

DESCRIPTION

TITLE OF THE INVENTION: INSPECTION DEVICE, MOUNTING APPARATUS, INSPECTION METHOD, AND PROGRAM

Technical Field

[0001] The present invention relates to an inspection device, a mounting apparatus, an inspection method, and a program.

Related Art

[0002] Conventionally, there has been known a technique for inspecting a mounting position of a semiconductor chip with respect to a substrate. For example, in a technique described in Patent Document 1, based on a positional relationship between an alignment mark of a semiconductor chip and a corner of the semiconductor chip that is recognized by image processing, it is inspected whether a mounting position of the semiconductor chip is within a desired range.

Prior-Art Documents

Patent Documents

[0003] Patent Document 1: WO 06-118018

SUMMARY OF THE INVENTION

Problems to Be Solved by the Invention

[0004] However, in the technique described in Patent Document 1, since an edge of the semiconductor chip is not always vertical, it may be difficult to accurately recognize the corner of the semiconductor chip by image processing, and there is still room for improvement from the viewpoint of accurately inspecting the mounting position of the semiconductor chip with reference to the corner of the semiconductor chip.

[0005] The present invention has been made to solve such a problem, and provides an inspection device, a mounting apparatus, an inspection method, and a program, in which a mounting position of a semiconductor chip can be accurately inspected.

Means for Solving the Problems

[0006] An inspection device according to one aspect of the present invention includes: a measurement part, measuring a reference position of a mounting section before mounting of a semiconductor chip, a reference position of a plurality of peripheral sections located around the mounting section, and a position of the semiconductor chip after mounting; and an inspection part, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections measured by the measurement part and a distance between the reference position of the plurality of peripheral sections and a mounting position of the semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.

[0007] An inspection method according to one aspect of the present invention includes steps of: measuring a reference position of a mounting section before mounting of a semiconductor chip; measuring a reference position of a plurality of peripheral sections located around the mounting section; measuring a position of the semiconductor chip after mounting; and, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections and a distance between the reference position of the plurality of peripheral sections and a mounting position of the semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.

[0008] A program according to one aspect of the present invention causes a computer to execute: processing for measuring a reference position of a mounting section before mounting of a semiconductor chip; processing for measuring a reference position of a plurality of peripheral sections located around the mounting section; processing for measuring a position of the semiconductor chip after mounting; and processing for, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections and a distance between the reference position of the plurality of peripheral sections and a mounting position of the semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.

Effects of the Invention

[0009] According to the present invention, a mounting position of a semiconductor chip can be accurately inspected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a side view showing a schematic configuration of a bonding apparatus according to the present embodiment.

FIG. 2 is a diagram showing a positional relationship between a mounting section and a peripheral section.

FIG. 3 is a diagram showing a positional relationship between a semiconductor chip and a peripheral section.

FIG. 4 is a flowchart showing a processing flow of processing for mounting a semiconductor chip.

FIG. 5 is a flowchart showing a processing flow of position measurement of a semiconductor chip.

DESCRIPTION OF THE EMBODIMENTS

[0011] A configuration of a bonding apparatus according to the present embodiment is described below.

[0012] As shown in FIG. 1, a bonding apparatus 100 includes a wafer holder 12, a handling unit 14, a bonding head 20, an XY table 26, a bonding stage 40, and a bonding controller 60. In the following description, a direction parallel to a bonding target surface is defined as an XY-axis direction, and a direction perpendicular to the bonding target surface is defined as a Z-axis direction.

[0013] The bonding apparatus 100 is an example of a mounting apparatus for mounting a semiconductor chip 72 (also referred to as “die”) of a wafer 70 on a substrate 80. An integrated circuit pattern is formed on a surface of the semiconductor chip 72. In the bonding apparatus 100, the semiconductor chip 72 is aligned with the substrate 80, and the semiconductor chip 72 is bonded to the substrate 80 so that a back surface of the semiconductor chip 72 faces the substrate 80. The bonding apparatus 100 like this is called a flip chip bonder or a die bonding apparatus.

