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(72) Inventors:

- **MATSUO, Ryosuke**
Tokyo 100-8322 (JP)
- **MIHARA, Kuniteru**
Tokyo 100-8322 (JP)
- **EGUCHI, Tatsuhiko**
Tokyo 100-8322 (JP)

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(74) Representative: **Forstmeyer, Dietmar**

(71) Applicant: **The Furukawa Electric Co., Ltd.**
Chiyoda-ku
Tokyo 100-8322 (JP)

Boeters & Lieck
Oberanger 32
D-80331 München (DE)

(54) **COPPER ALLOY MATERIAL FOR ELECTRICAL/ELECTRONIC COMPONENT**

(57) A copper alloy material for electrical/electronic components, which is **characterized by** containing 0.7-2.5% by mass of Co, while containing Si in such an amount that the mass ratio between Co and Si (Co/Si) is not less than 3.5 but not more than 4.0, with the balance

made up of Cu and unavoidable impurities. The copper alloy material is also **characterized by** having a crystal grain size of 3-15 [μ m].

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Description

TECHNICAL FIELD

[0001] The present invention relates to a copper alloy material for an electric/electronic part.

BACKGROUND ART

[0002] Hitherto, copper alloys, such as brass (C26000) and phosphor bronze (C51910, C52120, C52100), as well as beryllium copper (C17200, C17530) and Corson-series copper alloy (C70250), and the like, have been used for parts for electric/electronic equipments (specifically, for example, connectors, terminals, relays, and switches). Herein, the term "Cxxxx" denotes types of copper alloys specified in CDA (Copper Development Association).

In recent years, since a frequency of electric current applied to the electric/electronic equipments becomes high, metallic materials to be used in the parts for electric/electronic equipments have been required to have a higher electrical conductivity. So-called Corson-series copper alloys are high in electrical conductivity, but Cu-Co-Si-based alloys containing Co and Si are studied, as copper alloys which have an electrical conductivity higher than that of conventional Corson-series copper alloys, as well as a high tensile strength and a resistance to bending (for example, Patent Literatures 1 and 2).

[0003]

Patent Literature 1: JP-A-2008-88512 ("JP-A" means unexamined published Japanese patent application)

Patent Literature 2: JP-A-2008-56977

DISCLOSURE OF INVENTION

TECHNICAL PROBLEM

[0004] While the parts for electronic/electric equipments are required to have a high degree of resistance to bending, together with electrical conductivity and tensile strength, it cannot be said that the Cu-Co-Si-based alloys described in Patent Literatures 1 and 2 satisfy all of tensile strength, resistance to bending, and electrical conductivity (thermal conductivity), each at a high level.

Patent Literature 1 describes the results of a bending test under the conditions of $R/t = 1$, in which an inner bending radius of the material is represented by R , and a sheet thickness is represented by t . Patent Literature 2 describes the results of a bending test in a 90° V-bending test at a bending radius of 0.3 mm.

However, it is thought that with the level of this extent, definitely there will be instances where the resulting alloys are not capable of coping with the resistance to bending demanded in the future. Thus, it is necessary to develop a copper alloy material for electric/electronic parts that can pass severe bending tests.

The present invention is contemplated for providing a copper alloy material for electric/electronic parts, which has high electrical conductivity and high tensile strength, as well as excellent resistance to bending.

SOLUTION TO PROBLEM

[0005] The inventors of the present invention, having studied keenly, have found that a copper alloy material, which contains predetermined amounts of Co and Si, with the mass ratio of Co and Si being in a predetermined range, and which has a grain size in a predetermined range, has high electrical conductivity and high tensile strength, and can pass a severe bending test. The present invention is attained based on this finding.

[0006] According to the present invention, there is provided the following means:

(1) A copper alloy material for electric/electronic parts, comprising Co in an amount of 0.7 to 2.5 mass% and Si in an amount that gives a mass ratio of Co and Si (Co/Si ratio) within the range from 3.5 to 4.0, with the balance being Cu and unavoidable impurities, wherein the grain size is 3 to 15 μm .

