

TITLE OF THE INVENTION

High strength and high elongation ratio of Au alloy bonding wire

TECHNICAL FIELD

[0001]

The present invention relates to appropriate Au alloy bonding wire connecting between electrodes of IC chips and outer leads of substrates using for semi-conductor devices. Especially, it is used for high temperature conditions such as for in-vehicle devices and high speed devices.

BACKGROUND TECHNOLOGY

[0002]

Conventionally Au wire of the purity 99.99 mass % or higher has been widely used. This Au wire is added the small amount of other metallic elements into high purity Au, and it is excellent in reliability as the Au wire which connects outer leads with an IC chip electrodes of semiconductor devices. The one terminal of these Au wires are bonded to pure Al pads and to Al alloy pads on IC chip electrodes by ultrasonic thermal compression bonding method, and the other terminal of these Au wires are bonded to the outer leads on the substrates, then they become semiconductor devices by resin seal method. Conventionally these Al alloy pads are formed by vacuum deposition, and Al – Cu alloy, Al – Si alloy and Al – Si – Cu alloy are general.

[0003]

However, when resin sealed semiconductors are used for in-vehicle ICs required high reliability under high temperature and severe conditions and are used for high operating temperature of high frequency ICs, voids so called Kirkendall Voids and clucks, or corrossions by halogen component in the seal resin, are generated, consequently it may cause increase resistance and decrease bonding strength at bonding boundary between Al pads and Al alloy pads and pure Al wires. Therefore, it has been requested to secure the high bonding reliability (sustainability of the resistance value and bonding strength at bonding boundary of ball bonding under certain environment) more than before, and a bonding wire of Au – 1 mass % Pd alloy has been used.

This Au – Pd alloy wire can be inhibited by Pd that Au diffuse over whole Al pad at Al alloy pad and pure Au wire boundary under high temperature conditions, formation of inter-metallic compound of Au_4Al , which is easily affected corrosion by halogen component at bonding boundary, can be restrained relatively, so it has advantage of suppress degradation in a bonding portion at Al alloy pad and between Al alloy pad and Au alloy wire, and also it has advantage of decrease of bonding strength. Though this Au – 1 mass % Pd alloy wire has superior of mechanical characteristic comparing with the purity of 99.99 mass % or higher Au, it has higher specific electrical resistance value of bonding wire as electrical characteristic. For instance, the specific electrical resistance value of purity of 99.99 mass % or higher Au wire is $2.3 \mu\Omega \cdot \text{cm}$, on the contrary, one of Au – 1 mass % Pd alloy is $3.0 \mu\Omega \cdot \text{cm}$. Therefore, malfunction of device and disconnect may occur by heat generation of wire, and anxiety of delay of response speed of signals increases under high density implementation. Thinning from $25 \mu\text{m}$ to $15 \mu\text{m}$ of bonding wire diameter, this trend is more intensified. Though detail mechanism is still unknown, in the case of Au – 1 mass % Pd alloy, promotion of unexpected oxidization of Al occurs at bonding boundary because of existence of Pd. For instance, bonding wire of Au – 1 mass % Pd alloy without resin seal may become weaker than the purity of 99.99 mass % or higher Au bonding wire with trace additive elements because of generation of more amount of Al oxidization Al_2O_3 under high temperature test in the Air.

[0004]

The idea using alloying Ag, which forms all proportional solid solution into Au as bonding wire, is previously well known in the Japanese Unexamined Patent Application Publication No. Sho 52-51867 and in the Japanese Unexamined Patent Application Publication No. Sho 64-87734. Then it had been considered and tried to apply Au alloy added trace Ag adding Ca and La, which are known as trace additive elements enhancing mechanical strength against the purity of 99.99 mass % or higher Au. This is a semiconductor bonding wire, which is aimed to get as almost same specific electrical resistance value as it of the purity of around 99.99 mass % Au wire, alloying 0.06 – 0.95 mass % Ag, which forms all proportional solid solution with Au, and alloying of 0.001 – 0.005 mass % of Ca, Y and more than one element of rare-earth elements (Reference

Patent 1 described later). This bonding wire is Au alloy which contains 0.05 – 0.95 mass % of Ag, 0.0001 – 0.005 mass % of Ca, Y and more than one element among rare-earth elements, and residual is Au and inevitable impurities. This bonding wire aims to provide a semiconductor Au alloy wire, which has high strength, and inhibiting increase of specific electrical resistance without loop deformation (Paragraph 10 of Reference Patent 1).

