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(54) **COPPER ALLOY SHEET**

(57) {Problems} To provide a Corson-based copper alloy sheet material which satisfies characteristics required of terminals and connectors, such as mechanical strength and bending property.

{Means to solve} A copper alloy sheet material for electrical or electronic parts, which is composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being

Cu and inevitable impurities, wherein an area ratio of grains having a deviation angle of less than 15° from the Cube orientation is controlled to less than 10%, and an area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is controlled to 15% or greater, and wherein the copper alloy sheet material has excellent mechanical strength and bending property.

EP 2 508 632 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an excellent copper alloy sheet material, and specifically to a copper alloy sheet material excellent in mechanical strength and bending property, which copper alloy sheet material is suitable for connection parts, such as connectors and terminals for use in automobiles.

BACKGROUND ART

[0002] In recent years, there is an increasing demand for the size reduction and weight reduction of electronic equipments, and the size reduction and weight reduction of electrical or electronic parts are in progress. With respect to connectors and terminals, there is an ongoing trend for lowering the height and narrowing the pitch, and as a result, a copper alloy sheet material for use in these connectors and terminals is required to have even higher mechanical strength and superior bending property. As a copper alloy sheet material that is required to have high mechanical strength and excellent bending property, beryllium copper has been hitherto widely used. However, beryllium copper is very expensive, and metal beryllium is strongly toxic. Thus, as an alloy that can be an alternative to those materials, the amount to be use of Corson alloy (Cu-Ni-Si) is increasing.

[0003] Corson alloy is an alloy in which the solid solution limit of nickel silicide (Ni_2Si) compound to copper varies depending upon the temperature, and is a precipitation hardening-type alloy that is hardened by an aging precipitation treatment, and is favorable in heat resistance, electrical conductivity, and mechanical strength.

However, even for this Corson alloy, when the mechanical strength of the copper alloy sheet material is enhanced, electrical conductivity and bending property is lowered. That is, it is a very difficult problem to impart favorable electrical conductivity and bending property to high strength Corson alloy.

[0004] In regard to such problems, there is a technique of improving bending property by controlling the size of precipitates in Corson alloy, to obtain a high-strength copper alloy excellent in bending property (see, for example, Patent Literature 1). Further, there is proposed a technique of enhancing mechanical strength and bending property, by controlling the grain size of Corson alloy (see, for example, Patent Literature 2). However, in connector materials, BW bending is conducted along a bending line that is parallel to the rolling direction using, in particular, a specimen that has been cut out in parallel to the transverse direction of the rolled sheet, but such materials do not reach the level of satisfying the mechanical strength and bending property that are required by the market, and there is a demand for a further enhancement/improvement.

[0005] On the other hand, in recent years, attempts have been made to improve bending property, by controlling the crystal texture. For example, there is a method of making bending property favorable by controlling the Cube orientation (see Patent Literature 3). Further, there is also a method of improving bending property, by increasing the X-ray diffraction intensity of (2 0 0) plane (see, for example, Patent Literature 4). However, according to the findings of the inventors of the present invention, although increasing the Cube orientation or the X-ray diffraction intensity of (2 0 0) plane is certainly effective for an improvement of bending property, there is a problem that, when these characteristics are enhanced, the work hardening coefficient is decreased in deforming the material, to lower tensile strength.

CITATION LIST

PATENT LITERATURES

[0006]

Patent Literature 1: JP-A-6-184680 ("JP-A" means unexamined published Japanese patent application)

Patent Literature 2: JP-A-2006-161148

Patent Literature 3: JP-A-2006-152392

Patent Literature 4: JP-A-2009-007666

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] The inventors of the present invention, having studied the mechanism of bending in a Corson-based copper alloy, have confirmed that the shear band that occurs at the sheet surface upon bending is a cause of cracks. Further, we have confirmed that this shear band can be reduced by accumulating the Cube orientation, but we also found a

problem that, at the same time, tensile strength is lowered. As a cause for this lowering of mechanical strength, we presume that, since the Cube orientation is small in the work hardening coefficient upon deforming, deformation occurs even with relatively low mechanical strength, and fracture occurs, without enhancing mechanical strength sufficiently. Under such problems, the present invention is contemplated for providing a copper alloy sheet material for electrical or electronic equipments, which is excellent in bending property and mechanical strength, and which is favorable for lead frames, connectors, terminal materials, and the like, for electrical or electronic equipments, and in particular for connectors, for example, to be mounted on automobile vehicles, or terminal materials, relays, switches, and the like.

SOLUTION TO PROBLEM

[0008] The inventors of the present invention found that, when the area ratio of grains with crystals oriented having a deviation angle within 15° to 30° from the Cube orientation is defined to be within a specific range, a balance between excellent bending property and high mechanical strength can be achieved. The present invention has been attained based on this finding.

That is, the present invention is the following means:

(1) A copper alloy sheet material for electrical or electronic parts, which is composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, wherein an area ratio of grains having a deviation angle of less than 15° from the Cube orientation is controlled to less than 10%, and an area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is controlled to 15% or greater, and wherein the copper alloy sheet material has excellent mechanical strength and bending property.

(2) The copper alloy sheet material for electrical or electronic parts according to item (1), wherein the copper alloy composition further contains Cr in an amount of 0.05 to 0.5%.

(3) The copper alloy sheet material for electrical or electronic parts according to item (1) or (2), wherein the copper alloy composition further contains one, two or more from Zn, Sn, Mg, Ag, Mn, and Zr in an amount of 0.01 to 1.0% in total.

(4) The copper alloy sheet material for electrical or electronic parts according to any one of item (1) to (3), wherein the copper alloy sheet material is subjected, after a solution treatment, to cold-rolling with different friction

(5) A method of producing a copper alloy sheet material for electrical or electronic parts, containing the steps of: subjecting a molten copper alloy composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, to casting into an ingot; conducting heating or a homogenization heat treatment; hot-rolling with different friction; cold-rolling; conducting an intermediate annealing; conducting a solution treatment; cold-rolling with different friction; and conducting an aging treatment.

(6) The method of producing a copper alloy sheet material for electrical or electronic parts according to item (5), in which the cold-rolling with different friction is carried out with an upper roll and a lower roll having a surface roughness different from each other.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] The copper alloy sheet material of the present invention has high mechanical strength and favorable bending property, and exhibits high electrical conductivity. Furthermore, the above-described properties of the copper alloy sheet material can be further enhanced, by adding other additive elements. Moreover, the copper alloy sheet material can also realize an enhancement of migration resistance or heat resistant peelability upon soldering, or an enhancement of stress relaxation resistance or workability upon hot-rolling.