[0014] The wafer holder 12 holds the wafer 70. The wafer 70 includes a plurality of semiconductor chips 72 diced in a grid pattern. The wafer holder 12 holds the plurality of semiconductor chips 72 by, for example, vacuum sucking the wafer 70. The wafer holder 12 may hold the plurality of semiconductor chips 72 by, for example, sticking the wafer 70 on a film.

[0015] The handling unit 14 includes, for example, a stepping motor 15, a rotary shaft 16, an arm 17, a base 18, and a pickup tool 19. The stepping motor 15 rotates the rotary shaft 16 to invert the base 18 and the pickup tool 19. The arm 17 has one end attached to the rotary shaft 16 and extending obliquely downward in the Z-axis direction from the rotary shaft 16, and has the other end attached to an upper surface 18a of the base 18 in the Z-axis direction. The base 18 is fixed to a tip of the arm 17 with a bolt or the like. The pickup tool 19 is attached to a lower surface 18b of the base 18 in the Z-axis direction. The pickup tool 19 is configured to be movable in the Z-axis direction.

[0016] The handling unit 14 is moved to above the wafer holder 12 with the pickup tool 19 directed downward. The handling unit 14 sucks the semiconductor chip 72 from above by the pickup tool 19. On the other hand, the stepping motor 15 rotates the rotary shaft 16 and inverts the base 18 and the pickup tool 19, thereby causing the lower surface 18b of the base 18 to face upward in the Z direction and the pickup tool 19 to face upward. Accordingly, the handling unit 14 inverts the semiconductor chip 72 that has been picked up.

[0017] The bonding head 20 sucks the semiconductor chip 72 picked up from the wafer holder 12 and conveys it to a position of the substrate 80, and bonds the semiconductor chip 72 to the substrate 80.

[0018] A bonding tool 22 is attached to the bonding head 20 via a Z-axis drive mechanism 21. A camera 24 is attached to the bonding head 20. The bonding head 20 is configured to be movable in the X-axis direction and the Y-axis direction by the XY table 26. The bonding tool 22 and the camera 24 are configured to be movable in the X-axis direction and the Y-axis direction together with the bonding head 20.

[0019] The bonding tool 22 is configured in, for example, a rectangular parallelepiped shape or a truncated cone shape, and holds the surface of the semiconductor chip 72 on which the integrated circuit pattern is formed. The bonding tool 22 has a central axis parallel to the Z-axis direction, and is configured to be movable in each of the Z-axis direction, the X-axis direction, and the Y-axis direction by the Z-axis drive mechanism 21 and the XY table 26.

[0020] The bonding tool 22 is attached to the bonding head 20 via a θ -axis drive mechanism and a tilt drive mechanism (both not shown), and is configured to be rotatable around the Z-axis and movable in a tilt direction (inclination direction) by these drive mechanisms.

[0021] The camera 24 is configured to include, for example, an optical system such as a lens, and an imaging element such as a charge coupled device (CCD) image sensor, a complementary metal oxide semiconductor (CMOS) image sensor or the like. The camera 24 has, for example, an optical axis along a vertical direction, and photographs an upper surface of the bonding stage 40 in the case of being located above the bonding stage 40.

[0022] The bonding stage 40 is a stage for bonding the semiconductor chip 72 to the substrate 80. The bonding stage 40 includes a moving mechanism that moves the substrate 80 in the X-axis direction and the Y-axis direction, and a heating mechanism that heats the substrate 80.

[0023] The bonding controller 60 is realized, for example, by a hardware processor such as a central processing unit (CPU) executing a program (software). Some or all of these components may be realized by hardware (including circuitry) such as large scale integration (LSI), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or a graphics processing unit (GPU), or may be realized by cooperation between software and hardware. The program may be stored in advance in a storage device such as an HDD or a flash memory of the bonding controller 60, or may be stored in a removable storage medium such as a DVD or a CD-ROM and installed in an HDD or a flash memory of the bonding controller 60 by attachment of the storage medium to a drive device.