(2) A copper alloy material for electric/electronic parts, comprising Co in an amount of 0.7 to 2.5 mass%, at least one selected from the group consisting of Cr, Ni, Fe, Zr, Ti, Al, Sn, Mg, and Zn in an amount of 0.01 to 0.15 mass%, and Si in an amount that gives a mass ratio of the total mass of Co and at least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti to Si ((Co+X)/Si ratio) within the range from 3.5 to 4.0, wherein the grain size is 3 to 15 μm .

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present invention, a copper alloy material for electric/electronic parts can be provided, which is excellent in electrical conductivity and tensile strength, and which passes a severe bending test.

Other and further features and advantages of the invention will appear more fully from the following description.

BEST MODE FOR CARRYING OUT THE INVENTION

[0008] Preferable embodiments of the alloy composition of the copper alloy material of the present invention for electric/electronic parts, will be described in detail. Herein, the term "copper alloy material" means a product obtained after a copper alloy of a composition is worked into a given shape (for example, sheet, strip, foil, rod, or wire). Although explanation will be given on a sheet material and a strip material as preferable specific examples of the copper alloy material, but the shape of the copper alloy material is not limited to the sheet material or the strip material.

First, a first copper alloy material for electric/electronic parts of the present invention will be described.

In the first copper alloy material for electric/electronic parts of the present invention, Co and Si are essential elements: Co and Si in a copper alloy mainly form a precipitate of Co_2Si intermetallic compound. By adjusting the proportion of this precipitate to fall in a specific range, it is possible to provide a copper alloy material for electric/electronic parts high in tensile strength and electrical conductivity.

[0009] In the copper alloy material for electric/electronic parts of the present invention, Co is 0.7 to 2.5 mass%, and preferably 0.8 to 2.2 mass%, more preferably 0.9 to 1.7 mass%. When the amount of Co is within this range, a copper alloy material for electric/electronic parts high in tensile strength and electrical conductivity can be obtained.

In the present invention, if the amount of Co is too small, a less amount of the precipitate of the Co_2Si intermetallic compound is formed, and thus a copper alloy material for electric/electronic parts high in tensile strength and electrical conductivity cannot be obtained. If the amount of Co is too large, its effect is saturated. In regard to Si, it is preferable to add an amount appropriate for Co, so as to maintain the stoichiometric ratio of the Co_2Si intermetallic compound. If the amount of Si is inadequate, the same state as in the case where the amount of Co is inadequate occurs. That is, if the amount of Si is too small, a less amount of the precipitate of the Co_2Si intermetallic compound is formed, and a copper alloy material for electric/electronic parts high in tensile strength and electrical conductivity cannot be obtained. If the amount of Si is too large, its effect is saturated.

[0010] Based on the stoichiometric ratio of the Co_2Si intermetallic compound, an optimal mass ratio of Co to Si (Co/Si) is that Co/Si nearly equals to 4.2. In the copper alloy material of the present invention, the mass ratio of Co to Si (Co/Si) is adjusted to be within the range from 3.5 to 4.0. Preferably, the value of Co/Si, in terms of mass ratio, is within the range from 3.70 to 3.95. When the mass ratio of Co and Si (Co/Si ratio) is adjusted to be within this range, a copper alloy material for electric/electronic parts which is excellent in both tensile strength and bending, can be obtained. If the mass ratio of Co and Si (Co/Si ratio) is too small, Si is in excess, and therefore, a part of Si that does not form an intermetallic compound with Co is made into a solid solution, thereby lowering the electrical conductivity. If the mass ratio of Co and Si (Co/Si ratio) is too large, Co is in excess, and therefore, a part of Co that does not form an intermetallic compound with Si is made into a solid solution, thereby lowering the electrical conductivity.

When the amount of Co and the amount of Si exceed predetermined amounts, an alloy material cannot be obtained if the solution treatment temperature is not raised. Accordingly, if a heat treatment is carried out at a temperature higher than the solution treatment temperature usually employed (about 1,000°C), there occur problems, such as that the product shape cannot be maintained.

