

A WIRE HOLDING APPARATUS FOR WIRE BONDING

FIELD OF THE INVENTION

[001] The present invention relates to an apparatus used in a wire bonding process.

- 5 In particular, the invention relates to a wire holding apparatus for holding a wire during the wire bonding process.

BACKGROUND OF THE INVENTION

- 10 [002] Semiconductor assembly involves a series of packaging stages including without limitation, die preparation, die attach, wirebonding, encapsulation or sealing, etc. In the wirebonding stage, a wire bonding apparatus is used that connects a pad of a semiconductor chip to a lead of a lead frame using a wire. A number of conventional systems are used.

- 15 [003] US patent 8191759 discloses a wire bonding apparatus and method. In this art, a first clasper is configured to move in conjunction with a capillary and a second clasper is disposed in line with the first clasper along an extending direction of the wire, inserted through the capillary.

- 20 [004] Another prior art US patent 7025243 describes a bondhead for a wire bonding apparatus. The bondhead includes a wire clamping device which is movable relative to the bondhead body for feeding a bonding wire to a bonding tool and a wire clamping device actuator for moving the wire clamping device relative to the bondhead body.

- 25 [005] Yet another prior art wire bonding apparatus and its exemplary operation is shown in FIGs 1 (a-g). The wire bonding apparatus includes a wire 102 which is extended through a capillary 104 and a clasper 106 that holds the wire 102 in place. Steps (a-b) illustrate the process that connect the wire 102 to the object of bonding 108. In this process, the wire 102 used for bonding, is passed through the capillary
30 104. The wire 102 has an initial ball 110 formed at its extended end by an electrical

discharge device (not shown). The capillary 104 is lowered with the clasper 106 in an open state, to an object of bonding 108 in step (a) and is bonded to a first bonding point 112 in step (b).

5 [006] Next, in steps (c-f), the capillary 104 is raised slightly upwards and towards the lead with the clasper 106 in open state. Wire 102 is then pulled following a prescribed loop control process as shown in steps (d-e) and connected to a second bonding point 114. After bonding is complete, as shown in step (f), the capillary 104 is moved (raised) in the Z-axis direction while feeding the wire from the tip end of the capillary 104. Once the capillary 104 is raised to a prescribed height, the clasper 106 is shut, thereby cutting wire 102 in step (g). The capillary 104 and the clasper 106 are moved further upwards so that a tail wire of a predetermined length is extended from the tip end of the capillary 104. Subsequently, the capillary 104 is moved to a position of electronic flame off to roll the tail wire into an initial ball, and the wire is bonded to a next bonding point. Pads and leads are sequentially connected by repeating this bonding process.

[007] A shortcoming of the above prior art is that the system does not focus on wire slippage out of the capillary 104 due to sudden disconnection of the wire while the clasper 106 is open (steps (a) to (f)). This may lead to creation of a short tail or no tail at the capillary tip that may affect wire bonding quality and efficiency. It is therefore, desirable to develop an apparatus for holding the wire and preventing wire breakage at a capillary tip so as to ensure that the wire is always inside the capillary with successful tail formation.

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OBJECTS OF THE INVENTION

[008] It is an object of the present invention to overcome, or at least substantially ameliorate, the disadvantages and shortcomings of the prior art.

[009] It is also an object to provide an apparatus for holding a wire during the wire bonding process in the event of wire breakage.

[010] It is an object of the invention to provide a wire bonding process that
5 eliminates wire slippage through a capillary in the event of wire breakage during the wire bonding process.

[011] Other objects and advantages of the present invention will become apparent from the following description, taken in connection with the accompanying drawings,
10 wherein, by way of illustrations and examples, embodiments of the present invention are disclosed.

SUMMARY OF THE INVENTION

[012] According to the present invention, there is provided an apparatus for holding
15 a wire during a wire bonding process. The apparatus includes a body having a left body and a right body, a wire guide coupled to the left body for feeding the wire, at least two wire contact surfaces for providing suitable gripping on the wire such that one of the at least two wire contact surfaces is coupled to the left body and the other of the at least two wire contact surfaces is coupled to the right body, and a force
20 application mechanism coupled to the wire contact surface of the right body, wherein the force application mechanism exerts a holding force on the wire to hold the wire throughout the wire bonding process until a time of wire tail cutting.

