the expression 3. The estimating section 101 of the control unit 100 sets the value α_1 that is the depth of the cut mark 220 to 1 μm and can obtain the length L_1 of the divided image 302 in the longitudinal direction of the cut mark 220 because the radius R of the first blade 21-1 and the cutting-in depth d of the cut mark 220 are specified in advance.

Moreover, the estimating section 101 of the control unit 100 can obtain the length L_2 of the divided image 303 in the longitudinal direction of the cut mark 220 by setting the value α_2 to 1 μm and setting R to $R - \alpha_1$ in the expression 1, and can obtain the length L_3 of the divided image 304 in the longitudinal direction of the cut mark 220 by setting the value α_3 to 1 μm and setting R to $R - (\alpha_1 + \alpha_2)$. The estimating section 101 of the control unit 100 can obtain the lengths $L_1, L_2, L_3, \dots$, and L_N of all divided images 302, 303, 304, $\dots$, and 30N similarly. By reducing the lengths $L_1, L_2, L_3, \dots$, and L_N of the divided images 302, 303, 304, $\dots$, and 30N of the image 300, the lengths of the respective divided images 302, 303, 304, $\dots$, and 30N are reduced in such a manner that the lengths of the cut mark 220 in the

respective divided images 302, 303, 304, ..., and 30N become lengths as viewed from the tangential direction 29 of the tip of the cutting edge of the first blade 21-1.

The estimating section 101 of the control unit 100 combines the reduced divided images 302, 303, 304, ..., and 30N. This reduces the length of the image 300 in such a manner that the length of the cut mark 220 of the image 300 becomes the length as viewed from the tangential direction 29 of the tip of the cutting edge of the cutting blade 21 at the one end 221 of the cut mark 220. Thus, the image 400 that approximates to the outer circumferential shape of the cutting blade 21 approximates to an image obtained by imaging the one end 221 of the cut mark 220 from the imaging unit 30 (illustrated by dotted lines in FIG. 18) disposed on the tangential direction 29 of the cutting blade 21 at the one end 221 of the cut mark 220.

In the tip shape check step 1005, the calculating section 102 of the control unit 100 calculates a cutting-in depth 26-1 that allows the depth 215 of the cutout part 214 to become the above-described predetermined depth 219 on the basis of the tip shape of the cutting edge of the first blade 21-1 estimated by the estimating section 101 and the blade thickness 25-2 of the second

blade 21-2. Specifically, the shape of the inner surface of the first cut groove 216 is equivalent to the shape of the tip of the cutting edge of the first blade 21-1, and the shape of the inner surface of the second cut groove 218 is equivalent to the shape of the tip of the cutting edge of the second blade 21-2. Therefore, for example, the calculating section 102 of the control unit 100 obtains an intersection 222 of the first cut groove 216 and the second cut groove 218 on the basis of the tip shape of the cutting edge of the first blade 21-1 estimated by the estimating section 101 and the blade thickness 25-2 of the second blade 21-2, and calculates the cutting-in depth 26-1 of the first blade 21-1 when this intersection 222 is located at the predetermined depth 219.

In the tip shape check step 1005, the calculating section 102 of the control unit 100 causes the storing device to store the calculated cutting-in depth 26-1 as a new processing condition. In the tip shape check step 1005, the cutting-in depth 26-1 calculated by the calculating section 102 of the control unit 100 is larger than the predetermined depth 219 of the depth 215 of the cutout part 214. The cutting apparatus 1 proceeds to a step 1006 when the calculating section 102 of the control

unit 100 has caused the storing device to store the calculated cutting-in depth 26-1 as a new processing condition in the tip shape check step 1005.

The processing control section 103 of the control unit 100 determines whether or not the present timing is a predetermined timing when flat dressing is executed for the tip of the cutting edge of the first blade 21-1 (step 1006). The processing control section 103 of the control unit 100 determines whether or not the cutting-in depth 26-1 calculated by the calculating section 102 in the tip shape check step 1005 is equal to or larger than a value according to the thickness of the electrode 209. The value according to the thickness of the electrode 209 is a value of remaining of the metal that configures the electrode 209 in the uncut residual part 217 under the first cut groove 216 formed through cutting the electrode 209, and, for example, may be the thickness of the electrode 209 or may be a value slightly smaller than the thickness of the electrode 209.

