

[Document Name]

Specification

[Title of the Invention]

Winding Structure of Bonding Wire for Semiconductor Application

[Technical Field]

[0001]

The present invention relates to a winding structure of bonding wire wound on a spool and used for assembling semiconductor devices, etc.

[Background Technology]

[0002]

A bonding wire used for applications such as assembling semiconductor devices is wound around a cylindrical barrel of a spool as the main winding portion in a manner such that a length of several thousands of meters of wire is piled to a thickness of several tens of millimeters. In order to prevent the pile of the main winding portion from sliding to collapse a criss-cross winding structure (criss-cross winding structure portion 14), as shown in Fig. 3, is adopted, for example, wherein leftward progressing wire turns and rightward progressing wire turns are crossed each other as they are wound on the spool; according to this structure, a parallel-alignment winding portion (13) of a predetermined axial length is formed from the start-of-spooling end of the spool where the wires are not crossed, and the start-of-spooling end (11) of the wire (tail end when the coil is

despooled) and the end-of-spooling end (12) of the wire (head end when the coil is despooled) are fastened on an end face of the barrel or a flange (16) by means of a (temporary fastening) adhesive tape (15) so as to prevent the coil from sliding to collapse (ref. Publication-in-Patent 1).

[0003]

This wound body of wire - when in use, which is, after the spool is installed in a bonding device - has its head end freed, after removing the adhesive tape, and pulled out and employed as an earthing end, and has its tail end pulled out and set in a wire delivery conduit. Another method called a wire cut method is also adopted wherein the adhesive tape fastening the tail end of the wire on one of the flanges of the spool, etc. is not removed but the wire is cut free in the vicinity of the adhesive tape and the cut end is pulled out to be connected to the earth.

[0004]

The above-mentioned removal of the adhesive tape requires a very delicate work using a pair of tweezers, and on occasions either at the head end or the tail end of the wound wire, the bonding wire which is tensely fastened slips off from the tweezers while the adhesive tape is peeled off. On the other hand, in the case where the adhesive tape is not removed but the wire is cut and pulled out for use as the earthing end, the cut end of the tensed bonding wire can fly off the tweezers and the bonding wire can get loose. In the instance of the head end (which is the fore end upon wire spooling), its loosening does not affect the bonding wire in the main winding portion, but in the instance of the tail end (which is the rear end upon wire spooling) the loosening of the bonding wire at the tail end tends to cause that end to recede into the pile of wire wound round the barrel of the spool, or may cause a phenomenon so-called spring back, which is a loosening or entwining or both of the wire wound round the barrel of the spool

triggered by the cutting of the tensed bonding wire.

[0005]

In place of fastening the tail end of the wire on an end face of the barrel or a flange, a trial has been made, for example, of a bonding wire winding structure for semiconductor application, as shown in Fig. 4, wherein a lengthy material (18) for leading out the wire is connected to the end-of-spooling end (17) of the wire (ref. Publication-in-Patent 2). The reference numeral 19 denotes the flange. It is suggested that the lengthy material is preferably a semi-adhesive tape which releasably adheres to itself but does not adhere to other matters.

However, in this prior art, an additional item in the form of a semi-adhesive tape is required to be used and this increases the manufacturing cost as well as management cost. Also, it is feared that the semi-adhesive tape, which is not required in the bonding operation, may be drawn by mistake to be bonded together with the wire; furthermore, owing to the changes in the ambient temperature, there are occasions on which the time required to remove the semi-adhesive tape becomes unjustifiably long causing the lowering of the operation efficiency.

[0006]

A trial has also been made of a type of wire winding structure wherein alignment winding portions are provided one in the vicinity of each end of the main winding portion (ref. Publication-in-Patent 3). Fig. 5 shows an embodiment of this structure, wherein the main winding portion 21 consisting of a pile of wire having a trapezoidal profile resembling a Japanese traditional manner of piling rice bales (hereinafter "stepped pile" or so) is laid on the central portion of the spool 20 by means of criss-cross multi-layer winding, and the lead-end winding portion 22 and the tail-end winding portion 23 are wound parallel aligned

on the spool 20 at such locations that the main winding portion 21 comes between the portions 22 and 23, and each end of the wire is fastened on the flanges 25 by means of a terminal-fastening adhesive tape 24.