MODE FOR CARRYING OUT THE INVENTION

[0010] A preferred metal texture of the copper alloy sheet material for electrical or electronic parts of the present invention having high mechanical strength, favorable bending property, and high electrical conductivity, will be described in detail. Herein, the term "copper alloy material" means a product obtained after a copper alloy base material is worked into a predetermined shape (for example, sheet, strip, foil, rod, or wire). Among them, a sheet material refers to a material which has a specific thickness, is stable in the shape, and is extended in the plane direction, and in a broad sense, the sheet material is meant to encompass a strip material. Herein, with regard to the sheet material, the term "surface layer of the material (or material surface layer)" means the "sheet surface layer," and the term "position of a depth of the material" means the "position in the sheet thickness direction." There are no particular limitations on the thickness of the sheet material, but when it is considered that the thickness should well exhibit the effects of the present invention

and should be suitable for practical applications, the thickness is preferably 8 to 800 μm , and more preferably 50 to 70 μm . In the copper alloy sheet material of the present invention, the characteristics are defined by the accumulation ratio of the atomic plane in a predetermined direction of a rolled sheet, but this will be considered enough if the copper alloy sheet material has such characteristics. The shape of the copper alloy sheet material is not intended to be limited to a sheet material or a strip material, and it is noted that in the present invention, a tube material can also be construed and treated as a sheet material.

(Average grain size)

[0011] The average grain size of the copper alloy sheet material of the present invention is preferably set to 50 μm or less. When the average grain size is equal to or smaller than the upper limit, the shear band that would become a cause of cracking is not easily occurred in both the cases of Good Way (GW) bending and Bad Way (BW) bending, which is preferable. Herein, the term "Good Way" represents the direction parallel to the rolling direction, and the term "Bad Way" represents the direction perpendicular to the rolling direction. The grain size is determined, according to JIS H 0501 (cutting method).

(Definition by EBSD analysis)

[0012] The crystal texture of the copper alloy sheet material of the present invention has, particularly in order to achieve a good balance between mechanical strength and bending property, a crystal texture in which from the results of an analysis according to a SEM-EBSD method (which will be described below), the area ratio of grains having a deviation angle (orientation shift) of less than 15° from the Cube orientation is less than 10%, and the area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is 15% or greater, preferably equal to or greater than 20% and less than 50%.

[0013] In the case of a copper alloy sheet material, the material mainly forms crystal textures called the Cube orientation, the Goss orientation, the Brass orientation, the Copper orientation, the S orientation, and the like, which will be described below, and has crystal faces corresponding to those orientations, respectively.

The formation of these crystal textures occurs differently, even in the case of the same crystal system, depending on the differences in the methods of working and heat treatment. The crystal textures of a material, such as a sheet material produced by rolling, are indicated by planes and directions, such that a plane is expressed in the form of $\{A\ B\ C\}$, and a direction is expressed in the form of $\langle D\ E\ F \rangle$. The method of indicating the crystal orientation in the present specification is such that a Cartesian coordinate system is employed, representing the rolling direction (RD) of the material in the X-axis, the transverse direction (TD) in the Y-axis, and the direction normal to the rolling direction (ND) in the Z-axis, various regions in the material are indicated in the form of $(h\ k\ l)\ [u\ v\ w]$, using the index $(h\ k\ l)$ of the crystal plane that is perpendicular to the Z-axis and the index $[u\ v\ w]$ in the crystal direction parallel to the X-axis. In accordance with the expressions as described above, the respective orientations are expressed as follows.

The Cube orientation	$\{0\ 0\ 1\} \langle 1\ 0\ 0 \rangle$
The Goss orientation	$\{0\ 1\ 1\} \langle 1\ 0\ 0 \rangle$
The Rotated-Goss orientation	$\{0\ 1\ 1\} \langle 0\ 1\ 1 \rangle$
The Brass orientation	$\{0\ 1\ 1\} \langle 2\ 1\ 1 \rangle$
The Copper orientation	$\{1\ 1\ 2\} \langle 1\ 1\ 1 \rangle$
The S orientation	$\{1\ 2\ 3\} \langle 6\ 3\ 4 \rangle$
The P orientation	$\{0\ 1\ 1\} \langle 1\ 1\ 1 \rangle$

[0014] The crystal texture of a conventional copper alloy sheet material is composed of quite many orientation factors, as explained above. However, when the constitutional proportions of these crystal faces is changed, the plastic behavior of the material, such as a sheet material, changes, to change the workability in, for example, bending.

The crystal texture of a conventional Corson-based high-strength copper alloy sheet material is such that, when the sheet material is produced according to a usual method, the S orientation $\{1\ 2\ 3\} \langle 6\ 3\ 4 \rangle$ and/or the Brass orientation $\{0\ 1\ 1\} \langle 2\ 1\ 1 \rangle$ exists as a main component, in addition to the Cube orientation $\{0\ 0\ 1\} \langle 1\ 0\ 0 \rangle$, as presented in the examples that will be described below, and the proportion of the Cube orientation is decreased. For this reason, a shear band is apt to occur, particularly in the BW bending, to deteriorate the bending property. On the other hand, when the bending property is improved by increasing the accumulation of grains having a deviation angle of less than 15° from the Cube orientation, there is a problem that mechanical strength is lowered.

[0015] On the contrary, the crystal texture of the copper alloy sheet material of the present invention has a crystal

texture excellent in mechanical strength and bending property, in which the area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation $\{0\ 0\ 1\} \langle 1\ 0\ 0 \rangle$ is 15% or greater. However, in the present invention, as long as the area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is 15% or greater, the existence of other orientations as sub-orientations is allowable.

[0016] The measurement of the degree of accumulation of orientation grains having a deviation angle of 15° to 30° from the Cube orientation $\{0\ 0\ 1\} \langle 1\ 0\ 0 \rangle$ in the crystal texture of a copper alloy sheet material, is achieved by conducting an orientation analysis based on the data obtained by analyzing an electron micrographic texture by SEM with EBSD, by using the crystal orientation distribution function (ODF). A sample area measured 1,200 μm on each of the four sides and containing 400 or more grains, is subjected to an analysis of the orientation, by scanning in a stepwise manner at an interval of 0.5 μm . Since these orientation distributions vary in the thickness direction of the material, it is preferable to analyze the orientation distribution at any several points in the thickness direction, to determine the orientation distribution by taking an average of the data thus obtained.

