

PATENT SPECIFICATION (11)

1 465 956



- (21) Application No. 16057/74 (22) Filed 10 April 1974 (19)
 (31) Convention Application No. 48/102 039 (32) Filed 12 Sept. 1973 in
 (33) Japan (JA)
 (44) Complete Specification published 2 March 1977
 (51) INT. CL.² B23K 21/00
 (52) Index at acceptance
 B3R 10 17X

(54) IMPROVEMENTS IN OR RELATING TO WIRE BONDING

(71) We, HITACHI LTD., of 1-5-1 Marunouchi, Chiyoda-ku, Tokyo, Japan, a Japanese Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to a wire bonding apparatus having a control mechanism for the motion of a capillary tube which guides and presents the wire.

15 In assembling a semiconductor device such as a transistor or IC, an electrode of an element and an external lead are connected by wire. In one method of bonding the two together, the wire is held by a tapered ceramic tube called the capillary tube. The 20 capillary tube carries out the bonding in such way that, after transporting the wire in the horizontal or X and Y directions, it moves in the vertical or Z direction. In this equipment, when any interference exists 25 between the movements in the X and Y directions and the movement in the Z direction, an error will occur in the final bonding position and an inferior connection arises. Therefore, the applicant has already 30 proposed a mechanism which prevents interference between the movements in the X and Y directions and movement in the Z direction and which effects the motion of the capillary in the Z direction smoothly and 35 without error.

40 This previously proposed mechanism is shown in Fig. 1 of the accompanying drawings and is such that, on a fixed base 2 fixed on a machine bed 1, a movable base 5 is so secured as to be movable in the horizontal or X and Y directions (arrows 3 and 4). A supporting shaft 6 is mounted at an upper part of the movable base 5 with its axis lying along the X direction, and an arm 7 of which the vertical plane intersects 45 that of the supporting shaft 6 and extending in the Y direction is rockably mounted at the central part of the shaft 6, and a capillary tube 8 for guiding and holding wire is mounted at an extreme end of the arm 7

with its axis extending in the vertical or Z direction. A spherical protrusion (not shown) is provided at an upper surface part of the other end of the arm 7, while a movable rod 10 having a flange portion 9 is positioned 55 over the spherical protrusion. The movable rod 10 extends in the Z direction, its outer periphery being supported by a guide sleeve 11 provided on the fixed base 2, and it is vertically slidable. Mounted at the lower 60 end of the moving rod 10 is a roller 12, the outer periphery of which is held in contact with the outer periphery of a cam 14 which is mounted on a bearing 13 fixed to the machine bed 1. Accordingly, the actuating rod 10 moves up and down with the turning of 65 the cam 14, and transmits the motion of its flange portion 9 to the rockable arm 7 at the spherical protrusion. In this case, owing to the structure in which the up-and-down 70 motions of the actuating rod 10 are transmitted to the arm 7 through the medium of the flange portion 9 and the spherical protrusion, the arm 7 can be reliably caused to ascend and descend even when the moving 75 base 5 is adjusted in the X direction or the Y direction. Under the capillary tube 8, there is disposed a guideway 15 for a lead frame with a semiconductor element attached thereto (not shown). 80

In this mechanism, since the motion of the capillary tube 8 substantially in the Z direction is directly defined by the flange portion 9 moving up and down and via the spherical protrusion contacted therewith, the 85 room for an error to intervene in the course of the positioning is small, and the motion in the Z direction can be imposed on the capillary tube without unacceptable error.

Even when movements in the X and Y 90 directions are given to the capillary tube, the spherical projection of the arm 7 merely slides on the lower surface of the flange portion 9, and movement in the Z direction is not affected thereby. Likewise movement 95 of the flange portion 9 in the Z direction does not affect movements of the capillary tube 8 in the X and Y directions. Consequently, movement in the Z direction can be given to the capillary tube 8 indepen- 100

dently of movements in the X and Y directions.

