

DESCRIPTION

GOLD ALLOY WIRE FOR BONDING WIRE HAVING HIGH INITIAL
BONDABILITY, HIGH BONDING RELIABILITY, HIGH ROUNDNESS OF
5 COMPRESSION BALL, HIGH STRAIGHTNESS, HIGH RESIN FLOWABILITY
RESISTANCE, AND LOW SPECIFIC RESISTANCE

TECHNICAL FIELD

[0001]

10 The present invention relates to a gold alloy wire for
a bonding wire that is used to connect a chip electrode of a
semiconductor element such as a transistor, LSI, or IC to an
external lead part and has high initial bonding ability,
high bonding reliability, high roundness of a compression
15 ball, high straightness, high resin flowability resistance,
and low specific resistance. In particular, the invention
relates to a gold alloy wire for wire bonding that can be
used in a wide temperature range from low temperature to
high temperature (for example, in the range of -20 to 60°C)
20 and has a diameter less than 20 μm .

BACKGROUND ART

[0002]

An ultrasonic wave combined thermal compression bonding
25 is performed for a gold alloy wire for a bonding wire in
order to connect an electrode on an IC chip to an external
lead part. A gold alloy wire having the following
composition has been known as a gold alloy wire for a

bonding wire used in this case. The composition of the gold alloy wire includes at least one of Pd, Pt, Rh, Ir, Os, and Ru of 3 to 1000 ppm, Eu of 1 to 30 ppm, at least one of Be, Ca, Ge, and Sr of 1 to 30 ppm, and a balance being Au and inevitable impurities (see patent reference 1).

[Patent Reference 1]

Japanese Unexamined Patent Application, First
Publication No. Hei 08-109425

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DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0003]

Recently, as the integration of the semiconductor elements has increased, an Al pad area becomes small and a substrate having a low heat resistance has been used. As a result, it is required to obtain excellent initial bonding ability (resistance in separation of compression balls from the Al pad during the bonding of balls onto the Al pad) with a lower temperature and smaller area than those of the related art.

20

[0004]

In addition, the decrease of bonding strength due to a ball bonding or the occurrence of bonding failures due to a rise of electrical resistance in the bonding interface has caused problems in an automobile IC for requiring a high reliability at the severe use environments of a high-temperature and a high frequency IC in which the operating temperature is increased. Since the bonding failure is apt

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to gradually occur due to the deterioration of bonding conditions, such as a low temperature joint or a shrinking of the bonding areas, it is required to ensure the bonding reliability (persistence of the bonding strength or

5 electrical resistance due to the ball bonding in the bonding interface at some environments) higher than that of the related art.

[0005]

In addition, the roundness of the compression balls is
10 low at the ball bonding, a portion of the compression balls are protruded from the Al pad, and a short failure occurs by the contact of a neighboring compression ball. Since the contact failure is increasingly apt to occur by the shrinking of the Al pad area and a bonding pad pitch, it is
15 required that the roundness of the compression ball is higher than that of the related art compression ball.

[0006]

Furthermore, meanwhile, at the same time the length of a wire loop (hereinafter, referred to as a loop length) for
20 joining the chip electrodes of the semiconductor devices to the outer lead becomes long, the distance between the wire loop and a neighboring loop parallel to the wire loop becomes narrow. In order to cope with the above-described states, it is required to make the diameter of the gold
25 alloy wire used as a bonding wire increasingly thin.

However, when the diameter of the gold alloy wire is reduced, when the coiled gold alloy wire is extracted from a spool, a curling or meandering (curvature or bending) may easily

occur in the gold alloy wire. When the bonding is conducted by using the gold alloy wire in which the curling or meandering (curvature or bending) exists, since the neighboring bonding wire contacts and a short occurs, the bad semiconductor chips are produced to reduce the yield ratio. More particularly, when the diameter of the bonding wire made of the gold alloy is less than 20 μm , the curling or meandering (curvature or bending) may easily occur in the wire directly after being unreeled from the spool. The property of which the loop formed by the bonding without the occurrence of the curling or meandering (curvature or bending) in the wire directly after being unreeled from the spool does not contact to the neighboring loop is referred to as the straightness. When the straightness is insufficient, since the loop contacts to the neighboring loop and shorts out, the bad semiconductor devices are produced to reduce the yield ratio.

[0007]

In addition, the loop is formed by bonding the wire, and then being molded by the resin. However, at this time, when the bonding wire is influenced by the resin, since the bonding wire contacts to the neighboring loop and shorts out, the bad semiconductor devices are produced to reduce the yield ratio. With respect to the resin flow, when the diameter of the related art gold alloy wire for the bonding wire is 25 μm or 30 μm , the resin flow is hardly problem. However, as the high integration of the semiconductor devices increases, the distance of the chip electrodes of

the semiconductor devices becomes narrow. In order to cope with the high integration of the semiconductor devices, the bonding is performed by using the wire having the thin diameter. However, when the wire diameter is less than 20 μm , the loop is easily influenced during the molding of the resin. Accordingly, it is necessary to have the property (hereinafter, referred to as resin flowability resistance) of which the resin flow is difficult to produce, even though the wire has a thin diameter.

