

SORTING METHOD OF BONDING WIRE AND MANAGEMENT METHOD OF DIAMOND DICE FOR BONDING WIRE

FIELD OF THE INVENTION

[0001]

The present invention relates to sorting method of bonding wire drawn by diamond dice and management method for bonding wire, especially relates to prospecting method of leaning defect at loop forming as bonding wire is bonded, and relates to sorting method of ellipse wire of bonding wire and also to management method of bearing part of diamond dice for the final drawing.

STATE OF THE ART

[0002]

Bonding wire is metallic wire bonded between semiconductor chips and lead frames in general, and is wired 3-dimensionally in semiconductor packages. Many kinds of metallic wire has been developed, basically it is representative as purity of more than 99.99 mass % of Au. It is used pure metal or alloy of Cu and/or Pd as bonding wire, especially, as precious metal wire has same characteristics as purity of more than 99.99 mass % of high purity Au, it has been used as alternative wire. Generally bonding wire is drawn continuously to 25 micrometers diameter as ultra fine wire by using a series of diamond dices. It is used to generate defects on the bonding wire manufactured thus manner after bonding. These defects are generated mainly at package plastic molding, they are flown with plastic and meandered and cut in general. These defects of bonding wire can be detected by using non-destructive X-ray penetration examination with appropriate image processing programs. For example, according to printed-paper of "Inspection of Bonding wire of Integrated Circuit" by Kimiya Aoki ("Non-destructive Inspection" Vol.53. No. 4. Page 192), inspected examples of meandered and cut of bonding wire are illustrated in the Fig 10 on page 195.

However, in recent years, the degree of integration of integrated circuit has been enhanced, it has been progressed to be finer pitch and finer wire simultaneously. Pitch space has been changed finer rapidly from 100 to 35 micrometers, wire has become finer from 30 to 15 micrometers. Consequently, new defects so called leaning defect become problem.

Where leaning defect is abnormal incline near at root of the first bond, after forming the first

bond by bonding a free air ball of bonding wire to an Al pad of semiconductor chip, when the wire fed by a capillary to form a loop (Cf. Fig: 10. Japanese Patent Application Laid-Open Publication No. 2004-146715). This leaning defect is generated in order for an adjacent wire interval to narrow and to approach too much. 35 micrometers of pitch intervals were quickly formed into the fine pitch from 100 micrometers, and the interval of wires has narrowed as fine pitchization advances. For this reason, when the interval of wires was broad, it had not been judged with leaning defect of slight inclination, and on the contrary, it has been increased judging with leaning defect as the consequence of narrower space.

It will be mentioned later that although an error of roundness of diamond dice manufacturing for fine wire does not decrease, but leaning defect mainly originates in wire shape, and slight error of wire shape generates leaning defect by the fine wire. Therefore it has been necessary to prevent generation of leaning defect by strictly managing shape of inner diameter (such as bearing part) of final diamond dice.

[0003]

Since above-mentioned leaning defect occurs after bonding and before package plastic molding, if it can be discovered in the stage immediately after manufacturing the bonding wire in front of bonding, as the defect of semiconductor equipment for bonding may decrease, it will become possible to lower manufacturing cost greatly. On cause of generation of leaning defect, there is Japanese Patent Application Laid-Open Publication No. 2000-146715 as precedence technical reference above mentioned. At the [0007] paragraph in this document, it is disclosed that "Using measuring equipment with high precision for cross-section of ultra fine wire, by measuring cross-section of ultra fine wire, the abnormal loop depicted in Fig. 1 is generated in the case of ellipse cross-section of ultra fine bonding wire or in the case of such distorted shape."

[0004]

The method, which is described "defect is defined as more than 3 % of deference of the maximum diameter and the minimum diameter about rectangular cross-section along wire direction of bonding wire after drawing "as a measure in the hereinbefore mentioned document, is available for managing life of diamond dice. However, it is not exactly available for leaning defect as generated at the first bonding. Certainly, if ultra fine wire is continuing carrying out drawing by diamond dice, orifice of diamond dice gets wear, it becomes larger, in certain circumstances, this wear of diamond dice is generated

unevenly along the whole circumference of the diamond dice orifice. Hence, the difference of the maximum diameter and the minimum diameter of ultra fine wire becomes greater gradually, and it may become exceed more than 3 %.

