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GOLD ALLOY THIN WIRE AND GOLD ALLOY BUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a gold alloy bump and a gold alloy thin wire for the gold alloy bump applicable as a bump, or a metal projection, for connecting exterior leads to electrodes on semiconductor devices.

2. Description of the Related Art

Conventionally, the exterior leads and the electrodes on a semiconductor device are most commonly bonded by wire bonding. However, the wire bonding cannot successfully cope with recent miniaturization of IC chips and thin film devices, and therefore, wireless bonding is frequently used instead.

Tape automated bonding (TAB) process includes forming a circuit of a silver foil on a polyimide resin tape, and bonding the leads of the TAB circuit to the electrodes of an IC chip via metal projections called bumps. A bump is mostly a gold bump formed by plating on the electrodes of an LSI chip. The plated-gold bump has problems that it is necessary to form a barrier layer on the electrodes prior to plating, that the bump forming process is complicated to raise the production cost, and that wafers having the bumps formed thereon are not easily commercially available.

Another wireless bonding process called a flip chip process connects an LSI chip to a circuit board in a face down manner, so that the connection can be done within the LSI area facilitating high density mounting. In this process, however, the connections at the electrodes is mostly performed via bumps.

Figure 1 shows a stud bump process, in which the bump is formed from a gold alloy thin wire having an established reliability in wire bonding. This process

includes forming a ball by an electric discharge, like in the conventional wire bonding, at the tip of a gold alloy thin wire 1 directed through a hole of a capillary 3, bonding the ball to an aluminum electrode pad 6 on a silicon semiconductor chip 7 by an ultrasonic wave-aided thermocompression applied through the capillary 3, and then, raising the capillary 3 while nipping the wire 1 by a clamper 2 to forcibly break the wire 1 at a neck 4, thereby forming a bump 5 having desired neck length 8 and bump height 9.

Because the stud bump process is based on the established wire bonding process, it is advantageous in that bonding can be carried out at high speeds, that the production cost is low, and that the existing wire bonding equipment can be successfully utilized.

It is important that the bumps for connection to electrodes have an even height because the bump height has a significant influence on the distance between an LSI chip and the bonded circuit board and on the bond strength. Specifically, when forming a bump from a wire, it is important to reduce the breakage height immediately above the bump.

However, the conventional gold alloy thin wire used for wire bonding has the problem that the wire breakage length or neck length 8 immediately above the bonded ball is large, as shown in Fig. 2(a), up to 300 μm or longer, and that the breakage position also unstably varies and causes a large fluctuation in the neck height. This is thought to be because the conventional wire for wire bonding is designed to provide an increased strength of a heat-affected zone near the ball in order to reduce possible damage during loop connection and also to avoid disconnection due to vibration during processing and in use.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a gold alloy thin wire and a bump formed therefrom with a

small neck length stably obtained upon the wire breakage after ball bonding, such as shown in Fig. 2(b) in which an improved gold alloy stud bump has a small bump height 9.

The present inventors conducted a study to realize a gold alloy thin wire by which the breakage portion, or neck, has a controlled small length, and found that the neck strength can be reduced by a heat used upon ball formation and that the reduced neck strength can be controlled by additive elements in the gold alloy. It is also found that the base wire strength is desirably higher than the neck strength in order to reduce the fluctuation of the bump height and that the base wire strength must also be sufficient to provide the necessary workability in the wire production.

To achieve the above object according to the present invention, the following gold alloy thin wires are provided:

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm

by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities;

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities; and

A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

According to the present invention, there are also provided the following gold alloy bumps:

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total

amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities;

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at

least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities; and

A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view showing a stud bump forming process;

Figs. 2(a) and 2(b) are cross-sectional views showing (a) a conventional stud bump having a long neck and (b) a stud bump having a short neck according to the present invention, respectively; and

Fig. 3 is a graph showing the micro-hardness of the neck in the portion near the ball as a function of the distance from the ball, for the wires A, B, and C according to the present invention in comparison with the conventional wire.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The gold alloy thin wire and the gold alloy bump according to the present invention will be described more specifically below.

