DESCRIPTION

TITLE OF INVENTION: WIRE BONDING APPARATUS

Technical Field

[0001]

The present invention relates to a wire bonding apparatus.

Background Art

[0002]

Patent Literatures 1 and 2 disclose wire bonding apparatuses. The wire bonding apparatuses bond bonding wires to desired positions on substrates or semiconductor chips by using capillaries. Position control based on image processing, for example, is performed to cause the capillaries to correctly move to the bonding positions.

Citation List

Patent Literatures

[0003]

Patent Literature 1: Japanese Patent Laid-Open No. H08-306732

Patent Literature 2: Japanese Patent Laid-Open No. H10-242191

Summary of Invention

Technical Problem

[0004]

In the technical field of wire bonding, it has been desired to reliably bond a bonding wire to a target. A property at the bonded part called bondability is affected by some factors during bonding work. If vibration is applied from the outside to the capillary during the bonding work, and unintended vibration occurs in the capillary, for example, the bondability is degraded.

[0005]

An objective of the present invention is to provide a wire bonding apparatus capable of curbing degradation of bondability.

[0014]

According to the present invention, a wire bonding apparatus capable of curbing degradation of bondability is provided.

Brief Description of Drawings

[0015]

Fig. 1 is a diagram of a wire bonding apparatus according to an embodiment seen from the front.

Fig. 2 is a diagram of the wire bonding apparatus according to the embodiment seen from a side.

Fig. 3 is a diagram of an imaging unit seen from the front.

Fig. 4 is a diagram of the imaging unit seen from a side.

(a) of Fig. 5 is a diagram illustrating a first optical path; (b) of Fig. 5 is a diagram illustrating a second optical path.

(a) of Fig. 6 is a diagram illustrating a third optical path; (b) of Fig. 6 is a diagram illustrating a fourth optical path.

Fig. 7 is a diagram of the third optical path of the imaging unit seen from an oblique direction.

Fig. 8 is a functional block diagram of a controller.

Fig. 9 is a flow diagram illustrating main processes of a wire bonding method.

Fig. 10 is a process table illustrating details of a process of setting a camera offset value.

(a) to (d) of Fig. 11 illustrate examples of images acquired in the process of setting the camera offset value.

(a) and (b) of Fig. 12 are process tables illustrating details of a process of performing a positioning operation.

Fig. 13 illustrates an example of an image for explaining the process of performing the positioning operation.

Fig. 14 is a diagram of a modification of the imaging unit seen from a side.

Fig. 15 is a diagram of the modification of the imaging unit seen from a side in detail.

Fig. 16 is a diagram of a yet another modification of the imaging unit seen from a side.

Fig. 17 is a side view of a wire bonding apparatus illustrating a modification of a reference point.

Fig. 18 is a process table illustrating details of a modification of the process of setting the camera offset value.

Description of Embodiments

[0016]

Hereinafter, modes for carrying out the present invention will be described in detail with reference to the accompanying drawings. In the description of the drawings, the same elements will be denoted by the same reference signs, and repeated description will be omitted.

[0017]

Fig. 1 is a front view of a wire bonding apparatus 100 according to an embodiment of the present invention. Fig. 2 is a side view of the wire bonding apparatus 100 illustrated in Fig. 1. The wire bonding apparatus 100 bonds a bonding wire 200 to a semiconductor chip 20.

[0018]

The wire bonding apparatus 100 includes, as main components, a wire bonding unit 40, an imaging unit 50, a controller 60 (control section: see Fig. 2), and a base 70. The wire bonding unit 40 bonds the bonding wire 200 to the semiconductor chip 20. The imaging unit 50 obtains an image for controlling operations of the wire bonding unit 40. The controller 60 controls operations of the wire bonding unit 40 and the imaging unit 50. For example, the controller 60 controls the imaging unit 50. As a result, an image including the semiconductor chip 20, a

like.

[0026]

Fig. 3 is a view of the optical system 10 seen from the front. Fig. 4 is a view of the optical system 10 seen from a side. As illustrated in Fig. 3 and Fig. 4, the optical system 10 includes a first imaging device 30A, a second imaging device 31A, a mirror 36, half mirrors 30B, 31B, 34, 37, and 38, a first illumination 32, a second illumination 33, a first optical part 30, a second optical part 31, and a third optical part 39.