In the first copper alloy material for electric/electronic parts of the present invention, the amount of Si is determined so that the mass ratio of Co to Si (Co/Si) would be within the range from 3.5 to 4.0, and it is preferable to adjust the amount of Si to 0.2 to 0.7 mass%.

[0011] Next, a second copper alloy material of the present invention will be described.

The second copper alloy material of the present invention contains Co in an amount of 0.7 to 2.5 mass%, and at least one selected from the group consisting of Cr, Ni, Fe, Zr, Ti, Al, Sn, Mg, and Zn in an amount of 0.01 to 0.15 mass%, with the balance being Cu and unavoidable impurities, while the copper alloy material contains Si in an amount that gives a mass ratio of the total mass of Co and at least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti to Si ((Co+X)/Si ratio) within the range from 3.5 to 4.0.

The amount to be added of at least one selected from the group consisting of Cr, Ni, Fe, Zr, Ti, Al, Sn, Mg, and Zn is preferably 0.05 to 0.15 mass%. If the amount of addition is too small, the effect of addition is small. If the amount of addition is too large, the mechanical strength is lowered, and at the same time, as the added elements are made into solid solution, the electrical conductivity is lowered.

Cr, Ni, Fe, Zr, and Ti form precipitates together with both or one of Co and Si, or by themselves singly, and bring an effect of making the grain size finer. At least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti has a function of substituting a part of Co, to form a $(\text{Co}, \text{X})_2\text{Si}$ compound, to enhance mechanical strength.

On the other hand, Al, Sn, Mg, and Zn have a feature of being made into a solid solution in the copper matrix, to strengthen the resultant alloy. When made into a solid solution, Al, Sn, Mg, and Zn strengthen the alloy material or bring an improvement in resistance to stress relaxation. Furthermore, when both of Sn and Mg are added, the resistance to stress relaxation is improved synergistically. When the ratio of addition of Sn and Mg is set at $\text{Sn/Mg} \geq 1$, the stress relaxation resistance is further improved.

[0012] In the second copper alloy material of the present invention, the mass ratio of the total mass of Co and at least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti to Si ((Co+X)/Si ratio) is from 3.5 to 4.0. Preferably, the value of the (Co+X)/Si ratio is, in terms of mass ratio, within the range from 3.70 to 3.95. When the (Co+X)/Si ratio is adjusted to be within this range, a copper alloy material for electric/electronic parts which is excellent in both tensile strength and bending, can be obtained. If the (Co+X)/Si ratio is too small, Si is in excess, and therefore, a part of Si that does not form an intermetallic compound with Co and X is made into a solid solution, thereby lowering the electrical conductivity. If the (Co+X)/Si ratio is too large, Co or X is in excess, and therefore, a part of Co or X that does not form an intermetallic compound with Si is made into a solid solution, thereby lowering the electrical conductivity.

In the second copper alloy material for electric/electronic parts of the present invention, the amount of Si is determined so that the mass ratio of the sum of Co and the at least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti to Si ((Co+X)/Si ratio) would be within the range from 3.5 to 4.0, and it is preferable to adjust the amount of Si to 0.2 to 0.7 mass%.

In the first and second copper alloy materials of the present invention, if the content of elements, such as H, O, and S, as unavoidable impurities is less than 5 ppm mass%, the copper alloy material for electric/electronic parts can be obtained without impairing the purport of the present invention.

[0013] It is important to have a grain size of 3 to 15 μm in the copper alloy material of the present invention. According to the present invention, the grain size means a value measured by JIS H 0501 (cutting method). When the grain size is adjusted to be within the range of 3 to 15 μm , it is possible to obtain a copper alloy material for electric/electronic parts excellent in resistance to bending. When the grain size is less than 3 μm , the remaining worked structure is confirmed, which has an adverse effect on the resistance to bending. On the other hand, when the grain size is coarser than 15 μm , significant bending or cracks occurs in the grain boundary, and as a result, the resultant resistance to bending is lowered. The grain size is preferably 4 to 10 μm . In order to adjust the grain size to 3 to 15 μm , such a grain size can be realized, for example, by controlling the amounts of addition of elements, such as Co and Si, each within a specific range; controlling the ranges of the heat treatment conditions and rolling conditions in the respective steps to be carried out till the final recrystallization heat treatment, each within a specific range; or controlling the thermal history control conditions (a speed of temperature raising, and retention temperature and time period) of the recrystallization heat treatment, within a specific range.

