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(54) **COPPER ALLOY WIRE**

(57) Provided is a copper alloy wire rod superior in the balance of the strength, the electric conductivity and the drawability. A copper alloy wire rod comprises an alloy composition including 1.0% by mass or more and 6.0% by mass or less of Ag, a remainder being Cu and inevitable impurities, in which, for a peak intensity I(111) of 111 diffraction, a peak intensity I(200) of 200 diffraction, a peak intensity I(220) of 220 diffraction and a peak

intensity I(311) of 311 diffraction obtained by X-ray diffraction analysis of a surface, a peak intensity ratio of a total intensity of the peak intensity I(111), the peak intensity I(200) and the peak intensity I(311) relative to the peak intensity I(220) ((the peak intensity I(111) + the peak intensity I(220) + the peak intensity I(311)) / the peak intensity I(220)) is 1.20 or more and 3.00 or less.

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Description

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to a copper alloy wire rod.

BACKGROUND ART

10 **[0002]** Electrical wire diameters are in a trend of being further thinned in diameter compared to conventional due to a size reduction of products, space savings of electrical wires, an increase in signal lines, etc. in equipment connection cables. For example, in place of pure copper wire which is lacking in strength, wires of copper alloy such as Cu-Sn, Cu-Cr, Cu-Ag have come to be used. Among copper alloys, a Cu-Ag alloy is superior in the balance of high strength and high electric conductivity.

15 **[0003]** For example, Patent Document 1 discloses a manufacturing method of a copper alloy which cold works an ingot of a copper alloy composition containing 1 to 10% by weight of Ag, with a remainder consisting of Cu and inevitable impurities, then heat treats for 0.5 to 5 hours at a temperature of 570 to 680°C in a vacuum atmosphere or an inert gas atmosphere in the middle of this cold working, further performs cold working, and conducts heat treatment over 0.5 to 40 hours at a temperature of 400 to 550°C in a vacuum atmosphere or an inert gas atmosphere in the middle of this cold working.

20 **[0004]** In addition, Patent Document 2 discloses a Cu-Ag alloy wire having an Ag content of 1 to 10 wt%, and a remainder which is Cu and inevitable impurities, in which the entirety of the structure consisting of a solid solution of Cu consists of a recrystallized texture.

25 **[0005]** In the above Patent Documents 1 to 2, the eutectic phase of Cu and Ag is extended into filament shape, and achieves an improvement in strength and electric conductivity. In addition, in the manufacturing method of Cu-Ag alloy wire in Patent Document 2, an improvement in strength is achieved by heat treatment to develop a recrystallized texture, and high processing after the heat treatment.

30 **[0006]** However, in Patent Document 1, the strength characteristic is insufficient due to the control of the precipitation distribution of the eutectic phase contributing to the strength after wire drawing being improper. In addition, in Patent Document 2, since the appropriate wire drawing conditions are not being set prior to heat treatment, material embrittlement during heat treatment progresses, and it is difficult to perform wire thinning. For this reason, it is not a finished product having cost competitiveness due to the inferiority in productivity. In this way, in addition to improvements in strength and electric conductivity, it is difficult to simultaneously achieve an improvement in drawability, which is manufacturability, in Patent Documents 1 to 2.

[0007]

35 Patent Document 1: Japanese Patent No.3325639
Patent Document 2: Japanese Patent No.5051647

DISCLOSURE OF THE INVENTION

40 Problems to be Solved by the Invention

[0008] An object of the present disclosure is to provide a copper alloy wire rod superior in the balance of strength, electric conductivity and drawability.

45 Means for Solving the Problems

[0009] A copper alloy wire rod according to a first aspect of the present disclosure includes an alloy composition including 1.0% by mass or more and 6.0% by mass or less of Ag, a remainder being Cu and inevitable impurities, in which, for a peak intensity I(111) of 111 diffraction, a peak intensity I(200) of 200 diffraction, a peak intensity I(220) of 220 diffraction and a peak intensity I(311) of 311 diffraction obtained by X-ray diffraction analysis of a surface, a peak intensity ratio of a total intensity of the peak intensity I(111), the peak intensity I(200) and the peak intensity I(311) relative to the peak intensity I(220) ((the peak intensity I(111) + the peak intensity I(200) + the peak intensity I(311)) / the peak intensity I(220)) is 1.20 or more and 3.00 or less.

55 **[0010]** According to a second aspect of the present disclosure, in the copper alloy wire rod as described in the first aspect, the alloy composition further includes a total of 0.05% by mass or more and 0.30% by mass or less of at least one element selected from the group consisting of Sn, Mg, Zn, In, Ni, Co, Zr and Cr.

[0011] According to a third aspect of the present disclosure, in the copper alloy wire rod as described in the first or

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second aspect, tensile strength satisfies 1000 MPa or more, electric conductivity satisfies 60% IACS or more, and Ag content X (% by mass), tensile strength Y (MPa) and electric conductivity Z (% IACS) satisfy Formula (1), (2) and (3) below:

5
$$Y \geq 110X + 880 \quad \dots \text{Formula (1)}$$

$$Z \geq -4.6X + 82 \quad \dots \text{Formula (2)}$$

10
$$Y \geq -0.040Z + 117 \quad \dots \text{Formula (3)}$$

[0012] According to a fourth aspect of the present disclosure, in the copper alloy wire rod as described in any one of the first to third aspects, a cross section is circular shape having a diameter of 0.02 mm or more and 0.08 mm or less.

15 **[0013]** According to a fifth aspect of the present disclosure, in the copper alloy wire rod as described in any one of the first to third aspects, a cross section is a ribbon shape having a long side of 0.060 mm or more and 0.500 mm or less and a short side of 0.005 mm or more and 0.040 mm or less.

Effects of the Invention

20 **[0014]** According to the present disclosure, it is possible to provide a copper alloy wire rod superior in the balance of strength, electric conductivity and drawability.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

25 **[0015]** Hereinafter, the present invention will be explained in detail based on embodiments.