If the lead-end portion which is wound in parallel alignment is made to have a conventional wide winding pitch, as shown in Fig. 6 (a), and the wire cut method is adopted, the lead-end portion 22, upon cutting the bonding wire, would often undergo instant loosening, slipping and entwining - the so-called spring back phenomenon [ref. Figs 6(a) and 6(b)]. However, it is said that by aligning the bonding wire so closely that the neighboring wire parts are in tight contact with each other, the impact energy imparted to the bonding wire 26 upon cutting the same is allowed to be absorbed by and propagated to the neighboring wire parts [Fig. 6 (c)]. But this contrivance is not considered a perfect solution to the problem.

[Prior Publications]

[Publications in Patent]

[0007]

[Publication-in-Patent 1] Published utility model application
Showa 57-093144

[Publication-in-Patent 2] Published patent application
2000-277560

[Publication-in-Patent 3] Published patent application
2004-111449

[Summary of the Invention]

[The Problems the Invention seeks to solve]

[0008]

The present invention was made in view of the above-mentioned conventional circumstances, and it is an object of the invention to provide a winding structure of a bonding wire which does not allow the spring back phenomenon to take place when the lead-end portion of the bonding wire is accidentally slipped off the tweezers. Also, it is another object of the invention to propose a winding structure in which it is possible to tightly fasten the end-of-spooling end portion (lead portion) of the bonding wire by virtue of winding of the wire itself, without the necessity of twisting or bending the wire.

[Means to solve the Problems]

[0009]

In order to solve the above-mentioned problems, one of the embodiments of the winding structure of a bonding wire for semiconductor application according to the present invention is:

(a) a winding structure of a bonding wire for semiconductor application comprising a main winding portion formed of wire, to be used as the bonding wire, wound around the central portion of the cylindrical barrel of a spool, and an earthing portion formed of wire continuing from the end-of-spooling end of the wire of the main winding portion and wound around an end part of the cylindrical barrel of the spool, and a wire end portion formed of wire continuing from the earthing portion and fastened to a flange of the spool; wherein

the winding structure of the wire of the earthing portion is as a whole a one-layer winding structure consisting of the wire of a first winding quasi-layer and the wire of a second winding quasi-layer, the first winding quasi-layer being a plurality of

densely parallel-aligned wire turns wound on the spool barrel, and the wire of the second winding quasi-layer being a plurality of wire turns generally separated from each other, but some of the wire turns of the second winding quasi-layer being each laid highly closely between two neighboring parallel wire turns of the first winding quasi-layer.

[0010]

Also, another one of the embodiments of the winding structure of a bonding wire is:

(b) a winding structure of a bonding wire for semiconductor application comprising a main winding portion formed of wire, to be used as the bonding wire, wound around the central portion of the cylindrical barrel of a spool, and an earthing portion formed of wire continuing from the end-of-spooling end of the wire of the main winding portion and wound around an end part of the cylindrical barrel of the spool, and a wire end portion formed of wire continuing from the earthing portion and fastened to a flange of the spool; wherein

the winding structure of the wire of the earthing portion is as a whole a one-layer winding structure consisting of the wire of a first winding quasi-layer and the wire of a second winding quasi-layer, the wire of the first winding quasi-layer forming a main earthing section, which is a plurality of densely parallel-aligned wire turns wound on the spool barrel 4 in a manner so as to progress outwardly (away from the main winding portion), and an auxiliary earthing section, which is wound on the spool barrel in a manner so as to progress inwardly, the wire of the second winding quasi-layer being one or more wire turns generally separated from each other, but at least one of the wire turns of the second winding quasi-layer being laid highly closely between two neighboring parallel wire turns of the main earthing section.