[0017] This SEM-EBSD method is an abbreviation of the Scanning Electron Microscopy-Electron Back Scattered Diffraction Pattern method. That is, the method involves irradiating individual grains described in a scanning electron microscope (SEM) image with an electron beam, and identifying the individual crystal orientations from the diffracted electrons.

[0018] In regard to the deviation angle from the ideal orientation as shown with the above indexes, an angle of rotation around the axis of common rotation is calculated, and the angle of rotation is designated as the deviation angle. For example, with regard to the S orientation $(2\ 3\ 1) [6\ -4\ 3]$, the orientation $(1\ 2\ 1) [1\ -1\ 1]$ is in a relationship of being rotated by 19.4° around the $(20\ 10\ 17)$ direction as the axis of rotation, and this angle is designated as the deviation angle. As for the common axis of rotation, one that can be represented by the smallest deviation angle is employed. This deviation angle is calculated for all measurement points, and the number including up to the first decimal place is designated as the effective number. The area of grains having an orientation of less than 15° from, or within 15° to 30° from the Cube orientation is divided by the total measured area, and the resultant value is designated as the ratio of the area.

In regard to the EBSD analysis, in order to obtain a clear Kikuchi-line diffraction image, the analysis is conducted, after mirror polishing of the substrate surface, with polishing particles of colloidal silica after mechanical polishing.

[0019] Herein, the features of the EBSD analysis will be explained in comparison with the X-ray diffraction analysis. First, the first feature is that orientations that can be measured by the method of X-ray diffraction include only five kinds of planes which satisfy the Bragg's diffraction condition and can give sufficient diffraction intensities, namely, ND// $(1\ 1\ 1)$, $(2\ 0\ 0)$, $(2\ 2\ 0)$, $(3\ 1\ 1)$, and $(4\ 2\ 0)$ planes, and the orientations whose deviation angles from the Cube orientation correspond to 15° to 30°, for example, the crystal orientations indicated with higher indexes, such as ND// $(5\ 1\ 1)$ plane or ND// $(9\ 5\ 1)$ plane, cannot be measured. In other words, by employing the EBSD analysis, for the first time, information on those orientations is obtained, and the relationship between the metal texture to be specified by the orientations and the actions/effects thereof are made clear. The second feature is that X-ray diffraction analyzes the quantity of the crystal orientation that is included in the range of about $\pm 0.5^\circ$ with respect to ND// $\{h\ k\ l\}$. On the other hand, the EBSD analysis, which utilizes Kikuchi patterns, makes it possible to obtain a huge variety of comprehensive information on metal textures that are not limited to particular crystal faces, thereby to clarify those states that cannot be easily specified by X-ray diffraction in the overall alloy material. As explained above, the information obtainable by an EBSD analysis and the information obtainable by an X-ray diffraction analysis are different from each other in the contents and the natures. Unless otherwise specified, in the present specification, the results of EBSD are results obtained in connection with the ND direction of a copper alloy sheet material.

(Alloy composition and the like)

[0020] Next, the reason for limiting the chemical component composition for the copper alloy sheet material of the present invention will be described (in which the contents described with the unit '%' (percentage) each are in terms of 'mass%' (mass percent)).

• Ni, Co, Si

[0021] The content of Ni is set to 0.5 to 5.0%. Ni is an element that is contained together with Si, which will be described below, to form a Ni_2Si phase that is precipitated by an aging treatment, to contribute to enhancement of the mechanical strength of the resultant copper alloy sheet material. If the content of Ni is too small, the Ni_2Si phase is insufficient, and the tensile strength of the copper alloy sheet may not be enhanced. On the other hand, if the content of Ni is too large, the electrical conductivity lowers, and the hot-rolling workability is deteriorated. Thus, the content of Ni is set to the range of 0.5 to 5.0%, preferably 1.5 to 4.0%.

[0022] The content of Co is set to 0.5 to 5.0%. Co is an element that is contained together with Si, to form a Co_2Si phase that is precipitated by the aging treatment as in the case of Ni, to contribute to enhancement of the mechanical

strength of the resultant copper alloy sheet material. If the content of Co is too small, the Co_2Si phase is insufficient, and the tensile strength of the copper alloy sheet may not be enhanced. On the other hand, if the content of Co is too large, the electrical conductivity lowers, and the hot-rolling workability is deteriorated. Thus, the content of Co is set to the range of 0.5 to 5.0%, preferably 0.8 to 3.0%.

[0023] These Ni and Co may be contained in a total amount for both elements of 0.5 to 5.0%. When containing both of Ni and Co, both Ni_2Si and Co_2Si are precipitated upon the aging treatment, to enhance the aging strength. If the total content of Ni and Co is too small, the tensile strength may not be enhanced, and if the total content is too large, electrical conductivity and hot-rolling workability are deteriorated. Thus, the total content of Ni and Co is set in the range of 0.5 to 5.0%, preferably 0.8 to 4.0%. In particular, when a high electrical conductivity is required, it is preferable to increase the amount to be added of Co than the amount to be added of Ni.

[0024] Si is contained together with the Ni and/or Co, to form the Ni_2Si phase and/or Co_2Si phase that are(is) precipitated by the aging treatment, to contribute to enhancement of the mechanical strength of the copper alloy sheet material. When the content of Si is set such that the ratio Ni/Si as a stoichiometric ratio is set to 4.2, and the ratio Co/Si as a stoichiometric ratio is set to 4.2, the balance between electrical conductivity and mechanical strength is most favorably achieved. Thus, it is preferable to set the content of Si such that the ratios Ni/Si, Co/Si, and (Ni + Co)/Si are in the range of 3.2 to 5.2, preferably 3.5 to 4.5.

If Si is excessively contained in an amount outside this range, the tensile strength of the copper alloy sheet material can be enhanced, but the excess amount of Si is made into a solid solution in the matrix of copper, to lower the electrical conductivity of the copper alloy sheet material. Further, if Si is contained in excess, the casting property in casting, and/or hot- and cold-rolling workability are also deteriorated, to result in being apt to occurring casting cracks or rolling cracks. On the other hand, if the content of Si is outside this range and too small, the precipitated phase of Ni_2Si and/or Co_2Si is insufficiently formed, and the tensile strength of the sheet may not be enhanced.

• Other elements

[0025] In addition to the compositions described above, the copper alloy may also contain Cr in an amount of 0.01 to 0.5%. Cr has an effect of making grains in the alloy finer, to contribute to enhancement of the mechanical strength and/or bending property of the copper alloy sheet material. If the content is too small, the effect is not obtained, and if the content is too large, crystallized products are formed upon casting, to lower the aging strength. A preferred content of Cr is 0.05 to 0.3%.