However, since the difference of the maximum diameter and the minimum diameter of the cross-section shape is generated with wear of diamond dice, before using diamond dice until exceeding 3 % of difference of the maximum diameter and the minimum diameter, the (mean) wire diameter may change to exceed allowance.

As opposed to this, it is necessary to strictly manage the wire (mean) diameter of bonding wire, in practical management of diamond dice life. In general, it is rare to exceed 2 % of wire diameter of difference of the maximum diameter and the minimum diameter.

On one hand, leaning defect is used to be generated in the case of less than 1 % of difference of the maximum diameter and the minimum diameter, to a contrary, there are bonding wires which had not been generated leaning defect in the case of more than 3 % difference of wire diameter.

This means that though there are not generated leaning defect even exceed these more than 1 % differences, on the aspect of quality control, threshold of allowance should be set less than 1 %, on the other hand, it also became producing a tremendous loss, such bonding wire, which may not be generated leaning defect, had been thrown away.

First of all, since the difference of the maximum diameter and the minimum diameter is a measured value of one part of the whole circumference of the bonding wire, it is not a measured value to show characteristics of a whole wire, it is difficult to distinguish from measurement error in some cases. Hence, it is not practical to get characteristics of a whole wire from the difference; its accuracy may become low extremely. Thus current method shown in such as the precedence technical reference does not resolve leaning defect, consequently it is impossible to manage bearing part of final drawing diamond dice too. Moreover, only by the difference of the maximum diameter and the minimum diameter in the whole circumference of the bonding wire, sorting ellipse shape wire and polygonal shape wire has not been attained as describe hereinafter.

[Patent reference] Japanese Patent Application Laid-Open Publication No. 2000-146715
 [Non-patent reference] "Non-destructive Inspection" Vol. 53 No. 4 Printing paper
 "Inspection of Bonding wire of Integrated Circuit" by Kimiya Aoki Fig. 10 on Page 195

DISCLOSURE OF INVENTION

ISSUES TO BE SOLVED BY THE PRESENT INVENTION

[0005]

The present invention provides basically in order to prevent generation of leaning defect at bonding process. Namely, the present invention was held by resolving uncertain cause, why leaning defect occur at forming loop as connecting bonding wire so far. The inventors of the present invention on the way to resolve, found that the value of divided the difference of the maximum diameter and the minimum diameter of which distorted cross-section shape wire including ellipse or the difference of the maximum diameter and the minimum diameter of wire by the wire diameter has proportional relationship to the ratio of second moment of area, confirmed that there is no proportional relationship in polygonal shape wire. By using the ratio of the second moment of area and the difference of the maximum diameter and the minimum diameter of wire, it is successful to solve the problem, which was not able to distinguish and sort out ellipse wire and polygonal wire so far. Moreover, the inventors of the present invention resolved that the cause of leaning defect is related to shape of cross-section of bonding wire, were successful to solve leaning defect problem by sorting bonding wires at the stage of before bonding. In addition, since it was found that leaning defect is related to shape of bearing portion of the final diamond dice through bonding wire, the inventors of the present invention resolved the method of solving leaning defect by managing the final diamond dice.

ISSUES TO BE SOLVED BY THE PRESENT INVENTION

[0006]

In order to solve the problem mentioned hereinbefore, sorting method of foreseeing before bonding of the present invention is as follows:

- (a) On the process of sorting method of leaning defect of bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames.
 - 1) Process of measuring diameter of bonding wire, which divided imperceptibly the whole circumference of the bonding wire before bonding;
 - 2) Process of calculating each second moment of area by integration of each imperceptible part along axis direction using the value of diameter of the bonding wire;

- 3) Moreover, process of comparing the maximum value of the second moment of area calculated with the minimum value of the second moment of area calculated.

Sorting Method of judging leaning defect of bonding wire consists of above-mentioned sorting sequences at forming loop of the bonding wire bonded.

- (b) On the process of sorting method of uneven cross-section wire and ellipse cross-section wire on bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames.

- 1) Process of measuring diameter of bonding wire, which divided imperceptibly the whole circumference of the bonding wire before bonding;
- 2) Process of calculating each second moment of area by integration of each imperceptible part along axis direction using the value of diameter of the bonding wire;
- 3) Process of calculating maximum value of wire diameter and the minimum value of that from the said measured values, and the maximum value of the second moment of area and the minimum value of that at the said whole circumference of the bonding wire along axis direction;
- 4) Process of comparing with difference of the maximum value of wire diameter and the minimum value of that as plotting x-coordinates, and difference of the maximum value of the second moment of area and the minimum value of that as plotting y-coordinates.