[0005]

However, a bonding wire of former Au alloy followed almost same method for measurement of the mechanical property in Au bonding wire, which is the purity of 99.99 mass % or higher Au, and the breaking strength was measured at the range of 4 – 8 % of elongation. The relation between elongation and stress of bonding wire is evaluated by tensile test. The maximum stress value until a bonding wire fractures at measurement, the tensile strength is defined as the tensile strength (the breaking strength), and the elongation is called as tensile elongation at break. The greater tensile strength is the smaller tensile elongation as mechanical characteristics, there is an inverse tendency in general. When this tensile strength is made greater, the tensile elongation at break decreases and becomes easy to break. On the other hand the tensile elongation is made greater, tensile strength and stiffness of the bonding wire decreases and easy to generate flaw of leanings and wire flows. Therefore, from the aspect of balance of these mechanical characteristics, the value of around 4 % of elongation rate is usually adopted (Reference Patent 2). However, on relation of heat-treatment temperature, which relates such mechanical characteristics, the tensile strength curve, which is decreased with a rise of heat-treatment temperature and the tensile elongation rate curve, which is increased inversely, are crossing in this range. In the case of high purity 99.99 mass % or higher Au bonding wire, this tendency does not have big change though there is a range of heat-treatment condition at around 4 % elongation ratio, because elongation ratio is high primarily, moreover inclination of the curve shown elongation at break around 4 % and inclination of the curve shown break strength are gradual.

On the other hand, in the case of lower purity of Au alloy with high contents of additive elements, it is high strength in general, break strength is high and elongation ratio is

small. In order to get balance, increasing elongation ratio and decreasing break strength within the appropriate range by heat-treatment, it becomes very difficult to take balance of both values, when increasing elongation ratio by rising up heat-treatment temperature, the elongation ratio steeply goes up at around 4 % elongation ratio and break strength goes down steeply.

These relations are shown conceptually in Fig 3 (A) and (B) as a schematic diagram. High purity Au wire has gradual inclination curve shown the change of elongation ratio and break strength at heat-treatment temperature around 4 % elongation ratio, it has broader tolerance against change of heat-treatment temperature, and range of change in elongation ratio is small against width of heat-treatment range in the figure (width of change on break strength is also small), it is easy to condition break strength based on the elongation ratio.

On the other hand, as improved strength alloy wire with strengthen elements has steep inclination curve about elongation ratio and break strength against change of heat-treatment temperature, width of elongation ratio change (also width of break strength change) is greatly expanded against width of heat-treatment temperature range shown in (B), these values become largely change against slight change of heat-treatment temperature.

Therefore, imitating conventional heat-treatment based on around 4 % elongation ratio, in order to acquire balance between elongation ratio and strength or stiffness of these alloy wires, setting 5 – 10 and several % elongation ratio corresponding to these strength, change of elongation ratio corresponded change of temperature and curve of wire strength change are crossing steeply at the range of heat-treatment temperature range, it is difficult to set and maintain heat-treatment condition, and characteristic of wire gained are unstable.

Therefore, it is not able to acquire a constant nature bonding wire, and it causes broad distribution of leaning and loop height.

On the other hand, when bonding wires have become thin, bonding pitch have become narrower and higher density, and wiring at multi stages and setting difference long and short, distribution of second bondability and distribution of loop height by leaning have clarified on the Au alloy bonding wire, it has become considerably to affect quality of bondability of bonding wire.