[0026] The high-strength copper alloy sheet material of the present invention may contain, as an additive element(s) in addition to the above-mentioned basic composition, one, two or more of Sn: 0.05 to 1.0%, Zn: 0.01 to 1.0%, Ag: 0.01 to 1.0%, Mn: 0.01 to 1.0%, Zr: 0.1 to 1.0%, and Mg: 0.01 to 1.0%, each in terms of mass%. Herein, when the copper alloy sheet material contains two or more of those, the total content is set to 0.01 to 1.0%. These elements are elements having a common action/effect of further enhancing any of mechanical strength, electrical conductivity, and bending property, which all correspond to the main targets of the copper alloy of the present invention. The characteristic actions/effects and the significance of the content ranges of the respective elements will be described below.

[0027] Sn is an element that mainly enhances the mechanical strength of the resultant copper alloy sheet material, and in the case where the sheet is utilized in applications where these characteristics are regarded as important, Sn is selectively contained. If the content of Sn is too small, the strength enhancing effect is insufficient. On the other hand, when Sn is contained, the electrical conductivity of the copper alloy sheet tends to lower. In particular, if the content of Sn is too large, it is difficult to attain the electrical conductivity of the copper alloy sheet material to be 20 %IACS or higher. Thus, when contained, it is preferable to set the content of Sn to the range of 0.01 to 1.0%.

[0028] By containing Zn, it becomes possible to enhance the migration resistance or heat resistant peelability upon soldering. If the content of Zn is too small, the effects are insufficient. On the other hand, when Zn is contained, the electrical conductivity of the copper alloy sheet tends to lower, and if the content of Zn is too large, it is difficult to attain the electrical conductivity of the copper alloy sheet to be 20 %IACS or higher. Thus, it is preferable to set the content of Zn to the range of 0.01 to 1.0%.

[0029] Ag contributes to enhancement of the mechanical strength of the copper alloy sheet material. If the content of Ag is too small, the effects are insufficient. On the other hand, even if Ag is contained in excess, the effects are saturated, which is not preferable. Thus, when Ag is contained, it is preferable to set the content of Ag to the range of 0.01 to 1.0%.

[0030] Mn mainly enhances workability in hot-rolling of the alloy. If the content of Mn is too small, the effects are insufficient. On the other hand, if the content of Mn is too large, the melt fluidity in casting of the copper alloy is deteriorated, thereby to lower the casting yield. Thus, when Mn is contained, the content of Mn is set to the range of 0.01 to 1.0%.

[0031] Zr mainly makes grains finer, to enhance the mechanical strength and/or bending property of the copper alloy sheet. If the content of Zr is too small, the effects are insufficient. On the other hand, if the content of Zr is too large, compounds are formed, and the workability upon rolling or the like of the copper alloy sheet is deteriorated. Thus, when Zr is contained, the content of Zr is set to the range of 0.01 to 1.0%.

[0032] Mg enhances the stress relaxation resistance. Thus, in the case where stress relaxation resistance is required, Mg is selectively contained in an amount in the range of 0.01 to 1.0%. If the content of Mg is too small, the target effect is insufficient, and if the content is too large, an impediment of lowering of the electrical conductivity is caused, which is not preferable.

(Production method and the like)

[0033] Next, some preferable examples (preferable embodiments) of the production method of the copper alloy sheet material of the present invention will be described below.

The Corson alloy sheet material of the present invention is produced through the steps of: casting, hot-rolling, cold-rolling 1, intermediate annealing, cold-rolling 2, solution heat treatment, cold-rolling 3, aging heat treatment, finish cold-rolling, and low-temperature annealing. The method of producing the copper alloy sheet material of the present invention itself may be seen achievable by the similar method as in the case of conventional Corson alloy. However, with regard to the crystal texture, the production conditions in each step need to be limited, and in particular, in order to produce the copper alloy sheet material of the present invention, it is preferable to strictly control the conditions in the intermediate annealing and cold-rolling 3.

[0034] According to this one embodiment, casting is carried out to a molten copper alloy having its components set to any of the composition ranges described above. Then, the resultant ingot is face-milled, followed by subjecting to heating or a homogenization heat treatment at 800 to 1,000°C, hot-rolling, and then water-cooling the thus-hot-rolled sheet.

After the hot-rolling, the surface is face-milled, followed by cold-rolling 1. When the rolling ratio of this cold-rolling 1 is sufficiently high, even if production proceeds to obtain final products, the Brass orientation, the S orientation, and the like do not excessively develop, and the area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation can be sufficiently increased. For that reason, the rolling ratio of the cold-rolling 1 is preferably 70% or higher.

[0035] One feature of the method for the copper alloy material of the present invention is to add the cold-rolling 2 at a rolling ratio of 3 to 80% between the cold-rolling 1 and the solution heat treatment, subsequently to the intermediate annealing at 300 to 800°C for 5 seconds to 2 hours. In the intermediate annealing, a heat treatment is carried out at a temperature lower than the temperature of the solution heat treatment, and thereby a sub-annealed texture can be obtained, which is obtained not by complete recrystallization of the material but by partial recrystallization. In the cold-rolling 2, microscopically nonuniform strain can be introduced into the material, by rolling at a relatively low working ratio. Through the effects of these two steps, a desired crystal orientation can be obtained, in the recrystallized crystal texture obtained by the solution heat treatment. A more preferred range of the intermediate annealing is 10 seconds to 1 minute at 400 to 700°C, and an even more preferred range is 15 seconds to 45 seconds at 500 to 650°C. A more preferred range of the working ratio of the cold-rolling 2 is 5 to 55%, and an even more preferred range is 7 to 45%.

Conventionally, the heat treatment such as the intermediate annealing is carried out, to recrystallize the material to lower the mechanical strength, in order to reduce the load at rolling in the subsequent step. Further, rolling is intended to make the sheet thickness small, and with the capacity of conventional rolling machines, it is general to employ a working ratio of higher than 80%. The purpose of the intermediate annealing and cold working according to the present invention is to impart the preferentiality to the crystal orientation after recrystallization, which is different from the conventional purposes of those steps.

[0036] According to this one embodiment, the solution treatment is carried out at 600 to 1,000°C for 5 seconds to 300 seconds. Since the necessary temperature conditions vary depending on the concentration of Ni and/or Co, it is necessary to select appropriate temperature conditions according to the Ni and/or Co concentrations. When the solution temperature is equal to or higher than the lower limit, mechanical strength is sufficiently maintained in the aging treatment step. When the solution treatment is equal to or lower than the upper limit, the material is not softened more than necessary, and the shape control is suitably realized, which is preferable. At this time, it is preferable to set the area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation, to 15 to 50%.

