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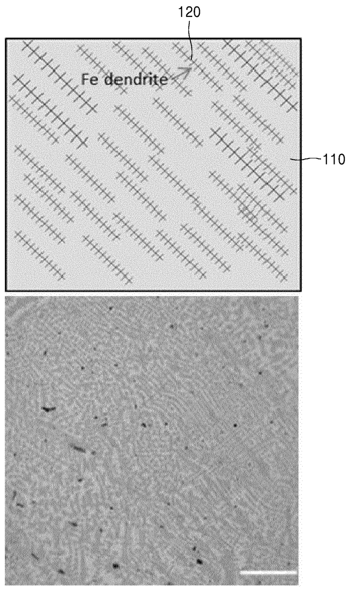
(54) **KINIZ ALLOY HAVING HOMOGENEOUS MICROSTRUCTURE**

(57) The present disclosure relates to KINIZ alloys having a homogeneous microstructure. A KINIZ alloy includes: copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and nickel (Ni) in an amount of 1 wt% to 20 wt%, zirconium (Zr) in an amount of 0.1 wt% to 5.0 wt%, and a balance of inevitable impurities. A KINIZ alloy includes: copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and manganese (Mn) in an amount of 2.0 wt% to 5.0 wt%, zirconium (Zr) in an amount of 0.3 wt% to 1.0 wt%, and a balance (excluding 0 %) of inevitable impurities.

FIG. 10



EP 3 985 140 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a KINIZ alloy having a homogeneous microstructure, and more particularly, to a KINIZ alloy having a homogeneous microstructure which is obtained by adding small amounts of elements such as nickel (Ni), zirconium (Zr), or manganese (Mn) to an alloy including copper (Cu) and iron (Fe).

BACKGROUND ART

[0002] In general, Cu-Fe alloys containing copper (Cu) and iron (Fe) are used in various industrial fields. A Cu-Fe alloy may be produced through a casting process by melting copper (Cu) and iron (Fe) and then cooling the molten metals. However, Cu-Fe alloys of the related art have the following problems.

[0003] FIG.1 shows a Cu-Fe phase diagram. When a Cu-Fe alloy containing copper (Cu) and iron (Fe) is cast, since the enthalpy of mixing copper (Cu) with iron (Fe) is high, a metastable region in which the liquid phase of the Cu-Fe alloy is separated into two phases is present just below the solidus at which the Cu-Fe alloy starts to solidify into a dendritic microstructure.

[0004] When the molten Cu-Fe alloy is rapidly cooled and solidified across the metastable region, the liquid phase of the molten Cu-Fe alloy is separated into two phases, and thus, a heterogeneous microstructure in which the two elements are separately present is formed.

[0005] Specifically, referring to FIG. 2, a Cu-Fe alloy which has undergone phase separation has a heterogeneous microstructure in which iron (Fe) 20 and copper (Cu) 10 are separately present in the form of Fe droplets within a Cu matrix.

[0006] Such Cu-Fe alloys as the Cu-Fe alloy shown in FIG. 2 which has undergone phase separation are difficult to process because of non-uniform deformation. Also, a Cu-Fe alloy which has undergone phase separation has a problem in that the Cu-Fe alloy has relatively low conductivity in a local region in which iron (Fe) having relatively low conductivity is separately present, and has relatively low strength in a local region in which copper (Cu) having relatively low strength is separately present.

DESCRIPTION OF EMBODIMENTS

TECHNICAL PROBLEM

[0007] The present disclosure is provided to solve the above problems, and particularly relates to a KINIZ alloy having a homogeneous microstructure which is produced by adding small amounts of elements such as nickel (Ni), zirconium (Zr), or manganese (Mn) to an alloy including copper (Cu) and iron (Fe).

SOLUTION TO PROBLEM

[0008] To solve the above problems, according to the present disclosure, a KINIZ alloy having a homogeneous microstructure includes: copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and nickel (Ni) in an amount of 1 wt% to 20 wt%, zirconium (Zr) in an amount of 0.1 wt% to 5.0 wt%, and a balance of inevitable impurities.

[0009] To solve the above problems, according to the present disclosure, the KINIZ alloy having a homogeneous microstructure may include copper (Cu) in an amount of 20 wt% to 80 wt%, iron (Fe) in an amount of 20 wt% to 80 wt%, nickel (Ni) in an amount of 2.0 wt% to 5.0 wt%, and zirconium (Zr) in an amount of 0.3 wt% to 1.0 wt%.

[0010] To solve the above problems, according to the present disclosure, the zirconium (Zr) may react with oxygen and form ZrO_2, and the ZrO_2 may function as nuclei for nucleation of dendrites during a casting process of the KINIZ alloy.

[0011] To solve the above problems, according to the present disclosure, a KINIZ alloy having a homogeneous microstructure includes: copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and manganese (Mn) in an amount of 2.0 wt% to 5.0 wt%, zirconium (Zr) in an amount of 0.3 wt% to 1.0 wt%, and a balance (excluding 0 %) of inevitable impurities.

[0012] To solve the above problems, according to the present disclosure, the KINIZ alloy having a homogeneous microstructure may have a weight ratio of iron (Fe) to copper (Cu) and iron (Fe) within a range of 70 % or more.

[0013] To solve the above problems, according to the present disclosure, the KINIZ alloy having a mechanical switch may further include nickel (Ni) in an amount of 2.0 wt% to 5.0 wt%.

[0014] To solve the above problems, according to the present disclosure, when the KINIZ alloy having a homogeneous microstructure is cast, molten metals may be cooled at a rate of 5.3×10^4 °C/sec or less.

ADVANTAGEOUS EFFECTS OF DISCLOSURE

[0015] According to the present disclosure, KINIZ alloys are produced by adding small amounts of elements, such as nickel (Ni), zirconium (Zr), or manganese (Mn), to alloys including copper (Cu) and iron (Fe), and thus the KINIZ alloys may have a homogeneous microstructure without phase separation.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

FIG. 1 is a view illustrating a Cu-Fe phase diagram having a metastable region.

FIG. 2 is a view illustrating a cross-section of a Cu-Fe alloy which includes copper (Cu) and iron (Fe) and underwent phase separation.