[0024] The bonding controller 60 includes, for example, a measurement part 61, an inspection

part 62, and a mounting part 63.

[0025] The measurement part 61 measures a reference position of the substrate 80 based on image data of the substrate 80 photographed by the camera 24. For example, the measurement part 61 identifies a position of a feature point of the substrate 80 by performing image recognition processing on the image data of the substrate 80 photographed by the camera 24, and measures the reference position of the substrate 80 based on the identified position of the feature point. The substrate 80 includes a mounting section in which the semiconductor chip 72 is to be mounted, and a peripheral section located around the mounting section. The mounting section and the peripheral section may also be substrates on which the semiconductor chip 72 formed on a wafer is mounted. Furthermore, the peripheral section may include a section before the semiconductor chip 72 is mounted and a section after the semiconductor chip 72 is mounted.

[0026] The measurement part 61 measures a mounting position of the semiconductor chip 72 based on image data of the semiconductor chip 72 mounted on the substrate 80 photographed by the camera 24. For example, the measurement part 61 identifies a position of a feature point of the semiconductor chip 72 by performing image recognition processing on the image data of the semiconductor chip 72 photographed by the camera 24, and identifies the mounting position of the semiconductor chip 72 based on the identified position of the feature point. The feature point of the semiconductor chip 72 is a feature point exposed on a surface opposite to a mounting surface of the semiconductor chip 72 after mounting, and includes, for example, an end of an electrode penetrating through the semiconductor chip 72 in a thickness direction.

[0027] The inspection part 62 calculates a distance between a reference position of the mounting section and a reference position of a plurality of peripheral sections measured by the measurement part 61. The inspection part 62 calculates a distance between the plurality of peripheral sections and the mounting position of the semiconductor chip 72 after mounting of the semiconductor chip 72. Based on the distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections measured by the

measurement part 61 and the distance between the reference position of the plurality of peripheral sections and the mounting position of the semiconductor chip 72 after mounting of the semiconductor chip 72, the inspection part 62 inspects a relative position of the semiconductor chip 72 with respect to the mounting section.

[0028] Based on the relative position of the semiconductor chip 72 with respect to the mounting section that is inspected by the inspection part 62, the mounting part 63 mounts the semiconductor chip 72 with respect to the mounting section. For example, based on the amount of deviation of the relative position of the semiconductor chip 72 inspected by the inspection part 62 from a target position, the mounting part 63 corrects the mounting position of the semiconductor chip 72 with respect to the mounting section.

[0029] An inspection method executed by the bonding apparatus 100 according to the present embodiment includes: a step (first step) of measuring a reference position of a mounting section before mounting of the semiconductor chip 72; a step (second step) of measuring a reference position of a plurality of peripheral sections located around the mounting; a step (third step) of measuring a position of the semiconductor chip 72 after mounting; and a step (fourth step) of, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections and a distance between the reference position of the plurality of peripheral sections and the mounting position of the semiconductor chip 72 after mounting of the semiconductor chip 72, inspecting a relative position of the semiconductor chip 72 with respect to the mounting section.

[0030] FIG. 2 shows an example of a state before mounting of the semiconductor chip 72, and is a diagram for describing the first step and the second step mentioned above. In the example shown in FIG. 2, a plurality of substrates 80 are arranged in parallel in a vertical direction (first direction) and a horizontal direction (second direction). Among these substrates 80, the substrate 80 located in the center is set as a mounting section 80A. The substrates 80 adjacent to the mounting section 80A on both sides in the vertical direction are set as a first peripheral section

80B and a second peripheral section 80C. The substrates 80 adjacent to the mounting section 80A on both sides in the horizontal direction are set as a third peripheral section 80D and a fourth peripheral section 80E. A feature point of the substrate 80 includes, for example, an alignment mark M1 indicating a position of the substrate 80. The alignment mark M1 is provided in the vicinity of two diagonally located corners of an upper surface of the substrate 80. For example, based on position information of two feature points of the substrate 80, the measurement part 61 measures an intermediate position between the two feature points as the reference position of the substrate 80.