Because of a heat effect during forming the ball, a recrystallization occurs in the bump neck and reduces the strength of the bump neck compared to the base wire. Upon forming the bump, it is important to control the wire breakage in the heat-affected zone. It is desirable to provide a reduced neck strength while maintaining a high strength of the base wire.

When Si is present in gold in an amount of from 0.2

to 5000 ppm by weight, the neck strength is significantly reduced, so that the breakage length can be easily reduced. This is because of a reduction in the high temperature strength by the Si addition, which is considered related to the fact that the gold-silicon system is a eutectic system.

The Si content must be 0.2 ppm by weight or more to provide a substantial effect to reduce the high temperature strength but must not be more than 5000 ppm by weight to provide good sphericity and avoid difficulty in bonding when the electrode pitch, or distance between electrodes, is small. A Si content of more than 100 ppm by weight has, on one hand, an advantage that it increases the strength to facilitate forming of thin wires having a diameter of 25 μm or less, but on the other hand, causes the problem that an intermediate annealing may occasionally be necessary to soften the wire being drawn in order to avoid significant wear of the wire drawing dies. Nevertheless, the Si content is desirably more than 100 ppm by weight because the Si precipitation occurs to increase the base wire strength, and thereby reduces the fluctuation of the bump height.

In addition to the strength of the recrystallized region of the neck, the length of the recrystallized region is also an important factor to control the wire breakage length.

Although the single addition of Si significantly reduces the neck strength, the heat-affected zone has a large length, which may possibly cause a fluctuation of the wire breakage length in accordance with the conditions under which the wire breaks.

To stably provide a small neck breakage length, at least one element selected from the group consisting of Ca, Be, La, and Ce (hereinafter referred to as "the first group elements") in a total amount of 0.2 to 300 ppm by weight is contained in the alloy, in addition to the above-mentioned Si. The Si addition facilitates the

recrystallization in the heat-affected zone whereas the addition of the first group elements suppresses the recrystallization at the end of the heat-affected zone and limits the region of the heat-affected zone to the ball vicinity alone to facilitate the wire breakage immediately above the ball, thereby reducing the fluctuation of the bump height.

Namely, the first group elements selectively suppress the Si-caused recrystallization grain growth at the end of the heat-affected zone and does not disturb the grain growth in the ball vicinity, which is subjected to a high temperature at which the Si-caused grain growth preferentially occurs. Figure 3 shows the hardness of the wire in the vicinity of the heat-affected zone. It can be seen from Fig. 3 that, in comparison with the conventional commercial wires, the Si-added wire A of the present invention has a reduced neck strength; the Si- and first group element-added wire B of the present invention has a reduced length of the recrystallized region having a reduced hardness while the low hardness is ensured in the ball vicinity. This means that the occurrence of the neck breakage is facilitated by the synergistic effect of Si and first group elements.

The first group elements must be present in a total amount of from 0.2 to 300 ppm by weight. When the amount of the first group elements is less than 0.2 ppm by weight, the occurrence of the neck breakage cannot be substantially facilitated. When the amount of the first group elements is more than 300 ppm by weight, a shrinkage cavity is formed in the ball tip to reduce the bondability after ball bonding.

To facilitate the breakage of wire at the neck, the neck desirably has a reduced strength relative to the base wire portion, which is not affected by heat. For this purpose, it is effective to increase the base wire strength. The addition of at least one element selected from the group consisting of Y, Sc, Sr, Ga, and Ge

(hereinafter referred to as "the second group elements") in a total amount of from 1 to 500 ppm by weight provides the effect to facilitate the neck breakage during forming of a bump. Figure 3 also shows that the Si- and second group element-added wire C has an increased base wire strength and provides an increased difference in strength between the base wire and the neck. The usual wire production process includes a tempering heat treatment for ensuring the straightness of drawn wires. This tempering, when carried out at a high temperature, may possibly reduce the strength of wires containing Si alone as an additive element. The addition of the second group elements increases the base wire strength without affecting the high temperature strength to prevent the breakage from occurring in a wire portion other than the neck and also provides good straightness of wires having a diameter of 25 μm or less for forming a small ball, which wires can be easily manufactured with good processability.