[0016] The present inventors, as a result of thorough research, found by focusing on the peak intensity of a predetermined plane obtained by X-ray diffraction analysis of the surface of a copper alloy wire rod, and controlling the ratio of peak intensities of the predetermined plane to within a predetermined range, that it was superior in the balance of strength, electric conductivity and drawability, and based on this knowledge, arrived at completion of the present disclosure.

30 **[0017]** A copper alloy wire rod of the embodiment has an alloy composition containing 1.0% by mass or more and 6.0% by mass or less of Ag, a remainder being Cu and inevitable impurities, in which, for a peak intensity I(111) of 111 diffraction, a peak intensity I(200) of 200 diffraction, a peak intensity I(220) of 220 diffraction and a peak intensity I(311) of 311 diffraction obtained by X-ray diffraction analysis of a surface, a peak intensity ratio of a total intensity of the peak intensity I(111), the peak intensity I(200) and the peak intensity I(311) relative to the peak intensity I(220) ((the peak intensity I(111) + the peak intensity I(220) + the peak intensity I(311)) / the peak intensity I(220)) is 1.20 or more and 3.00 or less.

[0018] First, the alloy composition of the copper alloy wire rod will be explained.

40 **[0019]** The copper alloy wire rod of the above embodiment has an alloy composition containing 1.0% by mass or more and 6.0% by mass or less of Ag, in which the remainder is Cu and inevitable impurities.

<Ag: 1.0% by mass to 6.0% by mass>

45 **[0020]** Ag (silver) is a necessary element for raising the strength of the copper alloy wire rod, and Ag is contained in 1.0% by mass or more and 6.0% by mass or less. If the content of Ag is 1.0% by mass or more, it is possible to increase the strength of the copper alloy wire rod by the solid solution and the precipitation of Ag. In addition, if the content of Ag is 6.0% by mass or less, it is possible to suppress a decline in electric conductivity of the copper alloy wire rod, and maintain high electric conductivity of the copper alloy wire rod. Furthermore, if the content of Ag exceeds 6.0% by mass, since enhanced strength cannot be expected to counterbalance the increase in material cost due to the increase in the amount used of Ag, it is difficult to contribute to the product added value for the customer. To achieve a balance in strength improvement and electric conductivity improvement of the copper alloy wire rod, the content of Ag is 1.0% by mass or more, and preferably 1.5% by mass or more, while being 6.0% by mass or less, and preferably 4.0% by mass or less.

55 <Sub Component of Copper Alloy Wire Rod: 0.05% by mass to 0.30% by mass>

[0021] The alloy composition of the copper alloy wire rod can further contain a total of 0.05% by mass or more and

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0.30% by mass or less of at least one element selected from the group consisting of Sn, Mg, Zn, In, Ni, Co, Zr and Cr. In other words, the copper alloy wire rod, in addition to the Ag which is an essential basic component, can further contain as a sub component which is an optional component, a total of 0.05% by mass or more and 0.30% by mass or less of at least one component selected from the group consisting of Sn, Mg, Zn, In, Ni, Co, Zr and Cr. If the content of the sub components is 0.05% by mass or more, the strength characteristic of the copper alloy wire rod improves, and some elements bring about an effect of alleviating brittleness of the copper alloy wire rod. In addition, if the content of the sub components is 0.30% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of the sub components is preferably 0.05% by mass or more, more preferably 0.08% by mass or more, and even more preferably 0.10% by mass or more, while preferably 0.30% by mass or less, more preferably 0.25% by mass or less, and even more preferably 0.20% by mass or less.

<Sn: 0.05% by mass to 0.20% by mass>

[0022] If the content of Sn (tin) is 0.05% by mass or more, it will contribute to enhanced strength of the copper alloy wire rod, and if the content of Sn is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of Sn is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Mg: 0.05% by mass to 0.20% by mass>

[0023] If the content of Mg (magnesium) is 0.05% by mass or more, there are effects contributing to enhanced strength of the copper alloy wire rod, and alleviating brittleness of the copper alloy wire rod. If the content of Mg is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod or the manufacturability during casting. For this reason, the content of Mg is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Zn: 0.05% by mass to 0.30% by mass>

[0024] If the content of Zn (zinc) is 0.05% by mass or more, there are effects contributing to enhanced strength of the copper alloy wire rod, and alleviating brittleness of the copper alloy wire rod. If the content of Zn is 0.30% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of Zn is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.30% by mass or less, more preferably 0.25% by mass or less, even more preferably 0.20% by mass or less, and particularly preferably 0.15% by mass or less.

<In: 0.05% by mass to 0.20% by mass>

[0025] If the content of In (indium) is 0.05% by mass or more, it will contribute to enhanced strength of the copper alloy wire rod, and if the content of In is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of In is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Ni: 0.05% by mass to 0.30% by mass>

[0026] If the content of Ni (nickel) is 0.05% by mass or more, there is an effect contributing to enhanced strength of the copper alloy wire rod. If the content of Ni is 0.30% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of Ni is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.30% by mass or less, more preferably 0.25% by mass or less, even more preferably 0.20% by mass or less, and particularly preferably 0.15% by mass or less.

<Co: 0.05% by mass to 0.20% by mass>

[0027] If the content of Co (cobalt) is 0.05% by mass or more, it will contribute to enhanced strength of the copper alloy wire rod, and if the content of Co is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of Co is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Zr: 0.05% by mass to 0.20% by mass>

[0028] If the content of Zr (zirconium) is 0.05% by mass or more, there are effects contributing to enhanced strength of the copper alloy wire rod, and alleviating brittleness of the copper alloy wire rod. If the content of Zr is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod or the manufacturability during casting. For this reason, the content of Zr is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Cr: 0.05% by mass to 0.20% by mass>

[0029] If the content of Cr (chromium) is 0.05% by mass or more, it will contribute to enhanced strength of the copper alloy wire rod, and if the content of Cr is 0.20% by mass or less, it will not greatly harm the electric conductivity of the copper alloy wire rod. For this reason, the content of Cr is preferably 0.05% by mass or more, more preferably 0.07% by mass or more, even more preferably 0.08% by mass or more, and particularly preferably 0.10% by mass or more, while preferably 0.20% by mass or less, more preferably 0.18% by mass or less, even more preferably 0.15% by mass or less, and particularly preferably 0.12% by mass or less.