[0031] The inspection part 62 calculates a distance L1 between a reference position PA of the mounting section 80A and a reference position PB of the first peripheral section 80B, a distance L2 between the reference position PA of the mounting section 80A and a reference position PC of the second peripheral section 80C, a distance L3 between the reference position PA of the mounting section 80A and a reference position PD of the third peripheral section 80D, and a distance L4 between the reference position PA of the mounting section 80A and a reference position PE of the fourth peripheral section 80E.

[0032] FIG. 3 shows an example of a state after mounting of the semiconductor chip 72, and is a diagram for describing the third step and the fourth step mentioned above.

[0033] In the example shown in FIG. 3, the inspection part 62 calculates a distance L1a between a mounting position PX of the semiconductor chip 72 and the reference position PB of the first peripheral section 80B, a distance L2a between the mounting position PX of the semiconductor chip 72 and the reference position PC of the second peripheral section 80C, a distance L3a between the mounting position PX of the semiconductor chip 72 and the reference position PD of the third peripheral section 80D, and a distance L4a between the mounting position PX of the semiconductor chip 72 and the reference position PE of the fourth peripheral section 80E.

[0034] For example, based on the distances L1, L2, L3, and L4 between the reference position

PA of the mounting section 80A and the reference positions PB to PE of the plurality of peripheral sections 80B to 80E before mounting of the semiconductor chip 72, the inspection part 62 identifies relative positions of the mounting section 80A and the peripheral sections 80B to 80E. Based on the distances L1a, L2a, L3a, and L4a between the plurality of peripheral sections 80B to 80E and the mounting position PX of the semiconductor chip 72 after mounting of the semiconductor chip 72, the inspection part 62 identifies relative positions of the semiconductor chip 72 and the peripheral sections 80B to 80E. Based on the relative positions of the mounting section 80A and the peripheral sections 80B to 80E and the relative positions of the semiconductor chip 72 and the peripheral sections 80B to 80E after mounting of the semiconductor chip 72, the inspection part 62 inspects the relative position of the semiconductor chip 72 with respect to the mounting section 80A.

[0035] Next, processing for mounting the semiconductor chip 72 that is executed by the bonding apparatus 100 according to the present embodiment is described.

[0036] As shown in FIG. 4, first, the bonding controller 60 moves the bonding head 20 and arranges the bonding tool 22 above the handling unit 14 (S10).

[0037] Next, the bonding controller 60 drives the Z-axis drive mechanism 21 to lower the bonding tool 22 and hold the semiconductor chip 72 at a tip of the bonding tool 22 (S11).

[0038] Next, the bonding controller 60 drives the Z-axis drive mechanism 21 to lift the bonding tool 22 to a preset height, and then moves the bonding head 20 to arrange the camera 24 above the bonding stage 40. Then, the bonding controller 60 executes processing for position measurement of the semiconductor chip 72 (S12).

[0039] As shown in FIG. 5, in the processing for position measurement of the semiconductor chip 72, first, the bonding controller 60 measures a reference position of the mounting section 80A based on image data of the mounting section 80A photographed by the camera 24 (S20).

[0040] Next, the bonding controller 60 measures the reference positions PB to PE of the plurality of peripheral sections 80B to 80E based on image data of the peripheral sections 80B to

80E photographed by the camera 24 (S21).

[0041] Next, by driving the bonding tool 22, the bonding controller 60 mounts the semiconductor chip 72 with respect to the mounting section 80A on the bonding stage 40 (S22).

[0042] Next, the bonding controller 60 measures the reference positions PB to PE of the plurality of peripheral sections 80B to 80E based on the image data of the peripheral sections 80B to 80E photographed by the camera 24 (S23).

