

DESCRIPTION

Title of Invention: NOTCH DETECTION APPARATUS, RESIN MOLDING
APPARATUS, PRODUCTION METHOD FOR RESIN MOLDED PRODUCT,
5 AND NOTCH DETECTION METHOD

Technical Field

[0001] The present invention relates to a notch detection apparatus, a resin
molding apparatus, a production method for a resin molded product, and a notch
10 detection method.

Background Art

[0002] Patent Document 1 discloses a resin molding apparatus for processing a
wafer. In Patent Document 1, a cutout called a notch is provided on an outer
15 peripheral edge of the wafer. The notch is used for positioning the wafer set in a
lower die during resin molding.

Citation List

Patent Document

20 [0003] Patent Document 1: JP 2020-107700A

Summary of Invention

Technical Problem

[0004] As in the example of Patent Document 1, a notch may be provided in a
25 plate-shaped target object such as a wafer. The notch can be used not only for
positioning the wafer as described above, but also for various purposes, such as
managing information on each chip by identifying each chip mounted on the wafer

based on the position of the notch. In order to utilize the notch for such various purposes, it is required to correctly detect the position of the notch when processing the plate-shaped target object such as a wafer.

[0005] The present invention aims to provide a notch detection apparatus, a resin molding apparatus, a production method for a resin molded product, and a notch detection method that enable correct detection of the position of a notch in a plate-shaped target object.

Solution to Problem

10 [0006] A notch detection apparatus according to one aspect of the present invention includes: a placing surface on which a plate-shaped target object having a notch is to be disposed; a sensor, and a processor. The sensor is configured to rotate about a predetermined rotary axis relatively along an outer peripheral edge of the target object disposed on the placing surface, and obtains a series of distance data along a circumferential direction by repeatedly measuring a distance from the rotary axis to the outer peripheral edge while rotating relatively along the outer peripheral edge. The processor detects a position of the notch on the outer peripheral edge based on the series of distance data obtained by the sensor. The outer peripheral edge, except for an area of the notch, extends along the circumferential direction to form predetermined repeated patterns. The processor divides the series of distance data along the circumferential direction into a plurality of groups corresponding to the repeated patterns, and detects the position of the notch by comparing the divided distance data between the groups.

[0007] A resin molding apparatus according to another aspect of the present invention includes the above-described notch detection apparatus and a molding die. The target object is to be disposed in the molding die such that the notch detected by the notch detection apparatus is disposed at a predetermined position, and is molded

with a resin in the molding die.

[0008] A production method for a resin molded product according to yet another aspect of the present invention is a production method for a resin molded product using the above-described resin molding apparatus. This production method includes:
5 detecting the position of the notch with use of the notch detection apparatus; disposing the target object in the molding die such that the notch detected by the notch detection apparatus is disposed at the predetermined position; and molding the target object with the resin in the molding die to produce the resin molded product.

[0009] A notch detection method according to yet another aspect of the present
10 invention includes: rotating a sensor about a predetermined rotary axis relatively along an outer peripheral edge of a plate-shaped target object having a notch; obtaining a series of distance data along a circumferential direction by repeatedly measuring a distance from the rotary axis to the outer peripheral edge with use of the sensor while the sensor rotates relatively along the outer peripheral edge; and detecting a position
15 of the notch on the outer peripheral edge based on the series of distance data obtained by the sensor. The outer peripheral edge, except for an area of the notch, extends along the circumferential direction to form predetermined repeated patterns. The detecting of the position of the notch includes dividing the series of distance data along the circumferential direction into a plurality of groups corresponding to the repeated
20 patterns, and detecting the position of the notch by comparing the divided distance data between the groups.

Advantageous Effects of Invention

[0010] According to the present invention, it is possible to correctly detect the
25 position of a notch in a plate-shaped target object.

Brief Description of Drawings

[0011] FIG. 1 is a schematic plan view of a resin molding apparatus according to one embodiment.

FIG. 2 is a plan view of a substrate before resin molding according to one embodiment.

5 FIG. 3 is a schematic side view of a positioning mechanism according to one embodiment.

FIG. 4 is a schematic lateral cross-sectional view of a part of a press module before mold clamping according to one embodiment.

10 FIG. 5 is a schematic lateral cross-sectional view of a part of the press module after mold clamping according to one embodiment.

FIG. 6 is a cross-sectional view taken along line VI-VI in FIG. 4.

FIG. 7 is a flowchart illustrating a flow of a notch detection method according to one embodiment.

15 FIG. 8A shows an example of a graph of a series of distance data along a circumferential direction.

FIG. 8B shows an example of a graph in which graphs of a plurality of groups are superimposed.

FIG. 8C shows an example of a graph of average values of a plurality of groups.

20 FIG. 8D shows an example of a graph of absolute values of deviations.

FIG. 9 is a plan view of a substrate according to a modification.

Description of Embodiments

[0012] An embodiment according to one aspect of the present invention
25 (hereinafter also referred to as “the present embodiment”) will be described below in detail with reference to the drawings. In the figures, identical or corresponding parts are denoted by the same reference numerals, and descriptions thereof will not be

repeated. Each drawing is schematically illustrated with omissions or exaggerations of objects as appropriate for ease of understanding.

[0013] [1. Configuration of Resin Molding Apparatus]

FIG. 1 is a schematic plan view of a resin molding apparatus 10 according to the present embodiment. The resin molding apparatus 10 is configured to perform resin molding on a target object, using a resin material R1. Examples of the target object include substrates 60 on which a large number of electronic components 61 such as semiconductor chips are mounted. For example, in the resin molding apparatus 10, a surface of a substrate 60 before resin molding on which the electronic components 61 are mounted is resin-sealed (resin-molded), and a resin-molded substrate 60 is produced. In the following description, the substrate 60 before resin molding (molding target object) may be denoted by reference numeral 60A, and the resin-molded substrate 60 (resin molded product) may be denoted by reference numeral 60B to distinguish them.

