

ELECTRONIC COMPONENT MOUNTING APPARATUS

BACKGROUND

5 Technical Field

[0001] The present invention relates to a structure of an electronic component mounting apparatus.

Related Art

[0002] An electronic component mounting apparatus that picks up a semiconductor die from
10 a wafer and mounts the semiconductor die on a substrate or a lead frame is frequently used. In
this electronic component mounting apparatus, the semiconductor die and a mounting position are
positioned by recognizing the mounting position on the substrate by a camera and aligning a center
position of a mounting collet with the mounting position. On the other hand, the semiconductor
die is mounted in a state that a temperature of the substrate is maintained at about 100°C.
15 Therefore, if the mounting is continued for a long time, due to temperature changes over time, a
position relationship between the camera, the collet, and the substrate may change and positioning
precision may decrease.

[0003] Therefore, it has been proposed to respectively arrange reference marks on a transport
path for transporting the substrate and a bonding head to which the collet is attached, capture each
20 reference mark by a camera to detect a position deviation of the camera and the bonding head with
respect to the transport path and correct the position relationship between the camera, the collet,
and the substrate (for example, see Patent Literature 1).

[Literature of related art]

[Patent literature]

25 **[0004]** Patent literature 1: Japanese Patent Laid-Open No. 2016-197630

SUMMARY

[Problems to be Solved]

5 **[0005]** Meanwhile, in the electronic component mounting apparatus, if the mounting is performed for a long time, a pickup part that picks up the semiconductor die from the wafer is also affected by the temperature changes over time. In the pickup part, the semiconductor die to be picked up is recognized by the camera, a center position of a pickup collet is aligned with a center position of the semiconductor die to pick up the semiconductor die, and the semiconductor die is transferred onto the substrate and mounted at the mounting position of the substrate. Therefore, 10 if the center position of the pickup collet and the center position of the semiconductor die to be picked up are deviated from each other, the mounting precision of the semiconductor die on the substrate may decrease.

[0006] Thus, an object of the present invention is to suppress a decrease in mounting precision of a semiconductor die on a substrate in an electronic component mounting apparatus.

15 [Means to Solve Problems]

[0007] The electronic component mounting apparatus of the present invention includes: a wafer ring which holds a wafer; a collet which has center holes and picks up an electronic component from the wafer; a collet drive part which drives the collet in a horizontal direction; a wafer-side illumination part which makes light incident to the center holes of the collet from a 20 root side of the collet; a wafer-side imaging apparatus which captures an image of the collet from the root side of the collet; an image processing part which processes the image captured by the wafer-side imaging apparatus; and a control part which adjusts a position of the collet. The wafer-side imaging apparatus captures an image of the reflected light which is the light incident to the center holes of the collet and reflected on a surface of the wafer directly below the collet. 25 The image processing part detects a center position of the center holes of the collet as a collet

center position based on the image of the reflected light reflected by the surface of the wafer which is captured by the wafer-side imaging apparatus, and detects deviations between the detected collet center position and a reference position in a visual field of the wafer-side imaging apparatus. The control part adjusts the horizontal position of the collet by the collet drive part based on the deviations.

[0008] Accordingly, the deviations between the collet center position and the reference position in the visual field of the wafer-side imaging apparatus are detected and the horizontal position of the collet is corrected based on the deviations to adjust the position of the collet. Therefore, when there is deviation in a position relationship between the collet center position and the reference position in the visual field of the wafer-side imaging apparatus, a deviation amount can be corrected at any time, and a semiconductor die can be accurately picked up from the wafer.

[0009] The electronic component mounting apparatus of the present invention may include a push-up pin which pushes up the electronic component picked up by the collet from below the wafer. The wafer-side imaging apparatus may capture an image of the push-up pin from above.

The image processing part may detect a center position of the push-up pin as a pin center based on the image of the push-up pin captured by the wafer-side imaging apparatus, and set the detected pin center as the reference position in the visual field of the wafer-side imaging apparatus. In addition, the electronic component mounting apparatus of the present invention may include a wafer ring drive part which drives the wafer ring in the horizontal direction. The wafer-side imaging apparatus may capture an image of the electronic component picked up by the collet from above the wafer. The image processing part may detect a center position of the electronic component picked up by the collet as a chip center based on the image of the electronic component picked up by the collet captured by the wafer-side imaging apparatus. The control part may adjust the horizontal position of the wafer ring by the wafer ring drive part in order that the chip center reaches the reference position in the visual field of the wafer-side imaging apparatus.

[0010] Accordingly, the center position of the push-up pin is set as the reference position in the visual field of the wafer-side imaging apparatus, and the horizontal position of the wafer ring is adjusted in order that the chip center which is the center position of the electronic component picked up by the collet reaches the reference position in the visual field of the wafer-side imaging apparatus. Therefore, the push-up pin and the center position of the semiconductor die to be picked up can be aligned. In addition, when there is deviation in the position relationship between the collet center position and the reference position in the visual field of the wafer-side imaging apparatus, the deviation amount is corrected at any time, and thus the semiconductor die can be picked up in a state that the push-up pin, the center position of the semiconductor die to be picked up, and the center position of the collet are aligned. Thereby, chip deviation during the pickup can be suppressed from occurring, and a decrease in precision of mounting the semiconductor die on a substrate can be suppressed even when a temperature changes over time.

[0011] The electronic component mounting apparatus of the present invention may include: a frame-side illumination part which makes light incident from the root side of the collet to the center holes of the collet; and a frame-side imaging apparatus which captures an image of the collet from the root side of the collet. The collet may mount the electronic component sucked on a front end of the collet on a mounting object. The image processing part may process the image captured by the frame-side imaging apparatus. The frame-side imaging apparatus may capture, in the state that the electronic component is sucked on the front end of the collet, an image of the reflected light which is the light incident to the center holes of the collet and reflected on the surface of the electronic component sucked on the front end of the collet. The image processing part may detect the center position of the center holes of the collet as the collet center position based on the image of the reflected light captured by the frame-side imaging apparatus, and detect a first deviation between the detected collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the

surface of the electronic component sucked on the front end of the collet. The control part may adjust the horizontal position of the collet by the collet drive part based on the first deviation.

[0012] Accordingly, the semiconductor die is picked up in the state that the push-up pin, the center position of the semiconductor die to be picked up, and the center position of the collet are aligned. In addition, the first deviation between the collet center position and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the collet is adjusted based on the first deviation. Therefore, when there is deviation in the position relationship between the collet center position and the reference position in the visual field of the frame-side imaging apparatus, the deviation amount can be corrected at any time, and the semiconductor die can be accurately mounted.

[0013] In the electronic component mounting apparatus of the present invention, the frame-side imaging apparatus may capture an image of the mounting object. The image processing part may detect a mounting position for mounting the electronic component based on the image of the mounting object captured by the frame-side imaging apparatus, and detect a second deviation between the detected mounting position and the reference position in the visual field of the frame-side imaging apparatus. The control part may adjust the horizontal position of the collet based on the first deviation and the second deviation by the collet drive part.

[0014] Accordingly, the second deviation between the mounting position of the substrate or a lead frame which is a mounting object and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the collet is adjusted based on the first deviation and the second deviation. Therefore, when there is deviation in a position relationship between the collet center position and the mounting position, a deviation amount can be corrected at any time, and the semiconductor die can be more accurately mounted on the mounting position.

[0015] The electronic component mounting apparatus of the present invention may include a

back-surface camera which is arranged between a pickup part which picks up the electronic component from the wafer and a mounting part which mounts the picked up electronic component on the mounting object, and captures an image of the front end of the collet and an image of the back surface of the electronic component sucked on the front end of the collet. The image processing part may detect position deviation amounts of the electronic component with respect to the collet based on the image of the front end of the collet and the image of the back-surface of the electronic component captured by the back-surface camera. The control part may adjust the horizontal position of the collet by the collet drive part based on the first deviation, the second deviation, and the position deviation amounts of the electronic component with respect to the collet.

[0016] Accordingly, even when there is deviation in the position of the electronic component with respect to the collet, the deviation of the position can be corrected, and the electronic component can be mounted on the substrate in a state that the chip center DC of the electronic component is aligned with the mounting position.