[0037] After the solution treatment, the cold-rolling 3 at a working ratio of 5 to 40% is carried out. In this cold-rolling, when the cold-rolling is carried out at this working ratio, the crystal texture falls in the range of the present invention, which is preferable. According to the findings of the inventors of the present invention, when rolling with different friction is carried out with rolls different in roughness from each other of the rolls for the cold-rolling, the grains having a deviation angle of less than 15° from the Cube orientation undergo slight rotation of orientation, to make it possible to accumulate at the orientation having a deviation angle of 15 to 30° from the Cube orientation. This can be presumed, because, in the case of rolling with different friction, the plastic constraint is different between the upper surface and the lower surface of the rolled material, and this difference in the plastic constraint causes the introduction of slight shear deformation. Herein, it is preferable to set the difference in the mean center-line roughness, Ra, between the upper roll and the lower roll, to 0.05 to 3.0 μm, more preferably to 2.4 to 2.8 μm. The roughness of the rolls may be controlled, by roughening the surfaces of the rolls with grinding paper. The cold-rolling 3 has an effect of increasing the amount of aging precipitation,

to contribute to enhancement in the mechanical strength.

[0038] The aging treatment is carried out in the range of at 400 to 600°C for 0.5 hours to 8 hours. Since the necessary temperature conditions vary depending on the concentration of Ni and/or Co, it is necessary to select appropriate temperature conditions according to the Ni and/or Co concentrations. When the temperature of the aging treatment is equal to or higher than the lower limit, the amount of aging precipitation does not decrease, and sufficient mechanical strength is maintained. Further, when the temperature of the aging treatment is equal to or lower than the upper limit, the resultant precipitate does not become coarse, and the mechanical strength is maintained.

It is preferable to set the working ratio of the finish cold-rolling after the solution treatment to 0 to 20% or less. If the working ratio is too high, the cube grains of crystal orientations may undergo rotation in orientation to the Brass orientation, the S orientation, the Copper orientation, or the like, and the resultant crystal texture may fall outside the range of the present invention.

The confirmation of characteristics of the copper alloy sheet produced according to the present invention, can be made by verifying whether the texture of the copper alloy sheet is within the defined range, through an EBSD analysis.

EXAMPLES

[0039] 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.

[0040] Examples according to the present invention will be described below. Copper alloys having the compositions shown in Table 1 were cast, to produce copper alloy sheets, and characteristics, such as mechanical strength, electrical conductivity, and bending property, were evaluated.

[0041] First, casting was conducted by a DC (direct chill) method, to obtain ingots with thickness 30 mm, width 100 mm, and length 150 mm. Then, these ingots were heated to 900°C, followed by maintaining at this temperature for one hour, hot-rolling to thickness 14 mm, and rapid cooling. Then, the respective surface of each of the thus-rolled sheets were face-milled respectively by 1 mm to remove oxide layer, followed by subjecting to cold-rolling 1 at a rolling ratio of 90 to 98%. Then, a heat treatment at 600 to 700°C for 1 hour was carried out, followed by cold-rolling 2 at a cold-rolling ratio of 5 to 20%. Then, solution treatment was carried out under any of conditions of 700 to 950°C, immediately followed by cooling at a cooling speed of 15°C/sec or higher. Then, cold-rolling 3 was carried out at a rolling ratio of 5 to 40%. At that time, rolls were used which had a difference in the surface roughness Ra between the upper roll and the lower roll of 0.05 to 3.0 μm. Then, an aging treatment at 400 to 600°C for 2 hours was conducted, under an inert gas atmosphere, followed by finish rolling at a rolling ratio of 20% or less. Thus, the final sheet thickness was aligned to 0.15 mm. After the finish rolling, the materials were subjected to low-temperature annealing at 400°C for 30 seconds, and evaluations of characteristics were carried out.

[0042] With respect to the thus-produced copper alloy sheets, in all cases, the tests and evaluations described below were carried out, using samples cut from the copper alloy sheets obtained after the aging treatment.

[0043] The textures of the copper alloy sheet samples, the area ratios of grains of a crystal orientation having a deviation angle of less than 15° from the Cube orientation, and the area ratios of grains of a crystal orientation having a deviation angle within 15 to 30° from the Cube orientation, were measured according to the methods described above. These results are shown in the tables.

As the EBSD analyzer, OIM5.0 HIKARI, manufactured by TSL Solutions, Ltd., was used.

[0044] Furthermore, (1) the area ratio of grains of crystal orientations, (2) tensile strength, (3) electrical conductivity, and (4) bending property, of the copper alloy sheet samples, were evaluated.

(1) The area ratio of grains of crystal orientations are shown by the area ratio of grains having a deviation angle of less than 15° from the Cube orientation, and the area ratio of grains having a deviation angle of 15 to 30° from the Cube orientation.

(2) The tensile strength was determined, with a No. 5 test piece as stipulated in JIS Z 2201, according to JIS Z 2241. The tensile strength is shown by an integer round up by multiple of 5 MPa.

(3) The electrical conductivity was determined according to JIS H 0505.

(4) The bending property was measured, by providing a bending test piece with width w of 5 mm, and 90° bending was conducted at a bending R of 0 to 0.6. The ratio of the minimum bending radius (R) at which no cracks occurred, and the sheet thickness (t), was defined as R/t.

[0045] Examples 1 to 31 of Table 1 indicate the examples according to the present invention. Examples 1 to 31 had the crystal textures within the range according to the present invention, and were excellent in the mechanical strength and bending property.

[0046] Table 2 shows Comparative examples against the present invention. Comparative Examples 1, 2, and 5 were too small in the content of Ni or/and Co as compared with the range defined by the present invention, and the tensile

strength was conspicuously low. Comparative examples 3, 4, 6, and 7 were too large in the content of Ni or/and Co, and cracks occurred upon the hot-rolling, to stop the production.

[0047] Table 3 presents examples, in which the effects on the crystal texture of the difference in the average roughness Ra between the upper and lower rolling rolls in the cold-rolling 3, were examined, using the same ingots as those in the examples of Table 1. In Examples 10-2, 10-3, 22-2, 22-3, 29-2, and 29-3 of Table 3, the crystal textures were fallen in the range of the examples according to the present invention, and the samples were excellent in the mechanical strength and bending property. On the other hand, in Comparative Examples 10-2, 22-2, and 29-2, since the difference of Ra was too small, the area ratio of grains having a deviation angle of less than 15° from the Cube orientation was too high, and the mechanical strength was poor. Further, in Comparative Examples 10-3, 22-3, and 29-3, since the difference of R was too large, the area ratio of grains having a deviation angle within 15° to 30° from the Cube orientation was too low, and the bending property was poor.