[0014] In the present embodiment, the substrates 60 are thin, plate-shaped members called wafers, but they are not limited thereto. Each substrate 60 is constituted, for example, by a semiconductor substrate such as a silicon wafer, a metal substrate, a resin substrate, a glass substrate, or a ceramic substrate. Each substrate 60 may also be constituted, for example, by a carrier used in fan-out wafer level packaging (FOWLP). Wiring may already be formed on the substrate 60, but need not necessarily be formed yet.

[0015] FIG. 2 is a plan view of the substrate 60A before resin molding. As shown in FIG. 2, the substrate 60A includes a thin, plate-shaped substrate body 62, and a large number of electronic components 61, such as semiconductor chips, that are integrated on the substrate body 62. A notch 63 is provided in the substrate 60A. In the example of FIG. 2, the notch 63 is formed in a V-shape. The notch 63 is a cutout provided on an outer peripheral edge P1 of the substrate 60A (i.e., the substrate body

62) for indicating the position and orientation of each electronic component 61 on the substrate body 62. Each electronic component 61 can be identified based on the position of the notch 63. In the present embodiment, the notch 63 is used for positioning the substrate 60A that is set in a molding die 305 during resin molding.

5 [0016] As shown in FIG. 1, the resin molding apparatus 10 includes a release film module 110, a resin module 120, a press module 130, a conveying module 140, and a controller 150. Each module can be attached to and detached from an adjacent module. Although one press module 130 is included in the example of FIG. 1, two or more press modules 130 may be included.

10 [0017] The controller 150 is configured to control the entire resin molding apparatus 10. The controller 150 controls, for example, the release film module 110, the resin module 120, the press module 130, and the conveying module 140. The controller 150 includes a central processing unit (CPU), which is a hardware processor, as well as a random access memory (RAM), a read only memory (ROM), and the like,
15 and is configured to execute information processing based on programs and various types of data. The controller 150 may be implemented by a plurality of computers. The controller 150 is typically disposed adjacent to the modules 110, 120, 130, and 140, or disposed within the same casing as that of the modules 110, 120, 130, and 140, but at least a part of the controller 150 may be disposed remotely. The controller 150
20 is an example of a processor. An input device (not shown) such as a button or touch panel, and a display (not shown) are connected to the controller 150.

[0018] In the release film module 110, a release film 11 of a desired shape is made. In the resin module 120, the resin material R1 is supplied onto the release film 11. In the present embodiment, the resin material R1 is liquid resin, but is not limited thereto,
25 and may be, for example, powder-like resin (granular resin). Further, the resin material R1 is typically a thermosetting resin, but it is not limited thereto.

[0019] In the press module 130, compression molding is performed with the

substrate 60A, which has been conveyed by the conveying module 140, and the release film 11, onto which the resin material R1 has been supplied, disposed at predetermined positions in the molding die 305. As a result, the substrate 60B, which is a resin molded product, is produced. The substrate 60B is conveyed by the conveying module 140 and housed at a predetermined position (second housing portion 146).
5 Each module will be described in detail below.

[0020] The release film module 110 is configured to cut and separate a circular release film 11 from a long release film. The release film 11 is used, after compression molding in the press module 130, for preventing the resin from adhering to the molding die 305 and facilitating removal of the substrate 60B from the molding die 305. As a material for the release film, a resin material having properties such as heat resistance, releasability, flexibility, and extensibility is used. Examples include polytetrafluoroethylene (PTFE), ethylene-tetrafluoroethylene copolymer (ETFE), polyethylene terephthalate (PET), tetrafluoroethylene-hexafluoropropylene copolymer (FEP), polypropylene, polystyrene, or polyvinylidene chloride.
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[0021] The release film module 110 includes a moving mechanism 111, a film roll 112, and a film gripper 113. The moving mechanism 111 is located between the film roll 112 and the film gripper 113 in the Y-arrow direction. The moving mechanism 111 is configured to move between the release film module 110 and the resin module 120. The moving mechanism 111 is movable, for example, in the X-arrow direction and the Y-arrow direction.
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[0022] A table 114 is disposed on an upper surface of the moving mechanism 111. The table 114 is a fixing platform for fixing the release film 11. A release film drawn out from the film roll 112 is fixed on the table 114. The film gripper 113 is configured to draw out the release film from the film roll 112 and fix a leading end of the release film that has been drawn out. On the moving mechanism 111, the release film is cut by a cutter (not shown), and a circular release film 11 is made. For example, the
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release film 11 may be fixed on the upper surface of the table 114 by suction performed using a suction mechanism such as a vacuum pump (not shown) through a suction hole (not shown) formed in the upper surface of the table 114.

[0023] The resin module 120 is configured to supply the resin material R1 onto
5 the release film 11 and convey the release film 11 onto which the resin material R1 has been supplied, to a predetermined position in the molding die 305. The resin module 120 includes a supply mechanism 123, a resin loader 121, and a post-processing mechanism 122.

[0024] The supply mechanism 123 is configured to supply the resin material R1
10 toward the release film 11 placed on the table 114 with the table 114 of the moving mechanism 111 located below. The supply mechanism 123 is movable, for example, in the X-arrow direction and the Y-arrow direction. For example, the supply position of the resin material R1 on the release film 11 is adjusted by moving the supply mechanism 123 during the supply of the resin material R1. Further, the supply
15 position of the resin material R1 on the release film 11 may be adjusted by moving the table 114 of the moving mechanism 111 during the supply of the resin material R1. It is preferable that the supply mechanism 123 moves relative to the table 114 when supplying the resin material R1.

[0025] The resin loader 121 and the post-processing mechanism 122 are
20 configured integrally, for example. The resin loader 121 and the post-processing mechanism 122 are configured to move between the resin module 120, the press module 130, and the conveying module 140 via rails 142.

[0026] The resin loader 121 is configured to hold the release film 11 by suctioning,
from above, a peripheral portion of the release film 11 onto which the resin material
25 R1 has been supplied, and move the release film 11 from the moving mechanism 111 to a predetermined position in the molding die 305. The post-processing mechanism 122 is configured to clean the molding die 305 and removes the release film 11 from

the molding die 305 after compression molding performed using the molding die 305.