<Remainder: Cu and inevitable impurities>

[0030] The remainder other than the aforementioned components is Cu (copper) and inevitable impurities. The inevitable impurities inevitably mix in the manufacturing process, and are also a factor decreasing at least any one of the strength, electric conductivity and drawability of the copper alloy wire rod according to the content, they impact the environment, and are a cause for material embrittlement. For this reason, a smaller content of inevitable impurities is more preferable. As the inevitable impurities, for example, elements such as S, Pb, Sb and Bi can be exemplified. The upper limit for the content of the above-mentioned inevitable impurities is preferably less than 0.0001% by mass for each of the above-mentioned elements, and the total of the above-mentioned elements is preferably less than 0.0005% by mass.

[0031] Next, the peak intensity ratio obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod will be explained.

[0032] When setting each peak intensity of 111, 200, 220, 311 diffraction obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod as $I(111)$, $I(200)$, $I(220)$, $I(311)$, the peak intensity ratio ((peak intensity $I(111)$ + peak intensity $I(200)$ + peak intensity $I(311)$) / peak intensity $I(220)$) (hereinafter also referred to as peak intensity ratio) of the total intensity of the peak intensity $I(111)$, the peak intensity $I(200)$ and the peak intensity $I(311)$ relative to the peak intensity $I(220)$ is 1.20 or more and 3.00 or less.

[0033] If the peak intensity ratio is 1.20 or more, it is possible to improve the drawability of the copper alloy wire rod. In addition, if the peak intensity ratio is 3.00 or less, it will be possible to increase the strength of the copper alloy wire rod. To establish both the strength improvement and the drawability improvement of the copper alloy wire rod, as well as achieve a balance with the electric conductivity, the peak intensity ratio is 1.20 or more, preferably 1.30 or more and more preferably 1.50 or more, while being 3.00 or less, preferably 2.80 or less and more preferably 2.50 or less.

[0034] The peak intensity $I(111)$ of 111 diffraction obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod is a maximum value (highest intensity) of the peak height within the range of $2\theta=43\pm 1^\circ$. For the correlated {111} plane, there is a tendency of contributing to enhanced strength of the copper alloy wire rod, while decreasing drawability of the copper alloy wire rod. However, in the case of not conducting heat treatment in the manufacturing process of the copper alloy wire rod described later, even in a state in which the peak intensity $I(111)$ is high, the copper alloy wire rod shows a drawability decline without strength enhancement.

[0035] The peak intensity $I(200)$ of 200 diffraction obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod is a maximum value (highest intensity) of the peak height within the range of $2\theta=50\pm 1^\circ$. For the correlated

{100} plane, there is a tendency of contributing to a drawability improvement of the copper alloy wire rod, while the contribution of enhanced strength is relatively low.

[0036] The peak intensity $I(220)$ of 220 diffraction obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod is a maximum value (highest intensity) of the peak height within the range of $2\theta=74\pm 1^\circ$. For the correlated {110} plane, if the total amount thereof is large, it is necessary to be a suitable value or less due to the proportion of the {111} plane, as well as the {100} plane relatively decreasing, and thus the effect reducing relatively, and although the contribution is relatively low, it contributes to enhanced strength and a drawability improvement of the copper alloy wire rod.

[0037] The peak intensity $I(311)$ of 311 diffraction obtained by X-ray diffraction analysis of the surface of the copper alloy wire rod is a maximum value (highest intensity) of the peak height within the range of $2\theta=90\pm 1^\circ$. For the correlated {311} plane, if the total amount thereof is large, it is necessary to be a suitable value or less due to the proportion of the {111} plane, as well as the {100} plane relatively decreasing, and thus the effect reducing relatively, and although the contribution is relatively low, it contributes to enhanced strength and a drawability improvement of the copper alloy wire rod.

[0038] X-ray diffraction analysis of the surface of the copper alloy wire rod measures in the following way. Using an X-ray diffractometer, and establishing a lateral face which is a surface of the copper alloy wire rod as the measurement target in the θ - 2θ method, the X-ray diffraction intensity between 40° to 100° is measured, and the background value that is noise was subtracted from the confirmed peak intensity to obtain the peak intensity of each plane. In the X-ray diffraction analysis, a plurality of copper alloy wire rods were brought into contact, and placed in parallel in the same direction on a sample holder.

[0039] In addition, for the copper alloy wire rod, it is preferable for the tensile strength to satisfy 1000 MPa or more, and the electric conductivity to satisfy 60% TAGS or more, and when defining the content of Ag as X (% by mass), the tensile strength of the copper alloy wire rod as Y (MPa) and the electric conductivity of the copper alloy wire rod as Z (%IACS), the Ag content X, the tensile strength Y and the electric conductivity Z preferably satisfy Formulas (1), (2) and (3) below. For the copper alloy wire rod satisfying such a configuration, the balance of the strength and the electric conductivity becomes more favorable.

$$Y \geq 110X + 880 \quad \dots \text{Formula (1)}$$

$$Z \geq -4.6X + 82 \quad \dots \text{Formula (2)}$$

$$Y \geq -0.040Z + 117 \quad \dots \text{Formula (3)}$$

[0040] The tensile strength of the copper alloy wire rod is measured by performing a tensile test based on JIS Z2241:2011.

[0041] The electric conductivity of the copper alloy wire rod is measured based on JIS H0505:1975.

[0042] In addition, the cross section of the copper alloy wire rod is preferably a circular shape having a diameter of 0.02 mm or more and 0.08 mm or less. Even if the copper alloy wire rod having a cross section which is circular having a diameter within the above-mentioned range, i.e. the copper alloy wire rod is a cylindrical extra fine wire, it is superior in the balance of the high strength and the high electric conductivity.

[0043] In addition, the cross section of the copper alloy wire rod may be a ribbon shape having a long side of 0.060 mm or more and 0.500 mm or less, and a short side of 0.005 mm or more and 0.040 mm or less. Even if an extra fine wire having a cross section which is a ribbon shape having a long side and a short side within the above-mentioned ranges, the copper alloy wire rod will be superior in the balance of the high strength and the high electric conductivity.