10 [0008]

Even though a gold alloy wire for the bonding wire in which the above-mentioned severe conditions are improved is obtained, the resistance of the gold alloy wire is desirable so as to be low in terms of heat or high frequency driving.

15 In particular, as described above, as the integration of the semiconductor elements has increased, the diameter of the gold alloy wire becomes smaller and a loop becomes longer. As a result, the resistance of the gold alloy wire tends to be long. Therefore, there has been a demand for a gold
20 alloy wire for a bonding wire that has a low specific resistance and satisfies the above-mentioned characteristics.

[0009]

For the above-mentioned difficult demand, the gold alloy wire for the bonding wire described in patent
25 reference 1 has problems in that a work hardening ability of a free-air ball is low and initial bonding ability is low. For this reason, it has not been possible to obtain a gold alloy wire for a bonding wire that can cope with the recent

above-mentioned demand. An object of the invention is to provide a more excellent gold alloy wire for a bonding wire having high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance.

MEANS FOR SOLVING THE PROBLEMS

[0010]

10 The inventors have done research so as to develop a gold alloy wire for a bonding wire having high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance. The results obtained by the research are as follows:

(A) A gold alloy wire has a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100 ppm, and Ca of more than 30 to 100 ppm and Eu of more than 30 to 100 ppm, which are more than those of the gold alloy wire for the bonding wire in the related art in a high-purity gold having purity of 99.999% by mass. The above gold alloy wire has high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance.

(B) The gold alloy wire having the composition described in (A) further comprises Be of 0.1 to 20 ppm. Since Be distorts a crystal lattice of Au to increase the

mechanical strength of the gold alloy wire for the bonding wire and the work hardening ability of a free-air ball and lowers a re-crystallizing temperature, it is possible to raise the height of a loop. As a result, since it is possible to obtain the proper height of a loop, Be can be added, if necessary.

(C) The gold alloy wire having the composition described in (B) further comprises one or more of La, Ba, Sr, and Bi of 30 to 100 ppm in total. Since the mechanical strength of the gold alloy wire for the bonding wire and the work hardening ability of a free-air ball are increased and a re-crystallizing temperature is raised in the gold alloy wire, it is possible to reduce the height of loop of the gold alloy wire.

(D) Even though Ag of 1 to 10 ppm is contained in the gold alloy wire that is described in (A) to (C) and has high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance, it has little influence on the properties.

[0011]

The invention based on the above-described research results is as follows:

(1) A gold alloy wire for a bonding wire having high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance has a component composition comprising one or more of Pt and

Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100 ppm, Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm, and a balance being Au and inevitable impurities.

(2) A gold alloy wire for a bonding wire having high
5 initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance has a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100 ppm,
10 Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm, Be of 0.1 to 20 ppm, and a balance being Au and inevitable impurities.

(3) A gold alloy wire for a bonding wire having high initial bonding ability, high bonding reliability; high
15 roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance has a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100 ppm, Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm,
20 Be of 0.1 to 20 ppm, one or more of La, Ba, Sr, and Bi of 30 to 100 ppm in total, and a balance being Au and inevitable impurities.

(4) The gold alloy wire having high initial bonding ability, high bonding reliability, high roundness of a
25 compression ball, high straightness, high resin flowability resistance, and low specific resistance described in any one of (1) to (3) may further comprise Ag of 1 to 10 ppm. In a method of manufacturing a gold alloy wire for a bonding wire

for annealing gold alloy wire materials obtained by
conducting a drawing process the gold alloy wire materials
having the component compositions described in (1) to (4) so
as to have a predetermined diameter, when 0.2% proof
5 strength (Pa) of the gold alloy wire for the bonding wire is
 $\sigma_{0.2}$, Young's modulus (Pa) is E, and fracture elongation
percentage is E_L , it may manufacture the gold alloy wire for
the bonding wire satisfying the following equations under an
annealing temperature of 550°C or less which is lower than
10 the related art annealing temperature:

$$E \geq 75 \text{ GPa,}$$

$$(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}, \text{ and}$$

$$2\% \leq E_L \leq 10\%$$

It is more preferable that a reduction ratio by one die
15 during the drawing process is 5% or less which is lower than
the related art reduction ratio. The gold alloy wire for
the bonding wire for satisfying the above-described
conditions has higher straightness and higher resin
flowability resistance.