When determining that the cutting-in depth 26-1 calculated by the calculating section 102 in the tip shape check step 1005 is smaller than the value according to the thickness of the electrode 209, the processing control section 103 of the control unit 100 determines

that the present timing is not the predetermined timing when flat dressing is executed for the tip of the cutting edge of the first blade 21-1 (step 1006: No), and the cutting apparatus 1 returns to the half cutting step 1002. When determining that the cutting-in depth 26-1 calculated by the calculating section 102 in the tip shape check step 1005 is equal to or larger than the value according to the thickness of the electrode 209, the processing control section 103 of the control unit 100 determines that the present timing is the predetermined timing when flat dressing is executed for the tip of the cutting edge of the first blade 21-1 (step 1006: Yes), and the cutting apparatus 1 proceeds to the planarization step 1007.

(Planarization Step)

The planarization step 1007 is a step of correcting and planarizing the shape of the tip of the cutting edge of the first blade 21-1 at a predetermined timing. In the embodiment, in the planarization step 1007, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the movement unit 40 and so forth to position the tip of the cutting edge of the rotating first blade 21-1 to a position that lines up with the dressing board 250 held on the sub-chuck table

15 in the Y-axis direction and to the lower side relative to the upper surface of the dressing board 250.

In the embodiment, in the planarization step 1007, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the movement unit 40 and so forth to cause the first cutting unit 20-1 to move in such a direction as to get closer to the dressing board 250 along the Y-axis direction and cause the tip of the cutting edge of the rotating first blade 21-1 to cut into the upper surface of the dressing board 250. In the embodiment, in the planarization step 1007, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the movement unit 40 and so forth to move the first cutting unit 20-1 along the Y-axis direction while causing the tip of the cutting edge of the rotating first blade 21-1 to cut into the upper surface of the dressing board 250, to execute flat dressing by which the tip of the cutting edge of the first blade 21-1 is made flat along the axial center direction. In the embodiment, in the planarization step 1007, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the movement unit 40 and so forth to move the first cutting unit 20-1 along the Y-axis direction a predetermined number of

times to execute the flat dressing for the first blade 21-1.

In the embodiment, the cutting apparatus 1 returns to the tip shape check step 1005 when having executed the flat dressing for the first blade 21-1 in the planarization step 1007. Although returning to the tip shape check step 1005 after the planarization step 1007 in the embodiment, the cutting apparatus 1 may return to the half cutting step 1002 after the planarization step 1007 in the present invention.

In the half cutting step 1002 subsequent to a return from the step 1004 or the step 1006, in the cutting apparatus 1, the processing control section 103 of the control unit 100 controls the respective constituent elements to cause the cutting edge of the first blade 21-1 to cut into the center of one planned dividing line 206 in the width direction by the cutting-in depth 26-1 calculated by the calculating section 102 in the tip shape check step 1005 while relatively moving the table 10 and the first blade 21-1 of the cutting unit 20-1 along the X-axis direction, the Y-axis direction, and so forth. In the half cutting step 1002, the cutting apparatus 1 cuts the planned dividing line 206 of the package substrate 200 by the first blade 21-1 to form the

first cut groove 216 in the planned dividing line 206 and form the uncut residual part 217 under the first cut groove 216. As above, in the half cutting step 1002 subsequent to a return from the step 1004 or the step 1006, the cutting apparatus 1 causes the first blade 21-1 to cut into the package substrate 200 by the cutting-in depth 26-1 that is calculated on the basis of the shape of the tip of the cutting edge of the first blade 21-1 checked in the tip shape check step 1005 and the blade thickness 25-2 of the second blade 21-2 and allows the depth 215 of the cutout part 214 to become the predetermined depth 219.