FIG. 3 is a view illustrating the variation of a metastable region in a Cu-Fe phase diagram for different contents of nickel (Ni) according to an embodiment of the present disclosure.

FIGS. 4 and 5 are views illustrating the occurrence of phase separation in examples of the present disclosure and comparative examples.

FIG. 6 is a view illustrating the conductivity of a KINIZ alloy with respect to the content of nickel (Ni) according to an embodiment of the present disclosure.

FIG. 7 is a view illustrating the variation of a metastable region in a Cu-Fe phase diagram for different contents of manganese (Mn) according to an embodiment of the present disclosure.

FIG. 8 is a view illustrating the conductivity of a KINIZ alloy with respect to the content of manganese (Mn) according to an embodiment of the present disclosure.

FIG. 9 is a view illustrating a region in which microstructural phase separation was observed with respect to the cooling rate of molten metals according to an embodiment of the present disclosure.

FIG. 10 is a view illustrating a cross-section of a KINIZ alloy having a homogeneous microstructure according to an embodiment of the present disclosure.

MODE OF DISCLOSURE

[0017] Hereinafter, various embodiments of the present disclosure will be described with reference to the accompanying drawings. The embodiments of the present disclosure may be variously modified to other embodiments, and thus only some specific embodiments are illustrated in the drawings and described below. However, the present disclosure is not limited to the specific embodiments, and it should be understood that all modifications and/or equivalents or substitutes of the embodiments of the present disclosure are included in the scope of the present disclosure. In the drawings, similar elements are denoted with similar reference numerals.

[0018] In various embodiments of the present disclosure, expressions such as "comprise," "include," or "may include" are used to specify the presence of disclosed functions, operations, or elements, but do not preclude the presence of one or more other functions, operations, or elements. In addition, it will be understood that terms such as "comprise," "include," or "have" when used herein, specify the presence of features, numbers, steps, operations, elements, components, or combinations thereof, but do not preclude the presence or addition of one or more other features, numbers, steps, operations, elements, components, or combinations thereof.

[0019] The terms used in the present disclosure are merely for describing specific embodiments of the present disclosure, and are not intended to limit various embodiments of the present disclosure. The terms of a singular form may include plural forms unless otherwise mentioned.

[0020] Unless defined otherwise, all terms used herein, including technical or scientific terms, have the same meanings as commonly understood by those of ordinary skill in the art to which various embodiments of the present disclosure pertain.

[0021] The present disclosure relates to a KINIZ alloy having a homogeneous microstructure, and more particularly, to a KINIZ alloy having a homogeneous microstructure which is produced by adding small amounts of elements such as nickel (Ni), zirconium (Zr), or manganese (Mn) to an alloy including copper (Cu) and iron (Fe). Hereinafter, preferred embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

[0022] According to an embodiment of the present disclosure, a KINIZ alloy having a homogeneous microstructure includes copper (Cu), iron (Fe), nickel (Ni), zirconium (Zr), and the balance of inevitable impurities.

[0023] The sum of the contents of copper (Cu) 110 and iron (Fe) 120 may be within the range of 75 wt% to 95 wt%, and the weight ratio of copper (Cu) 110 and iron (Fe) 120 may be varied according to the intended use of the alloy.

[0024] Specifically, the content of copper (Cu) 110 may be within the range of 20 wt% to 80 wt%, and the content of iron (Fe) 120 may be within the range of 20 wt% to 80 wt%. More preferably, the content of copper (Cu) 110 may be within the range of 40 wt% to 60 wt%, and the content of iron (Fe) 120 may be within the range of 30 wt% to 50 wt%. In these ranges, the sum of the contents of copper (Cu) 110 and iron (Fe) 120 may be within the range of 75 wt% to 95 w%. However, the weight percentages of copper (Cu) 110 and iron (Fe) 120 are not limited thereto and may be varied as necessary.

[0025] Referring to FIG. 1, when an alloy containing copper (Cu) and iron (Fe) is cast, since the enthalpy of mixing copper (Cu) with iron (Fe) is high, a metastable region, in which the liquid phase of the alloy is separated into two liquid phases, is present just below the solidus at which the molten alloy starts to solidify into a dendritic microstructure. When the molten alloy is rapidly cooled and solidified across the metastable region, the problem is the formation of a heterogeneous microstructure in which the two elements are separately present as shown in FIG 2.

[0026] The KINIZ alloy having a homogeneous microstructure of the embodiment of the present disclosure may include nickel (Ni) and zirconium (Zr) to solve the problem. FIG. 3 shows a Cu-Fe phase diagram for different contents of nickel (Ni). Referring to FIG. 3, it may be understood that a metastable region descends as the content of nickel (Ni) increases.

[0027] As the content of nickel (Ni) increases as shown in FIG. 3, the metastable region descends, and thus the gap between the solidus and the metastable region increases, such that when the molten KINIZ alloy is cooled and solidified, molten metals may be prevented from being cooled across the metastable region.

[0028] Since the molten KINIZ alloy is cooled and solidified not across the metastable region, it is possible to prevent the liquid phase of the KINIZ alloy from separating into two phases, and thus the KINIZ alloy may be produced without phase separation to have a homogeneous microstructure.

[0029] The content of nickel (Ni) may be within the range of 1 wt% to 20 wt%, and more preferably within the range of 2 wt% to 5 wt%. As the content of nickel (Ni) increases, the metastable region descends, but the conductivity of the KINIZ alloy decreases. (Since the conductivity of copper (Cu) is higher than the conductivity of nickel (Ni), the conductivity of the KINIZ alloy decreases as the content of nickel (Ni) increases.))

[0030] Therefore, the content of nickel (Ni) is preferably 20 wt% or less, and it is preferable that the content of nickel (Ni) be 5 wt% or less in terms of efficient prevention of a decrease in conductivity. In addition, when the content of nickel (Ni) is 1 wt% or less, the effect of lowering the metastable region is insufficient, and thus it is preferable that the content of nickel (Ni) be 1 wt% or more.

