

BONDING WIRE SPOOL HAVING A GROOVE

FIELD OF THE INVENTION

[0001]

The present invention relates to a structure of a spool for supplying a bonding wire used in a connection of a semiconductor device, and in particular relates to a structure of a spool suited to a bonding wire for a high-current semiconductor device made of a high-purity aluminum (Al) or aluminum (Al) alloy having a purity of at least 99.99% by mass.

RELATED ART

[0002]

Processing of a wire at the beginning of winding was difficult when attempting to mechanically wind a coil of a bonding wire used in the connection of a semiconductor device or a filter coil of an electric power supply line, etc. by a motor. Therefore, methods for beginning winding using a guide groove are known hitherto (refer to Patent Reference 1, Patent Reference 2, and Patent Reference 3).

For example, Patent Reference 1 recites, "a first filament of the wind-on end has a pulled-out configuration at a portion of a winding drum that stores a wire or other filament circumferentially wound onto a core shaft (same Patent Reference, page 1, left column, lines 17 - 19 /first drawing).

[0003]

Furthermore, Patent Reference 2 recites, "A pressurized guide 18 clamps a tip of the wire material 14 and applies tension to bring the wire material 14 into contact with the circumferential body 1a of the spool 1. ...a motor 10 rotates the spool 1. Thus, the wire material 14 catches in a recessed groove 6 of the spool 1, a tipward portion of the wire material 14 beyond the recessed groove 14 is wound into the outer circumferential groove 5, and a baseward portion is wound onto the circumferential portion body 1a" (same Patent Reference, page 2, right top column, lines 4-12, fourth drawing). Moreover, Patent Reference 3 recites, "having a groove positioned tangentially to a winding surface of the cylindrical member" (in "Japanese Utility Model Registration Scope of Claims," first drawing).

[0004]

The spool of the present invention as well follows such conventional methods using a guide groove. Here, the wire diameter of the bonding wire is fine (a general high-purity Al wire or Al alloy wire has a wire diameter on the order of 0.1 - 1.0 mm), and therefore the inlet shape of the guide groove is generally made as a notch or bugle-mouth shape for easy entrance of fine wires. The shape of the guide groove generally is a straight line, but curved shapes such as converging cycloids also are possible.

Furthermore, regarding the depth of the guide groove, it is normal to: make the groove depth even in its shallowest portion greater than the maximum wire diameter of the high-purity Al wire or Al alloy wire

being used; make the groove with a slope; and make it progressively shallower as it approaches the cylindrical body. The bonding wire passing through such a guide groove transfers from the guide groove to the cylindrical body and winds onto the spool.

[0005]

Basic winding process steps using a spool are briefly described with reference to Fig. 1, Fig. 2, and Fig. 3.

Fig. 1 illustrates the relative positional relationship of a fixed guide 1, a movable guide 2, a guide clamp 3, a spool 4 and a bonding wire 5; and Fig. 2 is a schematic representation thereof. Fig. 3 is a schematic process-step exploded view illustrating winding process steps.

The bonding wire 5 for a semiconductor device has modified mechanical properties such as a prescribed tensile strength and elongation, and is wound onto a bobbin (located outside to the right of Fig. 1). The bonding wire 5 unwound from the bobbin is wound onto the spool, as described hereinafter.

As illustrated in Fig. 1, the tip of the bonding wire 5 coming from the bobbin is clamped by the guide clamp 3 and is guided toward the spool 4 by way of the fixed guide 1 and the movable guide 2.

First, the bonding wire 5 clamped by the guide clamp 3 is brought into contact with and placed onto a periphery of the spool 4 at a prescribed location by the guide clamp 3 and the movable guide 2 (Fig. 2, Fig. 3(a)). Then, a tip of the placed bonding wire 5 is secured by an appropriate securing unit mounted on an exterior of

the spool 4 (Fig. 3(c)). The securing unit, for example, clamps and secures a tip portion of the bonding wire by a securing clamp 13 (Fig. 3) mounted to the prescribed location on the exterior of the spool 4. Upon the secure attachment of the tip portion of the bonding wire 5, the guide clamp 3 moves away from the bonding wire 5, returns to the original position, and stands by until a prescribed amount of the bonding wire finishes winding onto the spool (Fig. 3(d)).

[0006]

Then, upon moving the movable guide 2 to an interior of the spool 4 while rotating the spool 4 by a motor (top of Fig. 3(e)), the bonding wire 5 crosses over the grooved inlet 6 and is guided to be positioned above the cylindrical body 7 of the spool 4 (Fig. 3(e)). The spool 4 is rotated further by the motor; the bonding wire 5 engages the guide groove 8 of the spool 4; and upon further rotation of the spool 4, the bonding wire 5 progressively goes into the guide groove 8 of a flange 9.