[0014] There is a preferable range in a relationship between the amount to be added of Co and the temperature at which the recrystallization heat treatment is carried out. For example, when the amount to be added of Co is 0.7 to 1.0 mass%, the temperature at which the recrystallization heat treatment is carried out is preferable to be within a range of 850 to 900°C; and when the amount to be added of Co is 1.0 to 2.5 mass%, the temperature at which the recrystallization heat treatment is carried out is preferable to be within a range of 900 to 1,025°C. The upper limit temperature is more preferably 1,000°C. When the recrystallization heat treatment is carried out within this temperature range, the recrystallization heat treatment can be carried out surely, and deformation of the alloy material can be prevented.

[0015] Next, a preferable method for producing the copper alloy material of the invention is exemplified, for example, in the following embodiment. An outline of the main production steps for the copper alloy material of the present invention includes: melting → casting → hot rolling → face milling → cold rolling → solution and recrystallization heat treatment → rapid cooling → aging heat treatment → final cold-rolling → low-temperature annealing. The aging heat treatment and the final cold-rolling may be in a reversed order. Further, the low-temperature annealing of the final step may be omitted.

<Melt-casting>

[0016] A copper alloy ingot is obtained, by melting Cu, Co, Si, and the like, which are the raw materials of the target copper alloy, followed by pouring the resultant melt into a mold, and casting under cooling at a cooling speed from 10 to 30 K/sec (K is for "Kelvin" which represents the absolute temperature; hereinafter, the same). Herein, the following description will be made with an ingot of a size: width 160 mm, thickness 30 mm, and length 180 mm.

<Hot rolling/face-milling/cold rolling>

[0017] Then, the resultant ingot is kept at a temperature of 900 to 1,000°C for 30 to 60 min, followed by working by hot rolling to thickness 8 to 15 mm (a rolling reduction 50 to 73%), quenching by water cooling (rapid cooling) immediately, face-milling the rolled surface by approximately 1 mm for each side, to remove an oxide layer on the surface, and working

by cold rolling to thickness about 0.1 to 0.3 mm. The rolling reduction is set to be 95% or more (preferably, 99.5% or less).

<Recrystallization heat treatment>

[0018] Then, to cause solution and recrystallization, a recrystallization heat treatment is carried out for a given time period (e.g. for 30 sec) in a salt bath (salt bath furnace) kept at a temperature of 800 to 1,025°C, followed by quenching by water cooling. In the recrystallization heat treatment, the heat treatment is carried out by adjusting the temperature raising speed by interposing the subject between stainless steel plates different in plate thickness. A preferable temperature raising speed in this occasion is 10 to 300 K/sec at a temperature of 300°C or higher. Further, a preferable cooling speed is 30 to 200 K/sec.

<Aging heat treatment>

[0019] Then, for the purpose to cause aging precipitation, an aging heat treatment is carried out at a temperature from 400 to 600°C for 30 to 300 min. The temperature raising speed from room temperature to the highest temperature in that occasion is within the range from 3 to 25 K/min. With regard to temperature lowering, cooling is carried out inside the furnace at a speed within the range from 1 to 2 K/min until the temperature reaches 300°C, which is a temperature sufficiently lower than the temperature zone considered to affect the precipitation.

<Finish rolling>

[0020] The copper alloy material, to which the aging heat treatment has been completed for subjecting, is further subjected to a cold rolling at a working ratio of 20%, and thus a finish rolled-material is obtained. The finish rolling can be omitted.

<Strain-relieving annealing>

[0021] After the completion of the aging heat treatment (in the case of conducting the finish rolling, after the completion of the finish rolling), the copper alloy material is subjected to strain-relieving annealing, according to the necessity.