Sorting Method of judging leaning defect of bonding wire consists of said sorting sequences at forming loop of bonding wire bonded.

- (c) Management Method of diamond dice for bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames.

- 1) Process of measuring diameter of bonding wire, which divided imperceptibly the whole circumference of the bonding wire after diamond dice drawing;
- 2) Process of calculating each second moment of area along is direction by integration of each imperceptible part along said direction using the value of diameter of the wire;
- 3) Moreover, by process of comparing the maximum value of the second moment of area calculated with the minimum value of the second moment of area calculated.

Management Method of judging quality of bearing part of diamond dice used for the final drawing bonding wire, managing under appropriate condition, consists of said management sequences.

- (d) Management Method of diamond dice for bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames.
 - 1) Process of measuring diameter of bonding wire, which divided imperceptibly the whole circumference of the bonding wire after diamond dice drawing;
 - 2) Process of calculating each second moment of area along axis direction by integration of each imperceptible part along said direction using the value of diameter of the wire;
 - 3) Process of calculating the maximum value of wire diameter and the minimum value of that and the maximum value of the second moment of area and the minimum value of that from the said measured values;
 - 4) Process of calculating the difference of the maximum value of wire and the minimum value of that and the difference of the maximum value of the second moment of area and the minimum value of that;
 - 5) Moreover, process of comparing difference of the maximum value and the minimum value of wire diameter plotting as x-coordinates, with difference of the maximum value of the second moment of area and the minimum value of that plotting as y-coordinates.

Management Method of judging quality of bearing part of diamond dice used for the final drawing of bonding wire, managing under appropriate condition, consists of said management sequences.

[0007]

Moreover, concrete requirements are as follows:

- (e) Sorting method foreseeing the quality of said bonding wire mentioned hereinbefore in (a) and (b) by featured evaluating the ratio of second moment of area when difference of the maximum value and the minimum value divided by the maximum value or the minimum value comparing the maximum value with the minimum value of the said N order moment of area.
- (f) Management method of diamond dice mentioned hereinbefore in (c) and (d) by featured evaluating the ratio of second moment of area when difference of the maximum value and the minimum value divided by the maximum value or the minimum value comparing the maximum value with the minimum value of the said N order moment of area.

[0008]

First of all, relationship of leaning defect and the present invention is described. When the first bond is formed on the semiconductor chip by bonding after forming molten ball at the tip of bonding wire, plastic strain of the tip part of bonding wire is released by drawing, the part of unaffected heat remains plastic strain as it is. The boundary of the part unaffected heat and affected heat is weak on mechanical strength, it becomes to be a part which is easy to bend, wire the capillary is moving upward after the first bond forming, since bonding wire has not any bending stress, all bonding wires stand upright. However, as soon as the capillary starts to move and to draw loop from the first bond to the second bond, bonding wire is affected bending stress, and this bending stress concentrate to the said boundary of heat affected part, and this boundary bends. The inventors of the present invention confirmed this phenomenon using a high-speed camera. In other words, while drawing a loop from the first bond to the second bond direction by a capillary, the bonding wire is constrained and the bonding wire receives stress of the direction from the first bond to the second bond. There is a boundary affected heat slightly upper portion from the root of the first bond of bonding wire, and the portion receives strong bending stress. The loop bends at the timing of receiving very exceeded force to the weakest portion of wire material while progressing from the first bond to the place of largely bended by the capillary. This bend of wire is bending in different direction from the track of the capillary, namely, it is considered what is varied is principal phenomenon of leaning defect.

[0009]

The inventors of the present invention ascertained that factor of bending of the different direction (is varied) from the track of the capillary is caused to N order moment of area of unevenness of wire shape. Namely, it is successful to evaluate unevenness of wire cross-section shape affected to the mechanical characteristics, presenting the whole circumference characteristics of the wire cross-section shape by N order moment of area. It is explained N order moment of area by using representative second moment of area hereinafter.