[0007]

Afterwards, the bonding wire 5 is wound onto the cylindrical body 7 from edge to edge at a prescribed tension while rotating the spool 4 by the not-illustrated motor and making the movable guide 2 traverse. This movement is repeated to wind in multiple stages, and a bonding wire coil of the necessary length of about several hundred to several thousand meters is obtained.

Finally, the motor is stopped at a point where the movable guide 2 has come to a grooveless inlet 11; the movable guide 2 is moved;

the bonding wire 5 is clamped by the guide clamp 3 that had been standing by and guided toward an exterior of the spool 4; the bonding wire 5 crosses over the grooveless inlet 11 and then is severed; and the severed end is held/secured by secure attachment to the spool.

Finally, the bonding wires 5 on outer faces of each of flanges 9 and 9' are fastened with tape, etc.

[0008]

Patent Reference 1: Japanese Examined Utility Model Application Publication No. S39-37515

Patent Reference 2: Japanese Published Unexamined Patent Application No. S59-12018

Patent Reference 3: Microfilm of Japanese Utility Model Application S63-82863 (Japanese Utility Model Application Laid-Open No. H2-4866)

[0009]

However, in previous spools having grooves, one end of the bonding wire 5 is secured by the clamp of the exterior of the spool 4, and another end is positionally aligned by the movable guide 2 arranged at the exterior of the flange 9 of the spool 4. That is, the first row of the bonding wire 5 is guided onto the cylindrical body 7 of the spool 4 at an upward inclination, contacts at a location where the cylindrical body 7 and the flange 9 intersect, and the first row of the bonding wire is positionally aligned by the movable guide 2 and the intersection location of the cylindrical body 7. The movable guide 2

is located at a distance from the intersection location of the cylindrical body 7, and therefore in the case where tension is not applied to the bonding wire guided at the upward inclination, it is unfortunately wound onto the cylindrical body 7 at an unaltered angle. Therefore, for fine wires such as fishing line or motor coils, sufficient tension was applied to remove the sag in the wire.

On the other hand, bonding wires are for connecting semiconductor devices, and therefore mechanical properties such as elongation and tensile strength are modified beforehand by a final heat treatment. Therefore, in the case of a bonding wire modified beforehand as opposed to a fine wire such as fishing line or motor coils, upon applying excessive external forces higher than necessary from the exterior during winding onto the spool, bending or differing wire properties may result, and detrimental effects to the bonding wire properties may occur.

[0010]

Previous spools, as recited above, include a groove positioned tangentially to the winding surface of the cylindrical member (cylindrical body), and no particular measure/mechanism is provided at the transition portion from the flange to the cylindrical body. Therefore, upon attempting to positionally align the bonding wire onto the cylinder body without a sag as the bonding wire leaves the groove of the flange and transitions onto the cylindrical body, in the case where suitable tension cannot be applied, the bonding wire is stuck onto the cylindrical body in a hill-shape, and it is difficult to

provide a contact at a location on the intersection 10 (Fig. 2) of the outer circumferential face of the cylindrical body and an inner face of the flange. In particular, as bonding wire became finer, it became more difficult to apply excessive external force, and therefore the handling thereof had become difficult.

[0011]

Therefore, although normally the bonding wire of the second row should come adjacent to the bonding wire of the first row (winding), the bonding wire of the first row is curved in a hill-shape and is not adhered to the spool body, and therefore the bonding wire of the second row may go into the gap between the bonding wire of the first row and the spool body, and the arrangement of the bonding wire of the first row and the bonding wire of the second row may be reversed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a general schematic representation of an apparatus for winding a bonding wire onto a spool.

Fig. 2 is a schematic representation in which the bonding wire is inserted into a feed groove.

Fig. 3 is a schematic process-step exploded view illustrating winding process steps.

Fig. 4 is a conceptual view illustrating a cylindrical body of the spool of the present invention.

Fig. 5 is a conceptual view illustrating the bonding wire passing through a hoof-shaped groove of the spool of the present invention.

Description of the Reference Numerals

[0013]

- 1: Fixed guide
- 2: Movable guide
- 3: Guide clamp
- 4: Spool
- 5: Bonding wire
- 6: Grooved inlet
- 7: Cylindrical body (of the spool 4)
- 8: Guide groove (of the spool 4)
- 9, 9': Flange
- 10: Intersection (between the outer circumferential face of the cylindrical body and the inner face of the flange)
- 11: Grooveless inlet
- 12: Hoof-shaped groove
- 13: Securing clamp
- 14: Columnar portion

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0014]

In consideration of the problems recited above, the present

invention is directed to provide a spool having a groove capable of easily and reliably providing an initial winding beginning positional alignment of the bonding wire without an occurrence of a gap between the bonding wire of the first row and the spool body. In particular, the present invention has an object to provide a spool capable of winding without an intersection of the bonding wire of the first row and the bonding wire of the second row.