[0027]

The first imaging device 30A obtains an image at a high magnification. The second imaging device 31A obtains an image at a low magnification. The first imaging device 30A and the second imaging device 31A may be high-pixel cameras, for example. In a case where high-pixel cameras having a size of 1.1 inches and 12 million pixels are employed as the first imaging device 30A and the second imaging device 31A, for example, the field-of-view size is 4.2 mm × 3.5 mm on the assumption that the magnification is two times. The field-of-view size is about double a low-power field of twin-lens barrel that a conventional wire bonder has. In this case, a pixel resolution is 1.7 μm/pixel. It is possible to realize recognition precision of some fraction to one tenth of the pixel resolution through image processing. When required bonding precision is 2 μm, for example, it is possible to secure recognition precision which is sufficient for a high-precision wire bonder. In a case of a twin-lens barrel of a low magnification and a high magnification, it is possible to reduce the number of times imaging is performed at a lead locator, which will be described. In a case where a high-pixel camera is used and it is possible to secure a wide field-of view, the optical system 10 may have a single lens.

[0028]

The optical system 10 obtains an image of an object that is present in a first field-of-view 202 and an image of an object that is present in a second field-of-view 203. Therefore, the optical system 10 configures a first optical path R1 (see (a) of Fig. 5) and a second optical path R2 (see

(b) of Fig. 5). The first optical path R1 guides light from the first field-of-view 202 to the first imaging device 30A. The second optical path R2 guides light from the first field-of-view 202 to the second imaging device 31A. Moreover, the optical system 10 configures a third optical path R3 (see (a) of Fig. 6) and a fourth optical path R4 (see (b) of Fig. 6). The third optical path R3 guides light from the second field-of-view 203 to the first imaging device 30A. The fourth optical path R4 guides light from the second field-of-view 203 to the second imaging device 31A.

[0029]

The position of the first field-of-view 202 is different from the position of the second field-of-view 203. The optical path length from the first optical part 30 to the semiconductor chip 20 which is an imaging target is the same as the optical path length from the second optical part 31 to the reference point 21 which is an imaging target. Specifically, the optical path length can be represented as a1 + a2 = b1 + b2. a1 is the optical path length from the semiconductor chip 20 to the half mirror 34. a2 is the optical path length from the half mirror 34 to the half mirror 37. b1 is the optical path length from the reference point 21 to the mirror 36. b2 is the optical path length from the mirror 36 to the half mirror 37. The magnifications related to calibration values, which will be described later, are the same for the first field-of-view 202 and the second field-of-view 203.

[0030]

As illustrated in (a) of Fig. 5, the first optical path R1 guides light from the first field-of-view 202 to the first imaging device 30A. The semiconductor chip 20 is disposed in the first field-of-view 202. Therefore, the first optical path R1 guides light from the semiconductor chip 20 to the first imaging device 30A. The first optical path R1 is configured of the half mirror 34 (optical splitter section) and the first optical part 30.

[0031]

As illustrated in (b) of Fig. 5, the second optical path R2 guides light from the first field-of-view 202 to the second imaging device 31A. Therefore, the second optical path R2 guides

light from the semiconductor chip 20 to the second imaging device 31A. The second optical path R2 is configured of the half mirrors 34, 37, 30B, and 31B and the second optical part 31.

[0032]

In short, light from the semiconductor chip 20 is split to the optical path through which the light is guided to the first optical part 30 on the high magnification side by the half mirror 30B and the optical path through which the light is guided to the second optical part 31 on the low magnification side, after passing through the half mirrors 34 and 37. The light guided to the first optical part 30 on the high magnification side is imaged by the first imaging device 30A for the high magnification. The light guided to the second optical part 31 on the low magnification side is imaged by the second imaging device 31A for the low magnification. The field of view for imaging the semiconductor chip 20 by these optical paths is referred to as the first field-of-view 202.

[0033]

As illustrated in (a) of Fig. 6 and Fig. 7, the third optical path R3 guides light from the second field-of-view 203 to the first imaging device 30A. The reference point 21 provided at the ultrasonic horn 2 is disposed in the second field-of-view 203. Therefore, the third optical path R3 guides light from the reference point 21 to the first imaging device 30A. The third optical path R3 is configured of the mirror 36, the half mirror 37, and the first optical part 30.

[0034]

The second field-of-view 203 is for imaging the reference point 21 at an arbitrary location on the tool XY-stage 6. The reference point 21 is a marker formed on the upper surface of the ultrasonic horn 2. The reference point 21 is provided at a part which can be moved by the tool XY-stage 6.