In general, when wire is bended, easiness and difficulty of bending comes from physical characteristics caused to a section shape of wire. In the case of ultra fine wire of the diameter less than 25 micrometers manufactured by drawing using the final diamond dice, a bearing part of diamond dice had been presumed as a true circle because of less than 1 % of difference of the maximum diameter and the minimum diameter so far, the

inventors of the present invention enlarged this true circle portion presumed and have considered that it consists of multi size arcs.

Evaluating the cross-section by these different size arcs, it has been able to classify into two kinds of shape, which had been presumed as a true circle portion. One is an ellipse shape (where, the difference of the maximum diameter and the minimum diameter is less than 1 %.), and the other is a polygonal shape (where, the difference of the maximum diameter and the minimum diameter is less than 1 %.). Moreover, it was found that case of ellipse shape occurs leaning defect and case of polygonal shape generates glittering diffused reflection. It was found that second moment of area is effect to distinguish case of ellipse and case of polygon.

While the inventors of the present invention investigated details of many bonding results of ellipse shape bonding wire, in the case of stressing side direction to bonding wire by capillary, it was found that lean from vertical direction centered the first bond of bonding wire corresponds to a normal distribution. It was found that the more ellipse shape trend becomes strong, the more width of this normal distribution trends broader. What the width of normal distribution becomes wider indicates that lean of bonding wire becomes larger and lean which has more than certain value becomes leaning defect.

The inventors of the present invention thought that size of leaning defect should represent by second moment of area originated section shape of bonding wire. Hence, it is possible to predict difficulty of the bend, if second moment of area was measured precisely along each direction of divided imperceptibly to multiple directions of the bonding wire cross-section before bonding. Then the inventors of the present invention have succeeded predicting leaning defect after the first bond of bonding wire by calculating the maximum value of second moment of area and minimum value of that from the measured values of measuring multi directions along the whole circumference. Lean of wire bonded the first bond is represented as a normal distribution. It is preferable to compare the ratio divided the maximum value or the minimum value with comparison of quality of leaning defect and the maximum value of second moment of area and the minimum value of that. In addition, since it is drawn formable ultra fine wire such as high purity Au by using diamond dice, second moment of area of length direction of bonding wire can be handled that it has same trend along length direction of ultra fine wire reflected shape of bearing part of the final diamond dice.

Where, second moment of area is physical-properties value related to bending stress of wire material, it is considered that in the case of first moment of area or third moment of area, handling as dynamic moment, it shows same trend as second moment of area.

[0010]

To the next, sorting method of ellipse wire causing leaning defect and polygonal wire being not as cause is explained hereinafter.

In sorting method of ellipse wire on the above-mentioned precedence technology, it was comparing the maximum value of wire diameter with the minimum value, measured value of the diameter of wire by laser diffraction is gotten from diffraction pattern at measuring point, it does not indicate cross-section shape exactly, these differences may show ellipse and just only show difference of edge and neighborhood.

The inventors of the present invention resolved that evaluation method by N order moment of area is effective, as distinguishing method polygonal wire from uneven shape including ellipse, since cause of leaning defect is considered as unevenness of cross-section, or anisotropy of mechanical property originated distorted cross-section including ellipse.

When deformation of polygonal wire becomes large, it is used to become defect of appearance so called Gira (glittering). Gira means wire, which is glittering by diffused reflection. This phenomenon is generated because of uneven surface of wire when light reflected at bonding wire. Namely, cross-section of wire is not true circle, it cause of polytonality. However, method of sorting to distinguish ellipse wire and polygonal wire has not been found so far. The inventors of the present invention have succeeded quantification of ellipse wire, distinguishing ellipse wire and polygonal wire by comparing ratio value divided the maximum value of wire diameter and the minimum value of that of second moment of area or the maximum value of wire diameter and the minimum value of that divided by wire diameter. In addition, even here, it is considered that in the case of first moment of area or third moment of area, evaluating unevenness of mechanical property originated cross-section of wire, it shows same trend as second moment of area.

EFFECTS OF THE PRESENT INVENTION

[0011]

Effects of the present invention is solving leaning defect by sorting bonding wire before bonding stage. Moreover, it has been able to solve leaning defect now by quantification of ellipse wire. What's more, it has been able to solve leaning defect by managing of the final drawing diamond dice consequently, since surface morphology of bonding wire is related to shape of bearing part of the final drawing diamond dice.

