

【DESCRIPTION】**【Invention Title】**

COPPER ALLOY STRIP MATERIAL FOR ELECTRICAL OR ELECTRONIC
PART AND METHOD FOR MANUFACTURING THE SAME

5 **【Technical Field】**

The present invention relates to a Cu-Ni-Si-based
copper alloy strip material suitable for use in electrical
or electronic parts.

【Background Art】

10 Conventionally, Fe-based materials for use in
electrical or electronic parts are usually used, but
recently, Cu-based materials having excellent electricity and
heat conductivity such as phosphor bronze, tombac, brass,
Corson alloy and the like have been widely used. As the
15 electrical or electronic parts have become smaller, lighter
in weight and more densely integrated, in recent years, the
Cu-based materials for use in the electrical or electronic
parts need to be excellent in strength, conductivity, stress
relaxation resistance property, bending workability, plating
20 property, press formability, heat resistance and the like.

The Corson alloy that is made by adding Ni and Si to Cu
to form the precipitates of Ni-Si-based compound is a Cu-Ni-
Si-based alloy having very excellent strength. For example,
a CDA70250 alloy which has been registered on CDA (Copper
25 Development Association) is marketed.

Also, there have been proposed Corson alloys on which
the distribution states of the Ni-Si-based compounds are
prescribed and their properties are improved (for example,
they are disclosed in Japanese Patent Publication Laid-Open
30 Nos. 2005-298920 and 2001-49369).

However, the CDA70250 alloy and the Corson alloys

disclosed in the prior art Japanese Patent Publication Laid-Open Nos. 2005-298920 and 2001-49369 fail to fully satisfy the properties which are needed in the electrical or electronic parts, and especially, they do not provide any improved plating property, press formability and heat resistance.

【Disclosure】

【Technical Problem】

Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and it is an object of the present invention to provide a copper alloy strip material suitable for use in electrical or electronic parts such as lead frames, connectors, terminals, relays, switches and the like, while exhibiting excellent plating property, press formability and heat resistance, and a method for manufacturing the same.

The present inventors have made various studies on the copper alloy strip material suitable for use in electrical or electronic parts and have checked the grain diameter (the diameter of the compound grain) of the compound dispersed on the copper alloy strip material, the dispersion density, and the relationship between the particle diameter and the dispersion density and the properties such as the plating property, press formability and heat resistance. As a result, they have found that if the grain diameter and the dispersion density are properly provided, the properties are improved, and based upon on such knowledge, the present invention has been accomplished.

【Technical Solution】

To achieve the above object, according to an aspect of the present invention, there is provided a copper alloy strip material for use in electrical or electronic parts,

including: a copper alloy comprising 2.0 to 5.0 mass% Ni, 0.43 to 1.5 mass% Si, and the balance of Cu and unavoidable impurities, wherein there are three types of intermetallic compounds (A, B and C) comprising Ni and Si in a total amount of 50 mass% or more, the intermetallic compound A having a compound diameter (which is an arithmetic mean between a minimum value and a maximum value in the compound diameters, and hereinafter, it is defined as the same meaning) of 0.3 μm to 2 μm , the intermetallic compound B having a compound diameter of 0.05 μm to less than 0.3 μm , and the intermetallic compound C having a compound diameter of more than 0.001 μm to less than 0.05 μm .

According to the present invention, preferably, the dispersion density a of the intermetallic compound A, the dispersion density b of the intermetallic compound B, and the dispersion density c of the intermetallic compound C satisfy an expression $[a/(b+c) \leq 0.010]$.

According to the present invention, preferably, the dispersion density b of the intermetallic compound B and the dispersion density c of the intermetallic compound C satisfy an expression $[0.001 \leq (b/c) \leq 0.10]$.

According to the present invention, preferably, the horizontal length X(μm) and the vertical length y(μm) of the crystal grain diameter on a perpendicular section to the rolling direction of the copper alloy strip material satisfy an expression $[x/y \geq 2]$.

According to the present invention, preferably, the copper alloy strip material further includes a total of 0.005 to 1.5 mass% of at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb, Mn, Ta, V, Sn, Zn and Mg.