Means for Solving the Problem

[0015]

To accomplish the objects recited above, a bonding wire spool having a groove of the present invention comprises a cylindrical body and flanges extending at both sides of the cylindrical body and a guide groove extending from an outer circumferential edge of one of the flanges to the cylindrical body, characterized in that a hoof-shaped groove made by removing a recess extending from an intermediate portion of a cylinder surface of the cylindrical body toward an intersection with the flange is formed to connect with the guide groove.

[0016]

It is favorable for the hoof-shaped groove to have a maximum height from the flange surface in the axial direction of the cylinder larger than the diameter of the bonding wire. The reason therefore is that in the case of such a configuration: the bonding wire guided from an backward inclination reaches the hoof-shaped groove; the

progression direction is corrected; and it is even easier for a first row of the bonding wire to begin from the innermost layer of the cylindrical body. Moreover, a second row of the bonding wire reaches the hoof-shaped groove and then is lined up with the first row of the bonding wire, and therefore the first row and the second row of the bonding wire are wound to properly line up in an adjacently contacting configuration.

Hereinafter, similarly to conventional art, a first layer is wound onto the cylindrical body 7 from edge to edge with the bonding wire 5 at a prescribed tension while making the movable guide 2 traverse. This movement is repeated to wind multiple layers, and a bonding wire coil of the necessary length of about several hundred to several thousand meters is obtained.

Furthermore, it is favorable for the maximum depth of the hoof-shaped groove from the cylinder surface toward a center line to equal or exceed the diameter of the bonding wire. The reason therefore is that in the case of such a configuration, it is easier to wind along the cylindrical body and possible to wind stably.

[0017]

It is favorable for the spool to be made of an injection-molded thermoplastic resin. The reason therefore is ease of manufacture.

Furthermore, this is particularly suitable in the case where the bonding wire quality of the material is high-purity aluminum (Al) or aluminum (Al) alloy having a purity of at least 99.99% by mass.

Effect of the Invention

[0018]

Using the spool of the present invention enables winding to begin without any occurrence of gaps between the bonding wire of the first row and the cylindrical body, and therefore initial winding defects due to the sag of the bonding wire can be eliminated. Moreover, the bonding wire of the second row can be wound to line up in an adjacently contacting parallel configuration with the bonding wire of the first row, and therefore the bonding wires of the second row and the first row are not inverted.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0019]

Basic winding process steps using a spool of the present invention are once again briefly described with reference to Fig. 3.

Fig. 3(a) illustrates a state where the bonding wire 5, passing through the movable guide 2 and clamped by the guide clamp 3, is at a prescribed location on the exterior of the spool 4. Here, the securing clamp 13 on the exterior of the spool 4 is in an open state. Then, as illustrated in Fig. 3(b), the movable guide 2 and the guide clamp 3 move to place the bonding wire 5 onto the securing clamp 13. From this state, as illustrated in Fig. 3(c), the securing clamp 13 closes, and the tip of the bonding wire 5 is secured at the exterior of the spool 4. Then, as illustrated in Fig. 3(d), the guide clamp 3 releases the bonding wire 5, moves away from the spool 4, returns

to the original position, and stands by until the bonding wire finishes winding onto the spool.

[0020]

Then, as illustrated in Fig. 3(e), the movable guide 2 moves to an interior of the spool 4, after which the motor rotates the spool 4 until the bonding wire 5 goes into the guide groove 8 by way of the grooved inlet 6 of the spool 4. Then, from the state illustrated in Fig. 3(f) onward, the spool 4 is rotated while making the movable guide 2 traverse, winding is performed in multiple stages, and a bonding wire coil of the prescribed length is obtained.

Here, the configuration of the bonding wire 5 winding onto the cylindrical body 7 of the spool 4 in the process steps of Fig. 3(e) and Fig. 3(f) is further described in detail with reference to Fig. 4 and Fig. 5.

[0021]

Fig. 4 schematically illustrates the cylindrical body 7 of the spool 4 of the present invention, illustrating the cylindrical body 7 comprising a partially recessed columnar portion 14 of Fig. 4(a) and the hoof-shaped groove 12 illustrated in Fig. 4(b). Fig. 5 is a schematic view emphasizing the relationship of the hoof-shaped groove 12 and the guide groove 8 with the bonding wire 5.