[0022] The bending property can be evaluated by perpendicular bending ($R/t = 0$) in a 90° W bending test, under the conditions of a yield stress (YS) value of 600 MPa or more and an electrical conductivity of 60 %IACS or more. Herein, the term "R/t" means a result obtained by conducting a W bending test at a bending angle of 90° according to the "Standard test method of bend formability for sheets and strips of copper and copper alloys (JBMA T307)" of the Japan Copper and Brass Association Technical Standards. The "R/t" can be determined, by subjecting a sheet material cut out in a direction perpendicular to rolling, to a bending test under the condition of a predetermined bending radius (R), determining the R value of the limit at which any crack (breakage) does not occur at the top, and normalizing the value by the sheet thickness (t). In general, the smaller the value of R/t is, the more satisfactory the resistance to bending is. The copper alloy material of the present invention is excellent in the electrical conductivity and the tensile strength, and can pass a bending test under sever conditions.

EXAMPLES

[0023] The present invention will be described in more detail based on examples given below, but the invention is not meant to be limited by these.

(Example Nos. 1 to 13 and Comparative Example Nos. 14 to 40)

[0024] Alloys containing elements as shown in Table 1, with the balance being Cu and unavoidable impurities, were melted with a high-frequency melting furnace, followed by casting at a cooling speed of 10 to 30K/sec, to obtain ingots, respectively, with width 160 mm, thickness 30 mm, and height 180 mm. The cooling speed was set under the conditions which would not cause any cracks or the like in the ingot.

[0025] The thus-obtained ingots were kept at a temperature of 1,000°C for 30 min, followed by hot rolling to give hot-rolled sheets with thickness $t = 12$ mm. Then, each of the surfaces of the hot-rolled sheets were face-milled by 1 mm in each side, to thickness $t = 10$ mm, followed by cold rolling to finish to sheet thickness $t = 0.25$ mm. Then, the resultant sheets were subjected to a recrystallization heat treatment at a temperature from 870 to 1,000°C.

[0026] The recrystallization heat treatment was carried out by raising the temperature in a manner dependent on how large the amount to be added of Co was. Specifically, when the amount to be added of Co was 0.9 mass%, the temperature was 870°C; when the amount to be added of Co was 1.2 mass%, the temperature was 915°C; when the amount to be

added of Co was 1.4 mass%, the temperature was 940°C; when the amount to be added of Co was 1.65 mass%, the temperature was 965°C; when the amount to be added of Co was 1.9 mass%, the temperature was 980°C; and when the amount to be added of Co was 2.4 mass%, the temperature was 1,000°C. Furthermore, also in the case where additives other than Co and other than Si were contained (Alloys Nos. 4, and 7 to 11), the temperature for the recrystallization heat treatment was set in the same manner as in the case where additives other than Co and other than Si were not contained. In regard to Comparative Example Nos. 37 to 40, the temperature of the recrystallization heat treatment was set at 940°C, 1,050°C, 775°C, and 790°C, respectively, to change the grain size.

[0027] Then, the thus-prepared materials after the recrystallization heat treatment were subjected to the following process, to produce test specimens which correspond to the final products. The sheet thickness of the test specimens was set to $t = 0.2$ mm.

Process: Recrystallization heat treatment -Aging heat treatment (at a temperature of 525°C for 2 hours) - Cold working (20%)

[0028] Measurement of the following items was carried out with respect to those test specimens. The composition table and grain size of the copper alloys are shown in Table 1, and the evaluation results on the tensile strength and bending properties of the copper alloy materials are shown in Table 2.

a. Grain size (GS):

[0029] After a cross-section perpendicular to the rolling direction of the respective test piece was finished into a mirror surface by wet polishing and buff polishing, the thus-polished surface was corroded with a liquid of: chromic acid : water = 1:1, for several seconds. Then, photographs of the resultant polished and corroded surface were taken, with a magnification of 200X to 400X with an optical microscope, or with a magnification of 500X to 2,000X with a scanning electron microscope (SEM) using a secondary electronic image by the SEM, to measure a grain size on the cross-section, according to the cutting method of JIS H0501. Then, the measurement parameter was set at 200, and the arithmetic mean was determined. This value was designated as the arithmetic mean of the grain size. The results are shown in Table 1.