20 Accordingly, according to the invention,

(5) when 0.2% proof strength (Pa) of the gold alloy
wire for the bonding wire is $\sigma_{0.2}$, Young's modulus (Pa) is E,
and fracture elongation percentage is E_L , the gold alloy
wire having high initial bonding ability, high bonding
25 reliability, high roundness of a compression ball, high
straightness, high resin flowability resistance, and low
specific resistance described in any one of (1) to (4)
satisfies the following equations:

$E \geq 75 \text{ GPa},$

$(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}, \text{ and}$

$2\% \leq E_L \leq 10\%$

{0012}

5 Hereinafter, the reason why the component composition of the gold alloy wire for the bonding wire according to the invention having high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low
10 specific resistance is limited as described above will be explained.

[I] Component Composition

(a) Pt and Pd:

Both Pt and Pd, which form a complete solid solubility
15 with Au, cause the deterioration of the bonding strength of the compression ball and Al pad to inhibit and improve the bonding reliability. The layered-shape phase including Pt or Pd is formed in the vicinity of a bonding interface to act as a layer (so called, barrier layer with respect to Au
20 diffusion) for decreasing a diffusion velocity of Au, thereby inhibiting the generating velocity of voids generating in the bonding part in accordance with the diffusion of Au. Accordingly, it is considered that Pt and Pd inhibit the deterioration of the bonding strength of the
25 compression ball and Al pad and improve the bonding reliability. As the amount of Pt or Pd is rich, the effect for inhibiting (improving the bonding reliability) the deterioration of the bonding strength grows higher. However,

when the total amount of one or more of Pt and Pd is less than 500 ppm, the effect for inhibiting the deterioration of the bonding strength is not obtained. Meanwhile, when the total amount of one or more of Pt and Pd is larger than 1000 ppm, the resistance of the gold alloy is raised. For this reason, it is not preferable that the total amount of one or more of Pt and Pd be less than 500 ppm or 1000 ppm or larger. Accordingly, the total amount of one or more of Pt and Pd is set within the range of 500 to less than 1000 ppm.

10 (b) Ir:

Ir inhibits the growth of grains (coarsening of grains). For this reason, when forming a free-air ball, it prevents the grain of a wire part (heat-affected part) directly on the ball from being coarsened due to the effect of heat on the ball, and the solidified free-air ball is formed from a great number of fine grains. In addition, the compression ball evenly extends in a radial pattern, and the roundness of the compression ball is improved. However, when the amount of Ir is less than 1 ppm, it may not obtain a predetermined effect. Meanwhile, when the amount of Ir is larger than 100 ppm in the gold alloy wire for the bonding wire containing one or more of Pt and Pd of 500 to less than 1000 ppm in total, the effects are saturated and are not apparently improved, thus causing IC chips to destruct or impair. For this reason, it is not preferable that the amount of Ir be less than 1 ppm and larger than 100 ppm. Accordingly, the amount of Ir is set within the range of 1 to 100 ppm.

(c) Ca:

Ca which is an alkali earth metal and has the metal bond radius larger than that of Au distorts the crystal lattice of Au, thereby increasing the mechanical strength of the gold alloy wire for the bonding wire and work hardening ability of the free-air ball, raising the re-crystallizing temperature, and lowering the height of loop of the gold alloy wire. However, when the amount of Ca is less than 30 ppm, since the work hardening ability is lowered, thereby lowering the initial bonding ability. In addition, the strength is low, it is difficult to satisfy the conditions of $E \geq 75 \text{ GPa}$, $(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}$, and $2\% \leq E_L \leq 10\%$. Therefore, the straightness and resin flowability resistance are lower. Meanwhile, when the amount of Ca is larger than 100 ppm, a quantity of oxides is generated on the surface of a free-air ball during the bonding of balls, and large shrinkage holes, which do not contribute to the bonding, are formed at the bottom-center of the free-air ball. Since the initial bonding ability of the ball bonding is lowered, it is not preferable that the amount of Ca be 30 ppm or less or larger than 100 ppm. Accordingly, the amount of Ca is set within the range of more than 30 to 100 ppm.

(d) Eu:

Eu which is a rare earth metal and has the metal bond radius larger than that of Au distorts the crystal lattice of Au, thereby increasing the mechanical strength of the gold alloy wire for the bonding wire and the work hardening ability of free-air ball, raising the re-crystallizing

temperature, and lowering the height of loop of the gold alloy wire. In addition, since Eu has a metal bonding radius significantly larger than other metals, the above-mentioned effect is significant in the gold alloy wire for the bonding wire having a small diameter (in particular, diameter less than 20 μm). However, when the amount of Eu is 30 ppm or less, the work hardening ability is lowered, thereby lowering the initial bonding ability. Further, since the strength is lower, it is difficult to satisfy the conditions of $E \geq 75 \text{ GPa}$, $(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}$, and $2\% \leq E_L \leq 10\%$. Therefore, the straightness and resin flowability resistance are lower. Meanwhile, when the amount of Eu is larger than 100 ppm, a quantity of oxides is generated on the surface of free-air ball during the bonding of balls, and large shrinkage holes, which do not contribute to the bonding, are formed at the bottom-center of the free-air ball. Since the initial bonding ability of the ball bonding is lowered, it is not preferable that the amount of Eu be 30 ppm or less and larger than 100 ppm. Accordingly, the amount of Eu is set within the range of more than 30 to 100 ppm.