[013] In one embodiment of the invention, the wire contact surface includes one or
25 more of a metal plate or a soft fabric material plate. The metal plate may be a ruby plate or a sapphire plate while the soft fabric material plate may be a felt material plate.

[014] In one embodiment of the invention, the force application mechanism includes
30 a floating cylinder coupled to the wire contact surface of the right body, a

compression spring coupled to the floating cylinder, a vacuum inlet coupled to the compression spring and a vacuum generator operatively coupled to the vacuum inlet such that the floating cylinder exerts the holding force via the wire contact surface of the right body on the wire to hold the wire when the vacuum generator is turned off.

- 5 Further, the floating cylinder collapses to the surface of the right body due to a vacuum suction effect created by turning on the vacuum generator.

[015] In yet another embodiment of the invention, the holding force is lower than the pulling force of the wire so as to facilitate smooth feeding of the wire to the wire
10 guide.

[016] In yet another embodiment of the invention, the force application mechanism includes a piezoelectric material such that the wire contact surface exerts the holding force on the wire when the piezoelectric material is excited.

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[017] In yet another embodiment of the invention, the force application mechanism includes a piezoelectric plate such that the piezoelectric plate is deflected using a voltage source to exert or release the holding force on the wire.

20 [018] In yet another embodiment of the invention, the force application mechanism includes a permanent magnet, a coil operatively coupled to the permanent magnet, and a coil holder for positioning the coil such that a current generated in the coil within a radially orientated magnetic field of the permanent magnet causes the coil holder to move axially along the axis for holding the wire. Further, the coil holder
25 moves in a reverse direction by reversing the direction of current flow in the coil to open and release the wire during the wire bonding process.

[019] In yet another embodiment of the invention, the force application mechanism includes an electromagnetic coil and a ferromagnetic plunger operatively coupled to
30 the electromagnetic coil to exert or release the holding force on the wire.

[020] In yet another embodiment of the invention, an apparatus for holding a wire during a wire bonding process is provided that includes a body having a left body and a right body, a through-hole in between the left body and the right body for feeding the wire during the wire bonding process, and a force application mechanism provided in the right body such that the force application mechanism exerts a holding force on the wire provided in the through-hole to hold the wire throughout the wire bonding process until a time of wire tail cutting.

10 [021] In yet another embodiment of the invention, the force application mechanism includes a plurality of suction channels coupled to the through hole, and a vacuum inlet coupled to the suction channels, such that the force application mechanism holds the wire by means of a vacuum suction created through the plurality of suction channels when vacuum is created through the vacuum inlet.

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[022] In yet another embodiment of the invention, a wire bonding method using the wire holding apparatus is provided. The method includes:

- a) feeding a wire through a wire holding apparatus, a clasper and a capillary;
- b) closing the wire holding apparatus to hold the wire;
- 20 c) forming a ball at an extended end of the wire to be bonded to a first bonding point;
- d) bonding the ball to the first bonding point with the clasper in an open state and the wire holding apparatus in the closed state;
- e) pulling the wire through the clasper following a prescribed loop control;
- 25 f) connecting the wire to a second bonding point;
- g) pulling the wire by a prescribed feed amount from the capillary; and
- h) cutting the wire followed by closing of the clasper and opening the wire holding apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[023] The summary above, as well as the following detailed description of illustrative embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the disclosure is not limited to specific methods and instrumentalities disclosed herein. Wherever possible, like elements have been indicated by identical numbers.