b. Yield stress (YS):

[0030] Two test pieces of JIS Z2201 No. 5, which were cut in parallel to the rolling direction of the respective test specimen, were measured according to JIS Z2241, to determine the average value. According to an offset method, the proof strength in the case where the permanent elongation was 0.2%, was calculated from formula (1), as the yield stress. The results are shown in Table 2.

$$\sigma_{0.2} = F_{0.2} / A_0 \quad \text{formula (1)}$$

In the formula,

σ represents a proof stress (N/mm²) calculated by the offset method; and

F represents a force, which was determined, by obtaining a relationship curve diagram between a force and the resultant elongation, with using an elongation meter, drawing a line parallel to the straight line portion of the early stage of the test, from the point on the axis of elongation corresponding to the predetermined permanent elongation ($\epsilon\%$), and determining the force shown at the point at which the parallel line intersects the curve diagram.

c. Electrical conductivity (EC):

[0031] With respect to two respective test pieces, the electrical conductivity was measured in a thermostat controlled at 20°C ($\pm 1^\circ\text{C}$) by using the four-terminal method, to obtain the average value (%IACS), as shown in Table 2. The distance between the terminals was 100 mm.

d. Bending property A:

(1) W bending

[0032] A test piece of sheet thickness $t = 0.20$ (mm), sheet width $w = 10$ (mm), and length $l = 35$ (mm) was cut from the respective test specimens, according to JIS Z2248, and the surface of the test piece was lightly polished with metallic polishing powders, to remove an oxide layer. Then, 90° W bending in which an inner radius of bending would be $R = 0$

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mm, was performed in two directions of: bending parallel to the rolling direction (Good-way bending: hereinafter, "GW bending"); and bending perpendicular to the rolling direction (Bad-way bending: hereinafter, "BW bending"). The value of R/t at this time was 0.

(2) 180° Bending

[0033] In the same manner as in the W bending, 180° bending was performed, except for placing an object twice the given inner radius (herein, $R = 0.1$ mm) according to JIS Z2248, and pushing the two ends of the test piece one another. The same evaluation as in the 90° W bending was performed. The value of R/t at this time was $R/t = (0.1/0.2) = 0.5$, based on $R = 0.1$ (mm) and $t = 0.2$ (mm).

(3) Evaluation of whether cracks occurred or not in the bent portion

[0034] The bent portions were observed, to confirm whether cracks were occurred or not at the bent portion, in which the observation was made with the naked eye with an optical microscope with a magnification of 50X, and with a scanning electron microscope (SEM). For both of the 90° W bending and 180° bending, if there were no cracks on the surface of the test piece in at least one of the GW bending and the BW bending, the specimen was judged to be "○ (good)"; and if cracks were observed in both of the bending tests, the specimen was judged to be "× (poor)". Further, for any one of the 90° W bending and 180° bending, if cracks occurred in both of the GW bending and BW bending, the overall judgment was "× (poor)". The results are shown in Tables 1 and 2.

e. Bending property B

[0035] The test was performed according to the W bending test specified in JIS Z2248, using a strip-shape sample of width 10 mm. The bending direction was set at the Good Way and the Bad Way, respectively, and the bending radius R /sheet thickness t was set to 1.0. For the test piece after bending, whether cracks occurred or not, was observed with an optical microscope, on the surface and cross-section of the bent portion. If no cracks occurred in both of the Good Way and the Bad Way, the sample was judged to be "○ (good)"; and if cracks occurred in both or one of the Good Way and the Bad Way, the sample was judged to be "x (poor)". The results are shown in Table 2.