[0027] The conveying module 140 is configured to convey the substrate 60A housed in a first housing portion 145 to a predetermined position in the molding die 305, and convey the substrate 60B (resin molded product) produced in the press module 130 to a second housing portion 146. The conveying module 140 includes a substrate loader 141, the rails 142, a robot arm 143, the first housing portion 145, the second housing portion 146, and a positioning mechanism 147. In the conveying module 140, for example, the substrate loader 141 holding the substrate 60 moves on the rails 142 to convey the substrate 60. The rails 142 extend across regions of the conveying module 140, the press module 130, and the resin module 120.

[0028] The first housing portion 145 is configured to house the substrate 60A before resin molding, and the second housing portion 146 is configured to house the resin-molded substrate 60B. The robot arm 143 takes out the substrate 60A from the first housing portion 145 and delivers it to the positioning mechanism 147.

[0029] FIG. 3 is a schematic side view of the positioning mechanism 147. As shown in FIG. 3, the positioning mechanism 147 includes a rotary table 40, a shaft 41, a motor 42, and a sensor 43. The positioning mechanism 147 is a mechanism that detects the position of the notch 63 on the outer peripheral edge P1 of the substrate 60A and positions the substrate 60A in a rotational direction (circumferential direction). That is, the positioning mechanism 147 adjusts the orientation in the rotational direction of the substrate 60A based on the position of the notch 63. Thereafter, the substrate 60A is conveyed by the robot arm 143 and the substrate loader 141 to the molding die 305 and set in the molding die 305. At this time, the robot arm 143 and the substrate loader 141 convey the substrate 60A with the notch 63 fixed at a predetermined position relative to them. Then, the substrate 60A is set in the molding die 305 such that the notch 63 is fixed at the predetermined position in the molding die 305. Thus, the substrate 60A is positioned in the rotational direction in the molding

die 305.

[0030] The robot arm 143 places the substrate 60A taken out from the first housing portion 145 on a top surface (an example of a placing surface) of the rotary table 40. At this time, the substrate 60A is placed on the rotary table 40 with its mounting surface
5 for the electronic component 61 facing upward. Further, the robot arm 143 places the substrate 60A on the rotary table 40 such that a center C1 of the substrate 60A substantially overlaps a center C2 of the rotary table 40 in a plan view. The rotary table 40 is disc-shaped in the present embodiment. The substrate 60A is larger than the rotary table 40 in a plan view, and an outer circumferential portion of the substrate
10 60A protrudes outward beyond the rotary table 40 around the entire circumference.

[0031] The shaft 41 is fixed to a lower surface of the rotary table 40 so as to be coaxial with the rotary table 40. The shaft 41 is connected to the motor 42. The rotary table 40 rotates about a predetermined rotary axis A1 as a result of the motor 42 driving the shaft 41 to rotate. The rotation of the shaft 41 and the rotary table 40 is
15 controlled by the controller 150 connected to the motor 42. The rotary axis A1 extends in the up-down direction through the center C2 of the rotary table 40 in a plan view.

[0032] The sensor 43 includes a light source 431, a light receiver 432, and a frame 433. The frame 433 supports the light source 431 and the light receiver 432 such that
20 they face each other with a spacing therebetween. Light emitted from the light source 431 is detected by the light receiver 432 as long as nothing obstructs the space between them. The frame 433 is disposed on a side of the rotary table 40 such that the outer peripheral portion of the substrate 60A placed on the rotary table 40 is inserted between the light source 431 and the light receiver 432. For example, the light receiver 432
25 includes a plurality of light-receiving elements forming an array, and the plurality of light-receiving elements are arranged in a radial direction with respect to the rotary axis A1. Note that the light source 431 may also include a plurality of light sources

forming an array that faces the array of the light-receiving elements.

[0033] The sensor 43 is configured to rotate about the rotary axis A1 relatively along the outer peripheral edge P1 of the substrate 60A disposed on the rotary table 40. In the present embodiment, the sensor 43 is fixed, and the rotary table 40 rotates about
5 the rotary axis A1. However, the relative rotation such as that described above may alternatively be achieved by rotating only the sensor 43 or by rotating both the sensor 43 and the rotary table 40.

[0034] The controller 150 rotates the rotary table 40 on which the substrate 60A is placed. During this period (i.e., while the sensor 43 rotates relatively along the
10 outer peripheral edge P1 of the substrate 60A), the sensor 43 repeatedly measures the distance from the rotary axis A1 to the outer peripheral edge P1 of the substrate 60A. More specifically, the controller 150 causes the light source 431 to emit light while causing the light receiver 432 to detect the intensity of the light. The amount of light received by the light receiver 432 decreases from the amount of light from the light
15 source 431 when something blocking the light is present between the light source 431 and the light receiver 432. The greater the amount of blocked light is, the smaller the amount of light received by the light receiver 432 is. Here, as described above, the outer peripheral portion of the substrate 60A is inserted between the light source 431 and the light receiver 432, and this blocks the light traveling from the light source 431
20 to the light receiver 432. Therefore, the longer the distance from the rotary axis A1 to the outer peripheral edge P1 of the substrate 60A is, the greater the amount of blocked light becomes, and the weaker the intensity of the light received by the light receiver 432 becomes. Conversely, the shorter the distance from the rotary axis A1 to the outer peripheral edge P1 of the substrate 60A is, the smaller the amount of
25 blocked light becomes, and the stronger the intensity of the light received by the light receiver 432 becomes. Accordingly, data of the intensity of the light received by the light receiver 432 serves as distance data indicating the distance from the rotary axis

A1 to the outer peripheral edge P1 of the substrate 60A. The sensor 43 repeatedly measures the intensity of the light received by the light receiver 432 while the substrate 60A rotates about the rotary axis A1, thereby repeatedly obtaining distance data. Thus, the sensor 43 obtains a series of distance data along the circumferential direction
5 with respect to the rotary axis A1. The controller 150 detects the position of the notch 63 on the outer peripheral edge P1 of the substrate 60A based on the series of distance data obtained by the sensor 43. Then, the controller 150 rotates the rotary table 40, thereby rotating the substrate 60A such that the detected notch 63 comes to a predetermined position, and positions the substrate 60A in the rotational direction
10 (circumferential direction).