[024] FIG 1 is a view showing a conventional wire bonding method and wire clamping operation of the related prior art;

FIGs 2(a-g) depict steps involved in a wire bonding method using a wire holding apparatus of the present invention;

FIGs 3(a-b) depict a sectional front view of the wire holding apparatus according to a first embodiment of the present invention;

FIGs 4(a-b) illustrate a sectional front view of the wire holding apparatus according to a second embodiment of the present invention;

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FIGs 5(a-b) show a sectional front view of the wire holding apparatus according to a third embodiment of the present invention;

FIGs 6(a-b) depict a sectional front view of the wire holding apparatus according to a fourth embodiment of the present invention;

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FIGs 7(a-b) illustrate a sectional front view of the wire holding apparatus according to a fifth embodiment of the present invention;

FIGs 8(a-b) show a sectional front view of the wire holding apparatus according to a sixth embodiment of the present invention;

DETAILED DESCRIPTION OF THE INVENTION

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[025] The present invention will now be described in detail in connection with various embodiments with reference to the accompanying drawings.

[026] The present invention relates to an apparatus for holding a wire during a wire bonding process, thereby negating the chances of wire slippage in the event of wire breakage. The apparatus is in the form of a clamping device that holds and allows the wire to slide through easily. In an embodiment, the apparatus is installed above a wire clasper. The apparatus remains in a closed position to hold the wire in place throughout the wire bonding process until the time of tail cutting, after which the apparatus is opened to allow pulling of wire. Various embodiments of the apparatus are described in the following figures.

[027] FIGs 2(a-g) illustrate a wire holding apparatus 202 of the present invention used during a wire bonding process in accordance with an embodiment of the present invention. Wire 102 is passed through the wire holding apparatus 202, a wire clasper 106 and a capillary 104. In a preferred embodiment, the wire holding apparatus 202 is positioned above the wire clasper 106. However, it is also possible that the wire holding apparatus 202 is placed below the wire clasper 106. The wire clasper 106 may be any known wire clamping device. In an embodiment, the wire holding apparatus 202 may be fixed and therefore, stationary. This stationary positioning of the wire holding apparatus 202 above the wire clasper 106 does not limit vertical movement of the capillary 104. Thus, it has no effect on the drawing of the wire 102 to a prescribed height 116. A controller that operates and controls the movement of the wire 102, capillary 104 and wire clasper 106 is not shown due to clarity.

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[028] In FIG 2(a), on the commencement of the wire bonding process, wire 102 is passed through the wire holding apparatus 202, wire clamber 106 and capillary 104 such that a small piece of wire 102 extends at the capillary tip. The wire holding apparatus 202 is in closed position while the wire clamber 106 is in open position. By using a heating mechanism such as an electric discharge or electric flame off, an initial ball 110 is formed at the extended end of the wire 102. In FIG 2(b), the capillary 104 is moved downwards to position it close to an object 108 to which the wire 102 is to be bonded and once in place, the wire 102 is bonded to a first bonding point 112 on the object 108. While the capillary 104 is moved downwards, the wire clamber 106, which is in open position, moves downwards along with the capillary 104 while the wire holding apparatus 202 is stationary and in closed position.

[029] Next, when the connection to the first bonding point 112 is complete, the capillary 104 is raised upwards i.e. in the direction of the Z axis as indicated in FIG 2(c), with the wire clamber 106 still in open position and the wire holding apparatus 202 in the closed position. Wire 102 is pulled with the wire clamber 106 in the open position and the wire holding apparatus 202 in the closed position following a prescribed loop control as shown in FIG 2(d). The capillary 104 is then connected to a second bonding point 114 as shown in FIG 2(e). Thereafter, the capillary 104 and the wire clamber 106 are moved upwards (FIG 2(f)).

[030] Following this connection, the wire 102 is pulled out by a prescribed feed amount from the end of the capillary 104 and thereafter, the wire clamber 106 is closed and the wire holding apparatus 202 is opened as indicated in FIG 2(g). While in this state, the wire 102 is cut. At this stage, the wire holding apparatus 202 remains open and wire clamber 106 remains closed to allow the capillary 104 and the clamped wire to further rise to a prescribed height 116 for ball formation followed by returning to the state of step (a) with the wire clamber 106 open and wire holding apparatus 202 closed.