[0031] More preferably, the content of nickel (Ni) is within the range of 2 wt% to 5 wt%. FIGS. 4 and 5 are views showing the occurrence of phase separation according to the content of nickel (Ni). Referring to FIGS. 4 and 5, when the content of nickel (Ni) is 2 wt% or less, phase separation may occur, and when the content of nickel (Ni) is greater than 2 wt%, phase separation does not occur. Therefore, it is preferable that the content of nickel (Ni) be greater than 2 wt%.

[0032] In addition, according to an embodiment of the present disclosure, the KINIZ alloy having a homogeneous microstructure utilizes the merit of copper (Cu), that is, electrical conductivity, and it is preferable that the electrical conductivity of the KINIZ alloy be 40 % IACS or higher for utilizing electrical conductivity. However, as the content of nickel (Ni) increases, the resistivity of the KINIZ alloy may increase, and thus the electrical conductivity of the KINIZ alloy may decrease.

[0033] Referring to FIG. 6, when the content of nickel (Ni) is greater than 5 wt%, the conductivity of the KINIZ alloy decreases to 40 % IACS, and as the content of nickel (Ni) becomes greater than 5 wt%, the conductivity of the KINIZ alloy decreases steeply. Therefore, it is preferable that the content of nickel (Ni) be less than 5 wt%.

[0034] That is, according to an embodiment of the present disclosure, nickel (Ni) is added to the KINIZ alloy having a homogeneous microstructure within the range of the minimum amount (2 wt%) for suppressing phase separation to an amount (5 wt%) not causing a significant decrease in conductivity.

[0035] The KINIZ alloy having a homogeneous microstructure according to the embodiment of the present disclosure may include zirconium (Zr) for the effect of rapid solidification of a dendritic structure.

[0036] Specifically, zirconium (Zr) included in the KINIZ alloy may react with oxygen and form ZrO_2, and the ZrO_2 may function as nucleation nuclei forming dendrites when the KINIZ alloy is cast. Zirconium (Zr) functioning as described above has an effect of quickening the solidification of a dendritic structure, and thus, it is possible to solidify the molten KINIZ alloy before phase separation occurs in the liquid phase of the molten KINIZ alloy.

[0037] That is, according to the embodiment of the present disclosure, in the kinematic alloy having a homogeneous microstructure, nickel (Ni) prevents phase separation by descending the metastable region, and along with this, zirconium (Zr) quickens the solidification of a dendritic structure, thereby preventing the KINIZ alloy from solidifying across the metastable region from a molten state.

[0038] The content of zirconium (Zr) may be from 0.1 wt% to 5 wt%, and more preferably from 0.3 wt% to 1.0 wt%. Although dendritic solidification quickens as the content of zirconium (Zr) increases, the conductivity of the KINIZ alloy decreases as the content of zirconium (Zr) increases. (Since the conductivity of copper (Cu) is higher than the conductivity of zirconium (Zr), the higher the content of zirconium (Zr), the lower the conductivity.)

[0039] Therefore, the content of zirconium (Zr) is preferably 5 wt% or less, and it is preferable that the content of zirconium (Zr) be 1 wt% or less in terms of efficient prevention of a decrease in conductivity. In addition, when the content of zirconium (Zr) is 0.1 wt% or less, the effect of quickening the solidification of a dendritic structure is insufficient, and thus it is preferable that the content of zirconium (Zr) be 0.1 wt% or more.

[0040] More preferably, the content of zirconium (Zr) is preferably 0.3 wt% to 1.0 wt%. The content of zirconium (Zr) may be varied depending on the metastable region lowered by nickel (Ni), but when the solidification of a dendritic structure occurs slows due to a low zirconium (Zr) content, there is a risk that molten metals solidify across the metastable region. In addition, when the content of zirconium (Zr) is less than 0.3 wt%, the effect of suppressing phase separation may not be obtained because of insufficient formation of the ZrO_2. Therefore, to prevent this, the content of zirconium (Zr) is preferably 0.3 wt% or more.

[0041] In addition, it is preferable that the content of zirconium (Zr) is 1.0 wt% or less. When the content of zirconium (Zr) is greater than 1.0 wt%, the size of ZrO_2 increases, and thus, ZrO_2 may act as an inclusion rather than acting as nucleation nuclei and may thus have an adverse effect on conductivity. Therefore, it is preferable that the content of zirconium (Zr) be 1.0 wt% or less.

[0042] The KINIZ alloy having a homogeneous microstructure of the embodiment of the present disclosure may include carbon (C) in addition to copper (Cu), iron (Fe), nickel (Ni), and zirconium (Zr), and in this case, the content of carbon (C) may be 0.02 wt% or less (excluding 0 %). In addition, according to the embodiment of the present disclosure, the KINIZ alloy having a homogeneous microstructure may include the balance of inevitable impurities in addition to copper (Cu), iron (Fe), nickel (Ni), and zirconium (Zr), and the inevitable impurities may include various elements required for the KINIZ alloy. For example, the inevitable impurities may include chromium (Cr), magnesium (Mg), aluminum (Al), silicon (Si), or the like.

[0043] According to another embodiment of the present disclosure, a KINIZ alloy having a homogeneous microstructure includes copper (Cu), iron (Fe), nickel (Ni), zirconium (Zr), and the balance of inevitable impurities.

[0044] The sum of the contents of copper (Cu) 110 and iron (Fe) 120 may be within the range of 75 wt% to 95 wt%, and the weight ratio of copper (Cu) 110 and iron (Fe) 110 may be varied according to the intended use of the KINIZ alloy.

[0045] Specifically, the content of copper (Cu) 110 may be within the range of 20 wt% to 80 wt%, and the content of iron (Fe) 120 may be within the range of 20 wt% to 80 wt%. More preferably, the content of copper (Cu) 110 may be within the range of 40 wt% to 60 wt% %, and the content of iron (Fe) 120 may be within the range of 30 wt% to 50 wt%. In these ranges, the sum of the contents of copper (Cu) 110 and iron (Fe) 120 may be within the range of 75 wt% to 95 w%. However, the weight percentages of copper (Cu) 110 and iron (Fe) 120 are not limited thereto and may be varied as necessary.

