

3N Copper Wire with Trace Additions for Bonding in Microelectronics Device

FIELD OF INVENTION

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The present invention relates broadly to a 3N copper wire with trace additions for bonding in microelectronics.

BACKGROUND

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Fine Au, Cu and Al wires are widely used for interconnections in integrated chips. Silver wires have also been examined for unique applications. For Au and Al wires, usually 2N to 4N purity (99 to 99.99%) are applied, while for Cu typically only 4N purity is used. 5N to 8N purity Cu have been examined but are not in practice. Dopants are added for specific applications such as loop capabilities, reliability, bondability, corrosion resistance, etc. Wires in the range of typically 18 μ m to 75 μ m diameter are commonly used in wire bonding. For high current carrying applications, wires in the diameter range of typically 200 μ m to 400 μ m are applied.

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The alloys for the wire are typically continuous cast into rods of diameter of 2mm to 25mm and are further drawn in steps of what is referred to as heavy, intermediate and fine. The fine drawn wires were annealed at high temperature around 0.25 to 0.6 T_m (melting point of the wire) and later spooled, vacuum packed and stored for bonding.

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Several patents reported the benefit of doped and alloyed Cu wire. Pd addition in the range of 0.13 to 1.17mass% claims to have high reliability on pressure cooker test (PCT) test. Cu wire doped with Mg and P <700ppm, maintaining 30ppm of oxygen (O) and with a list of addition of elements Be, Al, Si, In, Ge, Ti, V (6-300ppm), Ca, Y, La, Ce, Pr, Nd <300ppm was found to be good for bonding. Addition of Nb and P in the range of 20-100ppm along with the elements Cs, Lu, Ta, Re, Os, Ir, Po, At, Pr, Pm, Sm, Gd <50ppm and Zr, Sn, Be, Nd, Sc, Ga, Fr, Ra <100ppm revealed soft and bondable wire. A bondable Cu wire was produced when doped with a maximum of 1000ppm of the elements Mn, Co, Ni, Nb, Pd, Zr and In. If the wire contained Be, Fe, Zn, Zr, Ag, Sn, V

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<2000ppm, it was found to be bondable and reliable. Addition of boron (B) up to 100ppm and a small amount of addition of Be, Ca, Ge <10ppm, and at the same time maintaining sulfur (S) <0.5ppm exhibited low ball hardness and reduced work hardening. Cu wire with Cr <25ppm, Zr<9ppm, Ag<9ppm, Sn<9ppm demonstrated good bondability as good as Au wire. Low level addition of Fe, Ag, Sn, Zr <9ppm produced a normal bondable wire. Addition of the elements of B, Na, Mg, Al, Si, Ca, K, V, Ga, Ge, Rb, Sr, Y, Mo, Cd, Cs, Ba, Hf, Ta, Ti, W <1000ppm revealed superior properties and suitable for bonding.

10 Cu wire processed using ultra high purity Cu such as 8N (99.999999%) having O, C, H, N, S, P <1ppm produced soft wire with 40HV hardness. Cu wires processed using purity 5N and 6N and doped with any one of the elements or combined with different combinations of Ti, Cr, Fe, Mn, Ni, Co and maintaining <4.5ppm showed good bondability. Combination of the addition of Hf, V, Ta, Pd, Pt, Au, Cd, B, Al, In, Si, Ge, Pb, S, Sb, and Bi <4.5ppm with Nb < 4.5ppm using 5N and 6N purity also showed good bondability. Addition of Ti of 0.12-8.4ppm along with Mg, Ca, La, Hf, V, Ta, Pd, Pt, Au, Cd, B, Al, In, Si, Ge, Pb, P, Sb, Bi, Nb of <0.16-8.1ppm were suitable for bonding. A Cu wire with an impurity of <4ppm and containing Mg, Ca, Be, In, Ge, Ti <1ppm performed equal to Au wire and as soft as 35HV.