[031] It may thus be seen that the wire holding apparatus 202 remains closed (also referred as a holding state) in steps (a-f) but is opened in step (g). The holding force of the wire holding apparatus 202 on the wire 102 is not greater than the pulling force of the wire tension to facilitate smooth feeding of the wire 102 in the capillary 104 while
5 still being able to hold on to the wire in the event of wire breakage.

[032] FIGs 3-8 illustrate various embodiments of the wire holding apparatus 202 of the present invention. Typically, a wire holding apparatus 202 includes a body segregated into a left body and a right body, two wire contact surfaces with one wire
10 contact surface attached to the left body and the other contact surface is attached to the right body and a force application mechanism functionally coupled to the wire contact surface on the right body. The force application mechanism applies a holding force on the wire during the wire bonding process due to which the wire is prevented from slipping even if the wire breaks during the wire bonding process. This state of the
15 force application mechanism/apparatus 202 is also referred to as a closed state. Once the wire bonding process is complete, the force application mechanism withdraws the holding force due to which the wire is released. This state is also referred to as an open state. Several embodiments of the force application mechanism of the present invention are described below.

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[033] FIGs 3(a-b) depict sectional front views of the wire holding apparatus 202 according to a first embodiment of the present invention. The wire holding apparatus 202 includes the force application mechanism in the form of a spring loaded vacuum system provided in the body. The body of the wire holding apparatus 202 is made of
25 two parts, a left body 302 and a right body 304. The left body 302 and the right body 304 may be made of for example, aluminum. To each of the left body 302 and the right body 304, a wire contact surface 306 is coupled which provides suitable gripping on the wire 102. In addition, a wire guide 308 is coupled to the left body 302 to allow the wire 102 to be inserted into the apparatus 202. As shown, the wire guide 308 is
30 coupled to the top portion of the left body 302.

[034] The wire 102 is fed between the bodies 302 and 304 through the wire guide 308 and the wire contact surfaces 306. The wire contact surfaces 306 may be either in the form of a metal plate and/or a soft fabric material plate. Examples of a metal plate include without limitation, a ruby or a sapphire plate, while an example of a fabric material plate includes without limitation, a felt material plate. On the left side, the wire contact surface 306 is directly coupled to the left body 302 while on the right side, the wire contact surface 306 is adhered to a floating cylinder 310 provided in the right body 304.

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[035] The right body 304 may be in the form of a housing that hosts the spring loaded vacuum system which is formed by the combination of the floating cylinder 310, a compression spring 312 and a vacuum inlet 314. The floating cylinder 310 and left body 302 are in relatively close contact when a holding force, which is lower than the wire pulling force, is applied so that the holding force is sufficient to hold the wire and not deform the wire. Also, a preload force of appropriate amount is setup using the compression spring 312. If the compression force is too large, it may deform the wire 102. Vacuum is supplied through the vacuum inlet 314 from a vacuum generator (not shown).

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[036] To release the wire, as described in FIG 2(g) of the bonding process, the vacuum generator is turned on to create a vacuum in the space 316 (FIG 3(a)). Due to the vacuum suction effect (indicated by arrow 318 in FIG 3(b)), the floating cylinder 310 is moved backwards and collapses to the surface of the right body 304. This causes the holding force to be released making the wire free and unattached to the wire contact surface 306. The wire may then be pulled as required.

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[037] However, to hold the wire in place (steps depicted in FIGs 2(a-f)), the vacuum generator is turned off. The compressed spring expands and the floating cylinder 310

returns to its initial position (FIG 3(a)) due to the preloaded spring force causing a holding force to be applied on the wire 102 by the wire contact surface 306.

[038] FIGs 4(a-b) depict sectional front views of the wire holding apparatus 202 according to a second embodiment of the present invention. In this embodiment, the force application mechanism of the wire holding apparatus 202 includes a suction system. The body is divided into two parts, a left body 402 and a right body 404 having a through-hole 406 through which the wire 102 is fed. The left body 402 and the right body 404 may be made of for example, aluminum. The right body 404 hosts the suction system which contains a plurality of suction channels 408 that open into the through-hole 406 on one side and a vacuum inlet 410 on the other side. The vacuum inlet 410 is coupled to a vacuum generator (not shown) at its free end.