According to the present invention, at least a portion of the hoof-shaped groove 12 of the cylindrical body 7 connects with the guide groove 8. Regarding the depth of the guide groove, similarly to conventional art, the groove depth even in its shallowest portion is

made greater than the maximum wire diameter of the wire being used, and the groove is made with a slope. Therefore, even when the bonding wire is wound in multiple stages, the bonding wire 5 inside the guide groove 8 passes through below the side face of the flange 9 and enters into the hoof-shaped groove 12 from backward along the slope of the guide groove 8. The bonding wire 5 reaches an inclined side wall defined by the removal from the columnar portion 14. The bonding wire 5 is made of soft metal fine wire, and a strong tension cannot be applied; and therefore it is necessary to prevent a sag in the bonding wire 5.

[0022]

However, the diameter of the bonding wire is as fine as 0.1 mm or less, and therefore the contact friction against the spool 4 becomes large; and additionally one end is held by the grooved inlet 6 of the spool 4 and the other end is held by the movable guide 2; and therefore a sag occurs easily therebetween. Therefore, it is favorable that the side wall of the columnar portion 14 is defined by removal in a curved shape, and it is desirable that the curve allows the bonding wire 5 rising from the backward inclination to contact the side wall of the columnar portion 14 over as large a surface area as possible, move downward and horizontally, and coil around the outer circumference of the cylindrical body 7.

As in the present invention, in the case where the side wall of the columnar portion 14 is formed, the bonding wire passing through below the flange side face exits above the side face of the flange 9

along the gradual slope surface of the flange 9; and because the bonding wire 5 is pulled by the guide clamp 3, the bonding wire 5 can contact the side wall of the columnar portion 14 and stick to the intersection 10 between the cylindrical body 7 of the spool 4 and the flange without a gap.

[0023]

Additionally, the bonding wire 5 of the second row is guided by the side wall of the columnar portion 14 and can stick adjacent to the bonding wire 5 of the first row without a gap.

Here, regarding the slope at which the bonding wire exits from an interior of the flange 9 to a surface of the flange, the inclination of the bonding wire is determined by the grooved inlet 6 of the spool 4 and the movable guide 2, and therefore having the bonding wire 5 placed as much as possible at the inclination angle prevents kinks in the bonding wire 5 and is therefore favorable.

On the other hand, in the case where the interior of the hoof-shaped groove 12 of the cylindrical body 7 is removed too deeply, the bonding wire 5 of the second row may then mistakenly move on top of the bonding wire 5 of the first row and remain so to form a second layer; and in the second layer the bonding wire 5 of the second row may mistakenly be wound with the bonding wire 5 of the first row.

EXAMPLE

[0024]

Example 1

The shape of a double-flanged spool was as follows.

The double-flanged spool was formed by a cylindrical body having an external diameter of 45 mm and a length of 25 mm, and flanges having external diameters of 90 mm; and one notch was made in each. A guide groove was made having a width and depth of 1 mm from a corner of one of the notches; a beginning point where one portion of the guide groove enters the cylindrical body was made as an entrance surface of a feed groove; and a completion spot where it exits from the cylindrical body was made as an apex of the feed groove. The maximum depth removed from the cylindrical body was 0.6 mm; the resulting height of the hoof-shaped groove was 0.2 mm; and the width of a surface of a flange notch was 0.15 mm.

A bonding wire made of Al - 1% by mass Si alloy and having a wire diameter of 0.2 mm was wound onto such double-flanged spools, and an inspection was made for initial winding defects. One hundred units of 500 m coils were fabricated, and there were zero winding defects.

[0025]

Comparative Example 1

A bonding wire similar to that of the example recited above was wound onto a double-flanged spool according to the Example 1, characterized in that no hoof-shaped groove was removed from the

cylindrical body and only the guide groove was made; and an inspection of initial winding defects showed gaps occurring horizontally between the bonding wire of the first row and the cylindrical body for all.

The Example 1 and the Comparative Example 1 above clearly demonstrate that the present invention made possible the elimination of initial winding defects of the bonding wire.

WHAT IS CLAIMED IS:

1. A bonding wire spool having a groove comprising a cylindrical body and flanges extending at both sides of the cylindrical body and a guide groove extending from an outer circumferential edge of one of the flanges to the cylindrical body, characterized in that a hoof-shaped groove made by removing a recess extending from an intermediate portion of a cylinder surface of the cylindrical body toward an intersection with the flange is formed to connect with the guide groove.
2. The bonding wire spool having a groove according to claim 1, wherein a maximum height of the hoof-shaped groove from the flange in an axial direction of the cylinder is larger than a diameter of a bonding wire.
3. The bonding wire spool having a groove according to claim 1, wherein a maximum depth of the hoof-shaped groove from the cylinder surface toward a center line is larger than a diameter of a bonding wire.
4. The bonding wire spool having a groove according to claim 1, made of an injection-molded thermoplastic resin.

5. The bonding wire spool having a groove according to claim 1, configured to wind a bonding wire made of one of high-purity aluminum (Al) or aluminum (Al) alloy having a purity of at least 99.99% by mass.