

WIRE BONDING APPARATUS

BACKGROUND

5 Technical Field

[0001] The present invention relates to a structure of a wire bonding apparatus.

Related Art

[0002] A wire bonding apparatus in which an electrode of a semiconductor die and a lead of a lead frame are connected by a wire is frequently used. After ultrasonically
10 vibrating a capillary in a state that the wire is pressed against the electrode by the capillary and joining the wire and the electrode, the wire bonding apparatus sets up the wire to the lead, ultrasonically vibrates the capillary in a state that the set-up wire is pressed against the lead, and connects the wire with the lead (for example, see Patent literature 1).

[0003] In the wire bonding apparatus described in Patent literature 1, the direction of
15 the ultrasonic vibration of the capillary is an extending direction (Y-direction) of an ultrasonic horn. Meanwhile, leads are radially disposed around the semiconductor die, and thus an extending direction of the lead and the direction of the ultrasonic vibration of the capillary do not match in some cases. In this case, there is a problem that the wire which is set up between the electrode and the lead will resonate due to the ultrasonic
20 vibration when the wire is connected to the lead, and a junction portion between the electrode of the semiconductor die and the wire will be peeled off. Therefore, in Patent literature 1, a method is proposed in which a placement table of the semiconductor die is rotated or one capillary is vibrated in an XY-direction by two ultrasonic horns, and thereby the direction of the ultrasonic vibration is matched with an extending direction of

a ratio of the gains of the PLL1 and the PLL2 of the ultrasonic vibrator driver 42 when the ratio $\Delta Y/\Delta X$ of the amplitude ΔY of the vibration in the Y-direction and the amplitude ΔX in the X-direction of the front end of the capillary 15 becomes tangent of the absolute value of the angle θ , that is, $\tan(|\theta|)$, wherein the angle θ between the extending direction 25 of the lead 22 and the Y-direction is input from the image processing unit 56. At this time, a map which specifies a relationship between the amplitude ΔY and the PLL1 and a relationship between the amplitude ΔX and the PLL2 or the like is stored in the memory 53, and the ratio of the PLL1 and the PLL2 may be calculated with reference to this map.

[0050] If the ratio of the gains of the PLL1 and the PLL2 is set in this way, as shown in FIG. 10, the ratio $(\Delta Y/\Delta X)$ of the amplitude ΔY in the Y-direction and the amplitude ΔX in the X-direction of the front end of the capillary 15 will be a ratio of the extending direction 25 of the lead 22 in the Y-direction and the X-direction. Then, a vibration range 60 of the front end of the capillary 15 becomes a rectangle, and an extending direction of a diagonal line of the vibration range 60 becomes the extending direction of the lead 22. In addition, the larger the angle θ between the extending direction 25 of the lead 22 and the Y-direction, the smaller the amplitude ΔY in the Y-direction, and the larger the amplitude ΔX in the X-direction. That is, the larger the angle θ , the smaller the ratio of the amplitude ΔY with respect to the amplitude $\Delta X = \Delta Y/\Delta X$.

[0051] In addition, based on the detected width W of the lead 22 and the angle θ between the extending direction 25 of the lead 22 and the Y-direction, the amplitude adjustment unit 57 calculates the amplitude ΔX or ΔY at which the vibration range 60 shown in FIG. 10 does not exceed the width W of the lead 22, calculates the gains of the PLL1 and the PLL2 from the calculated amplitude ΔX or ΔY and the ratio of the gains of the PLL1 and the PLL2 which has been calculated before, and stores the calculated gains

amplification unit 74 amplifies the ultrasonic vibration in the Y-direction input from the ultrasonic vibrator 16 and transmits the amplified ultrasonic vibration to the front end, and the vibration conversion unit 75 converts the ultrasonic vibration in the Y-direction to torsional vibration of the ultrasonic horn 71. The vibration amplification unit 74 has a quadrangular shape in a plan view, and the vibration conversion unit 75 is configured by upper-side slits 75a and lower-side slits 75b which are disposed obliquely with respect to the Y-direction. Besides, as long as the vibration amplification unit 74 has a polygonal shape in a plan view, the vibration amplification unit 74 is not limited to the quadrangular shape and may be hexagonal or octagonal.