[0017] The electronic component mounting apparatus of the present invention may include: a mounting collet which has center holes and mounts the electronic component sucked on a front end of mounting collet on a mounting object; a mounting collet drive part which drives the mounting collet in the horizontal direction; a frame-side illumination part which makes light incident from a root side of the mounting collet to the center holes of the mounting collet; and a frame-side imaging apparatus which captures an image of the mounting collet from the root side of the mounting collet. The image processing part may process the image captured by the frame-side imaging apparatus. The control part may adjust a position of the mounting collet. The frame-side imaging apparatus may capture, in a state that the electronic component is sucked on the front end of the mounting collet, an image of reflected light which is the light incident to the center holes of the mounting collet and reflected on the surface of the electronic component sucked on the front end of the mounting collet. The image processing part may detect a center position

of the center holes of the mounting collet as a mounting collet center position based on the image of the reflected light captured by the frame-side imaging apparatus, and detect a first deviation between the detected mounting collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the surface of the electronic component sucked on the front end of the mounting collet. The control part may adjust a horizontal position of the mounting collet by the mounting collet drive part based on the first deviation.

[0018] Accordingly, the semiconductor die is picked up in the state that the push-up pin, the center position of the semiconductor die to be picked up, and the center position of the mounting collet are aligned. In addition, the first deviation between the mounting collet center position and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the mounting collet is adjusted based on the first deviation. Therefore, when there is deviation in the position relationship between the mounting collet center position and the reference position in the visual field of the frame-side imaging apparatus, the deviation amount can be corrected at any time, and the semiconductor die can be accurately mounted.

[0019] In the electronic component mounting apparatus of the present invention, the frame-side imaging apparatus may capture an image of the mounting object. The image processing part may detect a mounting position for mounting the electronic component based on the image of the mounting object captured by the frame-side imaging apparatus, and detect a second deviation between the detected mounting position and the reference position in the visual field of the frame-side imaging apparatus. The control part may adjust the horizontal position of the mounting collet by the mounting collet drive part based on the first deviation and the second deviation.

[0020] Accordingly, the second deviation between the mounting position of the substrate or a lead frame which is a mounting object and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the mounting collet is adjusted

based on the first deviation and the second deviation. Therefore, when there is deviation in a position relationship between the mounting collet center position and the mounting position, a deviation amount can be corrected at any time, and the semiconductor die can be more accurately mounted on the mounting position.

5 **[0021]** The electronic component mounting apparatus of the present invention may include a back-surface camera which is arranged between a pickup part which picks up the electronic component from the wafer and a mounting part which mounts the picked up electronic component on the mounting object, and captures an image of the front end of the mounting collet and an image of the back-surface of the electronic component sucked on the front end of the mounting collet.

10 The image processing part may detect position deviation amounts of the electronic component with respect to the mounting collet based on the image of the front end of the mounting collet and the image of the back-surface of the electronic component captured by the back-surface camera. The control part may adjust the horizontal position of the mounting collet by the mounting collet drive part based on the first deviation, the second deviation, and the position deviation amounts of

15 the electronic component with respect to the mounting collet.

[0022] Accordingly, even when there is deviation in the position of the electronic component with respect to the mounting collet, the deviation can be corrected, and the electronic component can be mounted on the substrate in a state that the chip center DC of the electronic component is aligned with the mounting position.

20 **[0023]** The electronic component mounting apparatus of the present invention includes: a mounting collet which has center holes and mounts an electronic component sucked on a front end of the mounting collet on a mounting object; a mounting collet drive part which drives the mounting collet in a horizontal direction; a frame-side illumination part which makes light incident from a root side of the mounting collet to the center holes of the mounting collet; a frame-side

25 imaging apparatus which captures an image of the mounting collet from the root side of the

mounting collet; an image processing part which processes the image captured by the frame-side imaging apparatus; and a control part which adjusts a position of the mounting collet. The frame-side imaging apparatus captures, in a state that the electronic component is sucked on the front end of the mounting collet, an image of reflected light which is the light incident to the center holes of the mounting collet and reflected on a surface of the electronic component sucked on the front end of the mounting collet. The image processing part detects a center position of the center holes of the mounting collet as a mounting collet center position based on the image of the reflected light captured by the frame-side imaging apparatus, and detects a first deviation between the detected mounting collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the surface of the electronic component sucked on the front end of the mounting collet. The control part adjusts a horizontal position of the mounting collet by the mounting collet drive part based on the first deviation.

[0024] Accordingly, the first deviation between the mounting collet center position and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the mounting collet is adjusted based on the first deviation. Therefore, when there is deviation in the position relationship between the mounting collet center position and the reference position in the visual field of the frame-side imaging apparatus, the deviation amount of the position relationship can be corrected at any time, and the semiconductor die can be accurately mounted.

[0025] In the electronic component mounting apparatus of the present invention, the frame-side imaging apparatus may capture an image of the mounting object. The image processing part may detect a mounting position for mounting the electronic component based on the image of the mounting object captured by the frame-side imaging apparatus, and detect a second deviation between the detected mounting position and the reference position in the visual field of the frame-side imaging apparatus. The control part may adjust the horizontal position of the mounting

collet by the mounting collet drive part based on the first deviation and the second deviation.

[0026] Accordingly, the second deviation between the mounting position of the substrate or a lead frame which is a mounting object and the reference position in the visual field of the frame-side imaging apparatus is detected, and the horizontal position of the mounting collet is adjusted based on the first deviation and the second deviation. Therefore, when there is deviation in a position relationship between the mounting collet center position and the mounting position, a deviation amount can be corrected at any time, and the semiconductor die can be more accurately mounted on the mounting position.

[Effect]

[0027] The electronic component mounting apparatus of the present invention can suppress a decrease in precision of mounting a semiconductor die on a substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. 1 is an elevation view showing a configuration of an electronic component mounting apparatus according to an embodiment.

FIG. 2 is a plan view showing the configuration of the electronic component mounting apparatus according to the embodiment.

FIG. 3 is a cross-sectional elevation view of a pickup part of the electronic component mounting apparatus according to the embodiment (an A-A cross-sectional view shown in FIGS. 1 and 2).

FIG. 4 is a cross-sectional elevation view of a mounting part of the electronic component mounting apparatus according to the embodiment (a B-B cross-sectional view shown in FIGS. 1 and 2).

FIG. 5 is a flow chart showing an operation of the pickup part of the electronic component mounting apparatus according to the embodiment.

FIG. 6 is a cross-sectional elevation view showing a state in which a push-up pin is captured by a wafer-side camera from the above in the electronic component mounting apparatus according to the embodiment.

5 FIG. 7 is a diagram showing a visual field of the wafer-side camera in the state of FIG. 6.

FIG. 8 is a cross-sectional elevation view showing a state in which a collet of a pickup head is moved to a position directly above the wafer.

10 FIG. 9 is a diagram showing a visual field of the wafer-side camera in the state shown in FIG. 8.

FIG. 10 is a cross-sectional elevation view showing a state in which a center position of the collet of the pickup head is aligned with a reference position of the wafer-side camera.

FIG. 11 is a diagram showing a visual field of the wafer-side camera in the state shown in FIG. 10.

15 FIG. 12 is a cross-sectional elevation view showing a state in which a semiconductor die is picked up from the wafer.

FIG. 13 is a flow chart showing an operation of the mounting part of the electronic component mounting apparatus according to the embodiment.

20 FIG. 14 is a cross-sectional elevation view showing a state in which a mounting collet having a semiconductor die sucked on a front end is moved to a position directly above a substrate in the electronic component mounting apparatus according to the embodiment.

FIG. 15 is a diagram showing a visual field of a frame-side camera in the state shown in FIG. 14.

25 FIG. 16 is a cross-sectional elevation view showing a state in which a mounting position of the substrate is captured by the frame-side camera.

FIG. 17 is a diagram showing a visual field of the frame-side camera in the state of

FIG. 16.

FIG. 18 is a diagram which is obtained in a manner that the diagram of the visual field shown in FIG. 15 is superimposed on the diagram of the visual field shown in FIG. 17.

FIG. 19 is a diagram showing a visual field of the frame-side camera in a state that a center position of the mounting collet, a center position of the semiconductor die, and the mounting position are aligned with each other.

FIG. 20 is a cross-sectional elevation view showing a state in which the semiconductor die is mounted on the mounting position of the substrate by the mounting collet.

FIG. 21 is a cross-sectional elevation view showing a state in which the mounting of the semiconductor die ends.