[0044] The strength and the electric conductivity of the ribbon-shaped copper alloy wire rod do not greatly change from the strength and the electric conductivity of the cylindrical copper alloy wire rod prior to molding into a ribbon shape, e.g., cylindrical extra fine wire. In other words, so long as the strength and the electric conductivity of the cylindrical copper alloy wire rod prior to molding into a ribbon shape are the desired values or more, the strength and the electric conductivity of the ribbon-shaped copper alloy wire rod will be the desired values or more.

[0045] In this way, due to the copper alloy wire rod having high drawability, even if thinning the copper alloy wire rod to extra fine wire, it can obtain an extra fine wire superior in the balance of the high strength and the high electric conductivity which had not existed conventionally. A size reduction in electronic appliances, space savings of circuits, an increase in circuit number, etc. to a level which had not been realizable thus far thereby become possible, and thus can contribute to adding to the value of the finished product.

[0046] Next, a manufacturing method of the copper alloy wire rod of the present embodiment will be explained.

[0047] The manufacturing method of the copper alloy wire rod of the embodiment performs heat treatment at least one time while drawing an ingot having the above-mentioned alloy composition until the final wire diameter of the copper

alloy wire rod. This heat treatment is an aging heat treatment with the purpose of recrystallization and precipitation of Ag. The heat treatment temperature is preferably 400°C or more and 500°C or less. In addition, the heat treatment time is preferably 10 hours or more and 100 hours or less in order to obtain a sufficient precipitated amount of Ag.

[0048] In addition, cold wire drawing was performed on the sample before and after the above-mentioned heat treatment. Herein, cold wire drawing prior to the heat treatment is referred to as first wire drawing, and cold wire drawing after the heat treatment is referred to as second wire drawing. By performing the second wire drawing on the cooled sample after the heat treatment, it is possible to manufacture the copper alloy wire rod.

[0049] The ratio of the processing degree of the first wire drawing relative to the processing degree of the second wire drawing (the processing degree of the first wire drawing/the processing degree of the second wire drawing) (hereinafter referred to simply as processing degree ratio) is 5.0 or more and 12.0 or less. If the above-mentioned processing degree ratio is less than 5.0, since the final drawing ratio greatly declines for the copper alloy wire rod obtained after the second wire drawing, it is not possible to obtain the desired strength. If the above-mentioned processing degree ratio is 5.0 or more, it is possible to eliminate the accumulated strain by recrystallizing at an early stage from the temperature rise during the above-mentioned heat treatment to the heated and retained temperature region, and possible to suppress embrittlement which is a cause for poor wire drawing in the second wire drawing, which is a post process. If the above-mentioned processing degree ratio exceeds 12.0, since it comes to lower the wire drawing ratio of the first wire drawing prior to the heat treatment, it comes to heat treat the sample with a low processing degree. As a result thereof, the strain release during the heat treatment is slowed to progress the embrittlement, and thus wire thinning of the post process becomes difficult.

[0050] In addition, the 1-pass area reduction ratio in each wire drawing is 15% or more and 35% or less for wire diameter of more than 0.9 mm, and 10% or more and 25% or less for wire diameter of 0.9 mm or less. Other wire drawing conditions adopt the wire drawing speed, die dimensions, and capstan diameter, which are each very common conditions used in operation.

[0051] Herein, the processing degree of each wire drawing can be calculated by the following formula.

[0052] Processing degree: $\eta = 2 \times \ln(\text{wire diameter before wire drawing} / \text{wire diameter after wire drawing})$

In: natural logarithm

[0053] In addition, the processing degree of the wire drawing and the recrystallization orientation during heat treatment greatly contribute to the above-mentioned peak intensities of the copper alloy wire rod.

[0054] For example, in the case of not performing the heat treatment, since the final processing degree becomes high or the recrystallized structure is not formed, the peak intensity I(200) will be too low, the peak intensity I(111) will be too high, and the drawability of the copper alloy wire rod declines. Furthermore, normally, if the peak intensity I(111) increases, although enhanced strength of the copper alloy wire rod tends to be brought about, if not performing the heat treatment, the degree of rise in strength of the copper alloy wire rod may lower.

[0055] In addition, in the case of the above-mentioned processing degree ratio being less than 5.0, the peak intensity I(200) will be too high, the peak intensity I(111) will be too low, and thus affect the above-mentioned peak intensity ratio. In the case of the above-mentioned processing degree ratio exceeding 12.0, the peak intensity I(200) will be too low, the peak intensity I(111) will be too high, and thus affect the above-mentioned peak intensity ratio.

[0056] In addition, although not meant to actively control the peak intensity I(220) and the peak intensity I(311), if these ratios increase, there is an adverse effect in that the effect brought about by the peak intensity I(200) and the peak intensity I(111) relatively declines. By satisfying the above-mentioned manufacturing conditions, it becomes possible to converge to the desired range.

[0057] In this way, by performing the heat treatment, the first wire drawing and the second wire drawing, and setting the processing degree ratio to within the above-mentioned range, it is possible to control the peak intensity obtained in X-ray diffraction analysis.

[0058] In addition, for the above-mentioned heat treatment, if setting the temperature rising rate to 1°C/min or more, it is possible to efficiently suppress progression of embrittlement in the course of temperature rise. In addition, with higher temperature rising rate during the heat treatment, it is more effective in suppression of the embrittlement progression; however, the upper limit value of the temperature rising rate is preferably 15° C/min or less, for simplification of the device performing the heat treatment.

[0059] In addition, if the processing degree in the first wire drawing prior to the heat treatment is 0.69 or more and 2.31 or less, it is possible to suppress the progression of the embrittlement, and thus wire thinning in the second wire drawing which is the post process becomes easy.

[0060] In addition, prior to the above-mentioned heat treatment, solution heat treatment for promoting the precipitation of Ag in the above-mentioned heat treatment may be performed. For the solution heat treatment, the heat treatment temperature is preferably 700°C or more and 900°C or less, and the heat treatment time is preferably 10 minutes or more and 5 hours or less. The solution heat treatment is for making Ag into a solid solution, and is effective in abundantly

precipitating more homogeneous Ag phase.