(e) Be:

Be has the metal bond radius smaller than that of Au and distorts the crystal lattice of Au, thereby increasing the mechanical strength of the gold alloy wire for the bonding wire and the work hardening ability of free-air ball. In a case of containing Be together with Ca and Eu, since the re-crystallizing temperature lowers and the height of

loop rises to realize the proper height of loop, it is possible to add, if necessary. However, when the amount of Be is less than 0.1 ppm, it may not obtain a predetermined effect. Meanwhile, when the amount of Be is larger than 20 ppm, a quantity of oxides is generated on the surface of free-air ball during the bonding of balls, large shrinkage holes, which do not contribute to the bonding, are formed at the bottom-center of the free-air ball. Accordingly, the initial bonding ability of the ball bonding is lowered and the size of grains of the directly upper part of ball and the ball part increases, thus deteriorating the roundness of the compression ball part. For this reason, it is not preferable that the amount of Be be less than 0.1 ppm and larger than 20 ppm. Accordingly, the amount of Be is set within the range of 0.1 to 20 ppm.

(f) La, Ba, Sr, and Bi:

La which is a rare earth metal, Ba and Sr which are alkali earth metals, and Bi which is in a 5B group of the periodic system are possible to add, if necessary, in order to increase the mechanical strength of the gold alloy wire for the bonding wire and the work hardening ability of free-air ball, raise the re-crystallizing temperature, and lower the height of loop of the gold alloy wire. However, even though the amount of at least one of La, Ba, Sr, and Bi is less than 30 ppm, it may not obtain a predetermined effect. Meanwhile, when the amount of at least one of La, Ba, Sr, and Bi is larger than 100 ppm, a quantity of oxides is generated on the surface of free-air ball during the bonding

of balls; and large shrinkage holes, which do not contribute to the bonding, are formed at the bottom-center of the free-air ball. Accordingly, the initial bonding ability of the ball bonding is lowered. For this reason, it is not preferable that the amount of at least one of La, Ba, Sr, and Bi be less than 30 ppm and larger than 100 ppm. Accordingly, the amount of at least one of La, Ba, Sr, and Bi is set within the range of 30 to 100 ppm.

(g) Ag:

Even though Ag of 1 to 10 ppm is contained, it has little influence on the properties. Accordingly, Ag is added, if necessary. However, when the amount of Ag is over 10 ppm, the initial bonding ability tends to be lowered. Therefore, it is not preferable that the amount of Ag be over 10 ppm.

[II] mechanical Property

All of the gold alloy wires for the bonding wire containing the above-described component composition have high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance. However, when manufacturing the gold alloy wire for the bonding wire so as to satisfy the conditions of $E \geq 75 \text{ GPa}$, $(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}$, and $2\% \leq E_L \leq 10\%$ by defining 0.2% proof strength (Pa) of the gold alloy wire as $\sigma_{0.2}$, Young's modulus (Pa) as E , and fracture elongation percentage as E_L , all of the gold alloy wires for the bonding wire containing the above-described component composition have higher

straightness and higher resin flowability resistance.

[0013]

The reason is as follows;

In a case of $E < 75$ GPa, that is, when the Young's
5 modulus is low, the bonded gold alloy wire largely flows by
the resin (that is, the resin flow is large) during the
molding after the wire bonding, thereby the contact
frequency and short frequency of the gold alloy wires
adjacent to each other increase. Therefore, the yield ratio
10 of semiconductor chips is reduced. When $\sigma_{0.2}/E$ is 2.2×10^{-3}
and more, the straightness rapidly is improved, and when the
fracture elongation percentage is less than 2%, the residual
distortion of the gold alloy wire after drawing the wire
resides after annealing and the straightness is low. In
15 addition, when the fracture elongation percentage is higher
than 10%, Most of them satisfies the conditions of $E < 75$
GPa and $(\sigma_{0.2}/E) < 2.2 \times 10^{-3}$. Therefore, the straightness
is reduced or the resin flow increases.

[0014]

20 According to the invention, the fracture elongation
percentage E_L (%), the 0.2% proof strength $\sigma_{0.2}$ (Pa), and the
Young's modulus (Pa) of the gold alloy wire for the bonding
wire are measured by tensioning the gold alloy wire up to be
fractured by a tension tester in the conditions of the
25 distance between gauge points: 100 mm and a tension
velocity: 10 mm/minute at a room temperature.

[0015]

Here, strain and tension stress are defined as follows.