To achieve the above object, according to another aspect of the present invention, there is provided a method for manufacturing a copper alloy strip material for use in electrical or electronic parts, including the steps of:

5 reheating a cast ingot of a copper alloy comprising 2.0 to 5.0 mass% Ni, 0.43 to 1.5 mass% Si, and the balance of Cu and unavoidable impurities, at a temperature in a range between 850°C and 950°C for from two hours to ten hours; hot rolling the reheated cast ingot for from 100 seconds to 500 seconds

10 to make a copper alloy strip material; rapidly cooling the hot rolled copper alloy strip material to a temperature in a range between 600°C and 800°C; conducting aging heat treatment for the cold rolled copper alloy strip material at a temperature in a range between 400°C and 550°C for from one

15 hour to four hours.

According to the present invention, preferably, the copper alloy strip material further includes a total of 0.005 to 1.5 mass% of at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb,

20 Mn, Ta, V, Sn, Zn and Mg.

Another characteristics and advantages of the present invention will be more apparent from the following description with reference to the attached drawings.

【Description of Drawings】

25 FIGS.1a to 1c are photographs showing a copper alloy photographed by a transmissive electronic microscope having an accelerating voltage of 300kV, wherein FIGS.1a and 1b are photographs enlarged to 50000 times and FIG.1c is a photograph enlarged to 100000 times.

30 FIG.2 is a perspective view showing a crystal grain diameter of a copper alloy strip material.

【Best Mode for Invention】

A copper alloy strip material suitable for use in electrical or electronic parts according to a preferred embodiment of the present invention will be explained in detail. First, the copper alloy composition in the copper alloy strip material of the present invention will be described with reference to the operating effects of respective alloy elements and their content.

Ni and Si form the precipitates of a Ni-Si compound, thereby providing a strength-improving effect.

The Ni content is in a range from 2.0 to 5.0 mass%, preferably from 2.5 to 3.5 mass%, and the Si content is in a range from 0.43 to 1.5 mass%, preferably from 0.5 to 0.7 mass%, more preferably from 0.8 to 1.1 mass%.

The reason of prescribing the contents of Ni and Si is that if any one of them is less than a lower limit, a sufficient strength is not obtained, and contrarily, if any one of them is more than an upper limit, the strength is excessively high, thereby decreasing the conductivity.

The mass ratio of Ni and Si is not specially restricted, but it is preferable that if the mass ratio of Ni is 1, the mass ratio of Si is in a range of 0.2 to 0.3. Also, if the upper limit of the content of Si is about 1/4 of the content of Ni, the strength becomes highest, and if the content of Si is more than 1.5 mass%, hot rolling cracks are easily happened.

According to the present invention, preferably, the copper alloy strip material further includes at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb, Mn, Ta, V, Sn, Zn and Mg, which improves the strength. The total content of the elements is 0.005 to 1.5 mass%, preferably 0.01 to 1.0 mass%. If the content is less than 0.005 mass%, the effect cannot be

sufficiently obtained, and contrarily, if the content is more than 1.5 mass%, the conductivity becomes decreased.

According to the present invention, fine Ni-Si-based intermetallic compounds are produced in the copper-based parent phase alloy, and the strength of the alloy is increased, while the electrical conductivity is becoming good. However, the present invention notes the sizes of the compounds, and the arithmetic mean between the minimum value and the maximum value in the diameters of the compounds is defined as the diameter of the compound. Based on the diameter of the compound, the compounds are classified into compounds A, B and C. According to the present invention, furthermore, it is necessary that the compounds B and C are contained in the copper alloy strip material.

So as measure the diameters of the compounds, a round hole having a diameter of 3mm is punched on an alloy sample and the thin film is polished by means of twin-jet polishing. Next, the photographs enlarged to 50000 times and 100000 times are taken for arbitrary three positions of the alloy sample using a transmissive electronic microscope having an accelerating voltage of 300kV, such that the diameters of the compounds and the number of compounds are measured on the photographs. Accordingly, the compounds A, B and C are defined according to the diameters of the compounds (the arithmetic mean between the minimum value and the maximum value in the diameters of the compounds).

FIG.1 is a measured result of No.9 in the example 2 of the present invention by using the transmissive electronic microscope having an accelerating voltage of 300kV, wherein FIGS.1a and 1b are photographs enlarged to 50000 times and FIG.1c is a photograph enlarged to 100000 times. The

dispersion densities of the compounds A, B and C are obtained by the following manner.

First, the compounds appearing on the photographs taken at the arbitrary three positions are classified by sizes. In this case, the diameter of the compound is the arithmetic mean between the minimum value and the maximum value in the diameters of the compound.