[039] During the wire bonding process, wire 102 is fed through the through-hole 406. The vacuum generator is turned on to create vacuum suction indicated by the arrow 412 in the suction system through the suction channels 408. Due to the vacuum suction, a wire holding force is exerted on the wire 102 to keep the wire in place. The wire holding force is dependent on the amount of vacuum suction created through the suction channels 408 while the vacuum suction is controlled by the vacuum controller (not shown).

[040] In the apparatus depicted in FIGs 4(a-b), the vacuum suction is turned on for holding the wire from steps in FIGs 2(a-f) during the wire bonding process. To release the wire, the vacuum generator is turned off. This removes the suction force holding the wire, thereby freeing it to be pulled or extended.

[041] FIGs 5(a-b) depict sectional front views of the wire holding apparatus 202 according to a third embodiment of the present invention with the force application mechanism being a piezoelectric displacement system. In this embodiment, the left

body 302, the right body 304, the wire contact surfaces 306 and the wire guide 308 may be assembled as described in FIG 3.

[042] The wire contact surface 306 is directly coupled to the left body 302 on the left side while on the right side, the wire contact surface 306 is driven by a piezoelectric material 512. The right body 304 along with the piezoelectric material 512 acts as a miniature actuator. The piezoelectric material 512 may be, for example, ceramic, in the form of a plurality of layers. The piezoelectric material 512 and wire contact surface 306 may be positioned with a wire gap distance 514 of, for example, 100 micron(FIG 5(b)). The displacement of the piezoelectric material 512 may be varied for holding a wire depending upon the wire size by controlling the input voltage 516. The wire holding force is controlled by tuning the input voltage 516 corresponding to the required amount of piezo-displacement 518 necessary to hold the wire 102. For example, for thicker wires, more piezo-displacement 518 may be required compared to thinner wire.

[043] Thus, in the apparatus of FIG 5(a), voltage 516 is applied to hold the wire in steps depicted in FIGs 2(a-f) during the wire bonding process while input voltage 516 is cut off to release the wire.

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[044] FIGs 6(a-b) depict sectional views of the wire holding apparatus 202 having a piezoelectric deflection system as the force application mechanism in accordance with a fourth embodiment of the present invention. Here, the wire holding apparatus 202 includes a piezoelectric plate 602 that is deflected by applying a voltage through a voltage source 604. The amount of deflection can be controlled by controlling the applied voltage. In this embodiment, the left body 302 is directly coupled to the wire contact surface 306 while the right body consists of the piezoelectric plate 602 fixed or hinged at one end 606 and coupled to the wire contact surface 306 on the right side of the wire 102. In various embodiments, the piezoelectric plate 602 may be fixed or hinged at one end 606 or both ends of the right body. The wire contact surfaces

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306 coupled to the left body 302 and the piezoelectric plate 602 respectively, provide friction that enables the wire 102 to slide easily. Details of the left body 302, right body 304, wire contact surfaces 306 and wire guide 308 can be referred from FIG 3.

5 [045] In this embodiment, no voltage is supplied to the piezoelectric plate 602 during the wire bonding process steps of FIGs 2(a-f). This ensures that the wire holding apparatus 202 is in closed state and the holding force is applied on the wire 102 by the force application mechanism, namely the piezoelectric plate 602. To open the wire gap 608 (FIG 6(b)), a voltage is applied to the piezoelectric plate 602 which deflects
10 the plate 602 as shown by an arrow 610 in FIG 6(b). The holding force is thus, released on the wire 102 due to voltage application.