Strain = the elongation (mm) of the gold alloy wire for the bonding wire / 100 mm, and tension stress (Pa) = tension load (N) / initial sectional area (m^2) of the gold alloy wire for the bonding wire. In addition, the fracture elongation percentage E_L (%), the 0.2% proof strength $\sigma_{0.2}$ (Pa), and the Young's modulus (Pa) are defined as follows. The fracture elongation percentage E_L (%) = strain when the gold alloy wire is fractured $\times 100 = [\text{elongation (mm) when the gold alloy wire is fractured} / 100 \text{ (mm)}] \times 100$. The 0.2% proof strength $\sigma_{0.2}$ (Pa): tension stress (Pa) in applying a permanent deformation of 0.2% to the gold alloy wire for the bonding wire. In addition, the Young's modulus (Pa): the ratio of tension stress and strain, that is, tension stress (Pa) / strain, in the range where tension stress and strain are in direct proportion.

EFFECTS OF THE INVENTION

[0016]

As described above, the gold alloy wire for the bonding wire according to the invention has excellent initial bonding ability, excellent bonding reliability, excellent roundness of a compression ball, excellent straightness, excellent resin flowability resistance, and low specific resistance. Accordingly, when the gold alloy wire is used in bonding processes, it is possible to improve the yield ratio of semiconductor devices. As a result, the gold alloy wire for the bonding wire according to the invention has especially excellent effects in an industry.

BEST MODE FOR CARRING. OUT THE INVENTION

[0017]

A gold alloy wire having a wire diameter: 19 μm was
5 manufactured by a drawing process a gold alloy wire material
having a wire diameter: 50 μm and having component
compositions indicated in Tables 1 to 3 at a reduction ratio
by one die of 4.8%. Further, gold alloy wires for a bonding
10 wires according to the invention (hereinafter, referred to as
alloy wires for a bonding wire (hereinafter, referred to as
comparative wires) 1 to 20, and the related art gold alloy
wire for a bonding wire (hereinafter, referred to as the
related art wire) 1 were manufactured by annealing the gold
15 alloy wire at temperature indicated in Tables 4 to 6, and
taken-out by an immediate spool of radius: 50 mm. Here, in
the annealing and winding process, the radii of all of
sheaves (pulleys) using for changing paths of the wires are
9 mm. A fracture elongation percentage E_L , Young's modulus
20 (Pa) E , and 0.2% proof strength (Pa) $\sigma_{0.2}$ were measured by
winding by a spool having a radius of 25 mm by 2000 m the
wire taken-out by the immediate spool and removing the tip
of the wire by 15 m, and $\sigma_{0.2} / E$ was calculated. The
results were indicated in Tables 4 to 6. Further, the
25 specific resistances of the wires are measured, and the
results of the measurement were indicated in Tables 4 to 6.
The number of samples is five in each of the measurement,
thereby obtaining an average value. Resistances (Ω) of the

samples were measured by a digital multimeter in the conditions of the distance between gauge points: 500 mm at a room temperature, and the specific resistances of the wires were obtained with the following equation.

5 Specific resistance ($\mu\Omega\text{cm}$) = resistance (Ω) $\times$ cross-sectional area (cm^2) / 50 (cm) $\times 10^6$

10 The wires 1 to 34 according to the invention, the comparative wires 1 to 20, and the related art wire 1 having the component compositions indicated in Tables 1 to 3 and the mechanical properties indicated in Tables 4 to 6 were set in wire bond (maxam plus) manufactured by Kulicke & Soffa, and the bonding was performed on the substrate in which IC chips of the semiconductor were mounted under the conditions of heating temperature: 150°C, the length of loop: 5 mm, the height of loop: 220 μm , the diameter of a compression ball: 34 μm , and the height of the compression ball: 8 μm . The straightness, initial bonding ability, and roundness of the compression ball with respect to the wires 1 to 34 according to the invention, the comparative wires 1 to 20, and the related art wire 1 were estimated by following measurements.

Straightness Estimation:

25 10000 loops were manufactured at a pad pitch distance of 45 μm with respect to each of the samples, and the number (contacting number) of places for contacting between the neighboring loops was measured. Accordingly, the straightness was estimated by indicating the results in Tables 4 to 6.

Initial Bondability Estimation:

10000 loops attached to each of the samples were manufactured, and the number (number of ball lifts) of times that the compression ball is not bonded to the Al pad during the bonding of balls was measured. Accordingly, the initial bonding ability was estimated by indicating the results in Tables 4 to 6.

Compression Ball Roundness Estimation:

By observing 100 compression balls with respect to each of the samples, when all of them are good, it indicates as "O", and even though one bad exists, it indicates as "x". Accordingly, the roundness was estimated by indicating the results in Tables 4 to 6.

Bonding Reliability Estimation:

After holding for 1000 hours in air of 150°C, 100 proof tests with respect to each sample were conducted by hanging a tool on a bending part (kink) of the loop directly on the compression ball. The fracture in the proof tests is referred to as a fracture (ball lift) in the bonding interface of the compression ball and Al pad. By observing the compression balls, when all the fractures were occurred in a neck, it was estimated as "O", and even though one ball lift exists, it was estimated as "x".