The cutting apparatus 1 ends the processing operation, i.e. the processing method, when the processing control section 103 of the control unit 100 determines that the first cut grooves 216 have been formed in all planned dividing lines 206 of the package substrate 200 in the half cutting step 1002 and the package substrate 200 has been divided into the individual package chips 201 through cutting the uncut residual part 217 under the first cut grooves 216 in the full cutting step 1003 (step 1004: Yes).

As above, the processing method and the cutting apparatus 1 according to the embodiment check the shape

of the tip of the cutting edge of the first blade 21-1 in the tip shape check step 1005 and set the cutting-in depth 26-1 of the first blade 21-1 in such a manner that the depth 215 of the cutout part 214 corresponding to the shape of the tip of the cutting edge of the first blade 21-1 and the blade thickness 25-2 of the second blade 21-2 becomes the predetermined depth 219. Thus, the processing method and the cutting apparatus 1 according to the embodiment can suppress the error from the predetermined depth 219 regarding the depth 215 of the cutout part 214 of the package chip 201. As a result, the processing method and the cutting apparatus 1 according to the embodiment provide an effect that lowering of the reliability of inspection of the package chip 201 and connection failure can be suppressed.

Furthermore, as a result, the processing method and the cutting apparatus 1 according to the embodiment execute flat dressing for the first blade 21-1 in the planarization step 1007 at a predetermined timing to correct the shape of the tip of the cutting edge of the first blade 21-1 into a flat shape, and therefore can stably form the cutout part 214 with the predetermined depth 219. In general, it takes a long time to execute the flat dressing by which the shape of the tip of the

cutting edge of the cutting blade is corrected (it is not important to make the side surface of the cutout part be perpendicular), which lowers the productivity. However, the processing method and the cutting apparatus 1 according to the embodiment change the cutting-in depth 26-1 on the basis of the shape of the tip of the cutting edge of the first blade 21-1 and form the cutout part 214 with the predetermined depth 219. This can suppress execution of the flat dressing and suppress the lowering of the productivity.

[Modification Example]

A processing method and the cutting apparatus 1 according to a modification example of the embodiment of the present invention will be described on the basis of drawings. FIG. 20 is a partially sectional side view schematically illustrating a state in which the cutting edge of the first blade is caused to cut into the outer circumferential surplus region of the base substrate of the package substrate in the tip shape check step in the processing method according to the modification example of the embodiment. FIG. 21 is a plan view of the outer circumferential surplus region of the base substrate of the package substrate in which a cut mark is formed in the tip shape check step in the processing method

according to the modification example of the embodiment. In FIG. 20 and FIG. 21, the same part as the embodiment is given the same numeral, and description thereof is omitted.

The processing method and the cutting apparatus 1 according to the modification example of the embodiment are the same as the embodiment except that the method for forming a cut mark 220-1 in the tip shape check step 1005 is different. In the tip shape check step in the processing method according to the modification example, the cutting apparatus 1 forms the cut mark 220-1 illustrated in FIG. 21 by what is called the chopper traverse in which, as illustrated in FIG. 20, the first blade 21-1 is caused to cut into the planned dividing line 206 of the package substrate 200 similarly to the half cutting step 1002 and the first blade 21-1 is raised in the outer circumferential surplus region 205. The cut mark 220-1 formed in the modification example is formed to extend along the X-axis direction from the outer edge of the base substrate 202 in the outer circumferential surplus region 205 of the package substrate 200, and the tip 221 is formed into a shape similar to that in the embodiment. In the tip shape check step in the processing method according to the modification example, the cutting

apparatus 1 images a region including the tip 221 of the cut mark 220-1 by the imaging unit 30 and checks the shape similarly to the embodiment to calculate the cutting-in depth 26-1.

The processing method and the cutting apparatus 1 according to the modification example check the shape of the tip of the cutting edge of the first blade 21-1 and set the cutting-in depth 26-1 of the first blade 21-1 in such a manner that the depth 215 of the cutout part 214 becomes the predetermined depth 219. Therefore, they provide an effect that lowering of the reliability of inspection of the package chip 201 and connection failure can be suppressed similarly to the embodiment.