The surface roughness, Ra, of the roll was measured, according to JIS B 0601.

[0048]

Table 1

	No.	Ni	Co	Si	Cr	Other elements	Area ratio 1 *1	Area ratio 2 *2	Electrical conductivity	Tensile strength (MPa)	R/t
Ex	1	1.5		0.4		Mg: 0.1	5	18	44	740	0.33
Ex	2	2.3		0.5			7	15	42	850	0.67
Ex	3	2.3		0.5	0.3		8	20	41	870	0.67
Ex	4	2.3		0.5	0.1		6	19	42	865	0.67
Ex	5	2.3		0.5	0.1	Mg: 0.1, Sn: 0.1, Zn: 0.5	9	31	39	875	0.67
Ex	6	2.3		0.5		Mg: 0.1, Sn: 0.1	8	28	42	860	0.67
Ex	7	2.3		0.5		Ag: 0.1	6	22	43	855	0.67
Ex	8	2.3		0.5		Mn: 0.1	7	23	40	860	0.67
Ex	9	2.3		0.5		Zr: 0.1	7	22	40	860	0.67
Ex	10	3.8		0.9	0.1		7	23	38	900	1
Ex	11	3.8		0.9	0.1	Mg: 0.1, Sn: 0.1, Zn: 0.5	5	24	36	910	1
Ex	12	3.8		0.9		Sn: 0.1	4	19	37	900	1
Ex	13	3.8		0.9	0.2		8	27	37	920	1
Ex	14	4.9		1.2		Mg: 0.1	8	17	33	935	1.5
Ex	15	4.9		1.2			8	25	34	930	1.5
Ex	16	4.9		1.2		Mg: 0.1, Sn: 0.1, Zn: 0.5	7	19	31	940	1.5
Ex	17	1.2	1.2	0.6		Mg: 0.1	6	17	50	870	0.67
Ex	18	1.3	0.8	0.5		Mg: 0.1, Sn: 0.1, Zn: 0.5	8	16	51	860	0.67
Ex	19	1.3	0.8	0.5		Ag: 0.1	8	22	52	860	0.67
Ex	20	1.3	0.8	0.5		Mn: 0.1	6	24	49	865	0.67
Ex	21	1.3	0.8	0.5		Zr: 0.1	9	25	49	865	0.67

EP 2 508 632 A1

(continued)

	No.	Ni	Co	Si	Cr	Other elements	Area ratio 1 *1	Area ratio 2 *2	Electrical conductivity	Tensile strength (MPa)	R/t
Ex	22	1.3	0.8	0.5			5	21	50	840	0.67
Ex	23	2.1	0.7	0.7	0.1		7	27	47	880	1
Ex	24	2.4	1.2	0.9			8	40	42	900	1
Ex	25	0.8	2.6	0.8			7	19	41	880	1
Ex	26	0.6	2.8	0.8			8	26	62	890	1
Ex	27		0.8	0.2		Mg: 0.1	7	18	60	680	0
Ex	28		1.4	0.3		Mg: 0.1	4	20	55	780	0.5
Ex	29		2.3	0.5			8	16	55	860	0.67
Ex	30		3.1	0.7		Mg: 0.1, Sn: 0.1, Zn: 0.5	9	19	45	870	1
Ex	31		3.6	0.9		Ag: 0.1	6	20	55	890	1
"Ex" means Example according to this invention.											

[0049]

Table 2

		Ni	Co	Si	Cr	Other elements	Area ratio 1 *1	Area ratio 2 *2	Electrical conductivity	Tensile strength (MPa)	R/t
CEx	1	0.4		01			5	24	68	500	0
CEx	2	0.2	0.2	0.1	0.1	Mg: 0.1, Sn: 0.1, Zn 0.5	6	17	66	510	0
CEx	3	5.3		1.3			Production was stopped, due to cracks occurred in hot-working				
CEx	4	2.2	3.5	1.4			Production was stopped, due to cracks occurred in hot-working.				
CEx	5		0.3	0.1	02	Mg: 0.1	6	20	70	500	0
CEx	6		5.3	1.3			Production was stopped, due to cracks occurred in hot-working.				
CEx	7		5.8	1.4			Production was stopped, due to cracks occurred in hot-working.				
*2: Area ratio of grains having a deviation angle of less than 15° from the Cube orientation											
*3: Area ratio of grains having a deviation angle of 15 to 30° from the Cube orientation											
"C Ex" means Comparative Example.											

[0050]

Table 3

		Ni	Co	Si	Cr	Difference in Ra between upper and lower rolls	Area ratio 1 *1	Area ratio2 *2	Electrical conductivity	Tensile strength (MPa)	R/t
Ex	10-2	3.8		0.9	0.1	0.08 μm	9	23	38	880	1
C Ex						0.02 μm	13	10	38	840	1
Ex	10-3	3.8		0.9	0.1	2.7 μm	3	25	38	890	1
CEx						3.4 μm	5	11	38	875	1.5
Ex	22-2	1.3	0.8	0.5	0.1	0.08 μm	7	23	50	835	0.5
C Ex						0.02 μm	17	6	50	810	0.5
Ex	22-3	1.3	0.8	0.5	0.1	2.7 μm	5	26	50	840	0.5
C Ex						3.4 μm	2	7	50	840	1
Ex	29-2		2.3	0.5		008 μm	8	16	55	860	0.67
C Ex						0.02 μm	19	10	55	825	0.67
Ex	29-3		2.3	0.5		2.7 μm	3	25	55	860	0.67
C Ex						3.4 μm	3	6	55	865	1.5
"Ex" means Example according to the present invention, and "C Ex" means Comparative Example.											

[0051] Next, in order to clarify the difference between copper alloy sheet materials produced under the conventional production conditions and the copper alloy sheet material according to the present invention, copper alloy sheet materials were produced under the conventional conditions, and evaluations of the same characteristic items as described above were conducted. The working ratio was adjusted so that, unless otherwise specified, the thickness of the respective sheet material would be the same as the thickness in the examples described above. In all cases, the usual production conditions at the time of filing of the present application are taken into consideration, and the cold-rolling after the solution treatment was carried out under the conditions of not employing rolling with different friction.