Further, the height of loop and the resin flowability resistance with respect to the wires 1 to 34 according to the invention having the component compositions indicated in Tables 1 to 3 and the mechanical properties indicated in Tables 4 to 6, the comparative wires 1 to 20, and the

related art wire 1 were estimated.

Height of Loop:

The wires 1 to 34 according to the invention, the comparative wires 1 to 20, and the related art wire 1 having
5 the component compositions indicated in Tables 1 to 3 and the mechanical properties indicated in Tables 4 to 6 were set in the wire bond (maxam plus) manufactured by Kulicke & Soffa, and the looping were mounted was performed under the conditions of the diameter of the compression ball: 34 μm ,
10 the height of the compression ball: 8 μm , and the length of loop: 1 mm without doing reverse. The highest part of the loop and the height of the area of Al pad were measured by a light microscope, and the difference of the highest part of the loop and the height of the area of Al pad was obtained
15 as the height of loop. Accordingly, the height of loop was estimated by indicating the results in Tables 4 to 6.

Resin Flowability Resistance:

After sealing with an epoxy resin the substrate in which the bonded IC chips of the semiconductor were mounted
20 under the condition of the length of loop: 3.5 mm by using a molding apparatus, the inside of the semiconductor chip was X-ray projected by using a soft X-ray non-destruction inspection system and the flowing rates where the maximum portion of the wire flow were measured at 20 times. By
25 dividing the average value of the measured flow rates by the length of loop, the obtained value (%) was defined as a resin flow, and the resin flow was measured. Accordingly, the resin flowability resistance was estimated by indicating

the results in Tables 4 to 6.

[0018]

Table 1

Wire	Component Composition of Gold Alloy Wire (Mass ppm)												
	Pt	Pd	Ir	Ca	Be	Eu	La	Ba	Sr	Bi	Ag	Au	
The present invention	1	500	-	50	70	10	60	-	-	-	-	Balance	
	2	800	-	50	70	10	60	-	-	-	-	Balance	
	3	980	-	50	70	10	60	-	-	-	-	Balance	
	4	-	500	50	70	10	60	-	-	-	-	Balance	
	5	-	800	50	70	10	60	-	-	-	-	Balance	
	6	-	980	50	70	10	60	-	-	-	-	Balance	
	7	250	250	50	70	10	60	-	-	-	-	Balance	
	8	400	400	50	70	10	60	-	-	-	-	Balance	
	9	490	490	50	70	10	60	-	-	-	-	Balance	
	10	400	400	1	70	10	60	-	-	-	-	Balance	
	11	400	400	100	70	10	60	-	-	-	-	Balance	
	12	400	400	50	32	10	60	-	-	-	-	Balance	
	13	400	400	50	100	10	60	-	-	-	-	Balance	
	14	400	400	50	70	-	60	-	-	-	-	Balance	
	15	400	400	50	70	20	60	-	-	-	-	Balance	
	16	400	400	50	70	10	32	-	-	-	-	Balance	
	17	400	400	50	70	10	100	-	-	-	-	Balance	
	18	400	400	50	70	10	60	30	-	-	-	Balance	
	19	400	400	50	70	10	60	60	-	-	-	Balance	
	20	400	400	50	70	10	60	100	-	-	-	Balance	

[0019]

Table 2

Wire	Component Composition of Gold Alloy Wire (Mass ppm)											
	Pt	Pd	Ir	Ca	Ba	Eu	La	Ba	Sr	B1	Ag	Au
The present invention	21	400	400	50	70	10	60	30	-	-	-	Balance
	22	400	400	50	70	10	60	60	-	-	-	Balance
	23	400	400	50	70	10	60	100	-	-	-	Balance
	24	400	400	50	70	10	60	-	30	-	-	Balance
	25	400	400	50	70	10	60	-	60	-	-	Balance
	26	400	400	50	70	10	60	-	100	-	-	Balance
	27	400	400	50	70	10	60	-	-	30	-	Balance
	28	400	400	50	70	10	60	-	-	60	-	Balance
	29	400	400	50	70	10	60	-	-	100	-	Balance
	30	400	400	50	70	10	60	-	-	-	1	Balance
Comparative	1	300*	-	50	70	10	60	-	-	-	5	Balance
	2	1500*	-	50	70	10	60	-	-	-	10	Balance
	3	-	300*	50	70	10	60	-	-	-	-	Balance
	4	-	1500*	50	70	10	60	-	-	-	-	Balance
	5	150*	150*	50	70	10	60	-	-	-	-	Balance
	6	750*	750*	50	70	10	60	-	-	-	-	Balance

* means a value out of the range of the present invention

[0020]