[0064] As shown in FIG. 12, the vibration amplification unit 74 has a quadratic prism-like shape which has an upper surface 74a and a bottom surface 74b with an isosceles trapezoidal shape in a top view and in which the cross section is solid. On the upper surface 74a and the bottom surface 74b, two upper-side slits 75a and two lower-side slits 75b which constitute the vibration conversion unit 75 are formed. In addition, the vibration amplification unit 74 has side surfaces 74c and 74d, a back end surface 74e, and a front end surface 74f, all of which are surfaces with no vibration conversion unit 75 formed thereon. The ultrasonic vibrator 16 is mounted to the back end surface 74e. The vibration amplification unit 74 has a tapered shape which is tapered toward the front end surface 74f along the Y-direction, and is configured to amplify the amplitude in the Y-direction transmitted from the ultrasonic vibrator 16.

[0065] The upper-side slits 75a and the lower-side slits 75b are arranged at positions which are nodes of the vibration in the Y-direction of the vibration amplification unit 74. Each of the slits 75a and 75b has the same depth and width and does not penetrate the vibration amplification unit 74, and the largest depth of each of the slits 75a and 75b is

smaller than 1/2 of a thickness of the vibration amplification unit 4 in the up-down direction.

[0066] If ultrasonic vibrations with the two frequencies F1 and F2 are input to the ultrasonic horn 71 from the ultrasonic vibrator 16, the vibration in the Y-direction will be amplified in the vibration amplification unit 74. Then, if the vibration in the Y-direction passes through the vibration conversion unit 75, a part of the vibration in the Y-direction will be converted to a torsional vibration around an axis in the Y-direction.

[0067] Here, by the structure of the vibration conversion unit 75, a percentage to convert the vibration in the Y-direction with one of the frequencies F1 and F2 to the torsional vibration can be adjusted. For example, when a percentage to convert the vibration in the Y-direction with the frequency F2 to the torsional vibration is increased, and a percentage to convert the vibration in the Y-direction with the frequency F1 to the torsional vibration is reduced, similar to the embodiment described before, the gain of the PLL1 and the gain of the PLL2 can be adjusted to thereby adjust the ratio $\Delta Y/\Delta X$ of the amplitude ΔY in the Y-direction and the amplitude ΔX in the X-direction of the front end of the capillary 15.

[0068] Therefore, similar to the wire bonding apparatus 100 described before, the wire bonding apparatus 200 of the embodiment sets the gains of the PLL1 and the PLL2 for each lead 22 so that the ratio ($\Delta Y/\Delta X$) of the amplitude ΔY in the Y-direction and the amplitude ΔX in the X-direction of the front end of the capillary 15 becomes the ratio of the extending direction 25 of the lead 22 in the Y-direction and the X-direction, and thereby the extending direction of the diagonal line of the vibration range 60 of the front end of the capillary 15 can be taken as the extending direction 25 of the lead 22. In addition, when the angle θ between the extending direction 25 of the lead 22 and the Y-

direction increases, the amplitude ΔY in the Y-direction can be reduced, and the amplitude ΔX in the X-direction can be increased. Thus, the deformation of the lead 22 caused by the ultrasonic vibration can be suppressed, and degradation in the quality of the joining can be suppressed.

5 **[0069]** Next, a wire bonding apparatus 300 of another embodiment is described with reference to FIGS. 13 and 14. With regard to the wire bonding apparatus 300 of the embodiment, the ultrasonic vibrator 16 of the wire bonding apparatus 100 described before is changed to an ultrasonic vibrator 86 configured by ultrasonic vibration units 86a and 86b respectively vibrating at the frequencies F1 and F2 which are different, and an
10 ultrasonic vibrator driver 89 is configured to respectively supply driving electric power to each of the ultrasonic vibration units 86a and 86b. The rest parts are similar to the wire bonding apparatus 100 described before.

[0070] As shown in FIG. 13, the ultrasonic vibrator 86 is configured by two ultrasonic vibrations units 86a and 86b on the left and right. As shown in FIG. 14, the ultrasonic
15 vibrator 86 is configured by laminating a plurality of piezoelectric elements 81 in which left portions and right portions are insulated from each other because of a groove 82 arranged on the surface. One side and the other side of the groove 82 respectively constitute the ultrasonic vibration units 86a and 86b. Electric power with the frequency F1 is supplied to the ultrasonic vibration unit 86a from the ultrasonic vibrator driver 89,
20 and electric power with the frequency F2 is supplied to the ultrasonic vibration unit 86b.