The wire bonding equipment with this mechanism assembled therein, however, controls the vertical motion of the capillary tube by means of the cam 14, so that when the capillary tube is exchanged, the spacing between the lower end of the capillary tube and a semi-conductor chip or a lead becomes larger or smaller than a predetermined spacing. When the spacing is too large, the part of the gold wire held by the capillary tube which is to be bonded by pressing is not depressed very strongly, and contact of the part with an electrode portion or the lead on the chip is inferior. When the spacing is too small, the part of the gold wire pressed in at the bond is excessively crushed, and the thickness of the joined portion is lowered. When the capillary tube ascends, the gold wire can sever there, and will rise with the capillary tube and come off.

The distance between the capillary tube and the lead becomes large also when there is wear of the lower end of the capillary tube, so that the above-described problem arises.

According to the present invention there is provided a wire bonding apparatus including an actuating rod movable in its axial direction and bearing a control element, a rockable arm of which one end is movable in the axial direction of the rod by the control element, the other end of the arm carrying a capillary tube for guiding and pressing a wire, a pivot for the rockable arm between its ends and means for adjusting the position of the control element along the actuating rod.

A particular embodiment of the invention will now be described by way of example only with reference to Fig. 2 of the accompanying drawings, which is a side view partly in section. Referring to the figure, a fixed base 2 is fixed on a machine bed 1. On the upper surface of the fixed base 2, a movable base 5 is mounted which moves in the horizontal or X and Y directions along sliding shafts 16 and 17 respectively. A supporting shaft 6 is supported on the movable base 5 and in a manner to extend along the X direction, an arm 7 lying in a vertical plane which orthogonally intersects with that of the supporting shaft 6 and extending in the Y direction is attached to the supporting shaft 6 through fitting 18 and a capillary tube 8 for holding wire 19 is attached to an extreme end of the arm 7 and extends, as shown, in the Z direction, i.e. the vertical direction. Obtaining the wire 19 from an overlying spool 22, the capillary tube 8 couples it with an electrode portion of a chip 21 borne on a lead frame 20 of the underlying guide base 15.

A protrusion 23 is provided on the upper surface of the other end of the arm 7, a control member 24 having a flange portion 9 lies over the protrusion 23, and the control member 24 is provided with a movable actuating rod 10 which penetrates vertically through the central part thereof and which can be locked thereto by means of a bolt 25 and a lock nut 26. The actuating rod 10 is supported at its outer peripheral portion by a guide sleeve 11 mounted on the fixed base 2, and is slidable in the vertical ascent and descent (Z) directions. Further, a roller 12 is supported at the lower end of the actuating rod 10 by means of a shaft 27 extending in a horizontal direction, and the outer periphery of the roller 12 is in contact with the outer periphery of the cam 14. The cam 14 is mounted on a rotary shaft 28 which is journaled in a bearing 13 fixed to the machine bed 1. With the rotation of the cam 14 the rod 10 moves up and down, to rock the arm 7 in its fitting 18 about the supporting shaft 6 by means of the flange portion 9 of the control member 24 secured to the actuating rod 10 and to thus move the capillary tube 8 up and down substantially in the Z direction.

It will be seen that this apparatus resembles that illustrated in Fig. 1 except for the control member 24 and in the adjustment of the bonding pressure which will be described in more detail hereinafter.

In this embodiment in order that the cam 14 and the roller 12 may be kept in contact at all times, a coiled tension spring 29 is extended between the guide sleeve 11 and the control member 24. In addition, in order that the protuberance 23 at the other end of the arm 7 and the lower surface of the flange portion 9 may be kept in contact at all times, a bolt 38 is provided on fitting 37 attached to the moving base 5 and a tension spring 30 secured thereto is coupled with the arm 7. The bonding pressure to be applied at the lower sharp end of the capillary tube 8 can be adjusted by shifting the bolt 38 up or down.

If the actuating rod 10, were to turn within the guide sleeve 11 while moving, the state of contact between the roller 12 and the cam 14 etc. would change. In order to prevent turning, a long axial groove 31 is provided in the rod 10, and a bolt 32 for preventing the turning is mounted on the guide sleeve 11 in such manner that its end engages in the groove 31.