[0035] Thereafter, the robot arm 143 retrieves from the rotary table 40 the substrate 60A that has been positioned in the rotational direction (circumferential direction) by the positioning mechanism 147, and delivers the retrieved substrate 60A to the substrate loader 141. More specifically, the robot arm 143 flips the substrate
15 60A over and places the substrate 60A on an upper surface of the substrate loader 141. As a result, the substrate 60A is held by the substrate loader 141 with the mounting surface for the electronic components 61 facing downward. The substrate loader 141 conveys the substrate 60A from a predetermined position near the robot arm 143 to a predetermined position in the molding die 305, and delivers the substrate 60A to the
20 molding die 305 while keeping the mounting surface for the electronic components 61 facing downward.

[0036] Further, the substrate loader 141 retrieves the resin-molded substrate 60B from the molding die 305 while keeping the mounting surface for the electronic components 61 facing downward, and delivers the substrate 60B to the robot arm 143
25 directly or indirectly via another device. Upon receiving the substrate 60B, the robot arm 143 flips the substrate 60B over and houses the substrate 60B in the second housing portion 146. Thus, the substrate 60B is housed in the second housing portion

146 with the resin-molded surface facing upward.

[0037] FIGS. 4 and 5 are schematic lateral cross-sectional views of a part of the press module 130. FIG. 4 shows a state before mold clamping, and FIG. 5 shows a state after mold clamping. As shown in FIGS. 4 and 5, the press module 130 includes an outer frame member 301, a fixed platen 310, a movable platen 330, and the molding die 305. One example of the molding die 305 may be a metal mold. In the present embodiment, the press module 130 is configured to produce a resin molded product (substrate 60B) by using a so-called compression molding method. However, the resin molding method is not limited thereto. By replacing the press module 130 with another molding module, the substrate 60B may be produced using another method, e.g., a transfer molding method.

[0038] The outer frame member 301 is constituted by tie bars (column bodies) or hold frames (plate members). In the case where the outer frame member 301 is constituted by tie bars, for example, the outer frame member 301 is constituted by four tie bars disposed at four corners. Each of the four tie bars extends in the up-down direction. In the case where the outer frame member 301 is constituted by hold frames, for example, the outer frame member 301 is constituted by two hold frames disposed on the left and right sides. Wide surfaces of the two hold frames face each other in the left-right direction.

[0039] The fixed platen 310 is a plate-shaped member having a rectangular shape in a plan view. The fixed platen 310 is fixed to an upper portion of the outer frame member 301. The movable platen 330 is disposed below the fixed platen 310 within the outer frame member 301. The movable platen 330 is configured to move in the up-down direction. The movement of the movable platen 330 is achieved, for example, by a mold clamping mechanism (not shown). The mold clamping mechanism is achieved, for example, by a combination of a servomotor and a ball screw, a combination of a hydraulic cylinder and a link mechanism, or the like.

[0040] The molding die 305 includes an upper die 320 and a lower die 340. The molding die 305 is disposed between the fixed platen 310 and the movable platen 330 within the outer frame member 301. More specifically, the upper die 320 is fixed to a lower surface of the fixed platen 310, and the lower die 340 is fixed to an upper surface of the movable platen 330. As a result of the movable platen 330 moving in the up-down direction, the lower die 340 also moves in the up-down direction together with the movable platen 330. The molding die 305 is clamped as the movable platen 330 ascends.

[0041] The lower die 340 includes a base plate 344, a bottom member 341, springs 343, and a side member 342. The base plate 344 is a plate-shaped member having a rectangular shape in a plan view. The base plate 344 is fixed to the upper surface of the movable platen 330. The bottom member 341 is a block-shaped member having a rectangular shape in a plan view. The bottom member 341 is fixed to an upper surface of the base plate 344 and is located at a substantially central portion of the base plate 344. The side member 342 is a frame-shaped member that surrounds the periphery of the bottom member 341. The side member 342 is fixed to the bottom member 341 via a plurality of springs 343.

[0042] An upper surface of the side member 342 is located above an upper surface of the bottom member 341, and a recess (cavity) is formed in an upper surface of the lower die 340. The release film 11 on which the resin material R1 is placed is conveyed and disposed into this recess by the resin loader 121. The substrate 60A delivered from the substrate loader 141 is disposed on a lower surface of the upper die 320. At this time, the substrate 60A is held on the lower surface of the upper die 320 with the mounting surface for the electronic components 61 facing downward by suction or the like. Further, at this time, the controller 150 performs control such that the notch 63 is disposed at a predetermined position on the lower surface of the upper die 320. In other words, the controller 150 performs control such that the rotational

direction (circumferential direction) of the substrate 60A held on the lower surface of the upper die 320 becomes a predetermined direction, based on the position of the notch 63 detected by the positioning mechanism 147. As a result, positioning for the rotational direction of the substrate 60A is performed in the molding die 305. Then, the molding die 305 is clamped with the substrate 60A disposed on the lower surface of the upper die 320 and with the release film 11 and the resin material R1 disposed in the recess of the lower die 340. Thus, the mounting surface for the electronic components 61 of the substrate 60A is resin-sealed. During resin sealing, the resin material R1 is heated as appropriate by a heating mechanism (not shown).

[0043] FIG. 6 is a cross-sectional view taken along line VI-VI in FIG. 4. As shown in FIGS. 4 to 6, a positioning pin 321 is provided on the lower surface of the upper die 320. The substrate 60A is held on the lower surface of the upper die 320 with the pin 321 aligned with the notch 63. More specifically, the substrate loader 141 delivers the substrate 60A to the upper die 320 such that the pin 321 enters the notch 63. As a result, movement of the substrate 60A, including rotation, in the molding die 305 is more reliably prevented while resin molding is performed, and more stable resin molding is achieved.