DESCRIPTION OF THE MOST PREFERRED EMBODIMENT

[0012]

Metallic wire used for bonding wire is preferable Au wire which has purity of more than 99.99 mass % in the present invention. It is because it is soft, so the shape of the bearing part of the diamond dice by which drawing-out processing is carried out is reflected in profile of bonding wire as it is. From the same reason, it can be use high purity Cu and soft precious metal alloy, for instance, Au-15 mass % Ag alloy, Au-1 mass % Pd alloy, or these metal and alloy with partial additive elements such as Ca, Be, In, Sn and rare earth metals.

[0013]

There is no restriction in the present invention if the wire diameter is less than 30 micrometers, it is preferable the range of 10 - 25 micrometers. Leaning defect is generated in fine pitch area, and it is because a fine wire is generally used.

EMBODIMENT OF THE PRESENT INVENTION

[Example No. 1]

[0014]

High purity Au of 99.99 mass %, compounding with certain amount of partial additive elements to high purity Au of 99.999 mass % was prepared. This alloy was melted and was cast in vacuum furnace and was drawn into wire. Where the final wire diameter is 23 micrometers, preparing 6 kinds of diamond dice, which have different orifice (each nominal diameter is 23 micrometers), 6 kinds of ultra fine wire were formed, and then final heat-treatment was done to them. Diameter of these 6 kinds of wire was measured by diameter measuring instrument using laser diffraction. As such diameter measuring instrument can be used like digital measuring instrument (LS-7000) from KEYENCE CORPORATION, Laser Micro Gauge D5 from Tokyo Opto-electronics Co. Ltd. and

LDSN-200 from CERSA.

Measured results of 6 kinds of wire are shown as plotted from A to F in Fig. 1. And enlarged cross-sections of direction of radius of wire section are shown designated as A to F in Fig. 2. Plot A to F in Fig. 1 are corresponding with A to F in Fig. 2. Where ovality is defined as "value divided difference of the maximum diameter of wire and the minimum diameter of that by wire diameter (%)", or $100 \times ((\text{the maximum value of bonding wire diameter}) - (\text{the minimum value of bonding wire diameter}) / (\text{nominal bonding wire diameter}))$, and "ratio of second moment of area (%)" is defined as $100 \times ((\text{the maximum value} - \text{the minimum value}) / (\text{the maximum value}))$ getting the maximum value and the minimum value from 16 segments measured by stepping of 11.25 degrees against a semi circumference or 180 degrees.

Second moment of area is obtained as follows:

Dividing cross-section of wire into 16 segments evenly by 11.25 degrees step of a semi circumference shown in Fig. 3, measuring diameter for each segment of circumference, radius is calculated.

Corresponding to each radius of segments from measured radius shown in Fig. 4, y of height to x-axis and width projected to x-axis are given from each $r \sin \theta$ and $r \cos \theta$. On a concrete target, y of height is gotten from measured value of θ , measured at middle point of segment of circumference, or approximating mean value calculated from 0 divided imperceptibly the circumference and value of r, x of width is gotten as the width of its segment calculating each value of x from subtraction among the value of r and θ , measured back and forth of these segments of circumference.

Representing cross-sections approximated to rectangular from x value and y value for each circumference segment given in such manner is shown in Fig. 5. Doing in this way, second moment of area as wire section can be gotten from integrating each approximated second moment of area of segment. Doing in the same way, one by one to correspond to number of division or 16, shifting by a unit of 11.25 degrees, second moment of area is given for each direction of a same circumference.

In the explanation above-mentioned, dividing wire section evenly, by each direction of radius, approximating rectangular, second moment of area of wire section is calculated

as summation of second moment of area of each rectangular, these might be value of integration on the x-y coordinates as second moment of area of wire section.

This number of division is not definite 16, because it is not reflected to accurate cross-section while divided space is larger, it is preferable to measure by dividing more than 16 in general.

Moreover, a deep solid line and a thin solid line in Fig. 2 represent a semi circle shape of wire section, this figure shows 2 times measurement results at same measuring point apart 10 meters each other along the length direction. A small square shown in the center of bottom line depicts a center of wire section.

Comparing measured results of 6 kinds of wire diameter as in A to F in Fig.1 with referring cross-sections as in A to F in Fig. 2 enlarged radius direction of wire section.