[046] FIGs 7(a-b) depict sectional views of the wire holding apparatus 202 in accordance with yet another embodiment of the present invention. In this
15 embodiment, the force application mechanism of the apparatus 202 includes an electromagnetic device that converts electrical energy into a mechanical pushing and pulling force within the right body 304. The electromagnetic device includes a pair of permanent magnets 702, a coil 704, a coil holder 706 and an electrical terminal 708. Optionally, the coil holder 706 may be provided with a wire contact surface 306 to
20 enable smooth holding and sliding of the wire 102. The coil 704 may be a tubular coil. Details of the left body 302, right body 304, wire contact surfaces 306 and wire guide 308 can be referred from FIG 3.

[047] In the closed state, the coil holder 706 and the wire contact surface 306 hold
25 the wire 102 when voltage is passed across the electrical terminal 708 during the steps illustrated in FIGs 2(a-f) of the wire bonding process. The current generated in the coil 704 within a radially orientated magnetic field of the permanent magnet 702 causes the coil holder 706 to move axially along the axis of holding the wire 102, thereby applying a holding force on the wire 102. The holding force and the speed of
30 moving the coil holder 706 can be controlled precisely by adjusting the input voltage

across the electrical terminal 708. For example, the input voltage can be as low as 0.5V. To open and release the wire 102, the coil holder 706 is moved in a reverse direction by reversing the direction of the current flow in the coil 704.

5 [048] FIGs 8(a-b) depict a sectional front view of the wire holding apparatus 202 using an electromagnetic solenoid system as the force application mechanism. The electromagnetic solenoid system is an electromagnetic device that converts electrical energy into a mechanical pushing force and is hosted within the right body 304. The electromagnetic solenoid system includes an electromagnetic coil 802, a plunger 804,
10 a spring 806 and an electrical terminal 808. The plunger 804 may be a ferromagnetic plunger and located inside the right body 304.

[049] In the closed state of the apparatus 202, the plunger 804 is in a rest position, thereby holding wire 102 by the preloaded compression spring force during the wire
15 bonding process steps depicted in FIGs 2(a-f). In the step depicted in FIG 2(g), the wire holding apparatus 202 is in open state. In this state, a voltage is applied through the electrical terminal 808 due to which an electrical current passes through the electromagnetic coil 802. The coil 802 acts like an electromagnet and the plunger 804 is attracted towards the centre of the coil 802 by a magnetic flux setup within the coil
20 802, which in turn compresses the spring 806 attached to one end of the plunger 804 as shown in FIG 8(b). The force and speed of the movement of the plunger 804 is determined by the strength of the magnetic flux generated within the coil 802.

[050] When the voltage source is turned OFF during steps(a-f) of FIG 2, the coil 802
25 collapses and the energy stored in the compressed spring 806 forces the plunger 804 back to its original rest position which in turn holds the wire as shown in FIG 8(a).

[051] As described above, by using the wire holding apparatus 202 of the present invention, it is evident that there will be no wire slippage and/or wire breakage at the

capillary tip. Further, the present invention improves the efficiency of the wire bonding process and the stability of the bonding quality.

[052] There has thus, been shown and described a wire holding apparatus to be used
5 during a wire bonding process which fulfills all the objects and advantages sought
therefore. Many changes, modifications, variations and other uses and applications of
the subject invention will, however, become apparent to those skilled in the art after
considering this specification and the accompanying drawings which disclose the
preferred embodiments thereof. All such changes, modifications, variations and other
10 uses and applications which do not depart from the spirit and scope of the invention
are deemed to be covered by the invention, which is to be limited only by the claims
which follow.

[053] Although the invention has been described in detail for the purpose of
15 illustration based on what is currently considered to be most practical and preferred
embodiments, it is to be understood that such detail is solely for that purpose and
that the invention is not limited to the disclosed embodiments, but, on the contrary, is
intended to cover modifications and equivalent arrangements that are within the
spirit and scope of the appended claims. For example, it is to be understood that the
20 present invention contemplates that, to the extent possible, one or more features of
any embodiment can be combined with one or more features of any other
embodiment.