Leaning is defined as defect of fear of contact to neighboring wire, when a bonding wire is electing vertically at direct upper part of the ball after ball bonding at pad side as loop forming or tilting gently for the lead side. Especially, as a bonding wire is thin, and distance between wires becomes narrow, leaning is apt to generate in the high density implementation, so it is a major factor decreasing yields of semiconductor assembly.

[Reference Patent 1] Japanese Unexamined Patent Application Publication No. 2003 - 7757

[Reference Patent 2] Japanese Unexamined Patent Application Publication No. 2009 - 33127

BRIEF DESCRIPTION OF THE INVENTION

ISSUES TO BE SOLVED BY THE PRESENT INVENTION

[0006]

The present invention has been done to solve the above issues. The present invention aims to provide an Au alloy bonding wire with constant mechanical characteristics and small distribution of loop height about leaning under condition of broad variety of heat-treatment temperature and composition of Au alloy bonding wire.

MEANS TO SOLVE THE ISSUES

[0007]

Inventors of the present invention discovered that the Au bonding wire, which has flat area of elongation ratio corresponding to raise of heat-treatment temperature including at least more than one element of 0.5 – 30 mass % among Cu, Ag, Pd or Pt and residual is Au, using flat heat-treatment temperature range it is possible to acquire a bonding wire with small distribution of loop height about leaning by heat-treatment of bonding wire.

Moreover, it is found that the metallic system structure of wire cross section almost does not change though it includes at least one element at total of 10 to 150 mass ppm among Be, Ca, rare earth elements (Y, La, Ce, Eu, Gd, Nd and Sm), Si, Ge, Sn, In, Bi and B on the above mentioned alloy.

[0008]

(a) The first of the present invention is a bonding wire for semiconductor device comprising: having flat area of elongation ratio with rising heat-treatment temperature, and including at least more than one element of 0.5 – 30 mass % among Cu, Ag, Pd or Pt and residual Au, and heat-treated at the range of 450 – 650 °C at flat area of elongation ratio.

(b) The second of the present invention is a bonding wire for semiconductor device comprising: having flat region of elongation ratio with rising heat-treatment temperature, and including at least more than one element of 0.5 – 30 mass % among Cu, Ag, Pd or Pt and residual Au, and water cooling after heat-treatment at the range of 450 – 650 °C at flat area of elongation ratio.

[0009]

Au alloy of the present invention comprises at least more than one element of 0.5 – 30 mass % among Cu, Ag, Pd or Pt and residual Au.

Cu, Ag, Pd and/or Pt are representative additives as the alloying elements for Au alloy. As well known, Cu and/or Ag in these elements shows complete solubility in the solid state, and forms Au-Cu alloy and/or Au-Ag alloy though in the case of small amount of them. Au-Cu alloy or Au-Ag alloy has broader flat area of heat-treatment temperature range more than that of Au alloy of Pd or Pt. This is considered that atomic Cu or Ag is scattered all over in the lattice of Au and it depends on formation of homogeneous Au-Cu alloy or Au-Ag alloy.

On the other hand, on Pd it is preferable that the range of composition is the range of 0.5 – 2 mass % of Pd and residual Au from the aspect of practical use. From the same reason, on Pt it is preferable that the range of composition is the range of 0.5 – 5 mass % of Pt and residual Au. Moreover, from the same reason, on Ag it is preferable that the range of composition is the range of 5 – 20 mass % of Ag and residual Au. On the Au alloy of the present invention, when it includes 0.5 -30 mass % of at least one element of Cu, Ag and Pd or Pt, the Au alloy has a flat area with rise of heat-treatment temperature. The flat area of elongation ratio and elongation ratio is slightly different by the kinds and amount of alloying elements and by heat-treatment temperature. The preferable range for Au-Cu alloy is the range of 0.5 – 5 mass %. The

preferable range for Au-Ag alloy is the range of 5 – 20 mass %. It is because that both heat-treatment temperature range of flat area become broader.

On the other hand, the purity of 99.99 mass % or higher Au alloy does not have such flat area; the elongation ratio is rising along rise of heat-treatment temperature, when during heat-treatment with certain tension the wire is cut finally. By the way, elongation ratio of the above Au alloy is also rising along rise of heat-treatment temperature as same as the purity of 99.99 mass % or higher Au alloy, when heat-treatment temperature is too high, it is cut finally.