The reference point 21 is provided at the ultrasonic horn 2, for example. It is desirable that the reference point 21 be provided at a position at a short distance from the capillary 1. The wire clamper 3 is installed on the ultrasonic horn 2. However, the upper surface of the ultrasonic horn 2 can be seen from a clearance of the wire clamper 3. A recognition mark (a cross shape,

for example) that facilitates image recognition and can satisfy desired precision may be applied to the upper surface of the ultrasonic horn 2. The recognition mark is the reference point 21. For example, an edge of the ultrasonic horn 2 may be employed as the reference point 21 instead of the positively provided recognition mark. Also, a surface pattern of a metal member constituting the ultrasonic horn 2 may be used as the reference point 21.

[0035]

The bonding area is limited by the position of the reference point 21. In a case where precision required for positioning is relatively low, for example, it is possible to increase the degree of freedom of the position where the reference point 21 is provided. The reference point 21 is allowed to be located at a point at a long distance from the capillary 1. A degree of freedom in disposition of parts for causing the lengths of the optical paths configuring the first field-of-view 202 and the second field-of-view 203 to coincide with each other is enhanced. A modification of the reference point 21 will be described later.

[0036]

As illustrated in (b) of Fig. 6, the fourth optical path R4 guides light from the second field-of-view 203 to the second imaging device 31A. Therefore, the fourth optical path R4 guides light from the reference point 21 to the second imaging device 31A. The fourth optical path R4 is configured of the mirror 36, the half mirrors 37, 30B, and 31B and the second optical part 31.

[0037]

Light with which the reference point 21 is irradiated by the second illumination 33 passes through the mirror 36 and the half mirror 37 and is then split by the half mirror 30B into the optical path through which the light is guided to the first optical part 30 on the high magnification side and the optical path through which the light is guided to the second optical part 31 on the low magnification side.

The light guided to the first optical part 30 on the high magnification side is imaged by the first imaging device 30A for the high magnification. The light guided to the second optical

In the case of the first field-of-view mode, the first illumination 32 is turned on, and the second illumination 33 is turned off (see (a) of Fig. 5 and (b) of Fig. 5). In the case of the second field-of-view mode, the first illumination 32 is turned off, and the second illumination 33 is turned on (see (a) of Fig. 6 and (b) of Fig. 6). The turning on and off of the first illumination 32 and the turning on and off of the second illumination 33 may be controlled by control signals provided from the controller 60.

[0042]

As illustrated in Fig. 4, each part configuring the optical system 10 is fixed to a frame or the like, which is not illustrated. As a result, the relative positional relationship of each part configuring the optical system 10 is maintained. The frame with the parts attached thereto is attached to the optical system XY-stage 11. The optical system XY-stage 11 is attached to the base 70. For example, the optical system XY-stage 11 has a ceiling suspended structure suspended above the wire bonding unit 40. Position precision of the optical system XY-stage 11 is not required. For example, position precision of the optical system XY-stage 11 may be lower than position precision of the tool XY-stage 6.

[0043]

The first field-of-view 202 and the second field-of-view 203 are shifted in an X direction. In other words, the first field-of-view 202 is offset with respect to the second field-of-view 203. The reason that the first field-of-view 202 is offset is for avoiding interference with the bonding wire 200 extending from a bonding wire supply section (not illustrated) on the upper surface of the tool (ultrasonic horn 2) disposed in the second field-of-view 203. It is also possible to set the upper surface of the tool as the second field-of-view 203 without including the offset depending on the structure of the system for supplying the wire. A configuration of an optical system corresponding to such a case will be described later in detail as a modification.

[0044]

The first field-of-view 202 and the second field-of-view 203 pass through some optical

<Process for setting camera offset value>

The camera offset value is a moving distance required for the tool XY-stage 6 to perform bonding to the center of the first field-of-view 202 when the reference point 21 on the wire bonding unit mounted on the tool XY-stage 6 is at the center of the second field-of-view 203. The camera offset value in the present embodiment is another concept which is different from the camera offset as a term used in conventional wire bonder. Fig. 10 is a process table illustrating details of Process S3 for setting the camera offset value. In Process S3, a correlation between the optical system 10 and the bonding tool is set. The correlation between the optical system 10 and the bonding tool is also referred to as a camera offset value. Process S3 for setting the camera offset value includes a first operation S31 for setting the bonding point, a second operation S32 for forming bonding or indentation, and a third operation S33 for calculating the bonding position.