Next, the number of compounds by sizes is counted, and the counted number is removed from the area of each photograph and is continuously converted into unit area (mm^2).

This is conducted for all of the three photographs enlarged to 50,000 times and 100,000 times, thereby obtaining the average values for the total six photographs.

The compound A has a total of more than 50 mass% of Ni and Si and the diameter in a range from 0.3 μm to 2 μm , while exhibiting a relatively low tensile strength in the copper alloy strip material when compared with the compounds B and C. When the compound A is contained in an excessive amount in the copper alloy strip material, it may decrease the plating property of the copper alloy strip material. Furthermore, if the content of the compound A is increased, the contents of the compounds B and C contributing to the improvement of the properties of the copper alloy strip material are decreased, and it is therefore preferable that the content of the compound A should be small. The dispersion density a of the compound A is preferably less than 10 number/ mm^2 .

According to the present invention, the compound A is produced during the melting/casting, the solidification process, or upon the non-equilibrium heat treatment during hot working, and the compound A is easily lost or down-sized when the reheating treatment before hot rolling or the solution heat treatment (homogenizing treatment) after the

hot rolling is conducted at a high temperature or for a long period of time. The reheating treatment is conducted under the conditions of a temperature of more than 900°C for 0.5 hour or greater in the industrial field thereof, but in the
5 conditions, the compound A may remain or be produced during the hot rolling.

According to the present invention, the compound B has a total of more than 50 mass% of Ni and Si and the diameter in a range from 0.05 μm to less than 0.3 μm , while exhibiting
10 improved press formability. That is, when the copper-based parent phase of the copper alloy strip material is changed out of shape in a state of being fit by means of a punch and a die during press working, the compound is not changed out of shape because of its high hardness, but fine cracks occur
15 on the copper-based parent phase around the compound and the propagation of the cracks makes shearing working easy, thereby improving the press formability. The effect cannot be sufficiently obtained when the diameter of the compound is in a range from less than 0.05 μm to more than 0.3 μm . Even
20 though the content of the compound B is increased, the effect the compound B has is decreased, and further, the content of the compound C contributing to the improvement of other properties in the copper alloy strip material may be reduced.

The grain diameter and dispersion density of the
25 compound B can be controlled by adjusting the number of the rolling passes during hot rolling, the interval time of the rolling passes, the hot rolling finish temperature, and the time required until the water quenching after the completion of the rolling. The dispersion density b of the compound B
30 is preferably in a range from 10^2 number/ mm^2 to 10^6 number/ mm^2 .

According to the present invention, the compound C has a total of more than 50 mass% of Ni and Si and the diameter

in a range from more than 0.001 μ m to less than 0.05 μ m, while contributing to the improvement of the heat resistance. The lead frame after press working is subjected to the stress relief annealing so as to remove the residual stress generated during the press working, but the material having high heat resistance preferably exhibits a relatively small change in the hardness upon the stress relief annealing. However, if the content of the compound C is excessive, the conductivity may be decreased.

10 The diameter and dispersion density of the compound C are controlled by adjusting sample heat treatment conditions (temperature and time). If the temperature of the sample heat treatment is high and the time required for the sample heat treatment is long, the grain diameter of the compound becomes large and the conductivity becomes high, but the tensile strength becomes low. On the other hand, if the temperature of the sample heat treatment is low, the grain diameter of the compound becomes small and the conductivity becomes low. The dispersion density c of the compound C is preferably in a range from 10^4 number/mm² to 10^9 number/mm², more preferably in a range from 10^5 number/mm² to 10^7 number/mm².

25 According to the present invention, if the dispersion density a of the compound A, the dispersion density b of the compound B, and the dispersion density c of the compound C satisfy an expression $[a/(b+c) \leq 0.010]$, it is apparently appreciated that the press formability and strength are improved. If $a/(b+c)$ is more than 0.010, the press formability and strength are decreased and further the plating property is decreased.

30 According to the present invention, if the dispersion density b of the compound B and the dispersion density c of

the compound C satisfy an expression $[0.001 \leq (b/c) \leq 0.10]$, it is appreciated that the press formability is improved. If b/c is less than 0.001, the press formability is not sufficiently obtained, and contrarily, if b/c is more than 0.10, the precipitation strengthening is low so that the strength is not sufficiently obtained.