[0061] In addition, as described above, the strength and the electric conductivity of the cylindrical copper alloy wire rod prior to molding into a ribbon shape will not greatly change from the strength and the electric conductivity of the ribbon-shaped copper alloy wire rod. For this reason, by rolling the copper alloy wire rod obtained by the second wire drawing, it is possible to manufacture a ribbon-shaped copper alloy wire rod.

[0062] The above-mentioned copper alloy wire rod is suitably used in an equipment connection cable such as a micro speaker lead for which excellent balance in strength, electric conductivity and drawability is sought.

[0063] According to the above explained embodiment, by focusing on the peak intensity of predetermined planes obtained by the X-ray diffraction analysis of a surface, and controlling the ratio of the peak intensities of predetermined planes to within a predetermined range, it is possible to obtain a copper alloy wire rod superior in the balance of the strength, the electric conductivity and the drawability.

[0064] Although an embodiment has been explained above, the present invention is not to be limited to the above-mentioned embodiment, and it is possible to modify in various ways within the scope of the present disclosure, including every mode encompassed by the gist of the present disclosure and scope of the claims.

EXAMPLES

[0065] Next, examples and comparative examples will be explained; however, the present disclosure is not to be limited to these examples.

(Examples 1 to 34 and Comparative Examples 1 to 12 and 14)

[0066] For an ingot having the alloy composition shown in Table 1 and cast with an outside diameter of 6 mm or more and 39 mm or less, at the conditions shown in Table 2, the first wire drawing which is a cold wire drawing was performed until the wire diameter of 4 mm or more and 9 mm or less, the heat treatment with a temperature rising rate of 10°C/min was performed, and the second wire drawing which is a cold wire drawing was performed after cooling until the final wire diameter to manufacture a cylindrical copper alloy wire rod. The processing degree in each wire drawing was calculated from the processing degree $\eta=2 \times \ln(\text{wire diameter before wire drawing/wire diameter after wire drawing})$ (ln is natural logarithm). In addition, the processing degree ratio was calculated by dividing the processing degree of the first wire drawing by the processing degree of the second wire drawing.

(Example 35)

[0067] A cylindrical copper alloy wire rod was obtained similarly to Example 1. Next, a ribbon-shaped copper alloy wire rod having a cross section with a long side of 0.080 mm and a short side of 0.007 mm was manufactured by rolling the cylindrical copper alloy wire rod.

(Examples 36 to 37)

[0068] A copper alloy wire rod was manufactured similarly to Example 1, other than performing solution heat treatment for 2 hours at 800°C for the ingot, prior to performing the first wire drawing.

(Comparative Example 13)

[0069] The cylindrical copper alloy wire rod having the alloy composition shown in Table 1, and having a final wire diameter shown in Table 2 was manufactured by casting. In other words, the heat treatment, the first wire drawing and the second wire drawing of Example 1 were not performed in Comparative Example 13.

[0070] It should be noted that S, Pb, Sb and Bi were contained as inevitable impurities in the copper alloy wire rods shown in Table 1, and the content of inevitable impurities was less than 0.0001% by mass for every element, and less than 0.0005% by mass in total of the elements.

[Table 1]

	Alloy components (% by mass)										
	Ag	Sn	Mg	Zn	In	Ni	Co	Zr	Cr	Cu	Sub components total
Example 1	2.0	-	-	-	-	-	-	-	-	Bal.	-
Example 2	2.0	-	-	-	-	-	-	-	-	Bal.	-

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(continued)

	Alloy components (% by mass)										
	Ag	Sn	Mg	Zn	In	Ni	Co	Zr	Cr	Cu	Sub components total
5	Example 3	2.0	-	-	-	-	-	-	-	Bal.	-
	Example 4	4.0	-	-	-	-	-	-	-	Bal.	-
	Example 5	4.0	-	-	-	-	-	-	-	Bal.	-
10	Example 6	4.0	-	-	-	-	-	-	-	Bal.	-
	Example 7	1.0	-	-	-	-	-	-	-	Bal.	-
	Example 8	1.0	-	-	-	-	-	-	-	Bal.	-
15	Example 9	1.0	-	-	-	-	-	-	-	Bal.	-
	Example 10	1.0	-	-	-	-	-	-	-	Bal.	-
	Example 11	2.0	-	-	-	-	-	-	-	Bal.	-
	Example 12	2.0	-	-	-	-	-	-	-	Bal.	-
20	Example 13	2.0	-	-	-	-	-	-	-	Bal.	-
	Example 14	2.0	-	-	-	-	-	-	-	Bal.	-
	Example 15	3.0	-	-	-	-	-	-	-	Bal.	-
25	Example 16	3.0	-	-	-	-	-	-	-	Bal.	-
	Example 17	3.0	-	-	-	-	-	-	-	Bal.	-
	Example 18	3.0	-	-	-	-	-	-	-	Bal.	-
	Example 19	4.0	-	-	-	-	-	-	-	Bal.	-
30	Example 20	4.0	-	-	-	-	-	-	-	Bal.	-
	Example 21	4.0	-	-	-	-	-	-	-	Bal.	-
	Example 22	4.0	-	-	-	-	-	-	-	Bal.	-
35	Example 23	5.0	-	-	-	-	-	-	-	Bal.	-
	Example 24	5.0	-	-	-	-	-	-	-	Bal.	-
	Example 25	5.0	-	-	-	-	-	-	-	Bal.	-
	Example 26	5.0	-	-	-	-	-	-	-	Bal.	-
40	Example 27	2.0	0.10	-	-	-	-	-	-	Bal.	0.10
	Example 28	2.0	-	0.10	-	-	-	-	-	Bal.	0.10
	Example 29	2.0	-	-	0.30	-	-	-	-	Bal.	0.30
45	Example 30	2.0	-	-	-	0.10	-	-	-	Bal.	0.10
	Example 31	2.0	-	-	-	-	0.20	-	-	Bal.	0.20
	Example 32	2.0	-	-	-	-	-	0.10	-	Bal.	0.10
	Example 33	2.0	-	-	-	-	-	-	0.05	Bal.	0.05
50	Example 34	2.0	-	-	-	-	-	-	-	0.10	0.10
	Example 35	2.0	-	-	-	-	-	-	-	Bal.	-
	Example 36	2.0	-	-	-	-	-	-	-	Bal.	-
55	Example 37	2.0	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 1	<u>0.5</u>	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 2	<u>0.5</u>	-	-	-	-	-	-	-	Bal.	-