The second group elements must be present in a total amount of from 1 to 500 ppm by weight. When the amount is less than 1 ppm by weight, the base wire strength is not significantly increased. When the amount is more than 500 ppm by weight, the ball shape unstably varies, which makes it difficult to form the desired small balls corresponding to a reduced electrode pitch.

To form a bump on an aluminum electrode on an LSI chip, the gold alloy ball should have good bondability to aluminum. The single addition of Si does not improve the ball bondability to aluminum. Supplemental addition of at least one element selected from the group consisting of Cu, Pd, Pt, Al, In, and Mn (hereinafter referred to as "the third group elements") in a total amount of from 2 to 10000 ppm by weight increases the bond strength between a gold alloy ball and an aluminum substrate. To improve the bondability to an aluminum electrode, the surface aluminum oxide film must be broken upon bonding

the ball. Higher ball hardnesses would facilitate the breakage of the oxide film. It should be noted, however, that an excessively high hardness causes the problems that application of a supersonic wave causes the ball to sweep the aluminum film away to undesirably reduce the bond strength or to damage the chip during bonding. It was also found that, when forming small bumps corresponding to a reduced electrode pitch, better bondability is obtained by higher ball hardnesses.

When the third group element is present in a total amount of less than 2 ppm by weight, the bond strength is not significantly increased. When the total amount is more than 10000 ppm by weight, either a reduction of the bondability due to an excessively increased ball hardness or a defective ball shape frequently occurs.

Additions of the first and second groups, supplemental to the Si addition, provides a gold alloy thin wire having a reduced neck strength, a reduced neck length, and an increased base wire strength to further facilitate reduction of the breakage length. Further addition of the third group elements, other than Si and the first and second groups, makes it easy to form good bumps having an increased bond strength such that the bump does not separate when the base wire is pulled away.

EXAMPLE

By using an electrolytic gold having a purity of about 99.995 wt% or higher, gold alloys having the chemical compositions as shown in Tables 1, 3 and 6 were melted in a melting furnace, cast to ingots, rolled and wire-drawn to form gold alloy thin wires having a final diameter of 25 μm, which were then continuously annealed in air to produce wires having a controlled elongation.

A gold alloy ball was formed by arc discharge at the tip of a wire in a high speed automatic bonder for wire bonding, and was subjected to observation in a scanning electron microscope, in which the balls were graded as a "sound" ball denoted by "O" or a "defective" ball denoted

by "Δ", the defective ball not forming a good bond with an electrode on a semiconductor device because of having a defective shape, a shrinkage cavity at the ball tip, etc.

Gold alloy bumps were formed by using a high speed automatic bonder in a sequence such that the above-mentioned gold alloy ball was bonded by a supersonic wave-aided thermocompression bonding to a 1 μm thick, high purity aluminum film electrode patterned on a silicon semiconductor chip, and the base wire was then pulled in the upper portion thereof to break the wire at the neck.

The breakage length at the neck was estimated by the bump height and the fluctuation thereof, based on a microscopic measurement of 500 bumps.

The bond strength of the bump was estimated by a mean value of the breakage load for 100 runs of a shearing test in which the base wire was gripped in a jig at a point 3 μm above the aluminum electrode, the jig was moved perpendicularly to the chip surface, and a shear load upon breakage was then recorded.

The strength difference between the neck and the base wire was estimated from a room temperature strength and a high temperature strength, each measured for 20 wire samples. The room temperature strength is a tensile strength measured at room temperature and the high temperature strength is a tensile strength measured in a vertical furnace set at about 250°C in which a wire was held for about 20 seconds.

Tables 1 to 4 summarize the results of the wires according to the present invention, in which Wire Nos. 1 to 3 are according to claims 1 and 5, Wire Nos. 4 to 14 are according to claims 2 and 6, Wire Nos. 15 to 29 are according to claims 3 and 7, Wire Nos. 30 to 40 are according to claims 4 and 8, and Wire Nos. 41 to 47 are according to claims 1 to 8.

Tables 5 and 6 summarize the results of the

comparative wires having chemical compositions outside the claimed ranges.

It can be clearly seen from the results that the wires containing Si according to the present invention had a reduced bump height in comparison with Comparative Wire Nos. C1 and C2; that the present inventive wires further containing the first group elements, other than Si, had a reduced fluctuation of the bump height; that the present inventive wires further containing the second group elements, other than Si, had an increased difference between the room temperature strength and the high temperature strength, which facilitated reduction of the bump height. It can also be seen that the present inventive wires further containing the third group elements, other than Si, had an increased bond strength with the reduced bump height maintained.