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A clean spherical free air ball was achieved using 4N Cu wire containing Mg, Al, Si, P <40ppm. Similarly, a Cu wire of 40 to 50HV was attained, maintaining a purity < 10ppm with addition of La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y <20ppm or Mg, Ca, Be, Ge, Si <20ppm. Cu wire with an addition of Ni and Co <100ppm and Ti, Cr, Mn, Fe, Ni, Zr, Nb, Pd, Ag, In, Sn <150ppm showed corrosion resistant and hardness of 41HV. Also Cu wire containing Ti, Fe, Cr, Mn, Ni, Co <150ppm performed quite well on bonding. A soft Cu wire with <49HV was attained using zone refined Cu and maintaining Mg, Ca, Ti, Zr, Hf <100ppm. Addition of elements Be, Sn, Zn, Zr, Ag, Cr, Fe to a maximum 2wt% maintained H, N, O, C contents and control gas creation (H₂, CO, N₂, O₂) during free air ball, consequently attained a superior bond strength. Adding 400ppm of Mg, traces of Fe and Ag showed reduction in crack formation near the heat affected zone (HAZ). The wire was corrosion resistant and it was processed using 6N

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purity Cu. Addition of La<0.002wt%, Ce<0.003wt%, Ca<0.004wt% to a 4N Cu wire revealed a long storage life.

Generally, Cu wires with trace additions are in demand with good bondability, free air ball formation in an inert or reactive environment, reliability, in particular under highly accelerated stress test (HAST), good looping performance and easy to wire draw in mass production scale properties. Slight increase in the resistivity by 5-15% is typically the disadvantage of doped Cu wires. However, if the wire exhibits superior reliability performance especially under HAST, the wire is attractive even with increased resistivity and cost.

Example embodiments of the present invention seek to provide 3N Cu wire with trace additions for bonding in microelectronics that can provide high reliability performance with reduced compromises in other properties.

SUMMARY

According to an aspect of the present invention, there is provided a 3N copper wire with trace additions for bonding in microelectronics comprising one or more of a group of Ag, Ni, Pd, Au, Pt, and Cr as corrosion resistance addition material, wherein a concentration of said corrosion resistance addition material is between about 90wt.ppm to about 980wt.ppm.

The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Ag.

The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Ni.

The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Pd.

The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Au.

5 The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Pt.

The corrosion resistance addition material may comprise about 90wt.ppm to about 980wt.ppm of Cr.

10 The corrosion resistance addition material may comprise about 10wt.ppm to about 50wt.ppm of Ag, about 10wt.ppm to about 50wt.ppm of Ni, and about 10wt.ppm to about 880wt.ppm of Pd.

15 The corrosion resistance addition material may comprise about 10wt.ppm to about 300wt.ppm of Ag and about 10wt.ppm to about 100wt.ppm of Ni.

The corrosion resistance addition material may comprise about 10wt.ppm to about 300wt.ppm of Ag, about 10wt.ppm to about 100wt.ppm of Ni, and about 10wt.ppm to about 580wt.ppm of Pd.

20 The corrosion resistance addition material may comprise about 10wt.ppm to about 300wt.ppm of Ag and about 10wt.ppm to about 200wt.ppm of Ni.

25 The corrosion resistance addition material may comprise about 10wt.ppm to about 300wt.ppm of Ag, about 10wt.ppm to about 200wt.ppm of Ni, and about 10wt.ppm to about 480wt.ppm of Pd.

30 The corrosion resistance addition material may comprise about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, and about 10wt.ppm to about 50wt.ppm of Pd.

The corrosion resistance addition material may comprise about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, and about 10wt.ppm to about 50wt.ppm of Cr.

- 5 The corrosion resistance addition material may comprise about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, about 10wt.ppm to about 50wt.ppm of Pd, and about 10wt.ppm to about 50wt.ppm of Cr.

- 10 The corrosion resistance addition material may comprise about 10wt.ppm to about 300 wt.ppm of Ag, about 10wt.ppm to about 100 wt.ppm of Ni, and about 10wt.ppm to about 530wt.ppm of Pd.

- 15 The corrosion resistance addition material may comprise about 10wt.ppm to about 300 wt.ppm of Ag, about 10wt.ppm to about 100 wt.ppm of Ni, about 10wt.ppm to about 50wt.ppm of Pd, about 10wt.ppm to about 50 wt.ppm of Au, about 10wt.ppm to about 50wt.ppm of Pt, and about 10wt.ppm to about 50wt.ppm of Cr.

- 20 The 3N copper wire may further comprise about 3wt.ppm to about 15wt.ppm of a deoxidizer addition material.

 The deoxidizer addition material may comprise about 1wt.ppm to about 5wt.ppm of Ca and Ce, about 1wt.ppm to about 5wt.ppm of Mg and La, and about 1wt.ppm to about 5wt.ppm of Al.