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(continued)

	Alloy components (% by mass)											
	Ag	Sn	Mg	Zn	In	Ni	Co	Zr	Cr	Cu	Sub components total	
5	Comparative Example 3	0.5	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 4	0.5	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 5	6.5	-	-	-	-	-	-	-	-	Bal.	-
10	Comparative Example 6	6.5	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 7	6.5	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 8	6.5	-	-	-	-	-	-	-	-	Bal.	-
15	Comparative Example 9	2.0	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 10	2.0	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 11	2.0	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 12	4.0	-	-	-	-	-	-	-	-	Bal.	-
20	Comparative Example 13	4.0	-	-	-	-	-	-	-	-	Bal.	-
	Comparative Example 14	4.0	-	-	-	-	-	-	-	-	Bal.	-

[Table 2]

	Final wire diameter (mm)	Heat treatment conditions		Processing degree of first wire drawing	Processing degree of second wire drawing	Processing degree ratio (Processing degree of first wire drawing/ Processing degree of second wire drawing)	
		Temperature (°C)	Time (h)				
	Example 1	0.03	400	24	2.0	10.4	5.2
	Example 2	0.03	450	24	1.6	10.6	6.6
35	Example 3	0.03	425	24	1.4	10.1	7.2
	Example 4	0.02	425	16	1.8	10.0	5.6
	Example 5	0.03	450	24	1.5	10.2	6.8
40	Example 6	0.06	425	24	1.4	9.4	6.7
	Example 7	0.05	450	24	1.4	10.4	7.4
	Example 8	0.05	450	24	1.2	10.4	8.7
	Example 9	0.05	425	24	1.0	11.7	10.2
45	Example 10	0.05	400	48	1.0	10.6	10.6
	Example 11	0.03	400	24	1.8	10.4	5.8
	Example 12	0.03	450	24	1.6	10.4	6.5
	Example 13	0.03	400	24	1.2	10.2	8.5
50	Example 14	0.03	400	24	1.0	10.6	10.6
	Example 15	0.02	400	48	1.5	11.5	7.7
	Example 16	0.03	450	24	1.0	10.4	10.4
55	Example 17	0.06	425	24	1.0	10.4	10.4
	Example 18	0.08	400	24	1.2	9.0	7.5
	Example 19	0.02	400	24	1.8	10.6	5.9

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(continued)

	Final wire diameter (mm)	Heat treatment conditions		Processing degree of first wire drawing	Processing degree of second wire drawing	Processing degree ratio (Processing degree of first wire drawing/ Processing degree of second wire drawing)	
		Temperature (°C)	Time (h)				
5	Example 20	0.03	450	24	1.4	10.4	7.4
10	Example 21	0.06	425	24	1.2	9.6	8.0
	Example 22	0.08	400	24	1.2	9.5	7.9
	Example 23	0.02	475	12	1.8	10.4	5.8
15	Example 24	0.03	450	24	1.4	10.4	7.4
	Example 25	0.06	425	24	1.2	11.6	9.7
	Example 26	0.08	400	48	1.6	10.0	6.3
	Example 27	0.03	400	24	1.0	10.6	10.6
20	Example 28	0.03	450	24	1.8	10.4	5.8
	Example 29	0.03	400	24	1.6	10.4	6.5
	Example 30	0.03	400	24	1.0	10.6	10.6
25	Example 31	0.03	450	24	1.8	10.4	5.8
	Example 32	0.03	400	24	1.6	10.4	6.5
	Example 33	0.03	400	24	1.2	10.2	8.5
	Example 34	0.03	400	24	1.2	10.2	8.5
30	Example 35	Long side 0.080mm, Short side 0.007mm	400	24	1.2	10.2	8.5
35	Example 36	0.03	400	24	1.2	10.2	8.5
	Example 37	0.03	400	24	1.2	10.2	8.5
	Comparative Example 1	0.02	450	24	1.0	10.4	10.4
40	Comparative Example 2	0.03	450	24	1.0	10.4	10.4
	Comparative Example 3	0.06	425	24	1.4	10.2	7.3
45	Comparative Example 4	0.08	400	48	1.8	10.6	5.9
	Comparative Example 5	0.02	400	24	1.4	10.6	7.6
50	Comparative Example 6	0.03	450	24	1.2	10.2	8.5
	Comparative Example 7	0.06	425	24	1.4	10.2	7.3
55	Comparative Example 8	0.08	400	24	1.0	10.2	10.2
	Comparative Example 9	0.03	350	8	1.0	10.4	10.4

(continued)

	Final wire diameter (mm)	Heat treatment conditions		Processing degree of first wire drawing	Processing degree of second wire drawing	Processing degree ratio (Processing degree of first wire drawing/ Processing degree of second wire drawing)
		Temperature (°C)	Time (h)			
Comparative Example 10	0.06	350	24	1.4	102	7.3
Comparative Example 11	0.08	450	3	1.8	10.6	5.9
Comparative Example 12	0.02	475	12	2.5	8.0	32
Comparative Example 13	0.03	-	-	-	-	-
Comparative Example 14	0.02	400	6	0.4	9.0	22.5

(Measurement and Evaluation)

[0071] The following measurements and evaluations were carried out on the copper alloy wire rods obtained in the above examples and the comparative examples. The results are shown in Table 3.

(1) X-ray Diffraction Analysis

[0072] Using an X-ray diffractometer (X' Pert PROMRD manufactured by Spectris Co., Ltd.), the surface of the copper alloy wire rod was defined as the measurement target in the θ - 2θ method for the copper alloy wire rods obtained in the above examples and the comparative examples, the X-ray diffraction intensity between 40° to 100° was measured in a state lined up side by side so as to fill and secure the minimum area of $20\text{ mm} \times 40\text{ mm}$ due to the wire diameter being fine, and the background value that is noise was subtracted from the confirmed peak intensity to obtain the peak intensity of each plane. In the X-ray diffraction analysis, a plurality of copper alloy wire rods were brought into contact and placed in parallel in the same direction on a sample holder.