[0071] Similar to the wire bonding apparatus 100 described before, if the ultrasonic vibration unit 86a vibrates at the frequency F1, the ultrasonic horn 14 will resonate in a way of expanding and contracting in the Y-direction, and the front end of the capillary 15 at the front end of the ultrasonic horn 14 will vibrate in the Y-direction; and if the

WHAT IS CLAIMED IS:

1. A wire bonding apparatus, comprising:

an ultrasonic vibrator capable of vibrating at two different frequencies in a Y-direction;

5 an ultrasonic horn which resonates in the Y-direction by using ultrasonic vibration at a first frequency input by the ultrasonic vibrator and torsionally resonates around Y axis by using ultrasonic vibration at a second frequency, that is different from the first frequency, input by the ultrasonic vibrator to excite a bonding tool mounted to a front end with different frequencies in the Y-direction and an X-direction perpendicular
10 to the Y-direction;

a driver, which comprises a first circuit supplying power of the first frequency to the ultrasonic vibrator and a second circuit supplying power of the second frequency to the ultrasonic vibrator;

a control unit which is connected to the driver and adjusts a respective
15 magnitude of the two ultrasonic vibrations; and

an imaging device which captures an image of the electrode, wherein

the Y-direction is a direction in which the ultrasonic horn extends, and

the control unit processes the image of the electrode captured by the imaging device, calculates an angle of an extending direction of the electrode with respect to the
20 Y-direction, and

the control unit adjusts respective output of the first circuit and the second circuit according to the calculated angle to make an extending direction of a diagonal line of a vibration range of the bonding tool to be the extending direction of the electrode.

2. The wire bonding apparatus according to claim 1, wherein

the bonding tool connects a wire to a band-shaped electrode which is disposed inclined with respect to the Y-direction.

3. The wire bonding apparatus according to claim 2, wherein

the control unit reduces the output of the first circuit in a way that the larger
5 the calculated angle, the smaller the ratio of the amplitude of the bonding tool in the Y-direction with respect to the amplitude of the bonding tool in the X-direction.

4. The wire bonding apparatus according to claim 2, wherein

the control unit adjusts a ratio of the respective output of the first circuit and
the second circuit so that the ratio of the amplitude of the bonding tool in the Y-direction
10 and the X-direction becomes a ratio of the extending direction of the electrode in the Y-direction and the X-direction.

5. The wire bonding apparatus according to claim 3, wherein

the control unit processes the image of the electrode captured by the imaging
device to calculate a width of the electrode in a direction perpendicular to the extending
15 direction of the electrode, and

adjusts the respective output of the first circuit and the second circuit so that
the amplitude of the bonding tool in the direction perpendicular to the extending direction
of the electrode does not exceed the calculated width of the electrode.

6. The wire bonding apparatus according to claim 4, wherein

the control unit processes the image of the electrode captured by the imaging
20 device to calculate a width of the electrode in a direction perpendicular to the extending
direction of the electrode, and

adjusts the respective output of the first circuit and the second circuit so that
the amplitude of the bonding tool in the direction perpendicular to the extending direction

of the electrode does not exceed the calculated width of the electrode.

7. The wire bonding apparatus according to any one of claims 1, 4, 5 and 6, wherein the ultrasonic horn comprises:

5 a vibration amplification unit, which amplifies the ultrasonic vibration in the Y-direction input from the ultrasonic vibrator and transmits the amplified ultrasonic vibration to the front end, and

a vibration conversion unit, which converts the ultrasonic vibration in the Y-direction to torsional vibration of the ultrasonic horn.

8. The wire bonding apparatus according to claim 7, wherein
10 the vibration amplification unit has a polygonal shape in a plan view, and the vibration conversion unit is a slit which is disposed obliquely with respect to the Y-direction.

9. The wire bonding apparatus according to any one of claims 1, 4, 5 and 6, wherein
15 the first frequency and the second frequency are close to each other.