[0043] Next, the bonding controller 60 measures a position of the semiconductor chip 72 after mounting based on image data of the semiconductor chip 72 photographed by the camera 24 (S24).

[0044] Next, based on the distances L1 to L4 between the reference position PA of the mounting section 80A measured in the previous step S20 and the reference positions PB to PE of the plurality of peripheral sections 80B to 80E measured in the previous step S21 as well as the distances L1a to L4a between the reference positions PB to PE of the plurality of peripheral sections 80B to 80E measured in the previous step S23 and the mounting position PX of the semiconductor chip 72 after mounting measured in the previous step S24, the bonding controller 60 measures a relative position of the semiconductor chip 72 with respect to the mounting section 80A (S25).

[0045] Next, referring back to FIG. 4, based on the relative position of the semiconductor chip 72 with respect to the mounting section 80A measured in the previous step S25, the bonding controller 60 corrects a mounting position of the semiconductor chip 72 (S13).

[0046] Next, the bonding controller 60 moves the bonding head 20 and arranges the bonding tool 22 above the mounting section 80A (S14).

[0047] Next, the bonding controller 60 lowers the bonding tool 22 to the vicinity of the mounting section 80A, and mounts the semiconductor chip 72 in the mounting section 80A (S15).

[0048] Next, effects of the bonding apparatus 100 according to the present embodiment are described.

[0049] When the semiconductor chip 72 is mounted with respect to the mounting section 80A,

if a surface of the semiconductor chip 72 facing the mounting section 80A is provided with the alignment mark MA, it is difficult to photograph the alignment mark MA of the semiconductor chip 72 with a visible light camera. In particular, if a material non-transmissive to infrared light is interposed between the mounting section 80A and the semiconductor chip 72, even if an infrared camera is used, it is difficult to photograph the alignment mark MA of the semiconductor chip 72.

[0050] In this respect, in the bonding apparatus 100 according to the present embodiment, when the semiconductor chip 72 is mounted with respect to the mounting section 80A, a feature point on a surface of the semiconductor chip 72 opposite to the surface facing the mounting section 80A is photographed by the camera 24, and a position of the feature point is measured as the mounting position PX of the semiconductor chip 72.

[0051] Here, a positional relationship between the mounting section 80A and the peripheral sections 80B to 80E does not change between before and after mounting of the semiconductor chip 72. Hence, in the bonding apparatus 100, by using a positional relationship between the reference position PA of the mounting section 80A and the reference positions PB to PE of the peripheral sections 80B to 80E before mounting of the semiconductor chip 72 as a reference, it is possible to measure the relative position of the semiconductor chip 72 with respect to the mounting section 80A with reference to a positional relationship between the mounting position PX of the semiconductor chip 72 and the reference positions PB to PE of the plurality of peripheral sections 80B to 80E. Accordingly, the mounting position of the semiconductor chip 72 can be accurately inspected.

[0052] The above embodiment can also be implemented in the following forms.

[0053] In the above embodiment, the plurality of peripheral sections 80B to 80E are defined as follows. The substrates 80 adjacent to the mounting section 80A on both sides in the vertical direction and the substrates 80 adjacent to the mounting section 80A on both sides in the horizontal direction are defined as the peripheral sections 80B to 80E. Alternatively, the plurality of peripheral sections are not necessarily the substrates 80 adjacent in the vertical direction or

horizontal direction if they are substrates 80 located around the mounting section 80A. The number of peripheral sections does not necessarily have to be four and may be two or more.

[0054] In the above embodiment, the relative position of the semiconductor chip 72 with respect to the mounting section 80A is inspected each time the semiconductor chip 72 is mounted with respect to one mounting section 80A. Alternatively, the relative position of the semiconductor chip 72 with respect to a plurality of mounting sections 80A may be inspected in parallel after processing for mounting the semiconductor chip 72 with respect to these mounting sections 80A has been performed.