(2) Tensile Strength

[0073] Using two ($n=2$) copper alloy wire rods obtained in the above examples and the comparative examples, the tensile test was performed based on JIS Z2241:2011, and the tensile strength was calculated by averaging the two measured values.

(3) Electric Conductivity

[0074] Using two ($n=2$) copper alloy wire rods obtained in the above examples and the comparative examples, measurement was performed based on JIS H0505:1975, and the electric conductivity was calculated by averaging the two measured values.

[0075] (4)

$$\text{Formula (1)} \quad (Y \geq 110X + 880)$$

[0076] Defining the content of Ag as X (% by mass) and the tensile strength of the copper alloy wire rod as Y (MPa), Formula (1) was calculated, and the following rankings were given.

[0077]

Satisfies Formula (1): yes

Does not satisfy Formula (1): no

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[0078] (5)

$$\text{Formula (2)} \quad (Z \geq -4.6X + 82)$$

5

[0079] Defining the content of Ag as X (% by mass) and the electric conductivity of the copper alloy wire rod as Z (%IACS), Formula (2) was calculated, and the following rankings were given.

[0080]

10 Satisfies Formula (2): yes
Does not satisfy Formula (2): no

[0081] (6)

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$$\text{Formula (3)} \quad (Y \geq -0.040Z + 117)$$

[0082] Defining the tensile strength of the copper alloy wire rod as Y (MPa) and the electric conductivity of the copper alloy wire rod as Z (%IACS), Formula (3) was calculated, and the following rankings were given.

20 [0083]

Satisfies Formula (3): yes
Does not satisfy Formula (3): no

25 (7) Drawability

[0084] For the copper alloy wire rods obtained in the above examples and the comparative examples, the total length after drawing to a wire diameter of 0.02 mm and the number of disconnections occurred during overall wire drawing were measured, and the following rankings were given. It should be noted that, in Example 35, the cylindrical copper alloy wire rod (wire diameter of 0.02 mm) before rolling into ribbon shape was measured. When the number of times of disconnection relative to the wire drawing length is 1 time/ 100 km or less, the drawability is favorable.

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[0085]

35 Number of times of disconnection relative to the wire drawing length is 1 time/ 100 km or less: O
Number of times of disconnection relative to the wire drawing length is more than 1 time/ 100 km: X

[Table 3]

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	Peak intensity ratio (Peak intensity I (111) + Peak intensity I (200) + Peak intensity I (311)) / Peak intensity I (220)	Tensile strength (MPa)	Electric conductivity (%IACS)	Formula (1) $Y \geq 110X + 880$	Formula (2) $Z \geq -4.6X + 82$	Formula (3) $Y \geq -0.040Z + 117$	Drawability
Example 1	1.80	1120	79	Yes	Yes	Yes	○
Example 2	1.70	1140	80	Yes	Yes	Yes	○
Example 3	1.90	1130	80	Yes	Yes	Yes	○

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(continued)

	Peak intensity ratio (Peak intensity I (111) +Peak intensity I (200) +Peak intensity I (311))/ Peak intensity I (220)	Tensile strength (MPa)	Electric conductivity (%IACS)	Formula (1) $Y \geq 110X + 880$	Formula (2) $Z \geq -4.6X + 82$	Formula (3) $Y \geq -0.040Z + 117$	Drawability	
5								
10								
15								
20	Example 4	2.10	1355	70	Yes	Yes	Yes	○
	Example 5	1.80	1340	71	Yes	Yes	Yes	○
	Example 6	2.10	1330	72	Yes	Yes	Yes	○
	Example 7	2.90	1005	83	Yes	Yes	Yes	○
25	Example 8	2.40	1025	83	Yes	Yes	Yes	○
	Example 9	2.80	1003	83	Yes	Yes	Yes	○
	Example 10	2.50	1015	83	Yes	Yes	Yes	○
	Example 11	1.60	1120	80	Yes	Yes	Yes	○
30	Example 12	2.20	1130	80	Yes	Yes	Yes	○
	Example 13	2.10	1115	80	Yes	Yes	Yes	○
	Example 14	2.00	1100	80	No	Yes	Yes	○
35	Example 15	2.00	1220	75	Yes	Yes	Yes	○
	Example 16	1.90	1230	74	Yes	Yes	Yes	○
	Example 17	2.10	1180	76	No	Yes	Yes	○
	Example 18	1.70	1210	75	No	Yes	Yes	○
40	Example 19	2.00	1350	71	Yes	Yes	Yes	○
	Example 20	2.20	1340	72	Yes	Yes	Yes	○
	Example 21	2.30	1350	70	Yes	Yes	Yes	○
45	Example 22	1.90	1330	71	Yes	Yes	Yes	○
	Example 23	2.00	1550	65	Yes	Yes	Yes	○
	Example 24	1.80	1510	66	Yes	Yes	Yes	○
	Example 25	2.20	1490	66	Yes	Yes	Yes	○
50	Example 26	1.20	1500	67	Yes	Yes	Yes	○
	Example 27	2.10	1180	73	Yes	Yes	Yes	○
	Example 28	2.20	1160	73	Yes	Yes	Yes	○
55	Example 29	1.90	1170	74	Yes	Yes	Yes	○
	Example 30	2.00	1180	74	Yes	Yes	Yes	○
	Example 31	1.80	1155	75	Yes	Yes	Yes	○

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(continued)