[0044] Note that the pin 321 need not be inserted into the notch 63 to more reliably prevent movement of the substrate 60A, including rotation. For example, one or more holes may be formed, preferably near the outer peripheral portion of the substrate 60A, and one or more pilot pins provided in the upper die 320 may be inserted into the one or more holes. In this case, the controller 150 can position the pilot pins relative to the holes by positioning the substrate 60A in the rotational direction on the lower surface of the upper die 320 based on the position of the notch 63. Alternatively, as long as the substrate 60A is held fairly firmly on the lower surface of the upper die 320 by suction or the like, the positioning pins (including the above-described pin 321 and pilot pins) may be omitted.

[0045] Further, it is also possible that the substrate 60A is disposed within the recess of the lower die 340 with the mounting surface for the electronic components 61 facing upward, and the molding die 305 is clamped with the resin material R1 supplied onto the substrate 60A. In this case, a positioning pin similar to the above-described pin 321 or pilot pins can be provided in the lower die 340.

[0046] [2. Details of Substrate Shape]

Hereinafter, the shape of the substrate 60A according to the present embodiment will be described in detail with reference to FIG. 2. However, the shape of the target object to which the present invention is applied is not limited to the shape of the substrate 60A described herein.

[0047] The substrate body 62 included in the substrate 60A has the notch 63. The outer peripheral edge P1 of the substrate 60A (i.e., substrate body 62), except for the area of the notch 63, extends along the circumferential direction about the center C1 in a plan view to form predetermined repeated patterns. In the example of FIG. 2, four identical patterns PT1 to PT4 are repeated in this order along the circumferential direction. Note that the pattern PT1 includes the notch 63, and therefore has a shape different from the other patterns PT2 to PT4 only at the portion of the notch 63.

[0048] The substrate 60A has a rotationally symmetric shape in a plan view except for the area of the notch 63. In the example of FIG. 2, the outer peripheral edge P1 includes four patterns PT1 to PT4 and coincides with itself every 90 degrees of rotation, and therefore is four-fold rotationally symmetric. That is, the order of rotational symmetry is four.

[0049] The patterns PT1 to PT4 include respective arc sections B1 to B4 and linear sections L1 to L4. Each of the arc sections B1 to B4 is an arc with the center C1 as a reference point. Each of the linear sections L1 to L4 extends linearly so as to connect endpoints of two adjacent arc sections out of the arc sections B1 to B4. Note

that the linear section L1 is cut out at the portion of the notch 63. The substrate 60A is non-circular even if the portion of the notch 63 is excluded.

[0050] The shortest distance from the center C1 of the substrate 60A to the outer peripheral edge P1 is the distance between the center C1 and each of the linear sections L1 to L4. Therefore, in the present embodiment, the shortest distance from the center C1 to the outer peripheral edge P1 is different from the distance from the center C1 to the notch 63 (the innermost end of the outline of the notch 63 along the radial direction).

[0051] Use of the above-described sensor 43 makes it possible to obtain a series of distance data indicating the distance from the rotary axis A1 to the outer peripheral edge P1 of the substrate 60A along the circumferential direction with respect to the rotary axis A1. Accordingly, if the substrate 60A were circular except for the area of the notch 63, the position in the circumferential direction corresponding to the data indicating the shortest distance among the series of distance data could be determined as the position of the notch 63 by aligning the rotary axis A1 with the center C1 of the substrate 60A. However, the substrate 60A here is non-circular, and therefore the position of the notch 63 cannot be detected with the above algorithm. According to the following method, the position of the notch 63 can be correctly detected even for the non-circular substrate 60A.

[0052] [3. Production Method for Resin Molded Product]

Next, a production method for a resin molded product (substrate 60B) using the resin molding apparatus 10 will be described. In the process of producing the substrate 60B, the position of the notch 63 of the substrate 60A is detected by the above-described positioning mechanism 147 and controller 150 (an example of a notch detection apparatus), and the substrate 60A is positioned in the rotational direction. FIG. 7 is a flowchart illustrating a flow of a method for detecting the notch 63. In the following, the production method for the substrate 60B will be described mainly regarding the processing shown in FIG. 7.

[0053] First, when an instruction to start producing the resin molded product is given to the resin molding apparatus 10 via an input device, the controller 150 drives the robot arm 143. The robot arm 143 takes out the substrate 60A from the first housing portion 145 and places the substrate 60A that has been taken out onto the top surface of the rotary table 40 of the positioning mechanism 147. At this time, the robot arm 143 performs alignment such that the center C1 of the substrate 60A substantially overlaps the center C2 of the rotary table 40. In this state, the processing shown in FIG. 7 starts.

[0054] In step S1, the controller 150 drives the positioning mechanism 147 and obtains a series of distance data. More specifically, while rotating the rotary table 40 about the rotary axis A1 (while rotating the sensor 43 relative to the rotary table 40), the sensor 43 repeatedly measures the distance from the rotary axis A1 to the outer peripheral edge P1 of the substrate 60A. In the present embodiment, the rotary table 40 rotates at least once. During this period, the light source 431 emits light, and the light receiver 432 measures the intensity of the light emitted from the light source 431 at short time intervals. Thus, a series of light intensity data, i.e., a series of distance data indicating the distance from the rotary axis A1 to the outer peripheral edge P1 is obtained. The series of distance data includes a large number of data sets associating data indicating angles about the rotary axis A1 with data indicating distances from the rotary axis A1 to the outer peripheral edge P1 at those angles. The information regarding angles about the rotary axis A1 is obtained based on the rotational speed of the motor 42. The large number of data sets are obtained at minute angular intervals from 0° to 360°. Accordingly, the series of distance data obtained here constitutes a group of a series of data along the circumferential direction with respect to the rotary axis A1. Note that the series of distance data obtained by the sensor 43 may be data for one or more rotations of the rotary table 40, but the following calculations use the distance data for one rotation.

[0055] In subsequent step S2, the controller 150 corrects the series of distance data obtained in step S1. The series of distance data obtained in step S1 is a group of data arranged in the circumferential direction with respect to the rotary axis A1, i.e., with respect to the center C2 of the rotary table 40. In step S2, this is converted into a group of data arranged along the circumferential direction with respect to the center C1 of the substrate 60A. If, when the substrate 60A is placed on the rotary table 40, the center C1 of the substrate 60A coincides with the center C2 of the rotary table 40 in a plan view, or even if they do not coincide but the difference is negligible, step S2 may be omitted.