[0062]

The first operation S31 includes the following operations. The optical system XY-stage 11 is caused to move such that the semiconductor chip 20 is placed within the first field-of-view 202 (see S31a, S31b, and (a) of Fig. 11). Next, a center 202C of the first field-of-view 202 is set as the bonding point (S31c). Then, the tool XY-stage 6 is caused to operate such that the reference point 21 is placed within the second field-of-view 203 (S31d). Next, the second field-of-view 203 is imaged (see S32e and (b) of Fig. 11). Then, calculation is performed (S31f). Specifically, the tool XY-stage coordinates read from the encoder are set to (x0, y0). Then, the position (x0s'. y0s') of the reference point 21 in the camera coordinates of the second field-of-view 203 is obtained through image recognition (see S31e and (b) of Fig. 11). Next, the coordinates are converted into an actual length (μm) on the basis of the previously obtained first calibration value from the camera coordinates which are pixel units. As a result, coordinates (x0s, y0s) are obtained. The XY coordinates and the direction of the tool XY-stage 6 and the scale are the same. The origin is the same as the camera coordinates of the second field-of-view 203. Therefore, the reference point 21 is the center of the second field-of-view 203 if the tool

XY-stage 6 is caused to move by (-x0s, -y0s). In the actual operation, it is not necessary to cause the reference point 21 to move to the center of the field of view. After the first operation S31, the optical system XY-stage 11 evacuates (S31g).

[0063]

The second operation S32 includes the following operations. The tool XY-stage 6 is caused to operate by the distance of the camera offset value stored in the device such that the capillary 1 moves to the bonding point (S32a). Next, the Z-axis drive section 5 performs bonding (S32b). An operation of forming indentation may be performed instead of the bonding operation. After the second operation S32, the optical system XY-stage 11 evacuates (S32c).

[0064]

The third operation S33 includes the following operations. The optical system XY-stage 11 is caused to operate such that the bonding point 22 is placed within the first field-of-view 202 (S33a). The position of the optical system XY-stage 11 in S33a is the same as the position of the optical system XY-stage 11 in S31a and S31c. In other words, the output value of the encoder provided on the optical system XY-stage 11 or the pulse provided to the optical system XY-stage 11 is the same value. Next, the first field-of-view 202 is imaged (see S33b and (c) of Fig. 11). Then, calculation is performed (S33c). In this calculation, the bonding position with respect to the center of the first field-of-view 202 is obtained. First, coordinates (Xb', Yb') of the bonding point 22 are obtained on the basis of the camera coordinates of the first field-of-view 202. Next, the coordinates (Xb', Yb') are converted into the coordinates of the tool XY-stage 6. As a result, coordinates (Xb, Yb) are obtained. Next, the tool XY-stage 6 is caused to operate such that the reference point 21 is located within the second field-of-view 203 (S33d). Then, the second field-of-view 203 is imaged (see S33e and (d) of Fig. 11). Then, calculation is performed (S33f). Specifically, the tool XY-stage coordinates read from the encoder are set to (x1, y1). The position (x1s', y1s') of the reference point 21 in the camera coordinates of the second field-of-view 203 is obtained through image recognition. The position of the reference point 21 is converted into a

of the semiconductor chip 20 is registered, it is not necessary to cause the optical system XY-stage 11 to operate. In this case, the images obtained in Process S4 for registering the first alignment point may be used. Next, (2) an image is obtained by the first imaging device 30A, and an image is obtained by the second imaging device 31A, in a state where the semiconductor chip 20 on the lead side is located within the first field-of-view 202. Next, (3) the characteristic region of the semiconductor chip 20 on the lead side is registered as the second alignment point from the obtained images.

[0068]

<Process for performing pad centering>

Imaging is performed in a state where the individual pads are located within the first field-of-view 202 (Process S6). The individual images overlap each other in a specific region at an end of the field of view. As a result, it is possible to ascertain the position of the entire pads from the plurality of images. In a case where precision of the optical system XY-stage 11 is high, it is not necessary to cause the ends of the images to overlap each other.

[0069]

<Process for performing lead locator>

Process S7 for performing a lead locator is performed (see (a) of Fig. 12). The tool XY-stage 6 is caused to operate such that the individual leads 204 are located within the first field-of-view 202 (see Fig. 13) (S7a). Next, an image of the first field-of-view 202 is acquired (S7b). The image includes the individual leads 204. Imaging is performed in the state where the individual leads 204 are located within the first field-of-view 202. The individual images overlap in a specific region at an end of the field of view. As a result, it is possible to ascertain the position of the entire leads 204 from the plurality of images. In a case where precision of the optical system XY-stage 11 is high, it is not necessary to cause the ends of the images to overlap each other.