Furthermore, in this mechanism, the control member 24 is so constructed as to be vertically adjustable relative to the rod 10. More specifically, the control member 24 is formed with an external thread 33 at the outer periphery of its upper part, and a cap nut 35 formed with an internal thread 34 on its inner wall is threadably engaged with

the external thread 33. The actuating rod 10 extends through the central part of the cap nut 35. The part of the actuating rod 10 which passes through nut 35 is thinner so that the cap nut 35 is prevented from moving downwards on the rod 10. Also, at the boundary part of the actuating rod 10 projecting out of the cap nut 35, a snap ring 36 is disposed so that the cap nut 35 is prevented from coming upwardly off the actuating rod 10. The control member 24 can accordingly be adjusted vertically with respect to the actuating rod 10 in such way that, after the lock nut 26 and the bolt 25 which lock the control member 24 to the actuating rod 10 are loosened, the cap nut 35 is turned. After setting the position of the control member 24 by means of nut 35 the bolt 25 and the lock nut 26 are tightened again.

By means of this mechanism, where the spacing between the pointed end of the capillary tube and the electrode portion of the chip of the semiconductor device placed on the guide base 15 is too short or too long, the control member 24 is upwardly or downwardly moved and adjusted by loosening the bolt 25 as well as the lock nut 26 and thereafter turning the cap nut 35 as has been stated above. In consequence, the position of the lower surface of the flange portion 9 is changed, the position of the end part of arm 7 in contact with the lower surface is thus changed, and the position of the lower end of the capillary tube 8 is changed. Accordingly, by setting with the cap nut 35 the lowermost point to which the capillary tube 8 is brought by the cam, the difficulty in the previously described device such as insufficient bonding of the wire or disconnection of the wire attributed to excessive crush are prevented from arising or are reduced.

The wire bonding apparatus of the present invention is not restricted to the above-described embodiment, but the actuating rod and the control member for vertically controlling the arm may be provided with any suitable adjusting mechanism.

As described above, in the wire bonding apparatus of the present invention, the descent stop position of the capillary tube can be finely adjusted, and hence the tolerance for crushing in the specification of the wire can be increased, so that the troubles of disconnection ascribable to inferior bonding or excessive crush of the wire may be preventable. The quality of the output of the wire

bonding apparatus is accordingly enhanced.

WHAT WE CLAIM IS:—

1. A wire bonding apparatus including an actuating rod movable in its axial direction and bearing a control element, a rockable arm of which one end is movable in the axial direction of the rod by the control element, the other end of the arm carrying a capillary tube for guiding and pressing a wire, a pivot for the rockable arm between its ends, and means for adjusting the position of the control element along the actuating rod.

2. A wire bonding apparatus according to Claim 1 wherein the actuating rod is driven by a cam which is rotatable to cause movement of the actuating rod.

3. A wire bonding apparatus according to Claim 2 wherein means are provided for preventing rotation of the rod about its own axis.

4. A wire bonding apparatus according to Claim 1, Claim 2 or Claim 3 wherein the pivot of the rockable arm is supported so as to be displaceable in the X and Y directions relative to a substantially Z direction movement of the capillary tube, X, Y and Z being mutually orthogonal directions.

5. A wire bonding apparatus according to any one of the preceding claims wherein the said one end of the arm has a projection which contacts a flange of the control element so as to transmit movement of the actuating rod to the arm.

6. A wire bonding apparatus according to any one of the preceding claims wherein the control element is screw-threadedly engaged to the rod, for axial displacement relative to the rod by relative rotation between the rod and the control element.

7. A wire bonding apparatus according to any one of the preceding claims which includes a spring of which one end is attached to the arm for applying bonding pressure at the capillary tube, the other end of the spring being secured to an adjustable member so that the force applied by the spring to the arm can be adjusted.

8. A wire bonding apparatus substantially as herein described with reference to and as illustrated in Fig. 2 of the accompanying drawings.

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4. A wire bonding apparatus according to Claim 1, Claim 2 or Claim 3 wherein the pivot of the rockable arm is supported so as to be displaceable in the X and Y directions relative to a substantially Z direction movement of the capillary tube, X, Y and Z being mutually orthogonal directions.

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7. A wire bonding apparatus according to any one of the preceding claims which includes a spring of which one end is attached to the arm for applying bonding pressure at the capillary tube, the other end of the spring being secured to an adjustable member so that the force applied by the spring to the arm can be adjusted.

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