- (1) Plot A in Fig. 1 has the value less than "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" and also "the ratio of second moment of area", it is the shape near a true circle from as in A in Fig. 2.
- (2) Plot C and F in Fig. 1 have increased: value from the value of "the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" and also "the ratio of second moment of area", it can be confirmed that these are the shape near ellipse from as in C and F in Fig. 2.
- (3) On the other hand, though plot B, plot D and E in Fig. 1 have increased value of "the value of the difference of the maximum value and the minimum value divided by wire diameter (%)", but the increases of "the ratio of second moment of area" are small, then these are the shape of near polygon.

Therefore, from the relationship of plotting (1) to (3), by the size of "second moment of area" or "the ratio of second moment of area", it is discriminable ellipse wire and polygonal wire.

[Example No. 2]

[0015]

As in the same way of the [Example No. 1], the final wire diameter is 25 micrometers, using 6 kinds of diamond dice (each nominal diameter is 25 micrometers), 6 kinds of ultra fine wire were formed, then final heat-treatment was done to them.

Measured result of the 6 kinds of wire diameter is shown plotting as in G to L in Fig. 6. Moreover, section shapes enlarged along radius direction of wire section are shown as in G to L in Fig. 7. Plot G to L in Fig. 6 correspond to plot G to L in Fig. 7. Where, a deep solid line shows an estimated semi circle shape of wire section from wire diameter measured value at cross-section shape in Fig. 7 and, a thin solid line shows a semi circle shape at the time of assuming that it is a true circle.

A small square shown in the center of bottom line depicts a center of wire section. It is clear from comparison plot G to L in Fig. 6 and representing its cross-section of plot G to L in Fig. 7, K and L of ellipse wire shape has correlation between "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" and "the ratio of second moment of area", in the case of H, I and J of polygonal wire shape, even if "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" increases, "the ratio of second moment of area" is low, and it turns out among these that there is no correlation. According to the results of [Example No. 1] and [Example No. 2], it turns out that ellipse wire and polygonal wire can be identified and it is not dependent on especially the difference of measured value of wire diameter with correlation of "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" and "the ratio of second moment of area".

[Example No. 3]

[0016]

To the next, using the 6 kinds of wire in [Example No. 2], using the wire bonder (UTC-400 type) from Shinkawa Co. Ltd., in the air, molten ball (38 micrometers ball diameter) is formed at 0.5 msec discharge time, at 45 micrometers compressed diameter on pure Al pad of 100 micrometers square, at predetermined loop conditions (300 micrometers height, 4 mm length), when 10,000 times of bonding were carried out, leaning defect shown in Fig.10 occurred.

Result of this leaning defect (number of wire) is shown in Fig. 8 and Fig. 9 as correlation of "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" and "the ratio of second moment of area".

From Fig. 8, although correlation of "leaning defect (number of wire)" and "the value of the difference of the maximum value and the minimum value divided by wire diameter (%)" is low as 0.64, correlation of "leaning defect (number of wire)" and "the ratio of second moment of area" in Fig. 9 is high as 0.94, it turns out that it is mostly distributed in the shape of a straight line.

Therefore, it is limited to ellipse shape wire that leaning defect occurs, and in order to identify ellipse shape wire, "the ratio of second moment of area" is an indispensable condition.

Namely, though "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)" is higher value of like 3 %, if "the ratio of second moment of area" is lower value, leaning defect does not occur, and in fact, such many wires have been identified.

Hence, it is not able to predict leaning defect from "the value of the difference of the maximum value and the minimum value divided by the nominal wire diameter (%)", and it is not able to sort bonding wires. Moreover, it is not able to manage the final drawing diamond dice too.

Namely, it becomes to be possible to manage leaning defect by the method of identifying the final drawing diamond dice and wire, as management value of "the ratio of second moment of area". Since leaning defect varies by wire diameter used, kinds of packaging, and bonding conditions, it is not easy to define a solid value of "the ratio of second moment of area", it is considered that it is possible to control extreme leaning defect by managing less than 1 % of it shown in Fig.9.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

[Fig. 1] Example shows relationship of the ratio of second moment of area and the value of the difference of the maximum value and the minimum value divided by wire diameter.

[Fig. 2] A to F: Examples show 30 times enlarged cross-section from actual measurement value of only radius direction intersecting perpendicularly with the circumference.

[Fig. 3] Example of schematic diagram shows circumference portion divided into 16.