FIG. 22 is a diagram showing a visual field of the frame-side camera in the state shown in FIG. 21.

FIG. 23 is a cross-sectional elevation view of a pickup part of an electronic component mounting apparatus according to another embodiment.

FIG. 24 is a cross-sectional elevation view of a mounting part of the electronic component mounting apparatus according to another embodiment.

FIG. 25 is an elevation view showing a configuration of an electronic component mounting apparatus according to another embodiment.

FIG. 26 is a plan view showing the configuration of the electronic component mounting apparatus according to another embodiment.

FIG. 27 is a cross-sectional elevation view of a mounting part of the electronic component mounting apparatus according to another embodiment (a B-B cross-sectional view shown in FIGS. 25 and 26).

FIG. 28 is an elevation view showing a configuration of an electronic component mounting apparatus according to another embodiment.

FIG. 29 is a diagram showing a visual field of a back-surface camera of the electronic component mounting apparatus shown in FIG. 28.

DESCRIPTION OF THE EMBODIMENTS

5 **[0029]** <Configuration of electronic component mounting apparatus>

An electronic component mounting apparatus 100 of an embodiment is described below with reference to the drawings. Moreover, in each elevation view, each plan view, and each cross-sectional elevation view other than a diagram showing a visual field, a semiconductor die 36 and a collet 30 are drawn greater than actual dimensions for easy understanding.

10 **[0030]** As shown in FIGS. 1 and 2, the electronic component mounting apparatus 100 of the embodiment includes a base 10, a pickup part 101, a mounting part 102, and a control apparatus 80. In each drawing, a transport direction of the substrate 74 is described as an X-direction, a direction perpendicular to the X-direction is described as a Y-direction, and a vertical direction is described as a Z-direction. An XY-direction is a horizontal direction.

15 **[0031]** As shown in FIGS. 1 and 2, the pickup part 101 includes a wafer ring 42, a push-up unit 43, a pickup head 20 to which the collet 30 is attached, and a wafer-side camera 12 which is a wafer-side imaging apparatus.

20 **[0032]** As shown in FIG. 3, the wafer ring 42 holds a wafer 35 on an upper surface and is driven in the XY-direction by a wafer ring drive part 41 arranged on a side surface. The push-up unit 43 is attached to the base 10 below the wafer ring 42, and has a push-up pin 44 arranged in the center which is moved in the Z-direction and pushes up the semiconductor die 36 to be picked up from below the wafer 35. The pickup head 20 is guided by a linear guide 14 to be moved in the X-direction between the pickup part 101 and the mounting part 102, the linear guide 14 being fixed to the base 10 and extends in the X-direction through the pickup part 101 and the
25 mounting part 102.

[0033] The pickup head 20 has a main body 21 that is guided by the linear guide 14 to be moved between the pickup part 101 and the mounting part 102, a bracket 22 arranged on the lower side of the main body 21, an arm 23 attached to be capable of rotating around a rotation shaft 24 at a lower end part of the bracket 22, and the collet 30 attached to a positive end of the arm 23 in the X-direction. The collet 30 of the pickup head 20 picks up the semiconductor die 36 and mounts the semiconductor die 36 on the substrate 74. A spring 26 is arranged between a negative end of the arm 23 in the X-direction and a protrusion 25 attached to the upper side of the bracket 22. The spring 26 pulls the negative end of the arm 23 in the X-direction upward, and presses an upper surface of the negative end of the arm 23 in the X-direction against a lower surface of the bracket 22.

[0034] The main body 21 includes therein a Y-direction drive mechanism for driving the pickup head 20 in the Y-direction and a Z-direction drive mechanism for driving the collet 30 in the Z-direction. The Y-direction drive mechanism may be, for example, a linear motor, and the Z-direction drive mechanism may be configured by, for example, a servomotor and a screw mechanism. In addition, the linear guide 14 is moved in the X-direction by a linear guide drive mechanism not shown. The pickup head 20 and the linear guide drive mechanism configure a collet drive part that drives the collet 30 in the XY-direction.

[0035] The collet 30 is configured by a shaft 31 on a root side and a collet main body 33 on a front end side. The shaft 31 is made of metal and the collet main body 33 is made of, for example, heat-resistant resin or the like. At the centers of the shaft 31 and the collet main body 33, circular center holes 32 and 34 are arranged coaxially. An upper end of the shaft 31 is attached to a part of the arm 23 where a recess 23a is arranged, and the center hole 32 of the shaft 31 communicates with the recess 23a arranged in an upper part of the arm 23 and is open upward in the Z-direction from the recess 23a. The center hole 34 of the collet main body 33 communicates with the center hole 32 of the shaft 31 and is open downward in the Z-direction from a lower end surface.

[0036] A light source 27 and a beam splitter 28 are arranged on an upper surface of the recess 23a of the arm 23. In addition, the wafer-side camera 12 that captures an image of the collet 30 from the root side of the collet 30 is attached to an upper-side base 11 above the collet 30. By design, the wafer-side camera 12 is arranged in a manner of having the same horizontal position as that of an optical axis 13 and a pin center PC at the center of the push-up pin 44.

[0037] The beam splitter 28 is disposed directly above the center hole 32 of the shaft 31 and reflects light from the light source 27 to make the light incident into the center hole 32 of the shaft 31 and the center hole 34 of the collet main body 33. In addition, the beam splitter 28 transmits, upward in the Z-direction, the reflected light reflected on the surface of the wafer 35 positioned directly below the collet 30 and makes the reflected light incident on the wafer-side camera 12. The light source 27 and the beam splitter 28 configure a wafer-side illumination part 29. Here, the light source 27 may be a high-intensity LED or a laser light source. In addition, the beam splitter 28 may be replaced by a half mirror.

[0038] As shown in FIGS. 1 and 2, the mounting part 102 has a mounting stage 72 for sucking and fixing the substrate 74 which is a mounting object, and a frame-side camera 63 which is a frame-side imaging apparatus. As described above, the pickup head 20 is guided by the linear guide 14 extending through the pickup part 101 and the mounting part 102 to be moved between the pickup part 101 and the mounting part 102, and mounts the semiconductor die 36 on the substrate 74 at the mounting part 102.

[0039] The mounting stage 72 is attached to the base 10 via a pedestal 71. On both sides of the mounting stage 72 in the Y-direction, a transport mechanism 73 is arranged which is configured by two guide rails extending in the X-direction and transports the substrate 74 in the X-direction.

[0040] As shown in FIG. 4, the frame-side camera 63 that captures an image of the collet 30 from the root side of the collet 30 when the pickup head 20 is moved to the mounting part 102 is

attached above the mounting stage 72. The frame-side camera 63 is attached to a front end of an arm 62 which is guided by a linear guide 61 to be capable of moving in the Y-direction, the linear guide 61 being attached to the upper-side base 11 and extending in the Y-direction. Inside the arm 62, a Y-direction drive mechanism such as a linear motor or the like that moves the arm 62 in the Y-direction is attached.

[0041] The control apparatus 80 is a computer including a CPU and a memory therein, and has two functional blocks, that is, a control part 81 and an image processing part 82 which function in a manner that the CPU and the memory which is a storage part operate in cooperation with each other.

[0042] The wafer-side camera 12, the pickup head 20, the wafer ring drive part 41, the frame-side camera 63, the transport mechanism 73, and the mounting stage 72 are connected to a control part 81 and operate according to a command of the control part 81. The image captured by the wafer-side camera 12 is input to and processed by the image processing part 82. Data obtained by the image processing is input to the control part 81.

[0043] <Operation of pickup part>

The operation of the pickup part 101 of the electronic component mounting apparatus 100 configured as described above is described with reference to FIGS. 5 to 12.

[0044] As shown in step S101 of FIG. 5 and in FIG. 6, the control part 81 captures an image of the push-up pin 44 by the wafer-side camera 12 from above the wafer ring 42 and outputs the image to the image processing part 82. As shown in step S102 of FIG. 5, the image processing part 82 processes the input image data and detects a position of the front end of the push-up pin 44 as the pin center PC at the center of the push-up pin 44. The processing of the image data may utilize, for example, the fact that brightness of the image of the front end of the push-up pin 44 is higher than brightness of the image of a tapered surface near the front end of the push-up pin 44.