According to the present invention, if the compounds A, B and C have a total of more than 50 mass% of Ni and Si, the effect of the present invention can be achieved. It is preferable that they have a total of more than 75 mass% of Ni and Si. In addition thereto, Cu or other elements may be contained.

According to the present invention, the composition of the compounds A, B and C can be appropriately analyzed using an energy dispersive spectroscopy (EDS) attached on the transmissive electronic microscope. At this time, because the influence of the copper-based parent phase exists, the peak value of the copper and the background are removed from the obtained chart, and the peak values of Ni, Si and other detected elements are standardized to calculated values, thereby obtaining the percentage of the content of the Ni and Si contained in the compounds.

The copper alloy strip material having the dispersion densities of the compounds A, B and C satisfying the above expressions can, for example, be manufactured by the production processes set out below.

The cast ingot of a copper alloy comprising 2.0 mass% to 5.0 mass% Ni and 0.43 mass% to 1.5 mass% Si is reheated to a temperature range from 850°C to 950°C for from two hours to ten hours, and next, hot rolling is conducted for from 100 seconds to 500 seconds. The hot rolling finish temperature is in a range between 600°C and 800°C and next, the cooling

is rapidly conducted. The rapid cooling conditions are preferably set at a cooling speed in a range between 5°C/sec and 100°C/sec in a temperature range of more than 300°C. After that, the cold rolling and annealing are repeatedly
 5 conducted if necessary, and next, aging heat treatment is conducted in the conditions of the temperature between 400°C and 550°C for from one hour to four hours. As a result, the copper alloy strip material having excellent plating property, press formability, and heat resistance is produced.

10 It is more preferable that the reheating conditions at the temperature between 875°C and 925°C for from four hours to six hours, the hot rolling time for from 400 seconds to 600 seconds, the hot rolling finish temperature between 650°C and 750°C, the rapid cooling at the cooling speed in a range
 15 between 20°C/sec and 50°C/sec (in a temperature range of more than 300°C), and the aging heat treatment at the temperature between 425°C and 500°C for from 1.5 hours to 3.5 hours.

According to the present invention, if the ratio $[x/y]$ of a horizontal length x (μm) to a vertical length y (μm) of
 20 the grain diameter in the perpendicular section to the rolling direction of the copper alloy strip material is more than 2, the press formability is improved. It is more preferable that the ratio $[x/y]$ is more than 4. As shown in FIG.2, the horizontal length x is parallel to the width
 25 direction of the strip, and the vertical length y is parallel to the thickness direction of the strip. The ratio $[x/y]$ is controllable by the hot rolling conditions.

According to the copper alloy strip material of the present invention, the diameters (compound diameters) of the
 30 intermetallic compounds (hereinafter, referred simply to as compounds) contained in the Cu-Ni-Si-based copper alloy strip

material are appropriately prescribed, thereby especially improving the plating property, press formability and heat resistance, which is very helpful for use in the electrical or electronic parts. In addition, the dispersion densities of the grain diameters of the compounds or the crystal grain diameter of the copper-based parent phase are prescribed, thereby more improving the above-mentioned properties. Further, the copper alloy strip material further includes a total of 0.005 to 1.5 mass% of at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb, Mn, Ta, V, Sn, Zn and Mg, thereby more improving the strength.

The copper alloy strip material according to the present invention can be easily manufactured by prescribing the reheating conditions before the hot rolling process, the hot rolling conditions and the aging heat treatment conditions.

[EXAMPLES]

The present invention will be in more detail described below with reference to examples. On the other hand, the present invention is not limited to the following examples set out below.

[EXAMPLE 1]

The copper alloys (No.1 to No.6) having the compositions as listed in Table 1 comprising 2.0 to 5.0 mass% Ni, 0.43 to 1.08 mass% Si and the balance of Cu and unavoidable impurities were molten using a high frequency molting furnace and were cast at a cooling speed between 10°C/sec and 30°C/sec, thereby making cast ingots having a thickness of 30mm, a width of 100mm and a length of 150mm. The cast ingots were reheated on the conditions shown in Table 1, and the hot rolling as shown in Table 1 was

conducted to make hot rolled strips having a thickness of 12mm. Next, face milling for the strips was conducted by 1mm on the both surfaces thereof, thereby obtaining the strips having the thickness of 10mm. Next, the cold rolling for the strips was conducted to make cold rolled strips having a thickness of 0.167mm. After that, the solid heat treatment was conducted at a temperature of 950°C for 20 seconds, and then, the strips were immediately quenched in water. Next, the aging heat treatment as shown in Table 1 was carried out and finish cold rolling was conducted at a rolling reduction ratio of 10%, thereby obtaining respective test materials. Next, the properties for the produced test materials were investigated.