[Fig. 4] Schematic diagram for calculating height and width of circumference from radius r measured evenly dividing wire section.

[Fig. 5] Schematic and interpreting diagram for calculating approximate value of second moment of area approximated wire section to rectangular.

[Fig. 6] Example shows relationship second moment of area and value divided difference of the maximum diameter of wire and the minimum diameter of that by wire diameter (Ovality).

[Fig. 7] G to L: Examples show 30 times enlarged cross-section from actual measurement value of only radius direction intersecting perpendicularly with the circumference.

[Fig. 8] Example shows relationship difference of the maximum diameter and the minimum diameter and leaning defect.

[Fig. 9] Example of the present invention shows relationship second moment of area and leaning defect.

[Fig. 10] Drawing which looked at leaning defect generated in the case of forming loop of bonding wire from right above.

CLAIMS :

What is claimed is :

1. On the process of sorting method of leaning defect in bonding wires which bond 3-dimensionally between terminals such as semiconductor chips and lead frames, and the sorting method of bonding wire in order to judge leaning defect at loop forming comprises of the following sequential processes:

- 1) Diameter measuring process of bonding wires, which divided into small segments of the whole circumference of the bonding wires before bonding.
- 2) Process of each second moment of area calculation by integrating each divided segment along axis direction using the measured value of diameter of bonding wire.
- 3) Comparison process between the maximum and minimum value of the second moment of area.

2. On the process of sorting method of leaning defect of bonding wires which bond 3-dimensionally between terminals such as semiconductor chips and lead frames, and the sorting method of bonding wire in order to judge leaning defect at loop forming comprises of the following sequential processes:

- 1) Process of measuring diameter of bonding wire, which divided into small segments of the whole circumference of the bonding wire before bonding.
- 2) Process of calculating each second moment of area integrating each said small segment along axis direction using the said value of diameter of bonding wire.
- 3) Process of calculation of the maximum and minimum value of diameter at the circumference from the measured values, and the maximum and minimum value of second moment of area for which each divided axis direction at the circumference part.
- 4) Process of subtraction on the maximum and minimum value of wire diameter and the maximum and minimum value of second moment of area.
- 5) Process of comparing difference between the maximum and minimum value of diameter as plotting x-coordinates, and difference between the maximum and minimum value of second moment of area as plotting y-coordinates.

3. Sorting method of bonding wire, wherein said in claim 1 and/or claim 2, the method comprising:

On comparing with the maximum and minimum value of second moment of area, using the evaluation method by the ratio of second moment of area, which is calculated from the difference between the maximum and the minimum value of second moment of area is divided by either the maximum or minimum value of second moment of area.

4. On management method of diamond dice for bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames, and management method of bearing part of diamond dice to be used for the final drawing of bonding wire, which quality to be judged by the following sequential management processes:

- 1) Process of measuring wire diameter of divided circumference, which divided into small segments of the whole circumference of the bonding wire after diamond dice drawing.
- 2) Process of calculating each second moment of area integrating each small segment along the axis direction using the value of wire diameter.
- 3) Process of comparison between the maximum and minimum value of the second moment of area.

5. On management method of diamond dice for bonding wire which bonds 3-dimensionally between terminals such as semiconductor chips and lead frames, and management method of bearing part of diamond dice to be used for the final drawing, and judging quality of bonding wire by the following sequential management processes:

- 1) Process of measuring diameter of bonding wire, which divided into small segments of the whole circumference of the bonding wire after diamond dice drawing.
- 2) Process of calculating each second moment of area in the said direction, integrating each small segment along the axis direction using the measured values of wire diameter.
- 3) Process of calculating the maximum and minimum value of wire diameter and the maximum and minimum value of second moment of area at the said circumference part from those measured values.

- 4) Process of calculating difference of the maximum and minimum value of wire diameter and the difference of the maximum and minimum value of the second moment.
- 5) Moreover, process of comparing with difference between the maximum and minimum value of wire diameter as plotting x-coordinates, and difference between the maximum and minimum value of the second moment of area as plotting y-coordinates.

6. Management method of diamond dice for bonding wire, featured wherein said in claim 4 and/or claim 5, comprising of:

Evaluation by the ratio of second moment of area, which is calculated from the difference between the maximum and minimum value of second moment of area is divided by either the maximum or minimum value of second moment of area.