[0011]

Also, some of the preferred embodiments of the winding structure of the bonding wire for semiconductor application according the present invention are as follows:

- (c) The bonding wire is made of a heat-treated metal filament.
- (d) The wire of the first winding quasi-layer wound to form the main earthing section is wound in such a manner as to progress away from the main winding portion.
- (e) One or more turns of the wire of the second winding quasi-layer wound over the main earthing section wound on the spool barrel 4 is each laid in between two neighboring parallel-aligned turns of the wire of the first quasi-layer wound on the spool barrel 4, in a manner such that the second winding quasi-layer wire is trapped by pressure between the wire turns of the first quasi-layer.
- (f) The wire of the first winding quasi-layer wound in the auxiliary earthing section is wound in a direction opposite to a direction in which the wire of the first winding quasi-layer wound in the main earthing section is wound.

[Effects of the Invention]

[0012]

According to the invention, the bonding wire of the main winding portion wound around the cylindrical barrel of a spool has its end-of-spooling end (or start-of-despooling end) connected to an earthing portion which is of a one layer construction consisting of a first winding quasi-layer wire and a second winding quasi-layer wire, wherein the wire of the second winding quasi-layer is a

plurality of wire turns generally separated from each other, of which some are each laid highly closely between two neighboring parallel wire turns of the first winding quasi-layer, which are parallel-aligned closely on the spool barrel 4, so that it is possible to avoid with certainty the spring back phenomenon which entails collapsing of the wire pile. Furthermore, by making the earthing portion to have a two-part structure consisting of a main earthing section and an auxiliary earthing section in series of this order, it is possible to prevent the spring back phenomenon and pile collapsing with even higher certainty.

[0013]

The other effects of the invention include:

- (i) If bonding operation is carried out with the wire sprung back (that is, the wire is loosened on the spool), the wire is entwined and the chances are the wire is snapped. However, by virtue of the fact that the wire is arranged to be wound in a highly closed alignment, whereby the frictional resistance owing to the wire contact is substantially high, the wire of the main earthing section does not slacken and no adversary phenomenon is incurred.
- (ii) The wire winding structure of the present invention can be applied irrespective of the winding length and the winding conditions of the main winding portion.
- (iii) Since the tension at the earthing portion is higher compared to the conventional wire winding structure, the frequency of slackening of the earthing portion during transportation is greatly minimized.
- (iv) Usually, when slackening of wire occurs, the slackened wire is unwound one turn after another with human hand before using the spool again, but this labor can now be done away with,

because of the highly closed alignment of the winding structure.

[Brief Description of Drawings]

[0014]

[Fig. 1] An explanatory partial view illustrating the important part of the first winding structure of the present invention.

[Fig. 2] An explanatory partial view illustrating the important part of the second winding structure of the present invention.

[Fig. 3] An explanatory view illustrating a conventional technology wherein the main winding portion of the bonding wire is of a criss-cross winding structure.

[Fig. 4] An explanatory view illustrating a conventional technology wherein the bonding wire winding structure for semiconductor application is such that a lengthy material for leading out the wire is connected to the end-of-spooling end (17) of the wire.

[Fig. 5] An explanatory view illustrating a conventional technology wherein the winding structure is such that an alignment winding portion is provided on each side of the main winding portion.

[Fig. 6] A set of explanatory views, illustrating the spring back phenomenon happening at the lead-end winding portion of the bonding wire, of which the view (a) illustrates an ordinary lead-end winding portion which is wound in parallel alignment having a wide winding pitch, and of which the view (b) illustrates the spring back phenomenon happening as the wire cut method is practiced in the scene of (a), and of which the view (c) illustrates the lead-end winding portion wherein the wire is closely aligned.

[Examples of embodying the Invention]

[0015]

Now, examples wherein the current invention is embodied will be explained in detail with reference to the drawings.