The various properties for the produced test materials were obtained by the following manners set forth below.

(a) Conductivity

Specific resistance for each test material was obtained through four-point probe measurement in a thermostat where water is maintained at a temperature of 20°C (in a range between 19.5°C and 20.5°C), thereby calculating conductivity. The distance between the probe points was 100 mm.

(b) Tensile strength

The test pieces of JIS Z2201-5 cut in parallel direction to the rolling direction were taken by three from each test material, and the tensile strength test for the test pieces was conducted in compliance with the JIS Z2241, thereby obtaining the average value of each test piece.

(c) Heat resistance

The strip material taken from each test material was heated in inert gas in a temperature range from 400°C to 700°C for 30 minutes every 50°C, thereby measuring the surface hardness using a Vickers hardness tester. The

surface hardness for five positions was measured and the average value was obtained. The temperature having accurately intermediate hardness between the hardness for non-heat treated material (As material) and the hardness for the material having the lowest hardness was defined as half-softening temperature. If the half-softening temperature was more than 500°C, it was estimated as A, if it was in a range between 450°C and 500°C, it as B, and if it was less than 450°C, it was as C. The material having high heat resistance desirably exhibits excellent stability in the stress relief annealing after the press working.

(d) Press formability

The test materials were cut after setting the clearance of 10% between a punch and a die in a simple press machine, and the cut portion was filled with resin and was subjected to mechanical and wet polishing. After that, the cut face was observed using the optical microscope enlarging the image to 400 times, thereby measuring the lengths of burrs. Five burr lengths were measured in the parallel direction to the rolling direction and in the perpendicular direction to the rolling direction, thereby obtaining the average value (n=10).

If the length of the burr was less than 1 μm , it was estimated as A, if it was in a range between 1 μm and 3 μm , it was as B, and if it was more than 3 μm , it was as C. The shorter the length of the burr is, the better the press formability is.

(e) Plating property

The Ag plating for the test materials was conducted to a thickness of about 2 μm , and the plated test materials were heated at temperatures of 350°C, 400°C and 450°C for ten minutes. After that, the expansion of the Ag plated test

material was observed over a size of 30mm × 30mm using the optical microscope enlarging the image to 200 times. If the number of expanded portions is 0, it was estimated as A, if it is between 1 and 5, it was as B, and if it was more than 5, it was as C. If the plating expansion exists, the bonding force becomes low.

[EXAMPLE 2]

The copper alloys (No.7 to No.17) having the compositions as listed in Table 1 comprising 3.0 mass% Ni, 0.65 mass% Si, Mg or Zn having the contents shown in Table 1, and the balance of Cu and unavoidable impurities were subjected to the same treatments as the example 1, thereby making test materials. So as to check the properties of the test materials, next, the same experiments as the example 1 were carried out.

[EXAMPLE 3]

The copper alloys (No.21 to No.30) having the compositions as listed in Table 2 comprising 2.4 to 3.3 mass% Ni, 0.43 to 1.08 mass% Si, Mg, Zn or Sn having the contents shown in Table 2, and the balance of Cu and unavoidable impurities were subjected to the same treatments as the example 1, thereby making test materials. So as to check the properties of the test materials, next, the same experiments as the example 1 were carried out.

[COMPARATIVE EXAMPLE 1]

The copper alloys (No.31 to No.37) having the compositions as listed in Table 2 comprising 3.0 mass% Ni, 0.65 mass% Si, Mg or Zn having the contents shown in Table 2, and the balance of Cu and unavoidable impurities were subjected to the same treatments as the example 1, thereby making test materials, except that any one of the manufacturing conditions did not conform to the prescribed

value of the present invention. So as to check the properties of the test materials, next, the same experiments as the example 1 were carried out.

The experiment results of the example 1 and 2 were shown in Table 1, and those of the example 3 and the comparative example 1 were shown in Table 2. Tables 1 and 2 show the manufacturing conditions, $a/(b+c)$, b/c , total density (mass%) of Ni and Si in compounds A, B and C, and the horizontal to vertical ratio x/y of crystal grain.