(Comparative Example 101) ... Conditions described in JP-A-2009-007666

[0052] An alloy formed by blending the same metal elements as those in Example 1-1, with the balance of Cu and inevitable impurities, was melted in a high-frequency melting furnace, followed by casting at a cooling speed of 0.1 to 100°C/sec, to obtain an ingot. The resultant ingot was maintained at 900 to 1,020°C for 3 minutes to 10 hours, followed by subjecting to hot working, quenching in water, and then surface milling to remove oxide scale. For the subsequent steps, use was made of the treatments/workings of the following steps A-3 and B-3, to produce a copper alloy c01. The production steps included one, two times or more solution heat treatments. Herein, the steps were divided into those before and after the final solution heat treatment, so that the steps up to the intermediate solution treatment are designated as Step A-3, while the steps after the intermediate solution treatment are designated as Step B-3.

[0053] Step A-3: Cold working at a cross-sectional area reduction ratio of 20% or greater, a heat treatment at 350 to 750°C for 5 minutes to 10 hours, cold working at a cross-sectional area reduction ratio of 5 to 50%, and a solution heat treatment at 800 to 1,000°C for 5 seconds to 30 minutes.

Step B-3: Cold working (without any different friction) at a cross-sectional area reduction ratio of 50% or less, a heat treatment at 400 to 700°C for 5 minutes to 10 hours, cold working at a cross-sectional area reduction ratio of 30% or less, and temper annealing at 200 to 550°C for 5 seconds to 10 hours.

[0054] The test specimen c01 thus obtained was different from those in the examples according to this invention, in terms of the rolling with different friction, whether conducted or not conducted, in connection with the production conditions, and resulted in not satisfying the required level on the tensile strength.

(Comparative Example 102) ... Conditions described in JP-A-2006-283059

[0055] A copper alloy having the same composition as in Example 1-1 according to this invention was melted in the

air under charcoal coating with an electric furnace, to judge whether the copper alloy was able to be cast or not. The resultant ingot produced by melting was hot rolled, to finish to thickness 15 mm. Then, this hot-rolled sheet was subjected to cold-rollings and heat treatments (cold-rolling 1 → solution continuous annealing → cold-rolling 2 (without any different friction) → aging → cold-rolling 3 → short-time annealing), to produce a copper alloy sheet (c02) with a predetermined thickness.

[0056] The test specimen c02 thus obtained was different from that in Example 1 according to this invention, in terms of the intermediate annealing and the cold-rolling 2, whether conducted or not conducted, and the rolling with different friction, whether conducted or not conducted, in connection with the production conditions, and resulted in not satisfying the bending property.

(Comparative Example 103) ... Conditions described in JP-A-2006-152392

[0057] An alloy having the same composition as in Example 1-1 according to this invention was melted in the air under charcoal coating in a kryptol furnace, followed by casting in a book mold made of cast iron, to produce an ingot with a size of thickness 50 mm, width 75 mm, and length 180 mm. Then, the surface of the ingot was surface milled, followed by hot rolling at a temperature of 950°C until that the thickness became 15 mm, and then quenching in water from a temperature of 750°C or higher. Then, oxide scale was removed, followed by cold-rolling, to give a sheet with a predetermined thickness.

[0058] Then, the resultant sheet was subjected to a solution treatment by heating at the temperature for 20 seconds, in a salt bath furnace, followed by quenching in water, and then finish cold-rolling (without any different friction) of the second half, to produce a cold-rolled sheet with any of various thicknesses. At that time, as shown below, cold-rolled sheets (c03) were obtained by changing the working ratio (%) in these cold-rollings. These cold-rolled sheets were subjected to aging by changing the temperature (°C) and the time period (hr) as shown below.

[0059]

Cold-working ratio: 95%

Solution treatment temperature: 900°C

Artificial age-hardening temperature x time period: 450°C x 4 hours

Sheet thickness: 0.6 mm

[0060] The test specimen c03 thus obtained was different from that in Example 1 according to this invention, in terms of the intermediate annealing and the cold-rolling 2, whether conducted or not conducted, and the rolling with different friction, whether conducted or not conducted, in connection with the production conditions, and resulted in not satisfying the bending property.

(Comparative Example 104) ... Conditions described in JP-A-2008-223136

[0061] The copper alloy shown in Example 1 was melted, followed by casting with a vertical continuous casting machine. From the thus-obtained ingot (thickness 180 mm), a sample with thickness 50 mm was cut out, and this sample was heated to 950°C, followed by extracting, and then starting hot-rolling. At that time, the pass schedule was set to the rolling ratio in the temperature range of 950 to 700°C to be 60% or higher, and to conduct rolling even in the temperature range of lower than 700°C. The final pass temperature of hot-rolling was between 600°C and 400°C. The total hot-rolling ratio from the ingot was about 90%. After the hot-rolling, the oxide layer at the surface layer was removed by mechanical polishing (surface milling).

Then, after conducting cold-rolling, the sample was subjected to a solution treatment. The temperature change at the time of the solution treatment was monitored with a thermocouple attached to the sample surface, and the time period for temperature rise from 100°C to 700°C in the course of temperature rising was determined. The end-point temperature was adjusted in the range of 700 to 850°C, depending on the alloy composition, so that the average grain size (a twin boundary was not regarded as the grain boundary) after the solution treatment would be 10 to 60 μm, and the retention time period in the temperature range of 700 to 850°C was adjusted in the range of 10 sec to 10 min. Then, the sheet material obtained after the solution treatment was subjected to intermediate cold-rolling (without any different friction) at the rolling ratio, followed by aging. The aging temperature was set to a material temperature of 450°C, and the aging time period was adjusted to the time period at which the hardness reached the maximum upon the aging at 450°C, depending on the alloy composition. The optimum solution treatment conditions and the optimum aging time period had been found by preliminary experiments in accordance with the alloy composition. Then, finish cold-rolling was conducted at the rolling ratio. Samples that had been subjected to the finish cold-rolling were then further subjected to low-temperature annealing of placing the sample in a furnace at 400°C for 5 minutes. Thus, test specimens c04 were obtained. Surface milling was conducted in the mid course, as necessary, and thus the sheet thickness of the test specimens was

set to 0.2 mm. The principal production conditions are as described below.

[Conditions of Example 1 of JP-A-2008-223136]

[0062]

Hot-rolling ratio at below 700°C to 400°C: 56% (one pass)
Cold-rolling ratio before solution treatment: 92%
Cold-rolling ratio for intermediate cold-rolling: 20%
Cold-rolling ratio for finish cold-rolling: 30%
Time period for temperature rise from 100°C to 700°C: 10 seconds

[0063] The test specimens c04 thus obtained were different from that in Example 1 according to this invention, in terms of the intermediate annealing and the cold-rolling 2, whether conducted or not conducted, and the rolling with different friction, whether conducted or not conducted, in connection with the production conditions, and resulted in not satisfying the bending property.