[0056] When a point indicated by each data set (a pair of data indicating the angle and the distance with respect to the center C2) included in the series of distance data before conversion is plotted on a polar coordinate plane, the shape of the outer peripheral edge P1 of the substrate 60A is depicted. The coordinates of the center C1 of the substrate 60A are calculated by obtaining the center coordinates of the depicted outer peripheral edge P1. The center coordinates of the outer peripheral edge P1 can be calculated, for example, by geometric calculation or by image pattern matching. Then, by re-plotting each point indicated by the series of distance data before conversion on a polar coordinate plane with the calculated center C1 as the origin (i.e., by calculating the angle about the center C1 and the distance from the center C1 for each point), the series of distance data before conversion can be converted into a series of data along the circumferential direction with respect to the center C1. Note that the method for converting the origin of the polar coordinate system from the center C2 to the center C1 is not limited to the procedure described here, and may be any of various methods apparent to those skilled in the art.

[0057] In subsequent steps S3 to S5, the position of the notch 63 on the outer peripheral edge P1 of the substrate 60A is detected based on the series of distance data corrected in step S2. In the case where step S2 is omitted, in steps S3 to S5, the same

processing is performed on the series of distance data obtained in step S1. FIG. 8A shows an example of a graph of the series of distance data corrected in step S2. The horizontal axis indicates data number in time series, and the vertical axis indicates the distance from the center C1 to the outer peripheral edge P1. The horizontal axis, in other words, indicates the angle about the center C1, i.e., the circumferential direction. The controller 150 divides the series of distance data corrected in step S2 into multiple groups along the circumferential direction, and detects the position of the notch 63 by comparing the divided distance data between the groups.

[0058] In step S3, the controller 150 divides the series of distance data corrected in step S2 into N groups along the circumferential direction. N is an integer greater than or equal to 2. In the example of FIG. 8A, the series of distance data is divided into four groups G1 to G4. These groups G1 to G4 correspond to the repeated patterns PT1 to PT4 shown in FIG. 2, respectively. In this example, the shape of the substrate 60A is four-fold rotationally symmetric, and therefore $N = 4$. However, N need not match the order of rotational symmetry of the shape of the substrate 60A. For example, N may be an integer greater than or equal to 2 that is a divisor of the order of rotational symmetry.

[0059] Each of the groups G1 to G4 has M elements from a first to an M-th element. M is an integer greater than or equal to 2. M may be a value obtained by dividing the number of data points (number of points) included in the series of distance data by the number of groups N. In this case, if the number of data points is not divisible by N, data corresponding to the remainder can be omitted as appropriate. The omitted data can be, for example, data at the end of the entire series of distance data, data near boundaries between the groups, or the like. Note that even if measurement parameters such as the rotational speed of the rotary table 40 and the light-receiving interval of the light receiver 432 are set in advance such that the number of data points (for one rotation of the rotary table 40) included in the series of distance

data becomes an integer multiple of N , it is possible that the remainder still occurs. This is because, for example, various commands for measurement from the controller 150 are not necessarily issued at strictly equal intervals.

[0060] In subsequent step S4, the controller 150 calculates, for each order from
5 the first to the M -th, an average value of distances indicated by the N elements belonging to the respective N groups. That is, the average value of the N first elements (distances) included in the N groups is calculated, the average value of the N second elements (distances) is calculated, ..., and the average value of the N M -th elements (distances) is calculated. In other words, in step S4, graphs of the N groups
10 divided in step S3 are superimposed (see FIG. 8B), and average values of the N points having the same order along the horizontal axis within each group are calculated (see FIG. 8C).

[0061] In subsequent step S5, the controller 150 specifies, among the $N \times M$ elements (distances) belonging to the N groups, the element having the largest
15 deviation from the average value calculated in step S4. FIG. 8D is a graph of absolute values of deviations of the $N \times M$ elements (distances). Here, the average value compared with each of the $N \times M$ elements is the average value calculated in step S4 for the same order as that element among the first to M -th averages. That is, a value (difference) is calculated by subtracting the average value of the first elements
20 calculated in step S4 from each of the distances indicated by the N first elements included in the N groups. Thereafter, similarly, a difference is calculated by subtracting the average value of the second elements from each of the distances indicated by the N second elements, ..., and a difference is calculated by subtracting the average value of the M -th elements from each of the distances indicated by the N
25 M -th elements. In other words, in step S5, the graph of the average values calculated in step S4 is subtracted from each of the graphs of the N groups divided in step S3 to specify the element having the largest deviation. The element having the largest

deviation can be the element whose absolute value of deviation is the largest. In this case, the element whose absolute value of deviation is the largest among the $N \times M$ elements (distances) is specified. Then, the controller 150 detects the position in the circumferential direction of the thus-specified element having the largest deviation as the position of the notch 63. The position of the notch 63 is specified, for example, by the angle and distance indicated by the distance data corresponding to the element having the largest deviation among the series of distance data corrected in step S2. The processing of FIG. 7 ends here.

[0062] After the position of the notch 63 has been detected, the controller 150 drives the positioning mechanism 147 again and adjusts the rotational direction (circumferential direction) of the substrate 60A based on the detected position of the notch 63. More specifically, the rotary table 40 is rotated such that the notch 63 comes to a predetermined position along the circumferential direction. Thereafter, the robot arm 143 retrieves the substrate 60A for which the position of the notch 63 has been adjusted, from the rotary table 40 and delivers the retrieved substrate 60A to the molding die 305 via the substrate loader 141. The controller 150 controls the robot arm 143 and the substrate loader 141 such that the notch 63 is arranged at a predetermined position in the molding die 305 and places the substrate 60A in the molding die 305.

[0063] After the substrate 60A has been set in the molding die 305, the controller 150 clamps the molding die 305. Then, the substrate 60A is molded with resin in the molding die 305, and a resin molded product (substrate 60B) is produced. The controller 150 controls the substrate loader 141 and the robot arm 143 to retrieve the substrate 60B from the molding die 305 and house the retrieved substrate 60B in the second housing portion 146. Thus, production of the resin molded product ends.