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[Table 1]

Classi- fication	No	Alloy element Mass%			Manufacturing Condition							Characteristics									
		No		Si	Selected Element	Reheating		Hot rolling			Aging heat treatment		a/(b+c)	b/c	① Ni+Si in the com- pound	② x/y	Plating property	Press form- ability	Heat Resistan- ce	Conduct- tivity	Tensile Streng- th
						Temp. ℃	Time hr	Time Sec.	End Temp ℃	Cooling Speed ℃/Sec	Temp. ℃	Time hr									
Example No. 1	1	3.0	0.65	-	850	8	300	710	60	450	3	0.005	0.008	85	2.8	A	A	A	52	689	
	2	3.0	0.65	-	880	4	400	730	50	470	3.5	0.007	0.004	87	3.1	A	A	A	54	683	
	3	3.0	0.65	-	920	6	200	775	70	465	2.5	0.009	0.011	86	2.9	A	A	A	53	679	
	4	3.0	0.65	-	950	5	300	750	90	430	4	0.009	0.012	83	2.6	A	A	A	49	724	
	5	2.0	0.43	-	920	4	350	725	40	425	6	0.008	0.004	81	2.7	A	A	A	50	712	
	6	5.0	1.08	-	920	2	220	760	100	440	4	0.003	0.003	79	3.0	A	A	A	51	705	
Example No. 2	7	3.0	0.65	0.1Mg	900	5	300	700	80	450	2	0.008	0.015	89	3.1	A	A	A	51	699	
	8	3.0	0.65	0.1Mg	875	4	350	680	70	425	4	0.005	0.012	84	3.1	A	A	A	48	730	
	9	3.0	0.65	0.1Mg	850	5	180	780	120	500	1	0.003	0.004	82	2.7	A	A	A	57	635	
	10	3.0	0.65	0.1Mg	875	4	450	750	80	475	3	0.005	0.013	83	2.9	A	A	A	54	667	
	11	3.0	0.65	0.1Mg	900	3	300	720	180	450	2	0.008	0.002	81	2.4	A	A	A	51	699	
	12	3.0	0.65	0.1Mg	880	4	250	750	40	475	1.5	0.005	0.051	82	2.8	A	A	A	54	667	
	13	3.0	0.65	0.5Zn	900	6	350	720	50	440	3	0.008	0.055	77	3.1	A	A	A	50	711	
	14	3.0	0.65	0.5Zn	880	3	400	700	100	480	1.5	0.007	0.004	79	3.4	A	A	A	55	660	
	15	3.0	0.65	0.15Mg	920	5	350	690	50	450	2	0.006	0.055	80	2.8	A	A	A	51	699	
	16	3.0	0.65	0.15Mg	890	4	280	730	80	470	1.5	0.004	0.004	84	3.6	A	A	A	53	673	
	17	3.0	0.65	0.15Mg	920	3	220	780	40	440	2	0.004	0.004	83	3.1	A	A	A	50	711	

Note)① Ni + Si concentration of compounds A, B and C mass% ② Ration for horizontal length x to vertical length y of the grain

[Table 2]