The first example of the winding structure according to the invention takes a structure wherein a plurality of turns of the wire constituting a first quasi-layer are aligned parallel to each other on the barrel of the spool, and some of the turns of the wire constituting a second quasi-layer are each aligned closely between parallel turns of the first quasi-layer wire while other turns of the second quasi-layer wire are not parallel to each other nor closely aligned together. The influence of the wire of the main winding portion being pulled away from the main winding portion can now be ignored thanks to the plurality of the wire turns of the first quasi-layer which are aligned parallel to each other. Also, some of the wire turns of the second quasi-layer are each aligned tightly between parallel wire turns of the first quasi-layer which are wound parallel to each other on the spool barrel, so that they form a highly tightly aligned quasi-belt structure; owing to this structure even when the bonding wire, which is fixed to a flange of the spool, drops from the tweezers, the bonding wire of the main winding portion is not loosened - however, for a safety's sake, it is preferable to wrap round the bonding wire with a number of turns of the second quasi-layer wire.

[0016]

As shown in Fig. 1, around that portion of the spool barrel 2 which extends between the flange 1 of the spool and the main winding portion (not shown) are wound in a manner so as to progress outwardly (leftwardly in Fig. 1) an appropriate number of turns (at least 4 turns are necessary, and preferably 10 - 15 turns) of wire of the first quasi-layer 3 in a manner such that they are

closely aligned in parallel with each other and that the end-of-spooling end of the first quasi-layer is brought back to the start-of-spooling position of the first quasi-layer 3 to commence the winding of the second quasi-layer 4 wherein a turn of the wire of the second quasi-layer 4 is pressed closely between a central turn of the first quasi-layer wire and a turn immediately ahead of it, and then one turn or several unaligned turns of the second quasi-layer are wound, and the end-of-the-spooling end is affixed to the flange 1 (it is also possible to affix the same end to the spool barrel 2) with a piece of adhesive tape 5. In place of affixing with the adhesive tape, it is possible to utilize a lengthy material (semi-adhesive tape), which is conventionally used for drawing out wire end.

The winding of the first quasi-layer is conducted in a manner such that the neighboring wire turns are aligned parallel and in contact with each other, and the winding of the second quasi-layer is conducted in a manner such that the winding tension is as high as or even higher than that in the case of winding the first quasi-layer, whereby each turn of the second quasi-layer is caused to intrude between neighboring turns of the first quasi-layer with a result of creating a densely aligned layer. (Incidentally, the tension of the second quasi-layer is twice as high as that of the main winding portion.) As the things are, such troublesome phenomena as spring back whereby the bonding wire is let loose are prevented with certainty. The winding tension for the second quasi-layer is not prescribed, but preferably it is comparable to or greater than the winding tension for the first quasi-layer. (Incidentally, the winding tension for the second quasi-layer is twice as great as that for the main winding portion.)

For the sake of convenience, the wire turns of the first quasi-layer are represented by thick black lines and those of the second quasi-layer by outlined grey lines.

In the second example of the winding structure, the earthing portion consists of two parts: one is a main earthing section and the other is an auxiliary earthing section which succeeds the former. By virtue of the fact that the auxiliary earthing section is provided in succession from the main earthing section, the force that pulls the wire of the main winding portion from the main winding portion is not felt by the auxiliary earthing section. Also, the force that pulls the wire of the auxiliary earthing section from the auxiliary earthing section is not felt by the terminal tape by virtue of an increased frictional resistance which results from the increased contact areas of the main earthing wire and the auxiliary earthing wire. Hence, it is possible to maintain the force of the frictional resistance of the wire of the main winding portion and the auxiliary earthing wire greater than the force by which the auxiliary earthing wire itself is unwound without the help of tweezers to hold the wire end after the terminal tape is peeled off. This frictional resistance becomes greater as the number of wire turns of the main earthing section is increased.

[0018]

As shown in Fig. 2, around that portion of the spool barrel 2 which extends in the vicinity of the flange 1 of the spool are wound, as the first quasi-layer, outwardly (leftwardly) progressing turns of the wire of the main earthing section 6, which are aligned closely, and inwardly progressing turns of the wire of the auxiliary earthing section 7. Then, the end-of-spooling end of the auxiliary earthing section is brought back to the main earthing section 6, and winding of the second quasi-layer starts as the wire is forced in between neighboring turns of the main earthing section 7 (between the central turn and a turn immediately ahead of it), and then one turn or several unaligned turns of the second quasi-layer 4 are wound with its end-of-spooling end affixed onto the flange 1 (alternatively onto the barrel 2 of the spool) with an adhesive tape. In a like manner as the first example of the

winding structure, the winding tension for the second quasi-layer 4 is as great as or even greater than that for the winding of the first quasi-layer. (Incidentally, the winding tension for the second quasi-layer is twice as great as that for the main winding portion).