{Table 1}

[0036]

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Table 1

	Alloy No.	Elements I to be added			Elements II to be added	(Co+X)/Si in which X = Cr, Ni, Fe, Zr, Ti	GS μm
		Co mass%	Si mass%	Co/Si			
Example according to this invention	1	0.91	0.26	3.50	-	-	11
	2	0.91	0.24	3.79	-	-	12
	3	0.90	0.23	3.91	-	-	13
	4	1.21	0.34	-	Ni:0.1 mass%	3.85	12
	5	1.22	0.31	3.94	-	-	13
	6	1.41	0.38	3.71	-	-	14
	7	1.65	0.44	3.75	Mg:0.1 mass%	-	12
	8	0.90	0.26	-	Cr:0.1 mass%	3.85	7
	9	1.40	0.40	-	Cr:0.1 mass%	3.75	8
	10	0.90	0.28	-	Ti:0.15 mass%	3.75	10
	11	1.40	0.40	-	Zr:0.05 mass%	3.63	13
	12	2.40	0.62	3.87	-	-	5
	13	0.85	0.23	3.70	-	-	15

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(continued)

	Alloy No.	Elements I to be added			Elements II to be added	(Co+X)/Si in which X = Cr, Ni, Fe, Zr, Ti	GS μm
		Co mass%	Si mass%	Co/Si			
Comparative example	14	0.90	0.19	4.74	-	-	22
	15	1.40	0.32	4.38	-	-	20
	16	1.65	0.36	4.58	-	-	23
	17	1.91	0.41	4.66	-	-	18
	18	0.90	0.16	5.63	-	-	17
	19	0.91	0.31	2.94	-	-	14
	20	1.21	0.22	5.50	-	-	25
	21	1.20	0.40	3.00	-	-	12
	22	1.42	0.28	5.07	-	-	24
	23	1.40	0.52	2.69	-	-	14
	24	1.65	0.33	5.00	-	-	22
	25	1.64	0.62	2.65	-	-	13
	26	1.89	0.36	5.25	-	-	24
	27	1.90	0.65	2.92	-	-	12
	28	0.60	0.16	3.75	-	-	42
	29	3.00	0.80	3.75	-	-	4
	30	0.32	0.08	4.00	-	-	60
	31	4.20	1.15	3.65	-	-	Un-recrystallized (< 3 μm)
	32	0.90	0.19	-	Cr:0.2 mass%	<u>5.79</u>	8
	33	0.90	0.55	-	Cr:0.1 mass%	<u>1.82</u>	6
	34	1.40	0.30	-	Cr:0.2 mass%	<u>5.33</u>	6
	35	1.40	0.90	-	Cr:0.1 mass%	<u>1.67</u>	6
	36	1.40	0.82	-	Cr:0.5 mass%	2.32	6
	37	0.91	0.26	3.50	-	-	35
	38	1.41	0.38	3.71	-	-	50
	39	0.91	0.26	3.50	-	-	Un-recrystallized (< 3 μm)
	40	1.41	0.38	3.71	-	-	Un-recrystallized (< 3 μm)

{Table 2}

[0037]

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Table 2

	Alloy No.	YS MPa	EC %IACS	Bending property A	Bending property B
Example according to this invention	1	622	66	○	○
	2	619	66	○	○
	3	615	67	○	○
	4	665	64	○	○
	5	660	64	○	○
	6	674	63	○	○
	7	682	61	○	○
	8	645	63	○	○
	9	691	62	○	○
	10	632	65	○	○
	11	683	60	○	○
	12	695	60	○	○
	13	602	68	○	○

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(continued)

	Alloy No.	YS MPa	EC %IACS	Bending property A	Bending property B
5	14	589	66	×	○
	15	643	64	×	○
10	16	652	63	×	○
	17	664	62	×	○
15	18	671	61	×	○
	19	538	55	○	○
20	20	567	58	×	○
	21	542	52	○	○
25	22	573	52	×	○
	23	552	51	○	○
30	24	565	53	×	○
	25	567	49	○	○
35	26	555	51	×	○
	27	577	47	○	○
40	28	515	71	×	○
	29	692	52	○	○
45	30	488	72	○	○
	31	695	51	×	○
50	32	588	56	○	○
	33	562	48	○	○
55	34	594	60	○	○
	35	615	52	○	○
60	36	577	52	○	○
	37	525	61	×	○
65	38	607	58	×	○
	39	489	66	×	○
70	40	565	62	×	○