[0064] [4. Features]

According to the above-described resin molding apparatus 10, the position of

the notch 63 can be detected correctly. As a result, the target object (substrate 60A) having the notch 63 can be positioned correctly.

[0065] [5. Modifications]

The above embodiment is merely an example of the present invention in all
5 respects, and the present invention is not limited to the above embodiment. Various improvements and modifications can be made to the above embodiment within the scope of the present invention. For example, the following modifications are possible. Various technical features described in the present specification may be combined as appropriate within the gist of the present invention.

10 [0066] <5-1>

The shape of the target object (substrate 60) excluding the portion of the notch 63 need not be rotationally symmetric. In the case where repeated patterns exist along the circumferential direction on the outer peripheral edge P1 excluding the portion of the notch 63, the notch 63 can be correctly detected by the same method as
15 described above. For example, the shape of the target object excluding the portion of the notch 63 may be a line-symmetric shape such as that shown in FIG. 9. In this case, in step S3, the series of distance data may be equally divided into two groups, and in step S4, the graph of one group may be inverted and superimposed on the graph of the other group and then the average values may be calculated. In the other steps,
20 processing is performed in the same manner as in FIG. 7.

[0067] As another example, the shape of the target object excluding the portion of the notch 63 may be circular. In this case as well, it can be said that repeated patterns are present along the circumferential direction on the outer peripheral edge P1 excluding the portion of the notch 63, and the notch 63 can be correctly detected by
25 the same method as described above.

[0068] <5-2>

In the above embodiment, the position of the notch 63 of the substrate 60A

before resin molding is detected, but the position of the notch 63 of the substrate 60B after resin molding may be detected by the same method.

[0069] <5-3>

The information regarding the position of the notch 63 detected in the above
5 embodiment is used for positioning the substrate 60A set in the molding die 305. However, the information regarding the position of the notch 63 can also be used for other purposes.

[0070] For example, the position of the notch 63 may be detected and the information regarding the detected position can be utilized not only when setting the
10 substrate 60A in the molding die 305 but also in any situation where the target object needs to be positioned. The term “any situation” here includes not only processes implemented in the resin molding apparatus 10, but also processes before the substrate 60A is carried into the resin molding apparatus 10 and processes after the substrate 60B is carried out of the resin molding apparatus 10. For example, the position of
15 the notch 30 may be detected when the resin-molded substrate 60B is cut by a blade to divide the resin-molded substrate 60B into individual pieces for multiple packages. In this case, erroneous cutting of the electronic components 61 is prevented by fixing the position of the notch 30 in the resin-molded substrate 60B.

[0071] Further, each electronic component 61 mounted on the substrate 60 can be
20 identified based on the position of the notch 63. Accordingly, the information regarding the position of the notch 63 can also be utilized when managing information related to each electronic component 61 on the substrate 60. In this case, in any situation where each electronic component 61 needs to be identified, the position of the notch 63 can be detected by the above-described method, and the information
25 regarding the detected position can be utilized.

[0072] [6. Supplementary Notes]

<Technique 1>

(Configuration)

A notch detection apparatus including:

a placing surface on which a plate-shaped target object having a notch is to be disposed;

5 a sensor configured to rotate about a predetermined rotary axis relatively along an outer peripheral edge of the target object disposed on the placing surface, and to obtain a series of distance data along a circumferential direction by repeatedly measuring a distance from the rotary axis to the outer peripheral edge while rotating relatively along the outer peripheral edge; and

10 a processor configured to detect a position of the notch on the outer peripheral edge based on the series of distance data obtained by the sensor,

wherein the outer peripheral edge, except for an area of the notch, extends along the circumferential direction to form predetermined repeated patterns, and

the processor divides the series of distance data along the circumferential
15 direction into a plurality of groups corresponding to the repeated patterns, and detects the position of the notch by comparing the divided distance data between the groups.

[0073] (Effects etc.)

With this notch detection apparatus, the above series of distance data is divided into a plurality of groups corresponding to the above repeated patterns along
20 the circumferential direction, and the position of the notch in the plate-shaped target object can be correctly detected by comparing the divided distance data between the groups.

[0074] <Technique 2>

(Configuration)

25 The notch detection apparatus according to Technique 1,

wherein the target object has a rotationally symmetric shape except for the area of the notch.

[0075] (Effects etc.)

With this notch detection apparatus, the position of the notch can be correctly detected for the target object having a rotationally symmetric shape excluding the portion of the notch.

5 [0076] <Technique 3>

(Configuration)

The notch detection apparatus according to Technique 1 or 2,
wherein the target object is non-circular except for the area of the notch.

[0077] (Effects etc.)

10 With this notch detection apparatus, the position of the notch can be correctly detected for the target object having a non-circular shape excluding the portion of the notch.

[0078] <Technique 4>

(Configuration)

15 The notch detection apparatus according to any one of Techniques 1 to 3,
wherein a shortest distance from a center of the target object to the outer peripheral edge differs from a distance from the center to the notch.

[0079] (Effects etc.)

20 With this notch detection apparatus, the position of the notch can be correctly detected for a target object in which the shortest distance from the center to the outer peripheral edge differs from the distance from the center to the notch.

[0080] <Technique 5>

The notch detection apparatus according to any one of Techniques 1 to 4,
wherein the processor

25 corrects the series of distance data obtained by the sensor to obtain a second series of distance data indicating a plurality of distances from a center of the target object to the outer peripheral edge,

divides the second series of distance data obtained by the correction into N groups each having first to M-th elements along the circumferential direction, where N and M are each an integer greater or equal to 2,

calculates, for each order from the first to the M-th, an average value
5 of N elements belonging to the respective N groups,

specifies an element having a largest deviation from the average value for the same order out of the first to M-th orders among $N \times M$ elements belonging to the N groups, and

detects a position in the circumferential direction of the specified
10 element as the position of the notch.