[0055] In the above embodiment, each time the relative position of the semiconductor chip 72 with respect to the mounting section 80A is inspected, the mounting position of the semiconductor chip 72 with respect to the mounting section 80A is corrected based on the relative position of the semiconductor chip 72 with respect to the mounting section 80A. Alternatively, in the case where there are a plurality of mounting sections 80A in which the semiconductor chip 72 is to be mounted, a condition for correcting the mounting position of the semiconductor chip 72 based on the relative position of the semiconductor chip 72 with respect to some of the mounting sections 80A may be applied to mounting of the semiconductor chip 72 with respect to other mounting sections 80A.

[0056] The embodiments described above are for facilitating the understanding of the present invention rather than for interpreting the present invention in a limiting sense. The present invention may be modified/improved without departing from its spirit, and the present invention also includes equivalents thereof. That is, any embodiment appropriately modified in design by a person skilled in the art is also included in the scope of the present invention as long as it has a feature of the present invention. For example, each element provided in each embodiment and its arrangement, material, condition, shape, size, and the like are not limited to those illustrated and can be appropriately changed. Each embodiment is illustrative. It goes without saying that partial substitutions or combinations of configurations shown in different embodiments are

possible, and these are also included in the scope of the present invention as long as they include a feature of the present invention.

Description of Reference Numerals

[0057] 12: wafer holder; 14: handling unit; 15: stepping motor; 16: rotary shaft; 17: arm; 18: base; 19: pickup tool; 20: bonding head; 21: Z-axis drive mechanism; 22: bonding tool; 24: camera; 26: XY table; 40: bonding stage; 60: bonding controller; 61: measurement part; 62: inspection part; 63: mounting part; 70: wafer; 72: semiconductor chip; 80: substrate; 100: bonding apparatus.

CLAIMS

[Claim 1]

An inspection device, comprising:

a measurement part, measuring a reference position of a mounting section before mounting of a semiconductor chip, a reference position of a plurality of peripheral sections located around the mounting section, and a position of the semiconductor chip after mounting; and

an inspection part, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections measured by the measurement part and a distance between the reference position of the plurality of peripheral sections and a mounting position of the semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.

[Claim 2]

The inspection device according to claim 1, wherein

the measurement part measures the mounting position of the semiconductor chip based on a position of a feature point exposed on a surface opposite to a mounting surface of the semiconductor chip after mounting.

[Claim 3]

The inspection device according to claim 1 or 2, wherein

the mounting section is a section selected from among a plurality of sections arranged in parallel in a first direction and a second direction intersecting the first direction; and

the plurality of peripheral sections comprise a section adjacent to the mounting section in the first direction and a section adjacent to the mounting section in the second direction.

[Claim 4]

A mounting apparatus, comprising:

the inspection device according to any one of claims 1 to 3; and

a mounting part, mounting the semiconductor chip with respect to the mounting section,

wherein

based on an amount of deviation of the relative position of the semiconductor chip inspected by the inspection part from a target position, the mounting part corrects the mounting position of the semiconductor chip with respect to the mounting section.

[Claim 5]

An inspection method, comprising steps of:

measuring a reference position of a mounting section before mounting of a semiconductor chip;

measuring a reference position of a plurality of peripheral sections located around the mounting section;

measuring a position of the semiconductor chip after mounting; and,

based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections and a distance between the reference position of the plurality of peripheral sections and a mounting position of the semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.

[Claim 6]

A program, causing a computer to execute:

processing for measuring a reference position of a mounting section before mounting of a semiconductor chip;

processing for measuring a reference position of a plurality of peripheral sections located around the mounting section;

processing for measuring a position of the semiconductor chip after mounting; and

processing for, based on a distance between the reference position of the mounting section and the reference position of the plurality of peripheral sections and a distance between the reference position of the plurality of peripheral sections and a mounting position of the

semiconductor chip after mounting of the semiconductor chip, inspecting a relative position of the semiconductor chip with respect to the mounting section.