On these characteristics about the purity of 99.99 mass % or higher Au alloy (5N) and Au alloy added Ag, Cu, Pd and Pt, Au and Au alloy of composition in the Table 1, the relation between heat-treatment temperature and elongation, and the relation between heat-treatment temperature and break strength are shown in Figs. 1 and 2.

[Table 1]

Relation between heat-treatment temperature and Elongation, Break Strength (Break Load) of the present invention Au alloy and 5N high purity Au

	Heat-Treatment Temperature °C	25	300	400	450	500	550	600	650
Au-16%Ag	BL/MPa	799.0	635.0	522.0	405.0	312.0	247.0	202.0	183.0
	EL%	1.5	2.4	3.7	6.8	12.6	13.8	13.9	13.7
Au-18%Ag	BL/MPa	843.0	632.0	548.0	422.0	302.0	244.0	204.0	173.0
	EL%	1.5	2.3	3.5	6.0	13.2	13.5	13.4	13.5
Au-1%Cu	BL/MPa	602.0	439.0	314.0	262.0	223.0	185.0	161.0	
	EL%	1.5	3.0	5.8	13.0	13.5	13.5	13.5	
Au-1.5%Pd	BL/MPa	538.0	396.0	297.0	256.0	211.0	182.0	172.0	
	EL%	1.5	3.4	5.5	10.1	11.1	11.1	11.3	
Au-0.8%Pt	BL/MPa	540.0	402.0	279.0	240.0	219.0	183.0	162.0	
	EL%	1.4	3.1	5.5	7.9	10.8	11.1	11.1	
5N-Au	BL/MPa	403.0	298.0	209.0	184.0	158.0	121.0	63.0	
	EL%	1.7	4.2	5.8	13.9	17.8	20.1	2.2	

Legend) BL/Mpa: Break Strength, EL %: Elongation Ratio

[0010]

In the case of 5N high purity Au bonding wire, change of elongation ratio shows flat tendency relatively around 4 % elongation ratio at heat-treatment temperature of 350 –

400 °C as shown in Fig 1. On the other hand, on the relation shown in Fig 2 between break load and heat-treatment temperature, the change shows gentle tendency relatively to the same range of heat-treatment temperature as same manner.

In contrast, it is found that from the graph of relation between heat-treatment temperature and elongation ratio and between it and break load for each alloy of Au-16%Ag, Au-18%Ag, Au-1%Cu, Au-1.5%Pd, the change of elongation ratio goes up very steeply at the range of 5 – 10 and several % elongation ratio conventionally. On the other hand, break load goes down sharply to an opposite direction. Therefore, it is very difficult to control elongation ratio and strength in the desirable range in this temperature range.

However, in the range of higher heat-treatment temperature on these alloys, the change of elongation ratio depending on the composition of alloy, but it becomes flat mostly from around 450 °C at elongation ratio of 8 – 13 %, it is maintained at 600 °C or higher or even if at 650 °C.

Moreover, on the other hand, from the Fig 2 shown break load, the break load decreases as same as 5N high purity Au alloy, it is found that the change is maintained beyond the value of break load of 5N high purity Au alloy at 4 % elongation ratio, because it has high strength originally.

The above mentioned knowledge was obtained from the results of strictly evaluated verification adding these additive elements to high purity Au. The above mentioned strong Au alloy wire, which corresponds to the above mentioned elongation ratio is obtained under condition of stable heat-treatment or broader range of heat-treatment temperature using these characteristics. Moreover, different strength of Au alloy wires are obtained by controlling heat-treatment temperature and these are obtained under stable condition with small distribution of these characteristics.

These characteristics are shown at the range of Ag: 5 – 20 mass %, Cu: 0.5 – 30 mass %, Pd: 0.5 – 2 mass %, Pt: 0.5 – 5 mass % for each additive element of Ag, Cu, Pd and Pt to Au alloy wire. The balance between elongation ratio and strength may be determined by using these Au alloys of above mentioned characteristics, and it is possible to acquire bonding wires corresponding to the diverse characteristics of bonding wire required. The following is heat-treatment conditions of Au alloy bonding wire on the present invention.