[0046] Referring to FIG. 1, when an alloy containing copper (Cu) and iron (Fe) is cast, since the enthalpy of mixing copper (Cu) with iron (Fe) is high, a metastable region, in which the liquid phase of the alloy is separated into two phases, is present just below the solidus at which the alloy starts to solidify into a dendritic microstructure. When the molten alloy is rapidly cooled and solidified across the metastable region, the problem is the formation of a heterogeneous microstructure in which the two elements are separately present as shown in FIG 2.

[0047] According to the other method of the present disclosure, the KINIZ alloy having a homogeneous microstructure may include manganese (Mn) and zirconium (Zr) to solve the problem. FIG. 7 shows a Cu-Fe phase diagram for different contents of manganese (Mn). Referring to FIG. 7, as the content of manganese (Mn) increases, the metastable region descends.

[0048] As the content of manganese (Mn) increases as shown in FIG. 7, the metastable region descends, and thus the gap between the solidus and the metastable region increases, such that when the molten KINIZ alloy is cooled and solidified, the molten KINIZ alloy may be prevented from being cooled across the metastable region.

[0049] Since the molten KINIZ alloy is cooled and solidified not across the metastable region, it is possible to prevent the liquid phase of the KINIZ alloy from separating into two phases, and thus the KINIZ alloy may be produced without phase separation to have a homogeneous microstructure.

[0050] Here, the ratio of the weight of iron (Fe) to the sum of the weights of copper (Cu) and iron (Fe) is preferably 70 % or more. Referring to FIG. 7, when the ratio of the weight of iron (Fe) to the sum of the weights of copper (Cu) and iron (Fe) is preferably 70 % or more, the metastable region descends as the content of manganese (Mn) increases.

[0051] Therefore, to descend the metastable region by using manganese (Mn), the ratio of the weight of iron (Fe) to the sum of the weights of copper (Cu) and iron (Fe) is preferably set to be 70 % or more.

[0052] The content of manganese (Mn) may be from 2 wt% to 5 wt%. As the content of manganese (Mn) increases, the metastable region descends, but the conductivity of the KINIZ alloy decreases. (Since the conductivity of copper (Cu) is higher than the conductivity of manganese (Mn), the conductivity of the KINIZ alloy decreases as the content of manganese (Mn) increases.)

[0053] Specifically, referring to FIG. 7, when the content of manganese (Mn) is 2 wt% or less, the effect of lowering the metastable region is insufficient, and thus it is preferable that the content of manganese (Mn) is 2 wt% or more.

[0054] In addition, referring to FIG. 8, as the content of manganese (Mn) becomes greater than 5 wt%, the conductivity (% IACS) of the KINIZ alloy rapidly decreases. Therefore, it is preferable that the content of manganese (Mn) be less than 5 wt% for the prevention of a decrease in conductivity (% IACS).

[0055] The KINIZ alloy having a homogeneous microstructure of the other embodiment of the present disclosure may include zirconium (Zr) for the effect of rapid solidification of a dendritic structure. Zirconium (Zr) may be included within the range of 0.3 wt% to 1.0 wt%, and descriptions of the reason for adding zirconium (Zr) and the weight content of zirconium (Zr) are not provided here because the same descriptions are given in the above description of the KINIZ alloy including nickel (Ni).

[0056] In addition, the KINIZ alloy having a homogeneous microstructure according to the other embodiment of the present disclosure may further include nickel (Ni). When nickel (Ni) is included, the metastable region may be lowered as described above, and to this end, nickel (Ni) may be included in a range of 2.0 wt% to 5.0 wt%. Descriptions of the reason for adding nickel (Ni) and the weight content of nickel (Ni) are not provided here because the same descriptions are given in the above description of the KINIZ alloy including nickel (Ni).

[0057] The KINIZ alloy having a homogeneous microstructure according to the other embodiment of the present disclosure may include carbon (C) in addition to copper (Cu), iron (Fe), manganese (Mn), and zirconium (Zr), and in this case, the content of carbon (C) may be 0.02 wt% or less (excluding 0 %). In addition, the KINIZ alloy having a homogeneous microstructure of the other embodiment of the present disclosure may include the balance of inevitable impurities in addition to copper (Cu), iron (Fe), manganese (Mn), and zirconium (Zr), and the inevitable impurities may include various elements required for the KINIZ alloy. For example, the inevitable impurities may include chromium (Cr), magnesium (Mg), aluminum (Al), silicon (Si), or the like.

[0058] According to an embodiment of the present disclosure, a KINIZ alloy having a homogeneous microstructure may be cast while melting elements included in the KINIZ alloy and cooling the elements. In the casting process of the KINIZ alloy, the cooling rate of molten metals is preferably 5.3 x 10^4 °C/sec or less.

[0059] Referring to FIGS. 3 and 7, although the metastable region is lowered by using nickel (Ni) and manganese (Mn) and the solidification of the KINIZ alloy is quickened by using zirconium (Zr) as described above, the solidification of the KINIZ alloy may occur across the metastable region when the solidification rate of the KINIZ alloy is excessively high.

[0060] Referring to FIG. 9, it may be understood that as the cooling rate decreases below 5.3×10^4 °C/sec, the region in which phase separation is observed decreases. When the cooling rate is high, molten metals may solidify across the metastable region and thus undergo phase separation. However, as the cooling rate decreases below 5.3×10^4 °C/sec, the phase separation region gradually decreases. Therefore, when the KINIZ alloy of the embodiment of the present disclosure is cast, it is preferable that the cooling rate of molten metals be 5.3×10^4 °C/sec or less.

[0061] The KINIZ alloys having a homogeneous microstructure according to the above-described embodiments of the present disclosure may have the following effects.

[0062] Since the KINIZ alloys of the embodiments of the present disclosure are produced by adding small amounts of elements such as nickel (Ni), zirconium (Zr), or manganese (Mn), the KINIZ alloys may have a homogeneous microstructure without phase separation.

[0063] Specifically, in the KINIZ alloys of the embodiments of the present disclosure, the metastable region may be lowered by the addition of nickel (Ni) and manganese (Mn), and the dendritic solidification may be quickened by the addition of zirconium (Zr). Thus, when molten metals are cooled, phase separation caused by cooling across the metastable region may be prevented, and thus the KINIZ alloys may be produced to have a homogeneous microstructure without phase separation as shown in FIG. 5.