Table 3

Wire	Component Composition of Gold Alloy Wire (Mass ppm)											
	Pt	Pd	Ir	Ca	Be	Eu	La	Ba	Sr	Pi	Ag	Au
7	400	400	-*	70	10	60	-	-	-	-	-	Balance
8	400	400	150*	70	10	60	-	-	-	-	-	Balance
9	400	400	50	20*	10	60	-	-	-	-	-	Balance
10	400	400	50	120*	10	60	-	-	-	-	-	Balance
11	400	400	50	70	30*	60	-	-	-	-	-	Balance
12	400	400	50	70	10	20*	-	-	-	-	-	Balance
13	400	400	50	70	10	120*	-	-	-	-	-	Balance
14	400	400	50	70	10	60	120*	-	-	-	-	Balance
15	400	400	50	70	10	60	-	120*	-	-	-	Balance
16	400	400	50	70	10	60	-	-	120*	-	-	Balance
17	400	400	50	70	10	60	-	-	-	120*	-	Balance
18	400	400	50	70	10	60	-	-	-	-	20*	Balance
19	400	400	50	70	10	60	-	-	-	-	-	Balance
20	400	400	50	70	10	60	-	-	-	-	-	Balance
The Related Art 1	400	400	50	20*	5	20*	-	-	-	-	-	Balance

*: means a value out of the range of the present invention

[0021]

Table 4

Wire	Annealing Temperature (°C)	Mechanical Property				The number of contacts (Pieces)	The Number of ball lifts (Piece)	Roundness of Compression Ball	Bonding Reliability	Resin Flowability (%)	Height of loop (μm)	Specific resistance (μΩ cm)
		Fracture Elongation Percentage E _L (%)	Young's modulus E (GPa)	$\sigma_{0.2}$ × 10 ⁻³	σ _{0.2} (MPa)							
1	525	4.1	89	2.4	217	19	0	○	○	2.7	73	2.4
2	526	4.1	89	2.5	226	18	0	○	○	2.4	71	2.4
3	524	4.2	89	2.5	226	19	0	○	○	2.6	75	2.4
4	524	4.2	89	2.5	219	21	0	○	○	2.5	75	2.4
5	526	4.2	88	2.6	225	23	0	○	○	2.7	73	2.4
6	525	4.1	88	2.4	211	18	0	○	○	2.7	71	2.4
7	527	4.1	87	2.5	222	22	0	○	○	2.5	74	2.4
8	527	4.3	90	2.5	225	24	0	○	○	2.7	74	2.4
9	526	4.1	90	2.5	224	20	0	○	○	2.6	75	2.4
10	527	4.3	86	2.5	218	23	0	○	○	2.4	80	2.4
11	525	4.2	88	2.6	228	23	0	○	○	2.4	75	2.4
12	513	4.1	80	2.3	184	30	0	○	○	3.1	77	2.4
13	536	4.0	93	2.7	253	6	0	○	○	2.2	69	2.4
14	536	4.2	89	2.5	222	21	0	○	○	2.4	65	2.4
15	517	4.1	94	2.8	263	11	0	○	○	2.1	85	2.4
16	514	4.2	81	2.4	197	24	0	○	○	2.6	79	2.4
17	534	4.3	93	2.8	262	7	0	○	○	2.0	69	2.4
18	527	4.1	88	2.4	215	20	0	○	○	2.4	72	2.4

The present invention

[0022]

Table 5

Wire	Annealing Temperature (°C)	Mechanical Property				The number of contacts (Pieces)	The Number of ball lifts (Piece)	Roundness of Compression Ball	Bonding Reliability	Resin flowability	Height of Loop (μm)	Specific resistance (μΩ cm)
		Fracture Elongation Percentage EL(%)	Young's Modulus E (GPa)	$\sigma_{0.2}/E \times 10^{-5}$	$\sigma_{1.2}$ (MPa)							
The present invention	19	530	93	2.7	248	10	D	○	○	2.4	71	2.4
	20	534	99	2.7	270	14	D	○	○	2.2	66	2.4
	21	527	86	2.5	213	16	D	○	○	2.3	71	2.4
	22	531	92	2.7	248	19	D	○	○	2.3	72	2.4
	23	534	98	2.8	271	6	D	○	○	2.0	68	2.4
	24	527	89	2.5	224	19	D	○	○	2.4	71	2.4
	25	531	93	2.6	245	12	D	○	○	2.4	69	2.4
	26	534	97	2.8	276	7	D	○	○	1.9	68	2.4
	27	527	89	2.6	227	18	D	○	○	2.4	75	2.4
	28	532	92	2.6	239	11	D	○	○	2.1	70	2.4
	29	535	96	2.8	269	10	D	○	○	1.9	68	2.4
	30	524	90	2.5	224	22	D	○	○	2.4	74	2.4
	31	525	89	2.5	224	20	D	○	○	2.6	75	2.4
	32	525	89	2.6	232	16	D	○	○	2.5	74	2.4
	33	485	99	3.0	296	31	D	○	○	2.1	74	2.4
	34	542	80	2.2	176	22	D	○	○	3.2	72	2.4
Comparative	1	526	88	2.5	220	18	D	○	×	2.4	75	2.3
	2	526	87	2.5	218	24	D	○	○	2.7	71	2.5