Comparative example

[0038] As shown in Tables 1 and 2, Examples according to the present invention each exhibited a high electrical conductivity, with the electrical conductivity being 60% IACS or more, and a yield stress (YS) of 600 MPa or more. Further, Examples exhibited excellent results even under the severe bending test conditions, in which the value of R/t in the 90° bending was 0, and the value of R/t in the 180° bending was 0.5 or less. On the contrary, Comparative Examples each did not pass in one or more of the following points: the electrical conductivity was less than 60% IACS; the yield stress (YS) was less than 600 MPa; the value of R/t in the 90° bending did not satisfy 0; and the value of R/t in the 180° bending did not satisfy 0.5 or less. Further, as in the cases of Alloy Nos. 15 to 18, some alloys exhibited a high electrical conductivity such as an electrical conductivity of 60% IACS or more, and a yield stress (YS) of 600 MPa or more; however, although those alloys passed the W bending test with R/t = 1.0, they failed to pass the W bending test with the value of R/t being 0, or the 180° bending with the value of R/t being 0.5.

[0039] Having described our invention as related to the present embodiments, it is our intention that the invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

[0040] This application claims priority on Patent Application No. 2008-202469 filed in Japan on August 5, 2008, which is entirely herein incorporated by reference.

Claims

1. A copper alloy material for electric/electronic parts, comprising Co in an amount of 0.7 to 2.5 mass% and Si in an amount that gives a mass ratio of Co and Si (Co/Si ratio) within the range from 3.5 to 4.0, with the balance being Cu and unavoidable impurities, wherein the grain size is 3 to 15 μm .
2. A copper alloy material for electric/electronic parts, comprising Co in an amount of 0.7 to 2.5 mass%, at least one selected from the group consisting of Cr, Ni, Fe, Zr, Ti, Al, Sn, Mg, and Zn in an amount of 0.01 to 0.15 mass%, and Si in an amount that gives a mass ratio of the total mass of Co and at least one (X) selected from the group consisting of Cr, Ni, Fe, Zr, and Ti to Si ((Co+X)/Si ratio) within the range from 3.5 to 4.0, wherein the grain size is 3 to 15 μm .

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/063614

A. CLASSIFICATION OF SUBJECT MATTER C22C9/06(2006.01)i, C22F1/08(2006.01)i, H01B1/02(2006.01)i, C22F1/00(2006.01)n According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C22C9/06, C22F1/08, H01B1/02, C22F1/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) JSTPlus(JDreamII)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2008-88512 A (Nippon Mining & Metals Co., Ltd.), 17 April 2008 (17.04.2008), claims; table 1 & WO 2008/041696 A1 & KR 10-2009-0050101 A & CN 101522927 A	1, 2
Y	JP 2008-56977 A (Mitsubishi Electric Corp., Mitsubishi Electric Metecs Co., Ltd.), 13 March 2008 (13.03.2008), claims & US 2008/0056930 A1 & DE 10 2007 040 822 A1	1, 2
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 09 October, 2009 (09.10.09)		Date of mailing of the international search report 20 October, 2009 (20.10.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 63-307232 A (Sumitomo Metal Mining Co., Ltd.), 14 December 1988 (14.12.1988), claims; tables (Family: none)	1, 2
Y	JP 2-277735 A (Sumitomo Metal Mining Co., Ltd.), 14 November 1990 (14.11.1990), claims (Family: none)	2
Y	JP 2000-87158 A (The Furukawa Electric Co., Ltd.), 28 March 2000 (28.03.2000), claims; paragraph [0015]; table 1 (Family: none)	1, 2
Y	JP 2007-169764 A (The Furukawa Electric Co., Ltd.), 05 July 2007 (05.07.2007), claims; paragraph [0023]; table 1 (Family: none)	1, 2

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2008056977 A [0003]
- JP 2008202469 A [0040]