By virtue of this winding structure, such troublesome phenomena as spring back whereby the bonding wire is let loose are prevented with more certainty.

It is needless to say that in either of these examples of the winding structure it is possible to provide a lead-end section (earthing portion) on both sides of the main winding portion.

[0019]

As the material for the bonding wire is selected from Au, Ag, Al, Cu, or an alloy of two or more of them, it is possible to control the number of wire turns and wire pitch depending on selection of the wire material. Incidentally, the above-mentioned frictional resistance may be had by the first quasi-layer wire, but it works in the horizontal direction as a compressing force along the entire length of the second quasi-layer so that the wire is free from gaining abnormality in its glossy appearance caused by scratches and dents.

[Example]

[0020]

First, a main winding portion was formed by winding on a cylindrical barrel of a spool, having a diameter of 50 mm and a length of 45.5 mm, an Au bonding wire for semiconductor application, each spool length consisting of 10,000 meters, having a diameter of 25 μ m and a purity of 99.99 mass % or higher (which had been heat-treated so as to have an elongation per cent

of 4%), in a manner of criss-cross multilayer winding technique, until 4,000 layers are laid.

In this spooling operation, the stepped piling technique was adopted wherein the width of the wire layer is constantly decreased as the height of the pile increases. The spooling condition was such that the width of the first wire layer was 40 mm, and the pitch width was 5 mm.

After forming the main winding portion as described above, the spooling was progressed toward the position where the main and the auxiliary earthing wire is to lead out, and thereby the main and the auxiliary earthing sections are formed. On this occasion, the manner in which the main earthing wire was wound was such that the tension for the main earthing wire was twice as great as that for the main winding portion, and the pitch width was 25 μ m in the case where the wire diameter was 25 μ m, and eleven turns of wire were spooled, each new turn increasing the distance from the main winding portion. The manner wherein the auxiliary earthing wire was wound was such that the tension for it was twice as great as that for the main winding portion, and six parallel turns of wire, each generally adjoining the neighboring ones closely, were spooled between the main earthing section and the main winding portion, each new turn shifting from the main winding portion toward the main earthing section. Next, two turns of the wire were spooled between the main earthing wire turns which, like the auxiliary earthing wire, were wound with a tension twice as great as that for the main winding portion, and then the wire end was affixed to a peripheral portion of a flange by a conventional fixing means using an adhesive tape.

[Comparative Example]

[0021]

Excepting that an auxiliary earthing section was not provided

and that a main earthing wire was spooled by 20 turns, each new one of which shifted away from a main winding portion, all other steps are followed in the same manner as in the Example until the wire terminal was affixed to a peripheral portion of a flange with an adhesive tape.

Ten of each of the spools of the Example and the Comparative Example, on which the wires (25 μm in diameter) were fastened as described above, were prepared and, each spool was submitted to the following experiment wherein, using tweezers, the wire was cut in the vicinity of the adhesive tape, and the number of wire turns which were unfastened from the barrel of the spool were counted and average number was calculated. Table 1 shows the result.

[0022]

Table 1

Table 1: Comparison in average number of wire turns unfastened		
Diameter of the bonding wire	Example	Comparative Example
25 μm	0.9 turns	9.8 turns

[0023]

As is clear from the above result, the spring back phenomenon in the case of the winding structure of the bonding wire for semiconductor application according to the present invention, is extraordinarily restricted compared to the conventional winding structure. Incidentally, the wires despoiled from the spools of the Example and the Comparative Example were both free of appearance abnormalities such as scar and irregular reflection, and no clogging occurred when the wires were set in the bonding

apparatus. Experiments were conducted also in the cases of the wire diameters of 20 μm and 30 μm , and the number of unfastened turns were less than one for the winding structure of the present invention.