[0023]

Table 6

Wire	Annealing Temperature (°C)	Mechanical Property					The number of contacts (Plate)	The Number of bell lifts (Piece)	Roundness of Compression Ball	Bonding Reliability	Resin flowability (%)	Height of loop (μm)	Specific resistance (μΩ cm)
		Fracture Elongation Percentage	Young's Modulus E (GPa)	$\sigma_{\text{UT}}/E \times 10^{-2}$	σ_{UT} (MPa)	σ_{UT}							
3	525	4.4	85	2.6	224	224	20	0	O	x	2.5	74	2.3
4	526	4.3	89	2.6	226	226	15	0	O	O	2.6	75	2.5
5	526	4.3	85	2.5	212	212	17	0	O	x	2.5	75	2.3
6	525	4.1	87	2.5	218	218	22	0	O	O	2.3	71	2.5
7	524	4.2	87	2.5	212	212	19	0	x	O	2.4	82	2.4
8	526	4.2	87	2.5	221	221	A part of all pad is damaged						2.4
9	516	4.4	78	2.1*	167	167	156	18	O	O	4.3	83	2.4
10	535	4.3	94	2.7	254	254	7	5	O	O	2.1	61	2.4
11	514	4.3	93	2.8	260	260	12	3	x	O	2.6	83	2.4
12	514	4.3	80	2.1*	171	171	121	15	O	O	3.5	84	2.4
13	534	4.1	95	2.9	270	270	8	4	O	O	2.1	61	2.4
14	535	4.0	99	2.8	275	275	12	3	O	O	2.3	68	2.4
15	535	4.1	97	2.8	270	270	8	4	x	O	2.0	70	2.4
16	534	4.1	98	2.8	273	273	11	3	O	O	1.9	67	2.4
17	536	4.0	98	2.7	265	265	7	3	O	O	2.1	68	2.4
18	526	4.1	89	2.6	229	229	16	2	O	O	2.5	73	2.4
19	305	1.5*	105	3.3	345	345	258	0	O	O	1.9	71	2.4
20	548	12.0*	79*	2.1*	158	158	171	0	O	O	4.2	71	2.4
The Related Art 1	515	4.3	74*	2.1*	158	158	382	45	O	O	4.5	87	2.4

*: means a value out of the range of the present invention

[0024]

It can be understood from the results indicated in Tables 1 to 6 that the wires 1 to 34 according to the invention have low specific resistance, excellent
5 straightness, initial bonding ability, roundness of the compression ball, bonding reliability, and resin flowability resistance, and more particularly, with respect to the excellent straightness, initial bonding ability, roundness of the compression ball, bonding reliability, and resin
10 flowability resistance, the comparative wires 1 to 20 and the related art wire 1 have a defect of at least one of the above-described properties.

WHAT IS CLAIMED IS:

1. A gold alloy wire for a bonding wire that has high initial bonding ability, high bonding reliability, high
5 roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance, the gold alloy wire having:

a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100
10 ppm, Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm, and a balance being Au and inevitable impurities.

2. A gold alloy wire for a bonding wire that has high initial bonding ability, high bonding reliability, high
15 roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance, the gold alloy wire having:

a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir of 1 to 100
20 ppm, Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm, Be of 0.1 to 20 ppm, and a balance being Au and inevitable impurities.

3. A gold alloy wire for a bonding wire that has high
25 initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance, the gold alloy wire having:

a component composition comprising one or more of Pt and Pd of 500 to less than 1000 ppm in total, Ir 1 to 100 ppm, Ca of more than 30 to 100 ppm, Eu of more than 30 to 100 ppm, Be of 0.1 to 20 ppm, one or more of La, Ba, Sr, and Bi of 30 to 100 ppm in total, and a balance being Au and inevitable impurities.

4. The gold alloy wire for the bonding wire that has high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance according to any one of claims 1 to 3, further comprising:
Ag of 1 to 10 ppm.

5. The gold alloy wire for the bonding wire that has high initial bonding ability, high bonding reliability, high roundness of a compression ball, high straightness, high resin flowability resistance, and low specific resistance according to any one of claims 1 to 4,

wherein, when 0.2% proof strength (Pa) of the gold alloy wire for the bonding wire is $\sigma_{0.2}$, Young's modulus (Pa) is E, and fracture elongation percentage is E_L , the following equations are satisfied

$$E \geq 75 \text{ GPa};$$

$$(\sigma_{0.2}/E) \geq 2.2 \times 10^{-3}; \text{ and}$$

$$2\% \leq E_L \leq 10\%.$$