[0064] FIG. 2 is a view illustrating a cross-section of a conventional Cu-Fe alloy which includes copper (Cu) and iron (Fe) and underwent phase separation, and FIG. 10 is a view illustrating a cross-section of a KINIZ alloy having a homogeneous microstructure according to an embodiment of the present disclosure. When comparing FIGS. 2 and 10 with each other, since the KINIZ alloy of the embodiment of the present disclosure is produced by adding small amounts of elements such as nickel (Ni), zirconium (Zr), or manganese (Mn), the KINIZ alloy does not has a heterogeneous microstructure in which iron (Fe) 20 and copper (Cu) 10 are separately present in the form of Fe droplets in a Cu matrix, but has a homogeneous microstructure in which Fe dendrites 120 are uniformly distributed in copper (Cu) 110.

[0065] While preferred embodiments of the present disclosure have been described in detail, the present disclosure is not limited to the embodiments, and various modifications may be made in the embodiments without departing from the scope of the present disclosure. Therefore, the scope of the present disclosure should be defined by the following claims.

Claims

1. A KINIZ alloy having copper (Cu) and iron (Fe) and a homogeneous microstructure, the KINIZ alloy comprising:

   copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and
   nickel (Ni) in an amount of 1 wt% to 20 wt%, zirconium (Zr) in an amount of 0.1 wt% to 5.0 wt%, and a balance of inevitable impurities.

2. The KINIZ alloy of claim 1, wherein the KINIZ alloy comprises copper (Cu) in an amount of 20 wt% to 80 wt% and iron (Fe) in an amount of 20 wt% to 80 wt%.

3. The KINIZ alloy of claim 1, wherein the KINIZ alloy comprises nickel (Ni) in an amount of 2.0 wt% to 5.0 wt%, and zirconium (Zr) in an amount of 0.3 wt% to 1.0 wt%.

4. The KINIZ alloy of claim 1, wherein the zirconium (Zr) reacts with oxygen and forms ZrO_2, and
   the ZrO_2 functions as nuclei for nucleation of dendrites during a casting process of the KINIZ alloy.

5. A KINIZ alloy having copper (Cu) and iron (Fe) and a homogeneous microstructure, the KINIZ alloy comprising:

   copper (Cu) and iron (Fe) in a total amount of 75 wt% to 95 wt%; and
   manganese (Mn) in an amount of 2.0 wt% to 5.0 wt%, zirconium (Zr) in an amount of 0.3 wt% to 1.0 wt%, and a balance (excluding 0 %) of inevitable impurities.

6. The KINIZ alloy of claim 5, wherein the KINIZ alloy has a weight ratio of iron (Fe) to copper (Cu) and iron (Fe) within a range of 70 % or more.

7. The KINIZ alloy of claim 5, further comprising nickel (Ni) in an amount of 2.0 wt% to 5.0 wt%.

8. The KINIZ alloy of claim 1 or 5, wherein when the KINIZ alloy is cast, molten metals are cooled at a

rate of 5.3×10^4 °C/sec or less.