[0070]

<Process for performing positioning>

Positioning is performed by a series of operations illustrated in the process table in (b) of Fig. 12 (Process S8). Process S8 for performing positioning includes a fourth operation S81 of performing alignment, a fifth operation S82 of acquiring a correlation, a sixth operation S83 of performing alignment, and a seventh operation S84 of acquiring a correlation. Fig. 13 is an illustrative example of the image of the first field-of-view 202 acquired in the fourth operation S81 of performing alignment. A most part of the semiconductor chip 20 is located within the first field-of-view 202. The part 102 is a part for holding the position of the semiconductor chip 20, such as a wind clamper.

[0071]

The fourth operation S81 includes the following operations. The optical system XY-stage 11 is caused to operate such that a first lead alignment point L1, a first chip alignment point A1, and a second chip alignment point A2 are located within the first field-of-view 202 (S81a). Next, an image at a high magnification in the first field-of-view 202 is acquired using the first imaging device 30A (S81b). The image includes the first chip alignment point A1 and the second chip alignment point A2. Next, an image at a low magnification in the first field-of-view 202 is obtained using the second imaging device 31A (S81c). This image includes the first lead alignment point L1.

[0072]

In the fifth operation S82, a correlation between the tool XY-stage 6 and the first imaging device 30A is acquired. Moreover, in the fifth operation S82, a correlation between the tool XY-stage 6 and the second imaging device 31A is also acquired. The tool XY-stage 6 is caused to operate such that the reference point 21 is located within the second field-of-view 203 (S82a). Next, an image of the second field-of-view 203 is acquired (S82b). Then, the tool is caused to evacuate using the tool XY-stage 6.

[0073]

CLAIMS

[Claim 1]

A wire bonding apparatus comprising:

a bonding stage on which a bonding target is mounted;

a wire bonding unit comprising a capillary bonding a bonding wire to the bonding target, a capillary drive section reciprocating the capillary, and an XY-stage causing the capillary and capillary drive section to be moved along a two-dimensional plane intersecting a direction of the reciprocation;

an imaging unit imaging the bonding target mounted on the bonding stage; and

a base to which the wire bonding unit and the imaging unit are attached,

wherein the wire bonding unit is attached to a first portion of the base, and

the imaging unit is attached to a second portion that is different from the first portion of the base.

[Claim 2]

The wire bonding apparatus according to claim 1, wherein the imaging unit images a reference point that represents a position of the wire bonding unit and images the bonding target mounted on the bonding stage.

[Claim 3]

The wire bonding apparatus according to claim 2, wherein the imaging unit obtains a first image comprising the reference point and a second image that comprises the bonding target and is different from the first image.

[Claim 4]

The wire bonding apparatus according to claim 3, further comprising a control section acquiring a calibration value obtained by calculating a correlation between field-of-view coordinates of the reference point in the first image and position coordinates of the XY-stage.

[Claim 5]

The wire bonding apparatus according to claim 4, wherein the reference point is provided on an upper surface of an ultrasonic horn of the wire bonding unit.

[Claim 6]

The wire bonding apparatus according to any one of claims 1 to 5, wherein the imaging unit comprises an imaging section and a camera drive section causing the imaging section to be moved along a two-dimensional plane intersecting a direction of the reciprocation.

[Claim 7]

The wire bonding apparatus according to claim 5,

wherein the imaging unit comprises an imaging device and an optical system guiding light from the bonding target and the reference point to the imaging device,

the optical system comprises a lens and an optical splitter section disposed on an optical axis between the imaging device and the bonding target and between the imaging device and the reference point,

the lens is disposed on the imaging device side, and

the optical splitter section is disposed on the bonding target side and on the reference point side.

[Claim 8]

The wire bonding apparatus according to claim 7,

wherein the optical splitter section comprises a half mirror and an illumination irradiating the half mirror with light, and

the optical splitter section performs switching between an optical path acquiring the first image and an optical path acquiring the second image with the light with which the half mirror is irradiated.

[Claim 9]

The wire bonding apparatus according to claim 6,

wherein the control section calculates coordinates of the reference point converted based

on the calibration value in the second image, drives the camera drive section to obtain coordinates of a bonding point such that the bonding point is placed within a field-of-view for obtaining the first image, and then drives the XY-stage to acquire a camera offset value such that the reference point is placed within a field-of-view for obtaining the second image.