[0045] As described above, the optical axis 13 of the wafer-side camera 12 and the pin center PC at the center of the push-up pin 44 are arranged at the same position by design. Therefore, when the optical axis 13 of the wafer-side camera 12 and the push-up pin 44 are in the position as designed, the pin center PC of the push-up pin 44 shown in FIG. 7 is at the same position as a reference position C1 indicated by an intersection of a reference line 16 in the X-direction and a reference line 17 in the Y-direction of a visual field 15 of the wafer-side camera 12. However, as shown in FIG. 7, the position of the pin center PC may deviate from the position of the reference position C1.

[0046] As shown in step S103 of FIG. 5 and in FIG. 7, the control part 81 moves, in the XY-direction, the reference line 16 in the X-direction and the reference line 17 in the Y-direction which determine the reference position C1 in the visual field 15 in order that the reference position C1 is aligned with the pin center PC. Then, the position after the moving is set as the reference position C1 that is an intersection of a center line 45 in the X-direction and a center line 46 in the Y-direction in the visual field 15.

[0047] As shown in FIG. 8, the control part 81 drives the collet 30 directly above the wafer 35 by an XY-direction drive mechanism and the Z-direction drive mechanism of the main body 21 of the pickup head 20 in a manner that a lower surface of the collet main body 33 is positioned at a small height of, for example, about 0.1 mm from the wafer 35. Then, a central axis of the collet 30 and the optical axis 13 of the wafer-side camera 12 are aligned. Next, the control part 81 lights the light source 27 arranged in the pickup head 20. After travelling in the X-direction, the light from the light source 27 is reflected by the beam splitter 28, travels downward in the Z-direction, and is incident to the center hole 32 of the shaft 31 from the root side of the collet 30. The light incident to the center hole 32 passes through the center hole 34 of the collet main body 33 from the center hole 32 and is reflected on the surface of the wafer 35 directly below the collet main body 33. The reflected light reflected on the surface of the wafer 35 travels upward in the Z-direction through the center holes 34 and 32, passes through the beam splitter 28, and is incident

to the wafer-side camera 12.

[0048] Because a focus of the wafer-side camera 12 is aligned with the vicinity of the lower surface of the collet main body 33, as shown in FIG. 9, the reflected light from the surface of the wafer 35 positioned in the vicinity of the lower surface of the collet main body 33 appears as a white circular image of the center holes 32 and 34 in the visual field 15 of the wafer-side camera 12.

[0049] As described above, in each elevation view, each plan view, and each cross-sectional elevation view, sizes of the semiconductor die 36 and the collet 30 are drawn larger than the actual sizes, but in reality, sizes of the semiconductor die 36, the collet 30, and the center holes 32 and 34 are very small, and a size of the visual field 15 of the wafer-side camera 12 is smaller than a size of the recess 23a arranged in the upper part of the arm 23. In addition, the focus of the wafer-side camera 12 is aligned with the vicinity of the lower surface of the collet main body 33. Therefore, around the white circular image of the center holes 32 and 34 in the visual field 15 is not an image of a bottom surface of the recess 23a, and the recess 23a of the arm 23 between the wafer-side camera 12 and the lower surface of the collet main body 33 which is the focus surface appears as a black shadow background.

[0050] As shown in step S104 of FIG. 5, the wafer-side camera 12 captures a white image of the reflected light that emerges in the middle of the black background, the reflected light being the light incident to the center holes 32 and 34 of the collet 30 and reflected on the surface of the wafer 35. The captured image is output to the image processing part 82. Moreover, when there is light reflection on the bottom surface of the recess 23a, a blurred image of the bottom surface of the recess 23a may appear around the white circular image. In this case, the bottom surface of the recess 23a is shown in black, and thereby a black background can appear around the white circular image.

[0051] As shown in step S105 of FIG. 5, the image processing part 82 processes the input

image and detects a center position of the center holes 32 and 34 of the collet 30 as a collet center position CC1.

There are various image processing methods for detecting the collet center position CC1, and for example, the collet center position CC1 is detected by detecting a boundary line of the white circular image from a contrast between the black background and the white circular image of the center holes 32 and 34 and calculating a center position of the circle. As shown in FIG. 9, in the visual field 15, the collet center position CC1 is an intersection of an X-direction center line 37 and a Y-direction center line 38.

[0052] As shown in FIG. 9, position deviation may occur between the reference position C1 in the visual field 15 of the wafer-side camera 12 and the collet center position CC1. As shown in step S106 of FIG. 5, the image processing part 82 detects an X-direction deviation $\Delta X1$ and a Y-direction deviation $\Delta Y1$ between the detected collet center position CC1 and the reference position C1 in the visual field 15, and outputs the deviations $\Delta X1$ and $\Delta Y1$ to the control part 81. The control part 81 stores each of the input deviations $\Delta X1$ and $\Delta Y1$ in a storage part.

[0053] In addition, as shown in step S107 of FIG. 5 and in FIG. 9, the image processing part 82 recognizes the semiconductor die 36 to be picked up in the visual field 15, detects, as shown in step S108 of FIG. 5, a center position of the semiconductor die 36 as a chip center DC and outputs the chip center DC to the control part 81. The control part 81 stores the input chip center DC in the storage part. The chip center DC may be detected, for example, in a manner that the image of the recognized semiconductor die 36 is processed to obtain a square outline of the semiconductor die 36 and obtain an X-direction center line 36x and a Y-direction center line 36y, and the chip center DC is detected as the intersection of the X-direction center line 36x and the Y-direction center line 36y.

[0054] The control part 81 reads the chip center DC from the storage part and as shown in step S109 of FIG. 5, moves the wafer ring 42 by the wafer ring drive part 41 in order that the chip

center DC of the semiconductor die 36 to be picked up reaches the reference position C1 in the visual field 15 of the wafer-side camera 12. As described above, the reference position C1 is set to the same position as the position of the pin center PC of the push-up pin 44, and thus the chip center DC, the reference position C1, and the pin center PC can be set to the same position by this operation.

[0055] The control part 81 reads each of the deviations $\Delta X1$ and $\Delta Y1$ from the storage part, and as shown in step S110 of FIG. 5, corrects the position by the deviation $\Delta Y1$ to align the collet center position CC1 with the reference position C1 in the visual field 15 of the wafer-side camera 12. Specifically, if the deviation in the Y-direction between the collet center position CC1 and the reference position C1 is $\Delta Y1$ as shown in FIG. 9, when the control part 81 moves the pickup head 20 toward a positive side in the Y-direction, the control part 81 moves the pickup head 20 to a position where a scale of a linear scale that detects the Y-direction position of the pickup head 20 is greater than a scale corresponding to the reference position C1 by the deviation $\Delta Y1$. Accordingly, the deviation $\Delta Y1$ is corrected, and the Y-direction position of the collet 30 is aligned with the reference position C1. In addition, the deviation $\Delta X1$ is corrected by using the linear guide drive mechanism (not shown) to move the linear guide 14 in the X-direction by the deviation $\Delta X1$.

[0056] Accordingly, by adjusting the positions of the wafer ring 42 and the collet 30, in a state shown in FIG. 10, the chip center DC, the reference position C1, the pin center PC, and the collet center position CC1 can be set to the same position, as shown in FIG. 11.

[0057] In this state, as shown in step S111 of FIG. 5 and in FIG. 12, the control part 81 lowers the collet 30 onto the semiconductor die 36 to be picked up by the Z-direction drive mechanism of the main body 21 of the pickup head 20 to suck the semiconductor die 36 on the surface of the collet main body 33, and the control part 81 moves the push-up pin 44 upward to push up the semiconductor die 36 from below and picks up the semiconductor die 36 from the wafer 35.

[0058] At this time, because the chip center DC, the reference position C1, the pin center PC, and the collet center position CC1 are in the same position, the center of the semiconductor die 36 can be pushed up by the push-up pin 44, and the semiconductor die 36 can be sucked at the center of the collet main body 33. Therefore, the semiconductor die 36 can be accurately picked up from the wafer 35, and a decrease in precision of mounting the semiconductor die 36 on the substrate 74 can be suppressed.

[0059] In addition, because the semiconductor die 36 can be picked up at the center of the collet main body 33, the deformation of the front end of the collet main body 33 caused by the collet main body 33 picking up the semiconductor die 36 in a biased manner can be prevented.