[Explanation for reference numerals]

[0024]

- 1: flange
- 2: barrel of spool
- 3: first quasi-layer
- 4: second quasi-layer
- 5: tape
- 6: main earthing section
- 7: auxiliary earthing section
- 11: start-of-spooling end (of wire)
- 12: end-of-spooling end (of wire)
- 13: parallel-alignment winding portion
- 14: criss-cross winding structure portion
- 15: (temporary fastening) adhesive tape
- 16: flange (of spool)
- 17: end-of-spooling end
- 18: lengthy material for leading out the wire
- 19: flange
- 20: spool
- 21: main winding portion
- 22: lead-end winding portion
- 23: tail-end winding portion
- 24: terminal-fastening adhesive tape
- 25: flange
- 26: bonding wire

What is claims is:

1. A winding structure of a bonding wire for semiconductor application comprising a main winding portion formed of wire, to be used as the bonding wire, wound around the central portion of the cylindrical barrel of a spool, and an earthing portion formed of wire integrally continuing from the end-of-spooling end of the wire of the main winding portion and wound around an end part of the cylindrical barrel of the spool, and a wire end portion formed of wire integrally continuing from the earthing portion and fastened to a flange of the spool; wherein

the winding structure of the wire of the earthing portion is as a whole a one-layer winding structure consisting of the wire of a first winding quasi-layer and the wire of a second winding quasi-layer, the first winding quasi-layer being a plurality of densely parallel-aligned wire turns wound around the spool barrel, and the wire of the second winding quasi-layer constituting a plurality of wire turns generally separated from each other, but some of the wire turns of the second winding quasi-layer being each laid highly closely between two neighboring parallel wire turns of the first winding quasi-layer.

2. A winding structure of a bonding wire for semiconductor application comprising a main winding portion formed of wire, to be used as the bonding wire, wound around the central portion of the cylindrical barrel of a spool, and an earthing portion formed of wire integrally continuing from the end-of-spooling end of the wire of the main winding portion and wound around an end part of the cylindrical barrel of the spool, and a wire end portion formed of wire integrally continuing from the earthing portion and fastened to a flange of the spool; wherein

the winding structure of the wire of the earthing portion is as a whole a one-layer winding structure consisting of the wire of a first winding quasi-layer and the wire of a second winding quasi-layer, the wire of the first winding quasi-layer forming a main earthing section, which is a plurality of densely

parallel-aligned wire turns wound around the spool barrel in a manner so as to progress outwardly, and an auxiliary earthing section, which is wound around the spool barrel in a manner so as to progress inwardly, the wire of the second winding quasi-layer constituting one or more wire turns generally separated from each other, but at least one of the wire turns of the second winding quasi-layer being laid highly closely between two neighboring parallel wire turns of the main earthing section.

3. The winding structure of a bonding wire for semiconductor application as claimed in Claim 1 or 2, characterized in that the bonding wire is made of a heat-treated metal filament.

4. The winding structure of a bonding wire for semiconductor application as claimed in Claim 1 or 2, characterized in that the wire of the first winding quasi-layer wound to form the main earthing section is wound in such a manner as to progress away from the main winding portion.

5. The winding structure of a bonding wire for semiconductor application as claimed in Claim 1 or 2, characterized in that one or more turns of the wire of the second winding quasi-layer wound in the main earthing section, which is wound around the spool barrel, is each laid in between two neighboring parallel-aligned turns of the wire of the first quasi-layer wound around the spool barrel, in a manner such that the second winding quasi-layer wire is trapped by pressure between the wire turns of the first quasi-layer.

6. The winding structure of a bonding wire for semiconductor application as claimed in Claim 2, characterized in that the wire of the first winding quasi-layer wound in the auxiliary earthing section is wound in a direction opposite to a direction in which the wire of the first winding quasi-layer wound in the main earthing section is wound.