[0011]

(Heat-treatment temperature)

Starting temperature, where change of elongation ratio becomes flat to heat-treatment temperature of Au alloy of the present invention, is generally the temperature range of 450 – 650 °C. Preferably, heat-treatment of the present invention is from the range, where elongation ratio becomes flat (it is called as “ST” in the following.), to ST+200 °C, more preferably, it is good from ST to ST+100 °C. The crystal grain size is because it becomes more homogeneous.

[0012]

(Constant tension)

Since the heat-treatment of the present invention in the area, where elongation ratio is flat, is done between a final drawing die and a spool took up, constant tension is applied to the bonding wire.

[0013]

(Water cooling after heat-treatment)

Quenching after heat-treatment, partial coarsening of crystal grain size of bonding wire is able to prevent, and even in the case of several ten thousands meters of bonding wire, throughout more homogeneous crystal grain size is acquired.

Water quenching is preferable at just before winding of a bonding wire. Since a bonding wire is wound under constant tension, stiffness comes to a bonding wire. Therefore to the thinner bonding wire diameter such as 8 – 16μm, the more effect of quenching of heat-treatment is shown.

EFFECTS OF THE PRESENT INVENTION

[0014]

As mentioned above, the Au alloy wire for bonding wire of the present invention has the regularly aligned structure, which is greater crystal grain than ever before on the metallic system structure of bonding wire. Moreover, the mechanical property of bonding wire is softer than former similar alloy wire. Therefore, the Au alloy wire for bonding wire of the present invention has the smaller distribution of leaning and loop height than former bonding wire. Moreover it has the effect of smaller distribution of bonding strength at the second bonding by ultrasonic bonding. Since the Au alloy of the

present invention has good bondability to Al pads and Al alloy pads at the first bonding, so it is possible to keep the bonding reliability of ball bonding wire, moreover it is possible to secure the bonding reliability to the semiconductor device in spite of the use environment such as high temperature or room temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

[Fig 1] Elongation ratio change to heat-treatment temperature of high purity Au wire and Au alloy wire of the present invention

[Fig 2] Break strength (break load) change to heat-treatment temperature of high purity Au wire and Au alloy wire of the present invention

[Fig 3] Conceptual diagram shown relation between heat-treatment temperature and elongation ratio, break strength of high purity Au wire and Au alloy wire included enhancing elements

DESCRIPTION OF THE MOST PREFERRED EMBODIMENT

[0016]

The most preferred embodiment of the present invention is attained when the Au alloy of the present invention is drawn by a die continuously moreover while it is wound from the final die to the spool and the heat-treatment at $ST - ST + 100\text{ }^{\circ}\text{C}$ is done. Since the bonding wire is thin, so it may be quenched in the Air, but the quality is made more stable by water quenching. Especially, in the case of Au-20 mass % Ag alloy, Au-0.5 – 5 mass % Cu alloy, and Au-0.8 – 1.2 mass % Pd alloy, the stable reliability of bonding is obtained on the distribution of leaning and loop height (height of wire from a semiconductor chip. as follows.) and on the distribution of bonding strength of the second bonding.

[0017]

On the Au alloy wire of the present invention shown in Table 1, in order to confirm characteristics as a bonding wire, Examples of Au alloy contained the range of compositions of the components on the present invention were melted and casted, they were drawn into $20\mu\text{m}$ of diameter: No. 1 – 27 (hereinafter referred as Example.) and

comparative Example compositions of this invention fall within the scope: No. 28 – 36 (hereinafter referred as Control.) were manufactured.