- 25 The 3N copper wire may further comprise about 10wt.ppm to about 80wt.ppm of a deoxidizer addition material.

 The deoxidizer addition material may comprise about 10wt.ppm to about 80wt.ppm of P.

- 30 The 3N copper wire may further comprise about 3wt.ppm to about 95wt.ppm of a deoxidizer addition material.

The deoxidizer addition material comprises about 1wt.ppm to about 5wt.ppm of Ca and Ce, about 1wt.ppm to about 5wt.ppm of Mg and La, about 1wt.ppm to about 5wt.ppm of Al, and about 10wt.ppm to about 80wt.ppm of P.

- 5 The 3N copper wire may further comprise about 30wt.ppm to about 290wt.ppm of a grain refiner addition material.

10 The grain refiner addition material may comprise about 10wt.ppm to about 200wt.ppm of Fe, about 10wt.ppm to about 50wt.ppm of B, about 5wt.ppm to about 20wt.ppm of Zr, and about 5wt.ppm to about 20wt.ppm of Ti.

 The 3N copper wire may further comprise about 10wt.ppm to about 100wt.ppm of a grain refiner addition material.

- 15 The grain refiner addition material comprises about 10wt.ppm to about 100wt.ppm of B.

 The 3N copper wire may further comprises about 30wt.ppm to about 260wt.ppm of a grain refiner addition material.

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 The grain refiner addition material comprises about 10wt.ppm to about 200wt.ppm of Fe, about 10wt.ppm to about 20wt.ppm of B, about 5wt.ppm to about 20wt.ppm of Zr, and about 5wt.ppm to about 20wt.ppm of Ti.

- 25 The 3N copper wire may further comprise about 1wt.ppm to about 3wt.ppm of S.

BRIEF DESCRIPTION OF THE DRAWINGS

30 Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Fig. 1 shows comparative tensile stress-strain data illustrating for 3N Cu wires with trace additions according to an example embodiment.

Fig. 2 shows comparative polarization scan data for 3N Cu wires with trace additions according to an example embodiment.

Figs. 3a) show SEM image illustrating ball bond for 3N Cu wires with trace additions according to an example embodiment.

Figs. 4a) - b) show comparative ball bond and stitch bond process window data respectively for 3N Cu wires with trace additions according to an example embodiment.

Figs. 5a) - b) show comparative thermal ageing (also referred to as high temperature storage (HTS)) data for 3N Cu wires with trace additions according to an example embodiment.

DETAILED DESCRIPTION

The example embodiments described herein can provide 3N Cu wire with trace additions for bonding in microelectronics packaging industries. The major trace additions elements are Ag, Ni, Pd, Au, Pt, Cr, Ca, Ce, Mg, La, Al, P, Fe, B, Zr and Ti, using high purity Cu (>99.99%). Fine wires are drawn from the Cu with the trace additions. The wires in example embodiments are bondable to Al bond pads as well as Ag, Cu, Au, Pd plated surfaces. The results of HTS of the wire bonds are comparable to a commercially available 4N soft Cu reference wire, when bonded to an Al bond pad and stored at about 175°C for about 1000 hours. Corrosion resistance of the wires with trace elements is advantageously better than the 4N soft Cu reference wire. As will be appreciated by a person skilled in the art, HAST or THB (temperature humidity bias) tests are typically conducted for Cu wire bonded and epoxy molded devices, and for bias or unbiased conditions. During the test, the Cu wire bond interface (i.e. Cu wire welded to Al bond pad) undergoes electro-chemical based galvanic corrosion. Moisture absorption by the epoxy is the source for diffusion of hydroxyl ions (OH^-). Parts per million level of halogen

(Cl, Br, etc.) contamination in the epoxy is the source for Cl^- ions. Polarisation scans recorded for wires according to example embodiments of the present invention under an electrochemical reaction of the wire in dilute HCl acid, revealed a positive rest potential exhibiting corrosion resistance. Hence, 3N Cu wire with trace additions according to example embodiments are expected to perform better on reliability studies such as HAST and THB.

The 3N Cu with trace additions is continuous cast into rods. Elements are added individually or combined to a maximum of about 980 wt.ppm (parts per million by weight) and maintaining the composition of the wire to be 3N in the example embodiments. The cast rods are wire drawn to a fine diameter of about 10 μm to 250 μm . The fine wires in example embodiments advantageously exhibit good free air ball (FAB) formation, bondability, loop formation and reliability (HTS). Hardness, tensile strength, surface oxidation, electrical resistivity and fusing current of the wires with trace additions in example embodiments are close to the 4N soft Cu reference wire, for bonding in microelectronics packaging sectors, while advantageously revealing better corrosion resistance without compromising softness.