FIG. 1

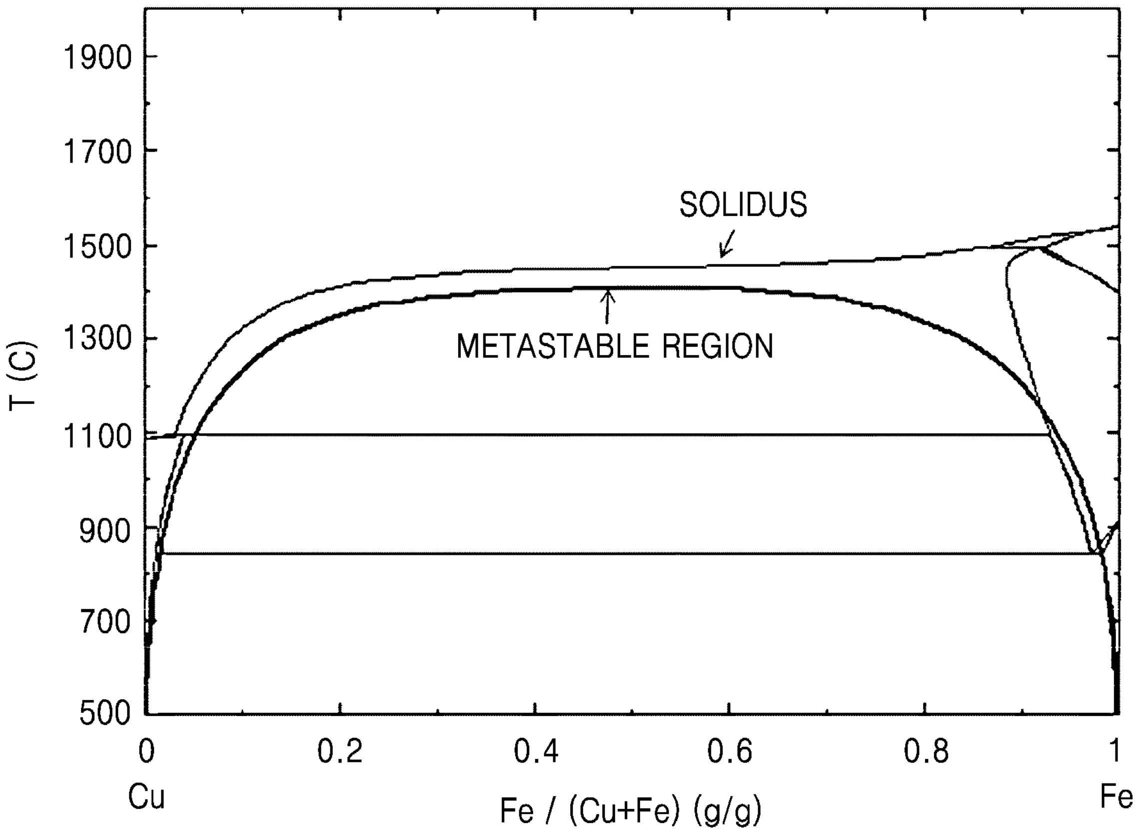

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FIG. 2

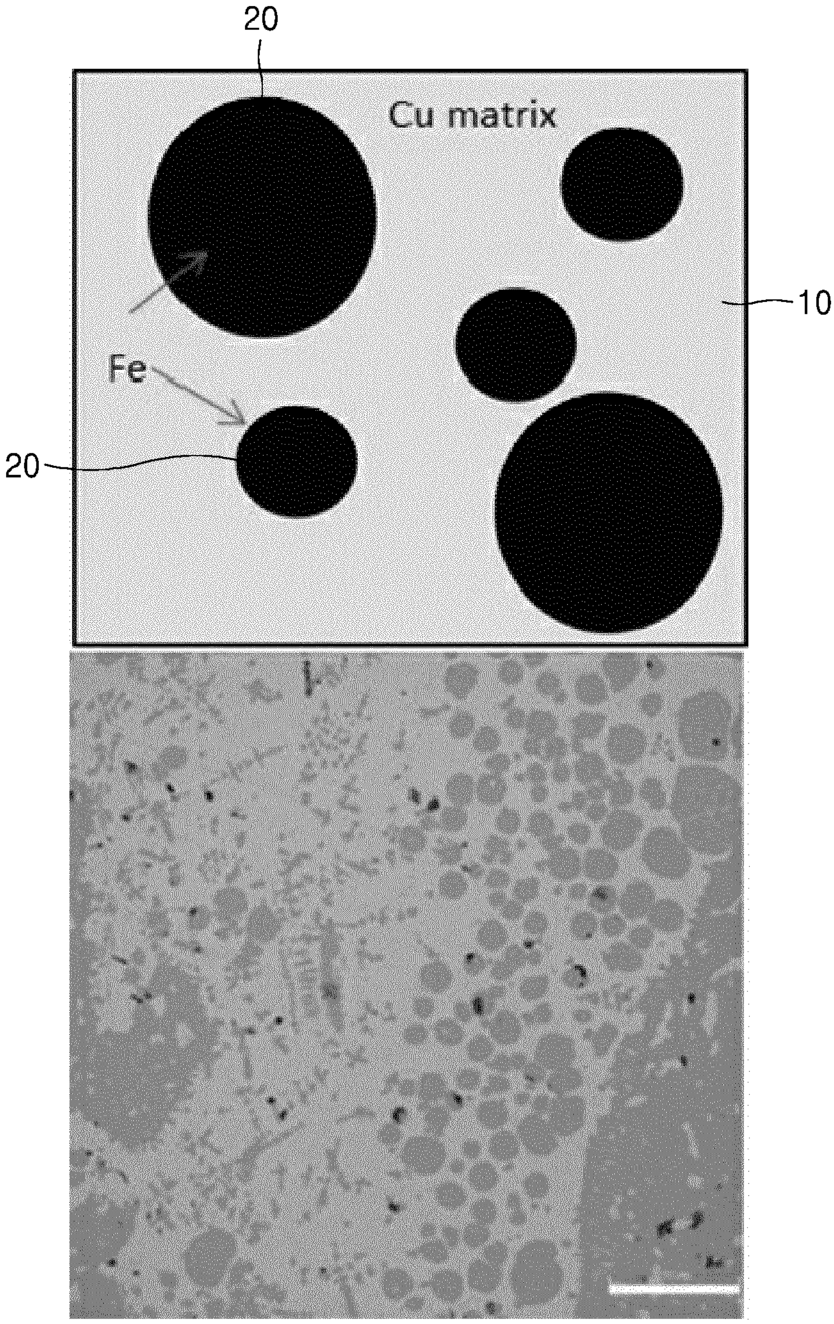
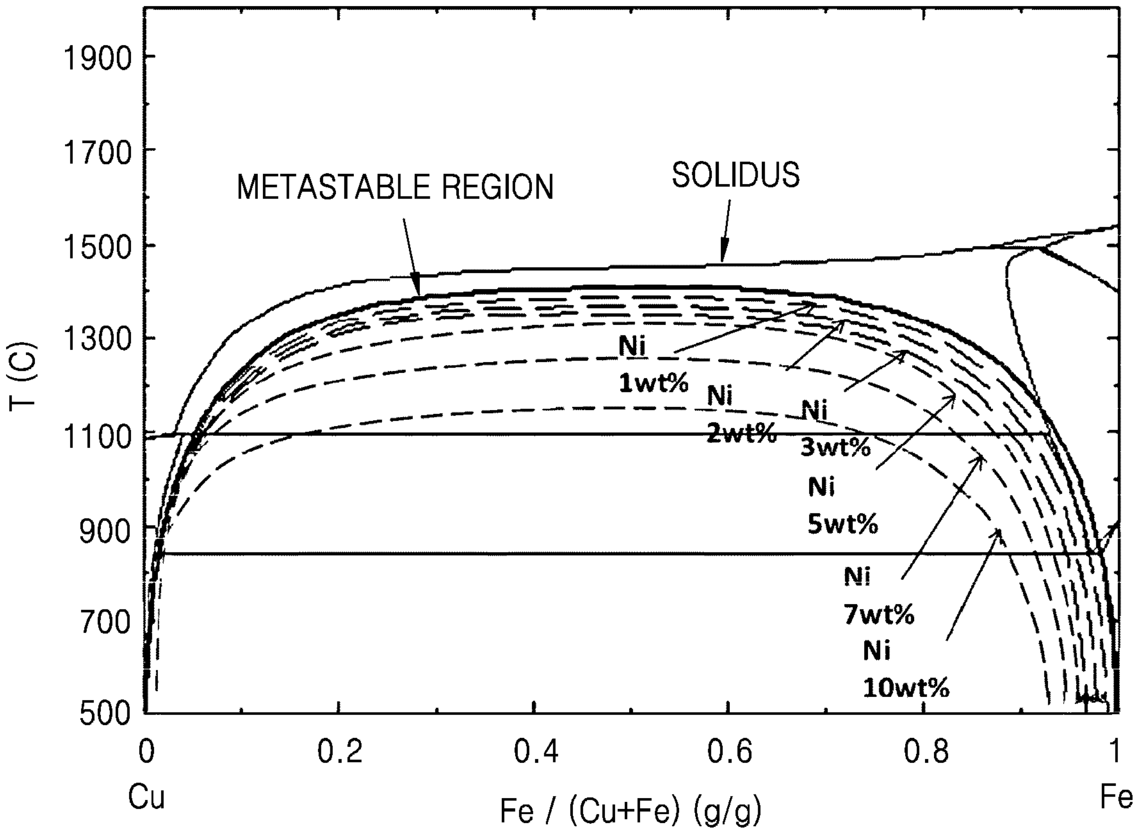