These wires on the present invention: No.1 -27 and comparative wire: No.28 – 36 were set on the wire bonder from Kulicke & Soffa company (brand name: sMaxum plus), they were bonded onto the 50 μm square Al alloy pads of Al-0.5 mass % Cu alloy on the semiconductor device under the condition of heating temperature: 200 $^{\circ}\text{C}$, loop length: 5 mm, loop height: 220 μm , diameter of compressed ball: 54 μm , and height of compressed ball: 8 μm . Then, distribution of loop height and bonding strength were evaluated.

For each alloy composition, the distribution was measured in leaning and loop height of 1,000 bonds. Those results as evaluation items in the column of Table 2 and Table 3 are shown.

(Evaluation method)

Where leaning is when drawing a loop through the second bond from the first bond, on the loop direction (direction Z) of the first bond, the highest point of the height from the chip to the XY plane is projected, displacement of the shortest distance from a straight line connecting the first bond and second bond on the XY plane by the automatic three-dimensional measuring system is measured, this is expressed as leaning lines (tilt amount). On the loop height, the highest point was measured at loop height direction (direction Z) as drawing a loop through the second bond from the first bond by following the camera of the automatic three-dimensional measuring system. Then, distribution of each leaning and loop height was calculated, quantitative evaluation by standard deviation was done. By the way, the bonding strength of the second bond was evaluated at 200 μm from the bonding portion of the second bond at the first bond side by the pull strength test by using the universal bond tester.

[Table 2]

Examples

No.	Containing elements (mass %)					Heat-treatment in the flat area		Evaluation Item		
	Au	Ag	Cu	Pd	Pt	Performed Temperature (°C)	Elongation ratio (%)	Leaning	Loop height	Distribution of the second bonding strength
1	residual	16				580	13.0	◎	◎	◎
2	residual	2				450	12.0	○	○	○
3	residual	6				480	11.5	○	○	◎
4	residual	8				490	12.5	○	○	◎
5	residual	12				530	10.3	◎	○	◎
6	residual	18				550	11.2	◎	◎	◎
7	residual	22				620	11.5	◎	○	○
8	residual	18				650	13.0	○	○	○
9	residual		1			480	12.5	◎	◎	◎
10	residual		4			500	14.1	◎	◎	○
11	residual		11			550	13.2	○	○	○
12	residual		15			580	10.5	○	○	○
13	residual		21			600	12.0	○	○	○
14	residual		27			620	12.1	○	○	○
15	residual		1			500	11.9	◎	◎	○
16	residual		1.5			530	10.9	◎	◎	◎
17	residual		0.8			620	12.3	○	○	◎
18	residual		1.8			500	12.6	◎	○	◎
19	residual		7			580	10.9	○	○	○
20	residual		3			550	11.3	○	○	◎
21	residual			0.8		490	11.2	◎	◎	○
22	residual			3.2		530	11.6	◎	○	◎
23	residual			13		600	11.9	○	○	○
24	residual			6.4		570	12.0	○	○	◎
25	residual	15	1	1.5		550	12.2	◎	◎	◎
26	residual		8	1.7	1	580	11.8	○	○	◎
27	residual	3	3	1.5	1.5	570	10.9	◎	◎	◎

[Table 3]
Controls

No.	Containing elements (mass %)					Heat-treatment in the flat area		Evaluation Item		
	Au	Ag	Cu	Pd	Pt	Performed Temperature (°C)	Elongation ratio (%)	Leaning	Loop height	Distribution of the second bonding strength
28	residual	0.3				430	11.2	○	○	×
29	residual	40				690	11.6	×	×	△
30	residual		0.3			480	11.3	○	○	△
31	residual		40			690	11.6	×	×	○
32	residual			0.3		480	11.3	△	△	○
33	residual			40		630	12.0	×	×	○
34	residual				0.3	470	10.8	△	△	○
35	residual				40	690	11.2	×	×	○
36	residual	15				530*	4	×	△	△

(*) The starting temperature (ST) of the flat area of Control No.36 is 550 °C, and 530 °C of performed temperature is lower than ST.

[0018]

In the column of evaluation item in Table 2 and 3, the leaning is shown deviation of wire tilt amount, the symbol ◎ means less than 5 μm, ○ means 5 μm or more and less than 8 μm, △ means 8 μm or more and less than 10 μm, and × means 10 μm or more.