[0060] The electronic component mounting apparatus 100 according to the embodiment makes the light incident into the center holes 32 and 34 from above the collet 30, and detects the collet center position CC1 by the reflected light from the wafer 35 directly below the collet 30, and thus, the operations from step S104 to step S106 of FIG. 5 of detecting the deviations can be performed during the operation of picking up the semiconductor die 36 from the wafer 35.

[0061] Therefore, the deviations can be corrected and the pickup can be continued every time the pickup operation is performed several times, and thus, the semiconductor die 36 can be accurately picked up even if there is a change over time, and the decrease in the precision of mounting the semiconductor die 36 on the substrate 74 can be effectively suppressed.

[0062] In addition, the deviation detection and correction may be performed for every pickup instead of every several times of pickup. In this case, the deviation $\Delta X1$ in the X-direction and the deviation $\Delta Y1$ in the Y-direction detected by the image processing part 82 are stored in the storage part of the control part 81, and in subsequent mounting, the correction can be performed using the deviations stored in the storage part and the picking up can be performed for a predetermined number of times. In this case, a decrease in bonding efficiency can be suppressed and the decrease in the precision of mounting the semiconductor die 36 on the substrate 74 can be

effectively suppressed.

[0063] <Operation of mounting part>

Next, an operation of the mounting part 102 is described with reference to FIG. 13 and FIGS. 14 to 22.

5 **[0064]** As shown in step S201 of FIG. 13 and in FIG. 14, the control part 81 operates the Y-direction drive mechanism arranged inside the main body 21 of the pickup head 20 to move the pickup head 20 to the underneath of the frame-side camera 63. At this time, the control part 81 moves the pickup head 20 in order that a collet center position CC2 of the collet 30 is aligned with a position of an optical axis 64 of the frame-side camera 63. In addition, because a focus of the
10 frame-side camera 63 is the surface of the substrate 74, the collet 30 is lowered in order that the surface of the semiconductor die 36 sucked on the front end of the collet 30 is positioned slightly separated from the surface of the substrate 74 for about 0.1 mm for example, and an upper-side surface of the semiconductor die 36 is within the depth of the focus of the frame-side camera 63. The collet 30 is lowered by the Z-direction drive mechanism arranged inside the main body 21 of
15 the pickup head 20.

[0065] As shown in FIG. 15, the position of the optical axis 64 of the frame-side camera 63 is a reference position C2 indicated by the intersection of a center line 66 in the X-direction and a center line 67 in the Y-direction in the visual field 65 of the frame-side camera 63. In addition, in the visual field 65, the collet center position CC2 is the intersection of an X-direction center
20 line 55x and a Y-direction center line 55y. When the collet center position CC2 is aligned with the position of the optical axis 64 of the frame-side camera 63, the collet center position CC2 is aligned with the reference position C2. However, as shown in FIG. 15, the collet center position CC2 may deviate from the reference position C2.

[0066] The control part 81 lights a light source 27 arranged in the pickup head 20 as described
25 above. Light from the light source 27 is incident to the center holes 32 and 34 of the collet 30

and forms a white image of the reflected light reflected on the surface of the wafer 35, and as shown in FIG. 15, around the white image is a black background. The frame-side camera 63 captures the white image of the reflected light that emerges in the middle of the black background. The captured image is output to the image processing part 82.

5 **[0067]** As shown in step S203 of FIG. 13, the image processing part 82 processes, as described above, the input image and detects the center positions of the center holes 32 and 34 of the collet 30 as the collet center position CC2.

10 **[0068]** As shown in FIG. 15, position deviation may occur between the reference position C2 in the visual field 65 of the frame-side camera 63 and the collet center position CC2. As shown in step S204 of FIG. 13, the image processing part 82 detects an X-direction first deviation $\Delta X2$ and a Y-direction first deviation $\Delta Y2$ between the detected collet center position CC2 and the reference position C2 in the visual field 65, and outputs the first deviations $\Delta X2$ and $\Delta Y2$ to the control part 81. The control part 81 stores the X-direction first deviation $\Delta X2$ and the Y-direction first deviation $\Delta Y2$ which are input in the storage part.

15 **[0069]** In addition, as shown in FIG. 16, the control part 81 moves the frame-side camera 63 in a manner that the reference position C2 in the visual field 65 of the frame-side camera 63 is consistent with a position where a mounting position BC of a center of a mounting region 75 for mounting the semiconductor die 36 on the substrate 74 enters the visual field. The movement in the Y-direction is performed by the Y-direction drive mechanism arranged in the arm 62.

20 **[0070]** Then, as shown in step S205 of FIG. 13, the control part 81 operates the frame-side camera 63 to capture the mounting region 75. The captured image is input to the image processing part 82. As shown in step S206 of FIG. 13, the image processing part 82 processes the acquired image, detects the mounting position BC at the center of the mounting region 75, and outputs the image to the control part 81. The control part 81 stores the input mounting position BC in the storage part. As for the image processing, for example, the recognized image of the
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mounting region 75 may be processed to obtain a square outline of the mounting region 75 and obtain an X-direction center line 76 and a Y-direction center line 77, and the mounting position BC is detected as an intersection of the X-direction center line 76 and the Y-direction center line 77.

5 **[0071]** As shown in FIG. 17, position deviation may occur between the reference position C2 in the visual field 65 of the frame-side camera 63 and the mounting position BC. As shown in step S207 of FIG. 13, the image processing part 82 detects an X-direction second deviation $\Delta X3$ and a Y-direction second deviation $\Delta Y3$ between the detected mounting position BC and the reference position C2 in the visual field 65, and outputs the X-direction second deviation $\Delta X3$ and
10 the Y-direction second deviation $\Delta Y3$ to the control part 81. The control part 81 stores the X-direction second deviation $\Delta X3$ and the Y-direction second deviation $\Delta Y3$ which are input in the storage part.

[0072] The control part 81 reads the X-direction second deviation $\Delta X3$ and the Y-direction second deviation $\Delta Y3$ from the storage part, and as shown in step S208 of FIG. 13 and in FIG. 18,
15 the control part 81 corrects the position by the Y-direction first deviation $\Delta Y2$ and the Y-direction second deviation $\Delta Y3$ and corrects the position by the X-direction first deviation $\Delta X2$ and the X-direction second deviation $\Delta X3$ to align the collet center position CC2 with the mounting position BC. Specifically, when the control part 81 moves the pickup head 20 toward the positive side in the Y-direction, the control part 81 moves the pickup head 20 to a position where a scale of the
20 linear scale that detects the Y-direction position of the pickup head 20 is greater than a scale corresponding to the mounting position BC by a sum of the Y-direction first deviation $\Delta Y2$ and the Y-direction second deviation $\Delta Y3$. In addition, the control part 81 moves the linear guide 14 in the X-direction by the linear guide drive mechanism (not shown) to correct the deviation $\Delta X2$. Accordingly, the Y-direction first deviation $\Delta Y2$, the Y-direction second deviation $\Delta Y3$, the X-
25 direction first deviation $\Delta X2$, and the X-direction second deviation $\Delta X3$ are corrected, and the

collet center position CC2 is aligned with the mounting position BC.

[0073] Accordingly, as shown in FIG. 19, the collet center position CC2 can be aligned with the mounting position BC in a state that the chip center DC is sucked so as to be aligned with the collet center position CC2 of the collet 30, and the semiconductor die 36 can be mounted on the substrate 74 in a state that the chip center DC of the semiconductor die 36 is aligned with the mounting position BC.

[0074] In step S209 of FIG. 13, the control part 81 lowers the collet 30 as shown in FIG. 20 in the state shown in FIG. 19 to mount the semiconductor die 36 on the mounting region 75.

[0075] As shown in FIG. 21, when the substrate 74 after the mounting of the semiconductor die 36 ends is captured by the frame-side camera 63 from above, the semiconductor die 36 is exactly mounted in the mounting region 75 as shown in FIG. 22.

[0076] As described above, in the electronic component mounting apparatus 100 according to the embodiment, the decrease in the precision of mounting the semiconductor die 36 on the substrate 74 when there is a change over time can be suppressed.