The present invention is not limited to the above-described embodiment. That is, the present invention can be carried out with various modifications without departing from the gist of the present invention. In the present invention, the processing method and the cutting apparatus 1 may hold a silicon piece or the dressing board 250 that is a cutting target object on the sub-chuck table 15 and cause the first blade 21-1 to cut into the silicon piece or the dressing board 250 in the tip shape check step 1005 to form the cut mark 220 or 220-1. Furthermore, in the present invention, instead of merely

correcting the cutting-in depth 26-1 at the time of continuous processing, the tip shape check step 1005 may be executed after the first blade 21-1 is replaced and dressing is executed and before the half cutting step 1002 is executed. In this case, the cutting-in depth 26-1 in the half cutting step 1002 may be adjusted from the checked shape of the tip of the cutting edge of the first blade 21-1.

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 method for forming a chip with a side surface in which a stair-shaped cutout part is formed by executing full cutting by a second blade with a thinner blade thickness than a first blade after executing, by the first blade, half cutting for a package substrate in which multiple planned dividing lines that intersect are set, the processing method comprising:

a half cutting step of causing the first blade to cut into the package substrate and cutting the package substrate by the first blade along the planned dividing line to form a first cut groove and form an uncut residual part under the first cut groove;

a full cutting step of cutting the uncut residual part along the first cut groove by the second blade thinner than the first blade after the half cutting step is executed; and

a tip shape check step of checking a tip shape of the first blade, the tip shape check step comprising

estimating a tip shape of the first blade on a basis of an image obtained through imaging; and

calculating a cutting-in depth of the first blade with which a depth of the cutout part becomes a predetermined depth on a basis of the tip shape of

the first blade estimated by the estimating section
and the blade thickness of the second blade,
wherein,

in the half cutting step, the first blade is caused
to cut into the package substrate to the cutting-in depth
that is calculated on the basis of the tip shape of the
first blade checked in the tip shape check step and the
blade thickness of the second blade.

2. The processing method according to claim 1,
wherein,

in the tip shape check step, a cut mark is formed
in an upper surface of the package substrate by the first
blade, and the tip shape of the first blade is checked on
a basis of the cut mark.

3. The processing method according to claim 2,
wherein,

in the tip shape check step, the cut mark is formed
in the outer circumferential surplus region of the upper
surface of the package surface by the first blade.

4. The processing method according to any one of
claims 1 to 3, further comprising:

a planarization step of correcting and planarizing
a tip of the first blade at a predetermined timing.

5. The processing method according to claim 4,

wherein,

a present timing is determined as the predetermined timing by determining whether or not the cutting-in depth calculated in the tip shape check step is equal to or larger than the value according to a thickness of an electrode disposed at a center of the planned dividing line.

6. A cutting apparatus that forms a chip with a side surface in which a stair-shaped cutout part is formed by executing full cutting by a second blade with a thinner blade thickness than a first blade after executing, by the first blade, half cutting for a package substrate in which multiple planned dividing lines that intersect are set , the cutting apparatus comprising:

a table that holds the package substrate;

a first cutting unit having the first blade that cuts the package substrate along the planned dividing line to form a first cut groove and form an uncut residual part under the first cut groove;

a second cutting unit having the second blade that cuts the uncut residual part along the first cut groove and is thinner than the first blade;

an imaging unit that images a cut mark formed through causing the first blade to cut into a cutting

target object; and

a control unit that controls the respective constituent elements, wherein

the control unit includes

an estimating section that estimates a tip shape of the first blade on a basis of an image obtained through imaging by the imaging unit, and

a calculating section that calculates a cutting-in depth of the first blade with which a depth of the cutout part becomes a predetermined depth on a basis of the tip shape of the first blade estimated by the estimating section and the blade thickness of the second blade.

7. The cutting apparatus according to claim 6, wherein,

when the cutting-in depth calculated by the calculating section is determined to be equal to or larger than a value according to the thickness of an electrode disposed at a center of the planned dividing line, a processing control section of the control unit determines that a present timing is a predetermined timing when flat dressing is executed for the tip of the cutting edge of the first blade.