FIG. 3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Cu
Fe
Fe / (Cu+Fe) (g/g)

FIG. 4

EXAMPLES	ALLOYING ELEMENTS (wt%)				TOTAL (wt%)	MICROSTRUCTURE
	Cu	Fe	Ni	Zr		
COMPARATIVE EXAMPLE 1	59.25	39.25	1.0	0.5	100	PHASE SEPARATION OCCURRED
COMPARATIVE EXAMPLE 2	59.00	39.00	1.5	0.5	100	PHASE SEPARATION OCCURRED
COMPARATIVE EXAMPLE 3	58.75	38.75	2.0	0.5	100	PHASE SEPARATION OCCURRED
EXAMPLE 1	58.50	38.50	2.5	0.5	100	PHASE SEPARATION DID NOT OCCUR
EXAMPLE 2	58.25	38.25	3.0	0.5	100	PHASE SEPARATION DID NOT OCCUR
EXAMPLE 3	57.25	37.25	5.0	0.5	100	PHASE SEPARATION DID NOT OCCUR

FIG. 5

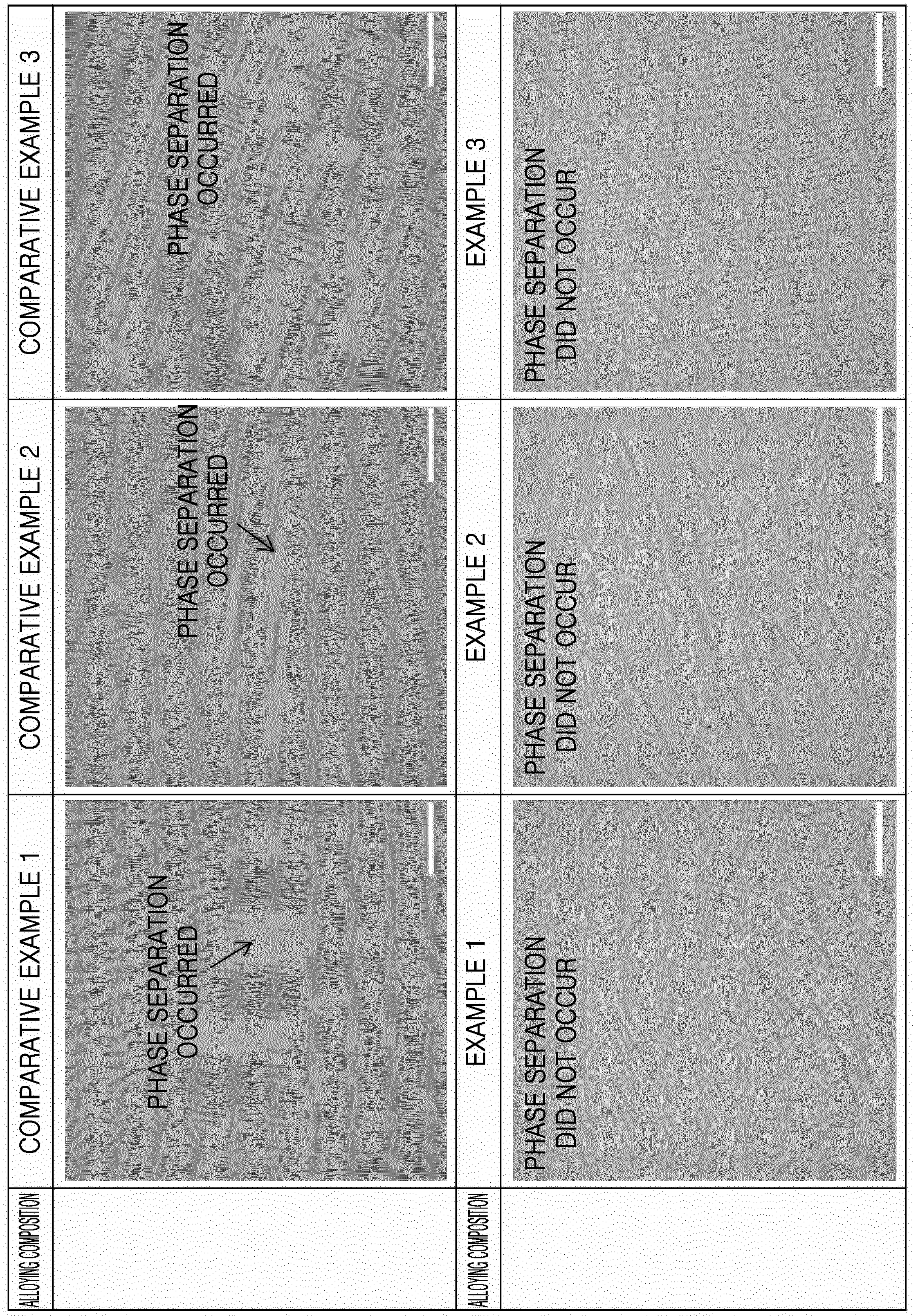

ALLOYING COMPOSITION
COMPARATIVE EXAMPLE 1
PHASE SEPARATION OCCURRED
COMPARATIVE EXAMPLE 2
PHASE SEPARATION OCCURRED
COMPARATIVE EXAMPLE 3
PHASE SEPARATION OCCURRED
ALLOYING COMPOSITION
EXAMPLE 1
PHASE SEPARATION DID NOT OCCUR
EXAMPLE 2
PHASE SEPARATION DID NOT OCCUR
EXAMPLE 3
PHASE SEPARATION DID NOT OCCUR