[0077] In the electronic component mounting apparatus 100 according to the embodiment, the light is incident to the center holes 32 and 34 from above the collet 30, and the collet center position CC2 is detected by the reflected light from the surface of the semiconductor die 36 sucked on the front end of the collet 30. Therefore, the operations from step S201 to step S204 in FIG. 13 of detecting the first deviation and the operations from step S205 to step S207 in FIG. 13 of detecting the second deviation and correcting the first and second deviations can be performed during the mounting of the semiconductor die 36.

[0078] For example, when the mounting part 102 repeatedly picks up and mounts the semiconductor dies 36, firstly, the mounting is started with the first deviation as a predetermined set value, and immediately before mounting the semiconductor die 36 on the substrate 74 after mounting has been performed several times, the first deviation is detected in the state that the

surface of the semiconductor die 36 sucked on the front end of the collet 30 is lowered to the position slightly separated from the surface of the substrate 74 for about 0.1 mm for example. The result is stored in the storage part of the control part 81, and in the subsequent mounting, the first deviation stored in the storage part is used for the correction, and the mounting can be performed a predetermined number of times.

[0079] Similar to the detection of the first deviation, the detection of the second deviation is performed after the mounting is performed several times, and the result is stored in the storage part of the control part 81. In the subsequent mounting, the second deviation stored in the storage part can be used for the correction, and the mounting can be performed a predetermined number of times.

[0080] Therefore, even if there is a change over time, the first deviation and the second deviation can be corrected every time the mounting is performed several times, and the mounting can be continued. Therefore, the bonding efficiency can be suppressed from decreasing and the decrease in the precision of mounting the semiconductor die 36 on the substrate 74 when there is a change over time can be effectively suppressed.

[0081] Moreover, in the electronic component mounting apparatus 100 according to the embodiment, the pickup head 20 for picking up and mounting the semiconductor die 36 is guided by the linear guide 14 extending between the pickup part 101 and the mounting part 102, and the position in the X-direction is adjusted by moving the linear guide 14 in the X-direction.

Therefore, when the X-direction first deviation $\Delta X2$ and the X-direction second deviation $\Delta X3$ are adjusted in the mounting part 102, deviation may occur between the collet center position CC1 in the X-direction in the pickup part 101 and the reference position C1 and the pin center PC. In this case, when the pickup operation is performed returning from the mounting part 102 to the pickup part 101, a difference between the deviation $\Delta X1$ and the X-direction first deviation $\Delta X2$ or the X-direction second deviation $\Delta X3$ may be used to correct the position of the collet 30.

[0082] In addition, the first deviation and the second deviation may be detected and corrected for every mounting instead of every several times of mounting. In this case, the decrease in the precision of mounting the semiconductor die 36 on the substrate 74 can be more effectively suppressed.

5 [0083] In the above description, the semiconductor die 36 is mounted on the substrate 74, but the present invention is not limited hereto, and the electronic component mounting apparatus 100 according to the embodiment can also be applied when another semiconductor die 36 is used as a mounting object and the semiconductor die 36 is mounted on the another semiconductor die 36. In this case, an image of the another semiconductor die 36 may be captured instead of the mounting
10 region 75 of the substrate 74, a center position thereof may be detected, and the second deviation between the mounting position BC and the reference position C2 of the frame-side camera 63 may be detected.

[0084] <Other Embodiments>

Next, an electronic component mounting apparatus 200 of another embodiment is described with
15 reference to FIGS. 23 and 24. FIG. 23 is a cross-sectional elevation view of the pickup part 101 of the electronic component mounting apparatus 200, and FIG. 24 is a cross-sectional elevation view of the mounting part 102. The same parts as those of the electronic component mounting apparatus 100 described above with reference to FIGS. 1 to 22 are designated by the same reference signs, and description thereof is omitted.

20 [0085] In the electronic component mounting apparatus 100, the light source 27 and the beam splitter 28 arranged on the arm 23 make the light incident into the center holes 32 and 34 of the collet 30. Instead of this, in the electronic component mounting apparatus 200, as shown in FIG. 23, ring illuminations 92 and 92a are arranged on lower end side surfaces of the wafer-side camera 12 and the frame-side camera 63, a glass cover 91 that covers the center hole 32 is attached to an
25 upper end of the shaft 31 of the collet 30, and light from the ring illumination 92 is incident to the

center holes 32 and 34 through the glass cover 91. The ring illumination 92 and the glass cover 91 configure a wafer-side illumination part 93, and the ring illumination 92a and the glass cover 91 configure a frame-side illumination part 93a.

[0086] The electronic component mounting apparatus 200 has the same operation effects as the electronic component mounting apparatus 100.

[0087] Next, an electronic component mounting apparatus 300 of another embodiment is described with reference to FIGS. 25 to 27. The same parts as those of the electronic component mounting apparatus 100 described above with reference to FIGS. 1 to 22 are designated by the same reference signs, and description thereof is omitted.

[0088] As shown in FIGS. 25 and 26, the electronic component mounting apparatus 300 has an intermediate stage 48 on which the semiconductor die 36 picked up by the pickup head 20 in the pickup part 101 is placed, and a mounting head 50 that picks up the semiconductor die 36 placed on the intermediate stage 48 and mounts the semiconductor die 36 on the mounting part 102.

[0089] The configuration of the pickup head 20 is the same as that of the pickup head 20 of the electronic component mounting apparatus 100 described with reference to FIG. 3. In the electronic component mounting apparatus 300 according to the embodiment, the pickup head 20 is guided by the linear guide 14 to be moved in the X-direction. In addition, the linear guide 14 is moved in the Y-direction by a linear guide drive mechanism not shown.

[0090] As shown in FIG. 27, the mounting head 50 has a main body 51 guided by a linear guide 18 extending in the Y-direction, a bracket 52 arranged on the lower side of the main body 51, an arm 53 attached to a lower end part of the bracket 52, and a mounting collet 55 attached to a positive end of the arm 53 in the X-direction. The linear guide 18 is moved in the X-direction by a linear guide drive mechanism not shown.

[0091] The main body 51 includes therein a Y-direction drive mechanism for driving the

mounting head 50 in the Y-direction and an X-direction drive mechanism for driving the mounting collet 55 in the X-direction. The Y-direction drive mechanism may be, for example, a linear motor, and the Z-direction drive mechanism may be configured by, for example, a voice coil motor. The mounting head 50 configures a mounting collet drive part that drives the mounting collet 55 in the Y-direction.

[0092] The mounting collet 55 is configured by a shaft 56 on a root side and a mounting collet main body 58 on a front end side. The shaft 56 is made of metal, and the mounting collet main body 58 is made of, for example, metal, ceramics, or the like. At the centers of the shaft 56 and the mounting collet main body 58, circular center holes 57 and 59 are arranged coaxially. The upper end of the shaft 56 is attached to a part on the upper side of the arm 53 in which a recess 53a is arranged, and the center hole 57 of the shaft 56 communicates with the recess 53a on the upper part of the arm 53 and is open upward in the Z-direction from the recess 53a. The center hole 59 of the mounting collet main body 58 communicates with the center hole 57 of the shaft 56 and is open downward in the Z-direction from a lower end surface. A light source 27a and a beam splitter 28a are arranged above the recess 53a on the upper part of the arm 53.

[0093] The beam splitter 28a is disposed directly above the center hole 57 of the shaft 56 of the mounting collet 55, reflects the light from the light source 27a, and makes the light from a root side of the mounting collet 55 incident into the center hole 57 of the shaft 56 and the center hole 59 of the mounting collet main body 58. In addition, the beam splitter 28a transmits, upward in the Z-direction, the reflected light reflected on the surface of the semiconductor die 36 sucked on a front end of the mounting collet main body 58 of the mounting collet 55, and makes the light incident to the frame-side camera 63. The light source 27a and the beam splitter 28a configure a frame-side illumination part 29a. Here, the light source 27a may be a high-intensity LED or a laser light source. In addition, a half mirror may be used instead of the beam splitter 28a.

[0094] As shown in FIGS. 25 and 26, the intermediate stage 48 is guided by a linear guide 47

and moved in the Y-direction by a drive mechanism not shown, the linear guide 47 being a long member arranged between the wafer ring 42 and the transport mechanism 73 and extending in the Y-direction.

[0095] The operation of the pickup part 101 of the electronic component mounting apparatus 300 according to the embodiment described above is different from the operation of the pickup part 101 of the electronic component mounting apparatus 100 described above only in the X-direction and the Y-direction, and the other movements are similar. In addition, the operation of the mounting head 50 of the mounting part 102 is the same as the operation after the pickup head 20 of the electronic component mounting apparatus 100 is moved to the mounting part 102.