In the example embodiments, copper of 4N to 5N purity was used to prepare the alloys and was melted in a vacuum induction furnace. At least one or more of Ag, Ni, Pd, Au, Pt, Cr, Ca, Ce, Mg, La, Al, P, Fe, B, Zr and Ti were added into the melt and held for about 2 to 15 minutes to allow a thorough dissolution. The elements were added individually or combined. The alloy was continuous cast into about 2mm to 25mm rods at a slow speed. No significant loss in dopant additions was observed. These rods were cold wire drawn at room temperature (about 23-25°C).

A tungsten carbide die was used to initially draw heavy wire, and a diamond die was used for further reduction to fine wire. The wire was drawn in three stages at a drawing speed of about 15m/s and less. The die reduction ratios were about 14-18% for heavy wires and about 4 to 12% for fine wires. During cold drawing, the wires were lubricated and intermediate annealed between stages to reduce the residual stresses. Finally, the drawn wires were strand annealed, spooled on clean anodized (plated) aluminum spools, vacuum packed and stored.

Hardness was measured using a Fischer scope H100C tester with a Vickers indenter applying 15mN force for 10s dwell time. Tensile properties of the wires were tested using Instron-5300. The wires were bonded using a Kulicke & Soffa (K&S) - iConn bonder. The bonded wires were observed in a LEO-1450VP scanning electron microscope.

The elements added and ranges of additions in the example embodiments are provided in Table.1. Nobel metals Ag, Au, Pd, Pt, and metals Ni and Cr are added to improve the corrosion resistance of the Cu wire. Ca, Ce, Mg, La, Al, P are added in some embodiments as a deoxidizer, softening the FAB. Fe, B, Zr, Ti are added in some embodiments as a grain refiner to influence FAB grains. Boron is added in some embodiments to influence the strain hardening of the wire along with Ag and Ni.

Table 1 - Composition (wt.ppm) of 3N Cu wire with trace additions

Alloy/ Elem ent	Ag	Ni	Pd	Au	Pt	Cr	Ca + Ce	Mg + La	Al	P	S	Fe	B	Zr	Ti	Total
4N soft Cu	<12	<1	<1	<1	<1	<1	<1	<1	<1	<3	<3	1.1	<1	<1	<1	=99
1	90-980	-	-	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
2	-	90-980	-	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
3	-	-	90-980	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
4	-	-	-	90-980	-	-	-	-	-	-	1-3	-	-	-	-	=999
5	-	-	-	-	90-980	-	-	-	-	-	1-3	-	-	-	-	=999
6	-	-	-	-	-	90-980	-	-	-	-	1-3	-	-	-	-	=999
7	10-50	10-50	10-880	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
8	10-300	10-100	-	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
9	10-300	10-100	10-580	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
10	10-300	10-200	-	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
11	10-300	10-200	10-480	-	-	-	-	-	-	-	1-3	-	-	-	-	=999
12	10-50	10-50	10-50	-	-	-	-	-	-	-	1-3	10-200	10-50	5-20	5-20	=999
13	10-50	10-50	-	-	-	10-50	-	-	-	-	1-3	-	-	-	-	=999
14	10-50	10-50	10-50	-	-	10-50	-	-	-	-	1-3	-	-	-	-	=999
15	10-50	10-50	10-50	-	-	-	1-5	1-5	1-5	-	1-3	-	-	-	-	=999

16	10-50	10-50	10-50	-	-	-	-	-	-	10-80	1-3	-	-	-	-	=999
17	10-50	10-50	10-50	-	-	10-50	-	-	-	10-80	1-3	-	-	-	-	=999
18	10-300	10-100	10-530	-	-	-	-	-	-	-	1-3	-	10-100	-	-	=999
19	10-300	10-100	10-50	10-50	10-50	10-50	1-5	1-5	1-5	10-80	1-3	10-200	10-20	5-20	5-20	=999

The mechanical and electrical properties of the wires with trace additions of the example embodiments are provided in Table 2. The properties advantageously are close to the 4N soft Cu reference wire. A representative tensile plot of 3N Cu wire with trace additions according to example embodiments is shown in Fig.1. As can be seen from a comparison of curve 100 (3N Cu wire with trace additions according to example embodiments) and curve 102 (the 4N soft Cu reference wire), the deformation behavior is advantageously similar on tensile loading. This demonstrates that a maximum of about 980 wt.ppm dopant addition advantageously does not alter the deformation characteristics of the wire with trace additions in example embodiments.