In the column of evaluation item in Table 2 and 3, the loop height is shown the value of standard deviation, the symbol ◎ means less than 15 μm, ○ means 15 μm or more and less than 20 μm, △ means 20 μm or more and less than 30 μm, and × means 30 μm or more.

In Table 2 and 3 bonding strength of the second bond is shown the value of standard deviation, the symbol ◎ means less than 0.8, ○ means 0.8 or more and less than 1.0, △ means 1.0 or more and less than 1.5 and × means 1.5 or more.

[0019]

It is obvious from the results shown in Table 2 and 3 that Au alloy of the present invention in the flat area of change of elongation ratio to the composition of alloyed components in the range of the invention is featured doing heat-treatment, consequently the wire of the present invention is soft and it has good mechanical property, it is good

at deviation of leaning, loop height and bonding strength of the second bond. On the contrary, comparative control wires: No.28 – 36, which are out of the range of the invention and have not these characteristics, it is known that at least one of evaluation items becomes bad.

Namely, as the wires of the present invention keep the elongation ratio at almost constant level in these range of heat-treatment temperature, using this condition, alloy wires with than a certain strength despite temperature change are acquired, by suitably selecting the range of temperature, alloy wires with different strength property to these elongation ratio are acquired. Moreover, from the combination of the conditions, it is possible to acquire almost constant nature with small deviation of leaning and loop height.

In contrast, elongation ratio of controls and change of strength of controls are large according to heat-treatment temperature change, it is difficult to obtain constant nature, and in order to enhance mechanical property and strength, though adding more additive elements, both leaning and loop height were bad, and balance of elongation ratio and strength did not maintain as the results.

POSSIBILITY FOR INDUSTRIAL USE

[0020]

The bonding wire of the present invention is using existence of flat area of elongation ratio change to heat-treatment temperature. Wires with expected break strength are obtained. Moreover, by doing heat-treatment in the flat area of elongation ratio change, or heat-treatment temperature range, these stable properties of wires are obtainable. It is possible to manufacture wires stably with various properties required to bonding wires. It is also possible to contribute to improve productivity.

CLAIMS

What is claimed is:

1. Bonding wire for semiconductor device comprising: bonding wires consist of 0.5 – 30 mass % of at least more than one element among Cu, Ag, and Pd or Pt and residual Au, and bonding wires are heat-treated in the range of 450 – 650 °C where increased elongation ratio with increasing heat-treatment temperature becomes flat.
2. Bonding wire for semiconductor device comprising: bonding wires consist of 0.5 – 30 mass % at total at least more than one element among Cu, Ag, and Pd or Pt and residual Au, and bonding wires are heat-treated in the range of 450 – 650 °C where increased elongation ratio with increasing heat-treatment temperature becomes flat.
3. Bonding wire for semiconductor device described in Claim 1 and/or Claim 2 comprising: bonding wires consist of 0.5 – 30 mass % of at least more than one element among Cu, Ag, and Pd or Pt and residual Au, and bonding wires are quenched after heat-treatment in the range of 450 – 650 °C where increased elongation ratio with increasing heat-treatment temperature becomes flat.
4. Bonding wire for semiconductor device described in Claim 1 and/or Claim 2 comprising: the above mentioned Au alloy consists of 0.5 – 5 mass % of Cu and residual Au.
5. Bonding wire for semiconductor device described in Claim 1 and/or Claim 2 comprising: the above mentioned Au alloy consists of 5 – 20 mass % of Ag and residual Au.
6. Bonding wire for semiconductor device described in Claim 1 and/or Claim 2 comprising: the above mentioned Au alloy consists of 0.5 – 2 mass % of Pd and residual Au.

7. Bonding wire for semiconductor device described in Claim 1 and/or Claim 2 comprising: the above mentioned heat-treatment is done within the range from starting temperature (hereinafter it is expressed as "ST".), where elongation ratio becomes flat to $ST + 200\text{ }^{\circ}\text{C}$.