Classification	No	Alloy element Mass%			Manufacturing Condition							a/(b+c)	b/c	① Ni+Si in the com- pound	② x/y	Characteristics				
					Reheating		Hot rolling		Aging heat treatment							Plating property	Press form- ability	Heat Resistan- ce	Conduct- tivity	Tensile Streng- th
No	Si	Selected Element	Temp. ℃	Time hr	Time Sec.	End Temp ℃	Cooling Speed ℃/Sec	Temp. ℃	Time hr											
Example No. 3	21	2.5	0.65	0.08Mg	845	2	350	720	30	425	4	0.002	0.01	92	3.1	A	A	53	690	
	22	2.7	0.65	0.12Mg	890	3	350	740	80	460	2.5	0.001	0.008	97	3	A	A	52	692	
	23	2.9	0.65	0.15Mg	900	2	380	750	40	480	3	0.003	0.009	95	2.8	A	A	55	702	
	24	3.3	0.65	0.08Mg+0.2Zn	925	2	370	730	50	420	4	0.004	0.011	92	2.8	A	A	53	705	
	25	2.4	0.43	0.12Mg+0.3Zn	900	2	300	720	30	455	2	0.002	0.005	92	2.9	A	A	56	658	
	26	2.7	1.08	0.15Mg+0.1Zn	915	4	280	780	90	420	3	0.005	0.006	92	3.3	A	A	52	705	
	27	3.3	0.65	0.08Mg+0.1Sn	890	2	290	720	100	435	2.5	0.005	0.012	90	3.1	A	A	53	700	
	28	2.6	0.65	0.08Mg+0.2Sn	880	4	310	700	90	490	2	0.002	0.017	82	3.4	A	A	52	692	
	29	2.7	0.65	0.08Mg	890	2	180	720	90	450	2.5	0.005	0.006	91	2.9	A	A	50	723	
	30	3.0	0.65	0.12Mg	900	3	280	790	70	420	3	0.002	0.016	92	3.3	A	A	53	703	
Comp. Example No. 1	31	3.0	0.65	-	800	2	300	650	70	410	1.5	0.012	0.071	53	3.4	B	A	42	625	
	32	3.0	0.65	0.1Mg	850	1	330	680	50	425	2	0.015	0.088	81	0.8	C	A	48	610	
	33	3.0	0.65	-	900	2	50	810	90	480	2	0.004	0.0008	88	3.4	A	C	55	660	
	34	3.0	0.65	0.15Mg	880	4	300	550	120	450	2	0.007	0.0007	84	3.1	A	C	51	699	
	35	3.0	0.65	-	850	3	280	700	10	425	4	0.008	0.0006	81	2.9	A	A	48	730	
	36	3.0	0.65	0.5Zn	900	3	400	690	70	600	3	0.007	0.12	86	1.5	A	B	68	508	
	37	3.0	0.65	-	850	2	280	710	60	475	5	0.006	0.15	76	1.8	A	A	54	520	

Note)① Ni + Si concentration of compounds A, B and C mass% ② Ration for horizontal length x to vertical length y of the grain

As apparent from Tables 1 and 2, the copper alloy strip materials (No.1 to No.30) according to the present invention exhibited excellent plating property, press formability and heat resistance. Also, they obtained good conductivity and tensile strength.

On the other hand, $[a/(b+c)]$ values of Nos.31 and 32 in the comparative example 1 did not conform to the prescribed value of the present invention, thereby exhibiting low degrees of press formability, strength and plating property. Since $[x/y]$ of No.32 was smaller than the prescribed value of the present invention, No.32 exhibited very low degree of press formability, and contrarily, since $[b/c]$ of Nos.33 to 35 was smaller than the prescribed value of the present invention, they exhibited low degree of press formability. Also, since $[b/c]$ of Nos.36 and 37 was larger than the prescribed value of the present invention, they exhibited low degree of strength, and contrarily, since their $[x/y]$ was smaller than the prescribed value of the present invention, they exhibited low degree of press formability.

On the other hand, experiments on the stress relaxation resistance property and bending workability of the copper alloy strip materials (Nos. 1 to 30) were additionally conducted, wherein the properties were also required for electrical or electronic parts. As a result, it was found that they had the stress relaxation resistance property and bending workability giving no trouble in practical use.

[EXAMPLE 4]

The copper alloys (No.38 to No.41) having the compositions as listed in Table 3 comprising Ni, Si, Co, and the balance of Cu and unavoidable impurities were subjected

to the same treatments as the example 1, thereby making test materials, except that the manufacturing conditions listed were adopted. So as to check the properties of the test materials, next, the same experiments as the example 1 were
5 carried out.

[Table 3]

Classification	No	Alloy element		Manufacturing Condition								a/(b+c)	b/c	① Ni+Si in the com- pound	② x/y	Characteristics					
		Mass%		Reheating	Hot rolling			Aging heat treatment		Plating property	Press form-ability					Heat Resistance	Conduct-ivity	Tensile Streng- Th			
		No	Si		Selected Element	Co	Temp. °C	Time hr	End Temp. °C										Cooling Speed °C/sec	Temp. °C	Time hr
Example No. 4	38	0.5	0.2	0.37	870	2	250	710	70	525	2.5	0.002	0.05	80	3.7	A	A	A	60	676	
	39	1.1	0.44	0.81	900	2	310	750	80	550	4	0.001	0.04	75	4.1	A	A	A	56	690	
	40	1.5	0.6	1.1	950	3	330	780	80	526	4.5	0.002	0.06	55	3.9	A	A	A	53	738	
	41	2.1	0.85	1.54	980	3	380	810	90	550	3	0.002	0.03	65	4.6	A	A	A	49	755	

As apparent from Table 3, the copper alloy strip materials (No.38 to No.41) according to the present invention exhibited excellent plating property, press formability and heat resistance, like the copper alloy strip materials in the examples 1 to 3. Also, they obtained good conductivity and tensile strength.