As hereinabove described, the present invention provides a gold alloy thin wire advantageously applicable to wireless bonding suitable for high density mounting in semiconductor chips. The gold alloy thin wire according to the present invention provides a gold alloy bump having a good bond strength and a reduced length and reduced length fluctuation of the neck breakage immediately above the ball bonded to the electrodes on a semiconductor chip.

Table 1 (Inventive Wires)

Wire No.	Chemical Composition (ppm by weight)															
	Si	Ca	Be	La	Ce	Y	Sc	Sr	Ga	Ge	In	Cu	Pd	Pt	Mn	Au & Impurity
1	0.3															Bal.
2	100															Bal.
3	4900															Bal.
4	30	1														Bal.
5	55	270														Bal.
6	50		2													Bal.
7	50		290													Bal.
8	55			0.5												Bal.
9	54			250												Bal.
10	50				0.4											Bal.
11	50				250											Bal.
12	50	50		40												Bal.
13	50	20	10		30											Bal.
14	50	50	20	50	50											Bal.
15	50					20										Bal.
16	50					387										Bal.
17	50						3									Bal.
18	50						348									Bal.
19	50							2.5								Bal.
20	50							387								Bal.
21	50								3							Bal.
22	50								445							Bal.
23	50									2						Bal.
24	50									256						Bal.

Table 2 (Inventive Wires)

Wire No.	Ball Shape	Wire Strength Difference (gf)	Bond Strength (gf)	Bump Height (μm)	
				Mean Value	σ
1	O	2.2	62.5	135.3	30.2
2	O	2.8	61.4	124.5	28.5
3	O	3.6	60.5	112.5	27.7
4	O	2.8	60.7	118.3	18.2
5	O	2.4	64.1	105.2	15.5
6	O	2.6	62.5	117.4	20.1
7	O	3.0	63.0	106.2	16.2
8	O	2.4	64.3	117.5	19.4
9	O	2.8	64.1	102.3	15.4
10	O	2.6	62.7	109.6	18.2
11	O	3.2	63.4	102.7	14.4
12	O	2.7	62.2	102.9	15.2
13	O	2.6	60.6	114.4	14.8
14	O	3.6	63.5	103.3	14.7
15	O	4.0	64.4	102.7	24.1
16	O	4.5	63.3	95.5	23.3
17	O	4.1	62.9	98.2	28.4
18	O	4.7	65.1	97.8	27.2
19	O	4.2	65.6	99.3	26.4
20	O	4.6	62.1	95.5	26.6
21	O	4.1	64.5	99.2	28.7
22	O	4.9	63.9	93.9	24.9
23	O	4.1	64.5	100.2	27.8
24	O	4.4	62.7	96.5	26.3

Table 3 (Inventive Wires)

Wire No.	Chemical Composition (ppm by weight)															
	Si	Ca	Be	La	Ce	Y	Sc	Sr	Ga	Ge	In	Cu	Pd	Pt	Mn	Au & Impurity
25	50										2					Bal.
26	50										420					Bal.
27	50					0.5		1	2							Bal.
28	50					15	20	45		25						Bal.
29	50						150		135		100					Bal.
30	50											5				Bal.
31	50											1200				Bal.
32	50												5			Bal.
33	50												2000			Bal.
34	50												8800			Bal.
35	50													10		Bal.
36	50													7500		Bal.
37	50														10	Bal.
38	50														8200	Bal.
39	50											50	250		200	Bal.
40	50											2000		2000	2000	Bal.
41	50	20	20		50	20		50			50					Bal.
42	50	30		20				50		50						Bal.
43	50	20		20									100		200	Bal.
44	50		20	50	50							600	1500	120		Bal.
45	50		10				20					500		3000		Bal.
46	50	20			20	20			50			300	2000		500	Bal.
47	50	20			50			50		50		3000	2000			Bal.