[0096] The electronic component mounting apparatus 300 according to the embodiment has the same operation effects as the electronic component mounting apparatus 100.

[0097] Next, an electronic component mounting apparatus 400 according to another embodiment is described with reference to FIG. 28. The electronic component mounting apparatus 400 includes, between the pickup part 101 and the mounting part 102, a back-surface camera 85 that captures an image of a semiconductor die 36 sucked on the front end of the collet 30, and a strobe 86 that is a light source. The strobe 86 is connected to the image processing part 82 and is turned on and off according to a command of the image processing part 82. In addition, the image captured by the back-surface camera 85 is input to the image processing part 82. Other configurations are the same as the electronic component mounting apparatus 100 described with reference to FIGS. 1 to 22.

[0098] As shown in FIG. 28, the back-surface camera 85 is arranged at a position where a back surface (a lower surface in the Z-direction) of the semiconductor die 36 sucked on the front end of the collet 30 is in focus when the collet 30 is moved to a predetermined position directly above the back-surface camera 85, and the back-surface camera 85 is adjusted in order that a sharp image of the back surface of the semiconductor die 36 can be obtained. The strobe 86 includes

a reflection mirror 86a that directs the emitted light toward the collet 30.

[0099] Hereinafter, in the electronic component mounting apparatus 400, an operation of detecting, by the back-surface camera 85, a position deviation amount of the semiconductor die 36 sucked on the front end of the collet 30 with respect to the collet 30 is described.

5 [0100] While the control part 81 moves the pickup head 20 from the pickup part 101 to the mounting part 102, as shown in FIG. 28, the collet 30 comes to a predetermined position directly above the back-surface camera 85, and if the center axis of the collet 30 is aligned with a center position of a lens of the back-surface camera 85, a trigger signal that makes the strobe 86 emit light is output. The trigger signal is transmitted to the image processing part 82.

10 [0101] If the trigger signal is input, the image processing part 82 outputs a command to make the strobe 86 emit light. The strobe 86 emits light according to this command. In addition, if the trigger signal is input, the image processing part 82 takes an image as shown in FIG. 29 from the back-surface camera 85 in synchronization with the light emission of the strobe 86. The taken image is stored in a memory of the image processing part 82. Moreover, the image is taken
15 as the collet 30 is moved (without stopping the movement).

[0102] FIG. 29 is a diagram showing a visual field 87 of the back-surface camera 85. As shown in FIG. 29, a circular image showing the front end of the collet 30 and a square image showing an outer shape of the semiconductor die 36 appear in the visual field 87 of the back-surface camera 85. The image processing part 82 processes the taken image to detect a circular
20 image 191 showing the outer shape of the collet 30 and a square image 192 showing the outer shape of the semiconductor die 36. Then, the image processing part 82 detects a position of a center 197 of the circular image 191 and a position of a center 198 of the square image 192, and sets an X-direction reference line 194, which passes through the center 197 of the circular image 191 and is directed in the X-direction of the visual field 87 of the back-surface camera 85, and a
25 Y-direction reference line 193, which passes through the center 197 of the circular image 191 and

is directed in the Y-direction of the visual field 87 of the back-surface camera 85. In addition, the image processing part 82 sets an X-direction measurement line 196, which passes through the center 198 of the square image 192 and is parallel to a side close to the X-direction reference line 194 of the square image 192, and a Y-direction measurement line 195 which passes through the center 198 of the square image 192 and is parallel to a side close to the Y-direction reference line 193 of the square image 192. Then, the image processing part 82 obtains deviation amounts $\Delta X4$ and $\Delta Y4$ respectively in the X-direction and the Y-direction between the position of the center 197 of the circular image 191 and the position of the center 198 of the square image 192. In addition, the image processing part 82 detects a rotation angle deviation $\Delta\theta4$ of the square image 192 in a θ direction from an angle difference in the θ direction between the X-direction reference line 194 and the X-direction measurement line 196 or from an angle difference in the θ direction between the Y-direction reference line 193 and the Y-direction measurement line 195.

[0103] The image processing part 82 outputs the detected deviation amounts $\Delta X4$ and $\Delta Y4$ respectively in the X-direction and the Y-direction and the rotation angle deviation $\Delta\theta4$ in the θ direction to the control part 81. The control part 81 stores the input $\Delta X4$, $\Delta Y4$, and $\Delta\theta4$ in the storage part.

[0104] As described above with reference to FIG. 18, the control part 81 corrects the position by the Y-direction first deviation $\Delta Y2$ and the Y-direction second deviation $\Delta Y3$ to align the collet center position CC2 with the mounting position BC, and when correcting the position by the X-direction first deviation $\Delta X2$ and the X-direction second deviation $\Delta X3$ to align the collet center position CC2 with the mounting position BC, the control part 81 aligns the collet center position CC2 with the mounting position BC in consideration of $\Delta X4$, $\Delta Y4$, and $\Delta\theta4$ which are position deviation amounts of the semiconductor die 36 with respect to the collet 30.

[0105] Even when there is deviation in the position of the semiconductor die 36 with respect to the collet 30, in the electronic component mounting apparatus 400 of the embodiment described

above, the deviation can be corrected and the semiconductor die 36 can be mounted on the substrate 74 in a state that the chip center DC of the semiconductor die 36 is aligned with the mounting position BC.

[0106] In the electronic component mounting apparatus 400 described above, the pickup head 20 is moved between the pickup part 101 and the mounting part 102, and the collet 30 picks up and mounts the semiconductor die 36. However, the configuration, in which the back-surface camera 85 and the strobe 86 of the electronic component mounting apparatus 400 are arranged between the pickup part 101 and the mounting part 102 to detect the position deviation amounts of the semiconductor die 36 with respect to the collet 30, can also be applied to the electronic component mounting apparatus 300 described above with reference to FIGS. 25 to 27. In this case, the image processing part 82 detects, based on the image of the front end of the mounting collet 55 and the image of the back surface of the semiconductor die 36 which are captured by the back-surface camera 85, the position deviation amounts $\Delta X4$, $\Delta Y4$, and $\Delta \theta4$ of the semiconductor die 36 with respect to the mounting collet 55, and outputs the position deviation amounts $\Delta X4$, $\Delta Y4$, and $\Delta \theta4$ to the control part 81. The control part 81 adjusts a horizontal position of the mounting collet 55 by the mounting collet drive part based on the first deviations $\Delta X2$ and $\Delta Y2$, the second deviations $\Delta X3$ and $\Delta Y3$, and the position deviation amounts $\Delta X4$, $\Delta Y4$, and $\Delta \theta4$.

[Reference Signs List]

[0107]	10	base
20	11	upper-side base
	12	wafer-side camera
	13, 64	optical axis
	14, 18, 47, 61	linear guide
	15, 65, 87	visual field
25	16, 17	reference line

	20	pickup head
	21, 51	main body
	22, 52	bracket
	23, 53, 62	arm
5	23a, 53a	recess
	24	rotation shaft
	25	protrusion
	26	spring
	27, 27a	light source
10	28, 28a	beam splitter
	29, 93	wafer-side illumination part
	29a, 93a	frame-side illumination part
	30	collet
	31, 56	shaft
15	32, 34, 57, 59	center hole
	33	collet main body
	35	wafer
	36	semiconductor die
	36x, 37, 55x, 76	X-direction center line
20	36y, 38, 55y, 77	Y-direction center line
	41	wafer ring drive part
	42	wafer ring
	43	push-up unit
	44	push-up pin
25	48	intermediate stage

	50	mounting head
	55	mounting collet
	58	mounting collet main body
	63	frame-side camera
5	66, 67	center line
	71	pedestal
	72	mount stage
	73	transport mechanism
	74	substrate
10	75	mounting region
	80	control apparatus
	81	control part
	82	image processing part
	85	back-surface camera
15	86	strobe
	86a	reflection mirror
	91	glass cover
	92, 92a	ring illumination
	100, 200, 300, 400	electronic component mounting apparatus
20	101	pickup part
	102	mounting part
	191	circular image
	192	square image
	193	Y-direction reference line
25	194	X-direction reference line