Table 2 - Corrosion, mechanical and electrical properties of 3N Cu wires with trace additions

Alloy/ Element	Wire Hardness (15mN/10s), HV	FAB Hardness (15mN/10s), HV	Modulus, GPa	Resistivity, $\mu\Omega\cdot\text{cm}$	Fusing current (for 10mm length, 300ms input pulse time), mA	Corrosion resistant (++++Excellent, +++very good, ++Good, +Satisfactory)
4N soft Cu	~85	~85	~90	~1.7	~340	
1	~90	~90	~90	~1.7	~340	+
2	~90	~90	~90	~1.7	~340	+
3	~90	~90	~90	~1.8	~340	++
4	~90	~90	~90	~1.8	~340	+
5	~90	~90	~90	~1.8	~340	++
6	~90	~90	~90	~1.8	~340	+
7	~90	~90	~90	~1.8	~340	++
8	~90	~90	~90	~1.7	~340	+
9	~90	~90	~90	~1.8	~340	++
10	~90	~90	~90	~1.7	~340	+
11	~90	~90	~90	~1.8	~340	++
12	~90	~90	~90	~1.9	~340	+
13	~90	~90	~90	~1.7	~340	+
14	~90	~90	~90	~1.8	~340	+
15	~90	~90	~90	~1.7	~340	+
16	~90	~90	~90	~1.7	~340	+
17	~90	~90	~90	~1.7	~340	+
18	~90	~90	~90	~1.9	~340	+
19	~90	~90	~90	~1.9	~340	+

The corrosion resistance of 3N Cu wires with trace additions according to example embodiments is better than that of the 4N soft Cu reference wire (Table 2). Figure 2 shows a representative scan of the Cu wire with trace additions according to example embodiments (curve 200), revealing a higher positive rest potential of -201mV compared to -255mV for the 4N soft Cu reference wire (curve 202). As will be appreciated by a person skilled in the art, in a polarization scan, if the rest potential (corrosion potential) of the test element is towards positive, the element is noble. On the other hand, if the rest potential is negative the element is active (corrosive). Therefore, the 3N Cu wire with trace additions according to example embodiments is "nobler" than the 4N soft Cu reference wire. The scan was obtained using dilute HCl acid electrolyte and stirring the solution kept at room temperature.

The 3N Cu wire with trace additions of example embodiments can be bonded to pads metallized (plated) with Au, Ag, Pd and Cu. On bonding to Al bond pad, the wire bonds are anticipated to have a longer reliability life especially under HAST and THB tests. Figure 3 show representative scanning electron microscope image of ball bonds respectively of a 3N Cu 0.8mil wire with trace additions according to example embodiments. With reference to Figures 4 and 5, the ball and stitch bond process window and reliability performance of the 3N Cu wire with trace additions according to example embodiments and of the reference soft Cu 4N wires are nearly the same. More particular, in Figure 4(a), the representative ball bond process window 400 for the 3N Cu wire with trace additions according to example embodiments is similar to the ball bond process window 402 of the 4N soft Cu reference wire. Similarly, in Figure 4(b) the representative stitch bond process window 404 for the 3N Cu wire with trace additions according to example embodiments is similar to the stitch bond process window 406 for the 4N soft Cu 0.8mil reference wire. A comparison of curve 500 (Figure 5(a)) and representative curve 502 (Figure 5(b)) illustrates that the thermal aging of the 4N soft Cu 0.8mil reference wire and the 3N Cu 0.8mil wire with trace additions according to example embodiments are also similar.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly

described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A 3N copper wire with trace additions for bonding in microelectronics comprising one or more of a group of Ag, Ni, Pd, Au, Pt, and Cr as corrosion resistance addition material, wherein a concentration of said corrosion resistance addition material is between about 90wt.ppm to about 980wt.ppm.
2. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Ag.
3. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Ni.
4. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Pd.
5. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Au.
6. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Pt.
7. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 90wt.ppm to about 980wt.ppm of Cr.
8. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 50wt.ppm of Ag, about 10wt.ppm to about 50wt.ppm of Ni, and about 10wt.ppm to about 880wt.ppm of Pd.
9. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300wt.ppm of Ag and about 10wt.ppm to about 100wt.ppm of Ni.

10. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300wt.ppm of Ag, about 10wt.ppm to about 100wt.ppm of Ni, and about 10wt.ppm to about 580wt.ppm of Pd.

5 11. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300wt.ppm of Ag and about 10wt.ppm to about 200wt.ppm of Ni.

10 12. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300wt.ppm of Ag, about 10wt.ppm to about 200wt.ppm of Ni, and about 10wt.ppm to about 480wt.ppm of Pd.

15 13. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, and about 10wt.ppm to about 50wt.ppm of Pd.

20 14. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, and about 10wt.ppm to about 50wt.ppm of Cr.

25 15. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 50 wt.ppm of Ag, about 10wt.ppm to about 50 wt.ppm of Ni, about 10wt.ppm to about 50wt.ppm of Pd, and about 10wt.ppm to about 50wt.ppm of Cr.

30 16. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300 wt.ppm of Ag, about 10wt.ppm to about 100 wt.ppm of Ni, and about 10wt.ppm to about 530wt.ppm of Pd.

17. The 3N copper wire as claimed in claim 1, wherein the corrosion resistance addition material comprises about 10wt.ppm to about 300 wt.ppm of Ag, about 10wt.ppm to about 100 wt.ppm of Ni, about 10wt.ppm to about 50wt.ppm of Pd,

about 10wt.ppm to about 50 wt.ppm of Au, about 10wt.ppm to about 50wt.ppm of Pt, and about 10wt.ppm to about 50wt.ppm of Cr.

18. The 3N copper wire as claimed in claim 13, further comprising about
5 3wt.ppm to about 15wt.ppm of a deoxidizer addition material.

19. The 3N copper wire as claimed in claim 18, wherein the deoxidizer
addition material comprises about 1wt.ppm to about 5wt.ppm of Ca and Ce, about
1wt.ppm to about 5wt.ppm of Mg and La, and about 1wt.ppm to about 5wt.ppm of Al.
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20. The 3N copper wire as claimed in claim 13 or 15, further comprising
about 10wt.ppm to about 80wt.ppm of a deoxidizer addition material.

21. The 3N copper wire as claimed in claim 20, wherein the deoxidizer
15 addition material comprises about 10wt.ppm to about 80wt.ppm of P.

22. The 3N copper wire as claimed in claim 17, further comprising about
13wt.ppm to about 95wt.ppm of a deoxidizer addition material.

20 23. The 3N copper wire as claimed in claim 22, wherein the deoxidizer
addition material comprises about 1wt.ppm to about 5wt.ppm of Ca and Ce, about
1wt.ppm to about 5wt.ppm of Mg and La, about 1wt.ppm to about 5wt.ppm of Al, and
about 10wt.ppm to about 80wt.ppm of P.

25 24. The 3N copper wire as claimed in claim 13, further comprising about
30wt.ppm to about 290wt.ppm of a grain refiner addition material.

25. The 3N copper wire as claimed in claim 24, wherein the grain refiner
addition material comprises about 10wt.ppm to about 200wt.ppm of Fe, about 10wt.ppm
30 to about 50wt.ppm of B, about 5wt.ppm to about 20wt.ppm of Zr, and about 5wt.ppm to
about 20wt.ppm of Ti.

26. The 3N copper wire as claimed in claim 16, further comprising about 10wt.ppm to about 100wt.ppm of a grain refiner addition material.

5 27. The 3N copper wire as claimed in claim 26, wherein the grain refiner addition material comprises about 10wt.ppm to about 100wt.ppm of B.

28. The 3N copper wire as claimed in claim 23, further comprising about 30wt.ppm to about 260wt.ppm of a grain refiner addition material.

10 29. The 3N copper wire as claimed in claim 28, wherein the deoxidizer addition material comprises about 10wt.ppm to about 200wt.ppm of Fe, about 10wt.ppm to about 20wt.ppm of B, about 5wt.ppm to about 20wt.ppm of Zr, and about 5wt.ppm to about 20wt.ppm of Ti.

15 30. The 3N copper wire as claimed in any one of the preceding claims, further comprising about 1 to about 3wt.ppm of S.