	Peak intensity ratio (Peak intensity I (111) +Peak intensity I (200) +Peak intensity I (311))/ Peak intensity I (220)	Tensile strength (MPa)	Electric conductivity (%IACS)	Formula (1) $Y \geq 110X + 880$	Formula (2) $Z \geq -4.6X + 82$	Formula (3) $Y \geq -0.040Z + 117$	Drawability	
5								
10								
15								
20	Example 32	2.70	1140	74	Yes	Yes	Yes	○
	Example 33	2.20	1180	75	Yes	Yes	Yes	○
	Example 34	2.10	1175	74	Yes	Yes	Yes	○
	Example 35	2.00	1120	77	Yes	Yes	Yes	○
25	Example 36	2.00	1146	78	Yes	Yes	Yes	○
	Example 37	1.90	1122	78	Yes	Yes	Yes	○
	Comparative Example 1	<u>3.30</u>	850	84	No	Yes	Yes	○
30	Comparative Example 2	<u>3.10</u>	830	84	No	Yes	Yes	○
	Comparative Example 3	<u>3.40</u>	815	84	No	Yes	Yes	○
35	Comparative Example 4	<u>3.30</u>	790	84	No	Yes	No	○
	Comparative Example 5	<u>0.25</u>	1400	58	No	Yes	No	○
40	Comparative Example 6	<u>0.35</u>	1395	58	No	Yes	No	○
	Comparative Example 7	<u>0.45</u>	1391	59	No	Yes	No	○
45	Comparative Example 8	<u>0.55</u>	1399	59	No	Yes	No	○
	Comparative Example 9	<u>3.30</u>	1010	72	No	No	No	×
50	Comparative Example 10	<u>3.40</u>	980	71	No	No	No	×
	Comparative Example 11	<u>3.20</u>	1000	72	No	No	No	○
55	Comparative Example 12	<u>0.15</u>	850	72	No	Yes	No	○
	Comparative Example 13	<u>3.50</u>	1050	65	No	Yes	No	×

(continued)

5	Peak intensity ratio (Peak intensity I(111) + Peak intensity I(200) + Peak intensity I(311)) / Peak intensity I(220)	Tensile strength (MPa)	Electric conductivity (%IACS)	Formula (1) $Y \geq 110X + 880$	Formula (2) $Z \geq -4.6X + 82$	Formula (3) $Y \geq -0.040Z + 117$	Drawability
10							
15							
20	Comparative Example 14	900	71	No	Yes	No	×

[0086] As shown in Tables 1 to 3, in Examples 1 to 37, since the content of Ag and the peak intensity ratio were respectively controlled to within predetermined ranges, the tensile strength, the electric conductivity and the drawability were all favorable. On the other hand, in Comparative Examples 1 to 14, since at least one of the content of Ag and the peak intensity ratio were not controlled to within the predetermined range, at least one of the tensile strength, the electric conductivity and the drawability were inferior.

Claims

1. A copper alloy wire rod comprising an alloy composition including 1.0% by mass or more and 6.0% by mass or less of Ag, wherein a remainder is Cu and inevitable impurities, wherein, for a peak intensity I(111) of 111 diffraction, a peak intensity I(200) of 200 diffraction, a peak intensity I(220) of 220 diffraction and a peak intensity I(311) of 311 diffraction obtained by X-ray diffraction analysis of a surface, a peak intensity ratio of a total intensity of the peak intensity I(111), the peak intensity I(200) and the peak intensity I(311) relative to the peak intensity I(220) ((the peak intensity I(111) + the peak intensity I(220) + the peak intensity I(311)) / the peak intensity I(220)) is 1.20 or more and 3.00 or less.
2. The copper alloy wire rod according to claim 1, wherein the alloy composition further includes a total of 0.05% by mass or more and 0.30% by mass or less of at least one element selected from the group consisting of Sn, Mg, Zn, In, Ni, Co, Zr and Cr.
3. The copper alloy wire rod according to claim 1 or 2, wherein tensile strength satisfies 1000 MPa or more, electric conductivity satisfies 60% IACS or more, and Ag content X (% by mass), tensile strength Y (MPa) and electric conductivity Z (% IACS) satisfy Formula (1), (2) and (3) below:

$$Y \geq 110X + 880 \quad \dots \text{Formula (1)}$$

$$Z \geq -4.6X + 82 \quad \dots \text{Formula (2)}$$

$$Y \geq -0.040Z + 117 \quad \dots \text{Formula (3)}$$

4. The copper alloy wire rod according to any one of claims 1 to 3, wherein a cross section is circular shape having a diameter of 0.02 mm or more and 0.08 mm or less.

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5. The copper alloy wire rod according to any one of claims 1 to 3, wherein a cross section is a ribbon shape having a long side of 0.060 mm or more and 0.500 mm or less and a short side of 0.005 mm or more and 0.040 mm or less.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/013377

5	A. CLASSIFICATION OF SUBJECT MATTER	
	<p><i>C22C 9/00</i>(2006.01)i; <i>C22F 1/00</i>(2006.01)n; <i>C22F 1/08</i>(2006.01)i FI: C22C9/00; C22F1/08 C; C22F1/00 602; C22F1/00 625; C22F1/00 630A; C22F1/00 630K; C22F1/00 661A; C22F1/00 685Z; C22F1/00 691A; C22F1/00 691B; C22F1/00 691C; C22F1/00 694A</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>	
10	B. FIELDS SEARCHED	
	<p>Minimum documentation searched (classification system followed by classification symbols) C22C9/00-9/10; C22F1/00; C22F1/08</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2022 Registered utility model specifications of Japan 1996-2022 Published registered utility model applications of Japan 1994-2022</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p>	
15	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
		Relevant to claim No.
25	A	JP 2005-336510 A (HITACHI CABLE, LTD.) 08 December 2005 (2005-12-08)
	A	WO 2007/046378 A1 (NATIONAL INSTITUTE FOR MATERIALS SCIENCE) 26 April 2007 (2007-04-26)
	A	JP 2000-199042 A (SHOWA ELECTRIC WIRE & CABLE CO., LTD.) 18 July 2000 (2000-07-18)
30	A	JP 2009-280860 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 03 December 2009 (2009-12-03)
35	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.	
40	* Special categories of cited documents:	<p>"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</p> <p>"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</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is considered with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
45	"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	
50	Date of the actual completion of the international search	Date of mailing of the international search report
	26 May 2022	07 June 2022
55	Name and mailing address of the ISA/JP	Authorized officer
	<p>Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan</p>	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3325639 B [0007]
- JP 5051647 B [0007]