Table 4 (Inventive Wires)

Wire No.	Ball Shape	Wire Strength Difference (gf)	Bond Strength (gf)	Bump Height (μm)	
				Mean Value	σ
25	O	3.9	63.5	100.7	26.1
26	O	4.6	66.2	97.0	23.7
27	O	4.0	64.1	98.4	26.2
28	O	4.6	63.8	97.2	26.3
29	O	4.8	65.1	98.3	27.1
30	O	2.6	70.8	124.5	29.2
31	O	3.0	88.9	117.3	27.6
32	O	2.4	72.3	121.5	25.1
33	O	2.6	87.1	118.1	26.9
34	O	2.7	87.1	116.5	24.1
35	O	2.5	73.5	128.7	25.9
36	O	2.7	84.1	121.4	25.0
37	O	2.6	72.2	127.5	22.1
38	O	2.8	84.5	118.5	23.2
39	O	2.8	77.1	124.0	24.3
40	O	2.7	86.4	128.4	23.6
41	O	4.5	64.1	93.4	15.3
42	O	4.3	63.8	92.2	14.9
43	O	2.6	82.4	91.8	14.2
44	O	4.4	85.6	91.6	13.7
45	O	4.2	87.7	90.6	13.1
46	O	4.2	83.1	92.2	12.8
47	O	4.1	85.2	92.3	13.4

Table 5 (Comparative Wires)

Wire No.	Chemical Composition (ppm by weight)															
	Si	Ca	Be	La	Ce	Y	Sc	Sr	Ga	Ge	In	Cu	Pd	Pt	Mn	Au & Impurity
C1	0															Bal.
C2	0.05															Bal.
C3	5500															Bal.
C4	50	350														Bal.
C5	30		0.1		0.05											Bal.
C6	55	100		200	100											Bal.
C7	50					0.5										Bal.
C8	50						0.3		0.4							Bal.
C9	55					200			150	200						Bal.
C10	54						350	100			100					Bal.
C11	50											1		0.5		Bal.
C12	50												0.5	0.5	0.5	Bal.
C13	50											12000				Bal.
C14	50												11000			Bal.
C15	50											3000		3000	5000	Bal.
C16	50												7000	5000		Bal.

Table 6 (Comparative Wires)

Wire No.	Ball Shape	Wire Strength Difference (gf)	Bond Strength (gf)	Bump Height (μm)	
				Mean Value	σ
C1	○	2.5	63.2	250.4	45.3
C2	○	2.2	62.8	220.5	35.4
C3	△	2.7	64.1	89.5	21.5
C4	△	3.0	33.3	94.5	10.9
C5	○	2.8	62.4	121.3	24.2
C6	△	3.0	64.7	92.5	10.5
C7	○	2.7	63.7	113.0	25.1
C8	○	3.4	65.4	109.5	23.6
C9	△	4.9	62.1	90.5	19.7
C10	△	5.0	63.2	89.2	18.9
C11	○	2.8	64.2	113.7	24.1
C12	○	2.4	66.0	120.4	24.4
C13	△	2.7	88.7	118.5	18.7
C14	△	2.4	87.6	114.1	20.1
C15	△	2.6	86.1	117.2	22.1
C16	△	2.5	87.1	110.3	20.5

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CLAIMS

1. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si and the balance of gold and unavoidable impurities.

2. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, and the balance of gold and unavoidable impurities.

3. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities.

4. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

5. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities.

6. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

7. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm

* C L M S *

by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

8. A gold alloy thin wire consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

9. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si and the balance of gold and unavoidable impurities.

10. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, and the balance of gold and unavoidable impurities.

11. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities.

12. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

13. A gold alloy bump having a reduced neck height,

consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, and the balance of gold and unavoidable impurities.

14. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

15. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.

16. A gold alloy bump having a reduced neck height, consisting of 0.2 to 5000 ppm by weight of Si, a total amount of 0.2 to 300 ppm by weight of at least one element selected from the group consisting of Ca, Be, La, and Ce, a total amount of 1 to 500 ppm by weight of at least one element selected from the group consisting of Y, Sc, Sr, Ga, Ge, and In, a total amount of 2 to 10000 ppm by weight of at least one element selected from the group consisting of Cu, Pd, Pt, Al, and Mn, and the balance of gold and unavoidable impurities.