Claims

1. A copper alloy sheet material for electrical or electronic parts, which is composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, wherein an area ratio of grains having a deviation angle of less than 15° from the Cube orientation is controlled to less than 10%, and an area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is controlled to 15% or greater, and wherein the copper alloy sheet material has excellent mechanical strength and bending property.
2. The copper alloy sheet material for electrical or electronic parts according to claim 1, wherein the copper alloy composition further contains Cr in an amount of 0.05 to 0.5%.
3. The copper alloy sheet material for electrical or electronic parts according to claim 1 or 2, wherein the copper alloy composition further contains one, two or more from Zn, Sn, Mg, Ag, Mn, and Zr in an amount of 0.01 to 1.0% in total.
4. The copper alloy sheet material for electrical or electronic parts according to any one of claim 1 to 3, wherein the copper alloy sheet material is subjected, after a solution treatment, to cold-rolling with different friction
5. A connector, which is composed of the alloy sheet material of claims 1 to 4.
6. A method of producing a copper alloy sheet material for electrical or electronic parts, containing the steps of:
 - subjecting a molten copper alloy composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, to casting into an ingot;
 - conducting heating or a homogenization heat treatment;
 - hot-rolling with different friction;
 - cold-rolling;
 - conducting an intermediate annealing;
 - conducting a solution treatment;
 - cold-rolling with different friction; and
 - conducting an aging treatment.
7. The method of producing a copper alloy sheet material for electrical or electronic parts according to claim 5, in which the cold-rolling with different friction is carried out with an upper roll and a lower roll having a surface roughness different from each other.

Amended claims under Art. 19.1 PCT

1. A copper alloy sheet material for electrical or electronic parts, which is composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, wherein an area ratio of grains having a deviation angle of less than 15° from the Cube orientation is controlled to less than 10%, and an area ratio of grains having a deviation angle of 15° to 30° from the Cube orientation is controlled to 15% or greater, and wherein the copper alloy sheet material has excellent mechanical strength and bending property.

2. The copper alloy sheet material for electrical or electronic parts according to claim 1, wherein the copper alloy composition further contains Cr in an amount of 0.05 to 0.5%.

3. The copper alloy sheet material for electrical or electronic parts according to claim 1 or 2, wherein the copper alloy composition further contains one, two or more from Zn, Sn, Mg, Ag, Mn, and Zr in an amount of 0.01 to 1.0% in total.

4. The copper alloy sheet material for electrical or electronic parts according to any one of claim 1 to 3, wherein the copper alloy sheet material is subjected, after a solution treatment, to cold-rolling with different friction.

5. Amended) A connector, which is composed of the alloy sheet material according to any one of claims 1 to 4.

6. Amended) A method of producing a copper alloy sheet material for electrical or electronic parts, in which the copper alloy sheet material is composed of a copper alloy composition containing, in terms of mass%, any one or both of Ni or Co in an amount of 0.8 to 5%, and Si in an amount of 0.2 to 1.5%, with the balance being Cu and inevitable impurities, the method comprising, in this order, the steps of.

[a step of subjecting a molten copper alloy having the elements adjusted to the composition range, to casting into an ingot]

[a step of subjecting the ingot to face-milling, followed by heating or a homogenization heat treatment at 800 to 1,000°C, hot-rolling, and water-cooling the thus-hot-rolled sheet]

[a step of conducting face-milling the surface of the hot-rolled sheet, followed by cold-rolling 1 at a rolling ratio of 70% or higher]

[a step, between the cold-rolling 1 and a solution treatment, of conducting an intermediate annealing at 300 to 800°C for 5 seconds to 2 hours, followed by cold-rolling 2 at a rolling ratio of 3 to 80%]

[a step of conducting a solution treatment at 600 to 1,000°C for 5 seconds to 300 seconds]

[a step, after the solution treatment, of conducting rolling with different friction with rolls in which a difference in the mean center-line roughness Ra between an upper roll and a lower roll is 0.05 to 3.0 μm, as cold-rolling 3, at a working ratio of 5 to 40%]

7. Cancelled)

Statement under Art. 19.1 PCT

1. Claim 5 Claim 5 was amended to correct the typographic errors.as indicated in the Written Opinion of the International Searching Authority.

2. Claim 6 Claim 6 was amended to incorporate the subject matters of Claim 7, and to clarify the production steps as indicated in the Written Opinion of the International Searching Authority.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/071494

A. CLASSIFICATION OF SUBJECT MATTER

C22C9/06(2006.01)i, C22C9/00(2006.01)i, C22C9/02(2006.01)i, C22C9/04(2006.01)i, C22C9/05(2006.01)i, C22C9/10(2006.01)i, C22F1/08(2006.01)i, H01B1/02(2006.01)i, H01B5/02(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)

C22C9/00-9/10, C22F1/08, H01B1/02, H01B5/02, C22F1/00, B21B3/00

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-152392 A (Kobe Steel, Ltd.), 15 June 2006 (15.06.2006), entire text; all drawings (Family: none)	1-7
A	JP 2006-283059 A (Kobe Steel, Ltd.), 19 October 2006 (19.10.2006), entire text; all drawings (Family: none)	1-7
A	JP 2009-242932 A (Nippon Mining & Metals Co., Ltd.), 22 October 2009 (22.10.2009), entire text; all drawings & WO 2009/122869 A1	1-7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
17 February, 2011 (17.02.11)

Date of mailing of the international search report
01 March, 2011 (01.03.11)

Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/071494

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-88512 A (Nippon Mining & Metals Co., Ltd.), 17 April 2008 (17.04.2008), entire text & WO 2008/041696 A1 & KR 10-2009-0050101 A & CN 101522927 A	1-7
A	WO 2008/105453 A1 (NGK Insulators, Ltd.), 04 September 2008 (04.09.2008), entire text; all drawings & US 2010/0009212 A1 & EP 2127766 A1 & CN 101622081 A & KR 10-2009-0113880 A	1-7
A	WO 2009/044822 A1 (The Furukawa Electric Co., Ltd.), 09 April 2009 (09.04.2009), entire text; all drawings & US 2010/0221576 A1 & EP 2202326 A1 & CN 101809177 A & KR 10-2009-0088850 A	1-7
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Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2006152392 A [0006]
- JP 2006161148 A [0006]
- JP 2009007666 A [0006]