【Industrial Applicability】

As set forth in the foregoing, there is provided the copper alloy strip material very suitable for use in electrical or electronic parts such as lead frames, connectors, terminals, relays, switches and the like.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

This application claims the priority of Japanese patent document No.2006-246961, filed Dec. 12, 2006 and the priority of Japanese patent document No.2007-236003, filed Sep. 11, 2007, the disclosure of which is expressly incorporated by reference herein.

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【CLAIMS】

【Claim 1】

A copper alloy strip material for use in electrical or electronic parts, including: a copper alloy comprising 2.0 to 5.0 mass% Ni, 0.43 to 1.5 mass% Si, and the balance of Cu and unavoidable impurities, wherein

a) there are three types of intermetallic compounds (A, B and C) comprising Ni and Si in a total amount of 50 mass% or more, the intermetallic compound A having a compound diameter of 0.3 μm to 2 μm , the intermetallic compound B having a compound diameter of 0.05 μm to less than 0.3 μm , and the intermetallic compound C having a compound diameter of more than 0.001 μm to less than 0.05 μm ,

(b) the horizontal length $X(\mu\text{m})$ and the vertical length $y(\mu\text{m})$ of the crystal grain diameter on a perpendicular section to the rolling direction of the copper alloy strip material satisfy an expression $[x/y \geq 2]$, and

(c) the dispersion density a of the intermetallic compound A, the dispersion density b of the intermetallic compound B, and the dispersion density c of the intermetallic compound C satisfy an expression $[a/(b+c) \leq 0.010]$ and an expression $[0.001 \leq (b/c) \leq 0.10]$.

【Claim 2】

The copper alloy strip material for use in electrical or electronic parts according to claim 1, the copper alloy strip material further includes a total of 0.005 to 1.5 mass% of at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb, Mn, Ta, V, Sn, Zn and Mg.

【Claim 3】

A method for manufacturing a copper alloy strip material for use in electrical or electronic parts, including the steps of:

reheating a cast ingot of a copper alloy comprising 2.0 to 5.0 mass% Ni, 0.43 to 1.5 mass% Si, and the balance of Cu and unavoidable impurities, at a temperature in a range between 850°C and 950°C for from two hours to ten hours;

hot rolling the reheated cast ingot for from 100 seconds to 500 seconds to make a copper alloy strip material;

rapidly cooling the hot rolled copper alloy strip material to a temperature in a range between 600°C and 800°C and

conducting aging heat treatment for the cold rolled copper alloy strip material at a temperature in a range between 400°C and 550°C for from one hour to four hours, and

obtaining a copper alloy strip material satisfying:
(a) there are three types of intermetallic compounds (A, B and

C) comprising Ni and Si in a total amount of 50 mass% or more, the intermetallic compound A having a compound diameter of $0.3\ \mu\text{m}$ to $2\ \mu\text{m}$, the intermetallic compound B having a compound diameter of $0.05\ \mu\text{m}$ to less than $0.3\ \mu\text{m}$, and the intermetallic compound C having a compound diameter of more than $0.001\ \mu\text{m}$ to less than $0.05\ \mu\text{m}$;

(b) the horizontal length $X(\mu\text{m})$ and the vertical length $y(\mu\text{m})$ of the crystal grain diameter on a perpendicular section to the rolling direction of the copper alloy strip material satisfy an expression $[x/y \geq 2]$; and

(c) the dispersion density a of the intermetallic compound A, the dispersion density b of the intermetallic compound B, and the dispersion density c of the intermetallic compound C satisfy an expression $[a/(b+c) \leq 0.010]$ and an expression $[0.001 \leq (b/c) \leq 0.10]$.

【Claim 4】

The method according to claim 3, the copper alloy strip material further includes a total of 0.005 to 1.5 mass% of at least one element selected from the group consisting of Al, As, Hf, Zr, Cr, Ti, C, Co, Fe, P, In, Sb, Mn, Ta, V, Sn, Zn and Mg.