5	195	Y-direction measurement line
	196	X-direction measurement line
	197, 198	center
	BC	mounting position
	C1, C2	reference position
	CC1	collet center position
	CC2	collet center position
	DC	chip center
	PC	pin center

WHAT IS CLAIMED IS:

1. An electronic component mounting apparatus, comprising:

a wafer ring which holds a wafer;

a collet which has center holes and picks up an electronic component from the wafer;

5 a collet drive part which drives the collet in a horizontal direction;

a wafer-side illumination part which makes light incident to the center holes of the collet from a root side of the collet;

a wafer-side imaging apparatus which captures an image of the collet from the root side of the collet;

10 an image processing part which processes the image captured by the wafer-side imaging apparatus; and

a control part which adjusts a position of the collet,

wherein the wafer-side imaging apparatus captures an image of a reflected light which is the light incident to the center holes of the collet and reflected on a surface of the wafer directly

15 below the collet,

the image processing part detects a center position of the center holes of the collet as a collet center position based on the image of the collet and the image of the reflected light reflected by the surface of the wafer which are captured by the wafer-side imaging apparatus, and detects deviations between the detected collet center position and a reference position in a visual field of

20 the wafer-side imaging apparatus, and

the control part makes the collet move with respect to the wafer-side imaging apparatus to adjust a horizontal position of the collet by the collet drive part based on the deviations.

2. The electronic component mounting apparatus according to claim 1, comprising

a push-up pin which pushes up the electronic component picked up by the collet from

25 below the wafer,

wherein the wafer-side imaging apparatus captures an image of the push-up pin from above; and

the image processing part

detects a center position of the push-up pin as a pin center based on the image of the

5 push-up pin captured by the wafer-side imaging apparatus, and

sets the detected pin center as the reference position in the visual field of the wafer-side imaging apparatus.

3. The electronic component mounting apparatus according to claim 2, comprising

a wafer ring drive part which drives the wafer ring in the horizontal direction,

10 wherein the wafer-side imaging apparatus captures an image of the electronic component picked up by the collet from above the wafer;

the image processing part

detects a center position of the electronic component picked up by the collet as a chip center based on the image of the electronic component picked up by the collet captured by the

15 wafer-side imaging apparatus; and

the control part adjusts a horizontal position of the wafer ring by the wafer ring drive part in a manner that the chip center reaches the reference position in the visual field of the wafer-side imaging apparatus.

4. The electronic component mounting apparatus according to any one of claims 1 to

20 3, comprising:

a frame-side illumination part which makes light incident from the root side of the collet to the center holes of the collet; and

a frame-side imaging apparatus which captures an image of the collet from the root side of the collet,

25 wherein the collet mounts the electronic component sucked on a front end of the collet

on a mounting object;

the image processing part processes the image captured by the frame-side imaging apparatus;

the frame-side imaging apparatus captures, in a state that the electronic component is
5 sucked on the front end of the collet, an image of the reflected light which is the light incident to the center holes of the collet and reflected on the surface of the electronic component sucked on the front end of the collet;

the image processing part detects the center position of the center holes of the collet as the collet center position based on the image of the reflected light captured by the frame-side
10 imaging apparatus, and detects a first deviation between the detected collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the surface of the electronic component sucked on the front end of the collet; and

the control part adjusts the horizontal position of the collet by the collet drive part based on the first deviation.

15 5. The electronic component mounting apparatus according to claim 4, wherein the frame-side imaging apparatus captures an image of the mounting object;

the image processing part detects a mounting position for mounting the electronic component based on the image of the mounting object captured by the frame-side imaging apparatus, and detects a second deviation between the detected mounting position and the
20 reference position in the visual field of the frame-side imaging apparatus; and

the control part

adjusts the horizontal position of the collet based on the first deviation and the second deviation by the collet drive part.

25 6. The electronic component mounting apparatus according to claim 5, comprising a back-surface camera which is arranged between a pickup part which picks up the

electronic component from the wafer and a mounting part which mounts the picked up electronic component on the mounting object, and captures an image of the front end of the collet and an image of a back surface of the electronic component sucked on the front end of the collet,

wherein the image processing part detects position deviation amounts of the electronic component with respect to the collet based on the image of the front end of the collet and the image of the back surface of the electronic component captured by the back-surface camera, and

the control part

adjusts the horizontal position of the collet by the collet drive part based on the first deviation, the second deviation, and the position deviation amounts of the electronic component with respect to the collet.

7. The electronic component mounting apparatus according to any one of claims 1 to 3, comprising:

a mounting collet which has center holes and mounts the electronic component sucked on a front end of the mounting collet on a mounting object;

a mounting collet drive part which drives the mounting collet in the horizontal direction;

a frame-side illumination part which makes light incident from a root side of the mounting collet to the center holes of the mounting collet; and

a frame-side imaging apparatus which captures an image of the mounting collet from the root side of the mounting collet,

wherein the image processing part processes the image captured by the frame-side imaging apparatus;

the control part adjusts a position of the mounting collet;

the frame-side imaging apparatus captures, in a state that the electronic component is sucked on the front end of the mounting collet, an image of reflected light which is the light

incident to the center holes of the mounting collet and reflected on a surface of the electronic component sucked on the front end of the mounting collet;

the image processing part detects a center position of the center holes of the mounting collet as a mounting collet center position based on the image of the reflected light captured by the frame-side imaging apparatus, and detects a first deviation between the detected mounting collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the surface of the electronic component sucked on the front end of the mounting collet; and

the control part adjusts a horizontal position of the mounting collet by the mounting collet drive part based on the first deviation.

8. The electronic component mounting apparatus according to claim 7, wherein the frame-side imaging apparatus captures an image of the mounting object;

the image processing part detects a mounting position for mounting the electronic component based on the image of the mounting object captured by the frame-side imaging apparatus, and detects a second deviation between the detected mounting position and the reference position in the visual field of the frame-side imaging apparatus; and

the control part

adjusts the horizontal position of the mounting collet by the mounting collet drive part based on the first deviation and the second deviation.

9. The electronic component mounting apparatus according to claim 8, comprising

a back-surface camera which is arranged between a pickup part which picks up the electronic component from the wafer and a mounting part which mounts the picked up electronic component on the mounting object, and captures an image of the front end of the mounting collet and an image of a back surface of the electronic component sucked on the front end of the mounting collet, wherein

the image processing part detects position deviation amounts of the electronic component with respect to the mounting collet based on the image of the front end of the mounting collet and the image of the back surface of the electronic component captured by the back-surface camera, and

5 the control part

adjusts the horizontal position of the mounting collet by the mounting collet drive part based on the first deviation, the second deviation, and the position deviation amounts of the electronic component with respect to the mounting collet.

10. An electronic component mounting apparatus, comprising:

10 a mounting collet which has center holes and mounts an electronic component sucked on a front end of the mounting collet on a mounting object;

a mounting collet drive part which drives the mounting collet in a horizontal direction;

a frame-side illumination part which makes light incident from a root side of the mounting collet to the center holes of the mounting collet;

15 a frame-side imaging apparatus which captures an image of the mounting collet from the root side of the mounting collet;

an image processing part which processes the image captured by the frame-side imaging apparatus; and

a control part which adjusts a position of the mounting collet, wherein

20 the frame-side imaging apparatus captures, in a state that the electronic component is sucked on the front end of the mounting collet, an image of reflected light which is the light incident to the center holes of the mounting collet and reflected on a surface of the electronic component sucked on the front end of the mounting collet;

the image processing part detects a center position of the center holes of the mounting
25 collet as a mounting collet center position based on the image of the reflected light captured by

the frame-side imaging apparatus, and detects a first deviation between the detected mounting collet center position and a reference position in a visual field of the frame-side imaging apparatus, wherein the reflected light is reflected on the surface of the electronic component sucked on the front end of the mounting collet; and

5 the control part adjusts a horizontal position of the mounting collet by the mounting collet drive part based on the first deviation.

11. The electronic component mounting apparatus according to claim 10, wherein
the frame-side imaging apparatus captures an image of the mounting object;

the image processing part detects the mounting position for mounting the electronic
10 component based on the image of the mounting object captured by the frame-side imaging apparatus, and detects a second deviation between the detected mounting position and the reference position in the visual field of the frame-side imaging apparatus; and

the control part

adjusts the horizontal position of the mounting collet by the mounting collet drive part
15 based on the first deviation and the second deviation.