CLAIMS

1. An apparatus for holding a wire during a wire bonding process, the apparatus comprising:
 - a body having a left body and a right body;
 - 5 a wire guide coupled to the left body for feeding the wire;
 - at least two wire contact surfaces for providing suitable gripping on the wire, wherein one of the at least two wire contact surfaces is coupled to the left body and the other of the at least two wire contact surfaces is coupled to the right body; and
 - 10 a force application mechanism coupled to the wire contact surface of the right body, wherein the force application mechanism exerts a holding force on the wire to hold the wire throughout the wire bonding process until a time of wire tail cutting.
- 15 2. The apparatus as claimed in claim 1, wherein the wire contact surface comprises one or more of a metal plate or a soft fabric material plate.
3. The apparatus as claimed in claim 2, wherein the metal plate comprises a ruby plate or a sapphire plate.
- 20 4. The apparatus as claimed in claim 2, wherein the soft fabric material plate comprises a felt material plate.
5. The apparatus as claimed in claim 1, wherein the force application mechanism comprises:
 - a floating cylinder coupled to the wire contact surface of the right body;
 - a compression spring coupled to the floating cylinder;
 - a vacuum inlet coupled to the compression spring; and
 - a vacuum generator operatively coupled to the vacuum inlet,
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wherein the floating cylinder exerts the holding force via the wire contact surface of the right body on the wire to hold the wire when the vacuum generator is turned off, wherein the floating cylinder collapses to the surface of the right body due to a vacuum suction effect created by turning on the vacuum generator.

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6. The apparatus as claimed in claim 5, wherein the holding force is lower than the pulling force of the wire so as to facilitate smooth feeding of the wire to the wire guide.

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7. The apparatus as claimed in claim 1, wherein the force application mechanism comprises a piezoelectric material, wherein the wire contact surface exerts the holding force on the wire when the piezoelectric material is excited.

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8. The apparatus as claimed in claim 1, wherein the force application mechanism comprises a piezoelectric plate, wherein the piezoelectric plate is deflected using a voltage source to exert or release the holding force on the wire.

9. The apparatus as claimed in claim 1, wherein the force application mechanism comprises:

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a permanent magnet;

a coil operatively coupled to the permanent magnet; and

a coil holder for positioning the coil,

wherein a current generated in the coil within a radially orientated magnetic field of the permanent magnet causes the coil holder to move axially along the axis for holding the wire.

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10. The apparatus as claimed in claim 9, wherein the coil holder moves in a reverse direction by reversing the direction of current flow in the coil to open and release the wire during the wire bonding process.

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11. The apparatus as claimed in claim 1, wherein the force application mechanism comprises an electromagnetic coil and a ferromagnetic plunger operatively coupled to the electromagnetic coil to exert or release the holding force on the wire.

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12. An apparatus for holding a wire during a wire bonding process, the apparatus comprising:

a body having a left body and a right body;

10 a through-hole in between the left body and the right body for feeding the wire during the wire bonding process; and

a force application mechanism provided in the right body, wherein the force application mechanism exerts a holding force on the wire provided in the through-hole to hold the wire throughout the wire bonding process until a time of wire tail cutting.

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13. The apparatus as claimed in claim 12, wherein the force application mechanism comprises:

- a plurality of suction channels coupled to the through hole; and
- a vacuum inlet coupled to the suction channels,

20 wherein the force application mechanism holds the wire by means of a vacuum suction created through the plurality of suction channels when the vacuum is created through the vacuum inlet.

14. A wire bonding method using the apparatus for holding wire as claimed in any of the preceding claims, the method comprising:

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- i) feeding a wire through a wire holding apparatus, a clasper and a capillary;
 - j) closing the wire holding apparatus to hold the wire;
 - k) forming a ball at an extended end of the wire to be bonded to a first
- 30 bonding point;

- l) bonding the ball to the first bonding point with the clasper in an open state and the wire holding apparatus in the closed state;
- m) pulling the wire through the clasper following a prescribed loop control;
- n) connecting the wire to a second bonding point;
- o) pulling the wire by a prescribed feed amount from the capillary; and
- p) cutting the wire followed by closing of the clasper and opening the wire holding apparatus.

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