[0081] <Technique 6>

(Configuration)

A resin molding apparatus including:

the notch detection apparatus according to any one of Techniques 1 to 5; and
15 a molding die,

wherein the target object is to be disposed in the molding die such that the notch detected by the notch detection apparatus is disposed at a predetermined position, and is molded with a resin in the molding die.

[0082] (Effects etc.)

20 With this resin molding apparatus, the notch can be correctly positioned in the molding die during resin molding.

[0083] <Technique 7>

(Configuration)

A production method for a resin molded product using the resin molding
25 apparatus according to Technique 6, the production method including:

detecting the position of the notch with use of the notch detection apparatus;
disposing the target object in the molding die such that the notch detected by

the notch detection apparatus is disposed at the predetermined position; and

molding the target object with the resin in the molding die to produce the resin molded product.

[0084] (Effects etc.)

5 With this production method for a resin molded product, the position of the notch in the plate-shaped target object can be correctly detected, and the notch can be correctly positioned in the molding die based on the position of the notch.

[0085] <Technique 8>

A notch detection method including:

10 rotating a sensor about a predetermined rotary axis relatively along an outer peripheral edge of a plate-shaped target object having a notch;

obtaining a series of distance data along a circumferential direction by repeatedly measuring a distance from the rotary axis to the outer peripheral edge with use of the sensor while the sensor rotates relatively along the outer peripheral edge;

15 and

detecting a position of the notch on the outer peripheral edge based on the series of distance data obtained by the sensor,

wherein the outer peripheral edge, except for an area of the notch, extends along the circumferential direction to form predetermined repeated patterns, and

20 the detecting of the position of the notch includes dividing the series of distance data along the circumferential direction into a plurality of groups corresponding to the repeated patterns, and detecting the position of the notch by comparing the divided distance data between the groups.

[0086] (Effects etc.)

25 With this notch detection method, the above series of distance data is divided into a plurality of groups corresponding to the above repeated patterns along the circumferential direction, and the position of the notch in the plate-shaped target object

can be correctly detected by comparing the divided distance data between the groups.

List of Reference Numerals

	[0087]	10	Resin molding apparatus
5		147	Positioning mechanism
		150	Controller (processor)
		305	Molding die
		320	Upper die
		321	Pin
10		340	Lower die
		40	Rotary table
		41	Shaft
		42	Motor
		43	Sensor
15		431	Light source
		432	Light receiver
		433	Frame
		60, 60A, 60B	Substrate (target object)
		61	Electronic component
20		62	Substrate body
		63	Notch
		P1	Outer peripheral edge
		PT1–PT4	Repeated pattern
		A1	Rotary axis
25		C1	Center of substrate
		C2	Center of rotary table
		B1–B4	Arc section

L1–L4 Linear section

G1–G4 Group

R1 Resin material

CLAIMS

[Claim 1] A notch detection apparatus comprising:

5 a placing surface on which a plate-shaped target object having a notch is to be disposed;

a sensor configured to rotate about a predetermined rotary axis relatively along an outer peripheral edge of the target object disposed on the placing surface, and to obtain a series of distance data along a circumferential direction by repeatedly measuring a distance from the rotary axis to the outer peripheral edge while rotating
10 relatively along the outer peripheral edge; and

a processor configured to detect a position of the notch on the outer peripheral edge based on the series of distance data obtained by the sensor,

wherein the outer peripheral edge, except for an area of the notch, extends along the circumferential direction to form predetermined repeated patterns, and

15 the processor divides the series of distance data along the circumferential direction into a plurality of groups corresponding to the repeated patterns, and detects the position of the notch by comparing the divided distance data between the groups.

[Claim 2] The notch detection apparatus according to claim 1,

20 wherein the target object has a rotationally symmetric shape except for the area of the notch.

[Claim 3] The notch detection apparatus according to claim 1 or 2,

25 wherein the target object is non-circular except for the area of the notch.

[Claim 4] The notch detection apparatus according to any one of claims 1 to 3,

wherein a shortest distance from a center of the target object to the outer

peripheral edge differs from a distance from the center to the notch.

[Claim 5] The notch detection apparatus according to any one of claims 1 to 4,
wherein the processor

5 corrects the series of distance data obtained by the sensor to obtain a
second series of distance data indicating a plurality of distances from a center of the
target object to the outer peripheral edge,

divides the second series of distance data obtained by the correction
into N groups each having first to M-th elements along the circumferential direction,
10 where N and M are each an integer greater or equal to 2,

calculates, for each order from the first to the M-th, an average value
of N elements belonging to the respective N groups,

specifies an element having a largest deviation from the average
value for the same order out of the first to M-th orders among $N \times M$ elements
15 belonging to the N groups, and

detects a position in the circumferential direction of the specified
element as the position of the notch.

[Claim 6] A resin molding apparatus comprising:

20 the notch detection apparatus according to any one of claims 1 to 5; and
a molding die,

wherein the target object is to be disposed in the molding die such that the
notch detected by the notch detection apparatus is disposed at a predetermined position,
and is molded with a resin in the molding die.

25

[Claim 7] A production method for a resin molded product using the resin molding
apparatus according to claim 6, the production method comprising:

detecting the position of the notch with use of the notch detection apparatus;
disposing the target object in the molding die such that the notch detected by
the notch detection apparatus is disposed at the predetermined position; and
molding the target object with the resin in the molding die to produce the resin
5 molded product.

[Claim 8] A notch detection method comprising:

rotating a sensor about a predetermined rotary axis relatively along an outer
peripheral edge of a plate-shaped target object having a notch;

10 obtaining a series of distance data along a circumferential direction by
repeatedly measuring a distance from the rotary axis to the outer peripheral edge with
use of the sensor while the sensor rotates relatively along the outer peripheral edge;
and

detecting a position of the notch on the outer peripheral edge based on the
15 series of distance data obtained by the sensor,

wherein the outer peripheral edge, except for an area of the notch, extends
along the circumferential direction to form predetermined repeated patterns, and

the detecting of the position of the notch includes dividing the series of
distance data along the circumferential direction into a plurality of groups
20 corresponding to the repeated patterns, and detecting the position of the notch by
comparing the divided distance data between the groups.