FIG. 5

CONTENT OF DISSOLVED Ni (wt%)	RESISTIVITY ($\Omega \cdot m$)	RESISTANCE (Ω at 1g-1m)	%IACS
0	5.11	0.4568	32.9
0.1	4.58	0.4095	36.7
1	4.15	0.3710	40.5
1.5	3.42	0.3057	49.1
2	3.22	0.2879	52.2
2.5	3.07	0.2745	54.7
3	3.19	0.2852	52.7
5	3.43	0.3066	49.0
10	5.68	0.507792	29.6

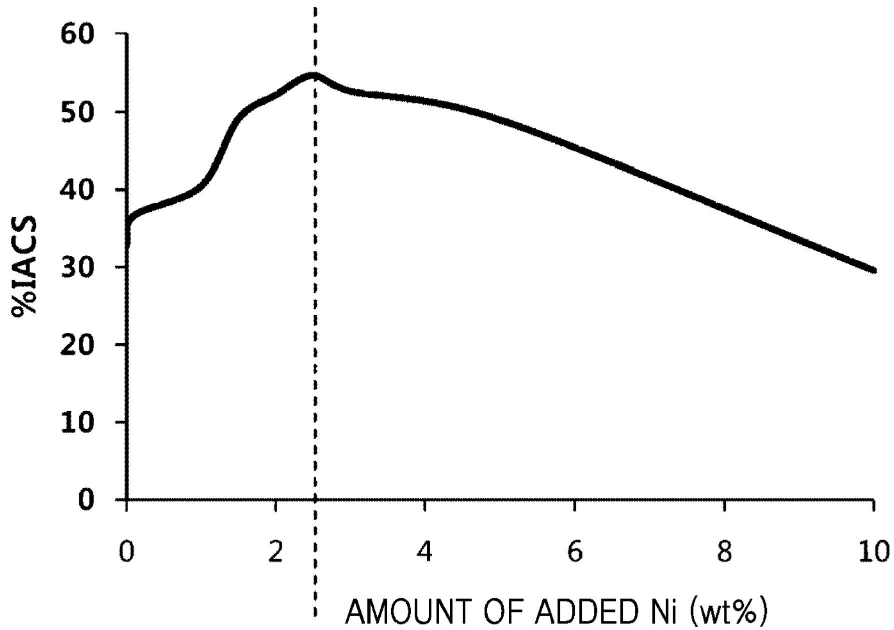


FIG. 7

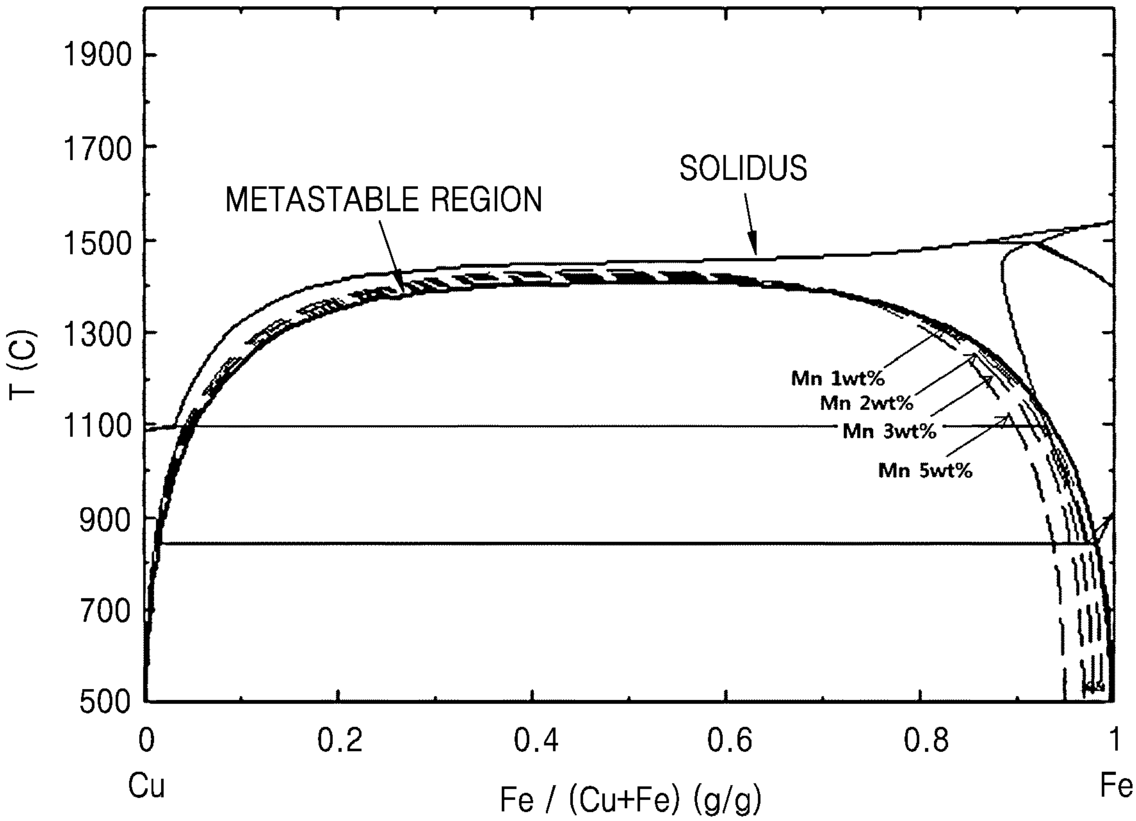

1900
1700
1500
1300
1100
900
700
500
T (C)
METASTABLE REGION
SOLIDUS
Mn 1wt%
Mn 2wt%
Mn 3wt%
Mn 5wt%
0
0.2
0.4
0.6
0.8
1
Cu
Fe
Fe / (Cu+Fe) (g/g)

FIG. 8

CONTENT OF DISSOLVED Mn (wt%)	RESISTIVITY (Ω·m)	RESISTANCE (Ω at 1g-1m)	%IACS 30
0	6.13	0.5480	27.4
0.1	5.58	0.4989	30.1
1	5.16	0.4613	32.6
1.5	4.44	0.3969	37.8
2	4.02	0.3594	41.8
2.5	4.17	0.3728	40.3
3	4.38	0.3916	38.4
5	5.92	0.5292	28.4
10	10.68	0.954792	15.7

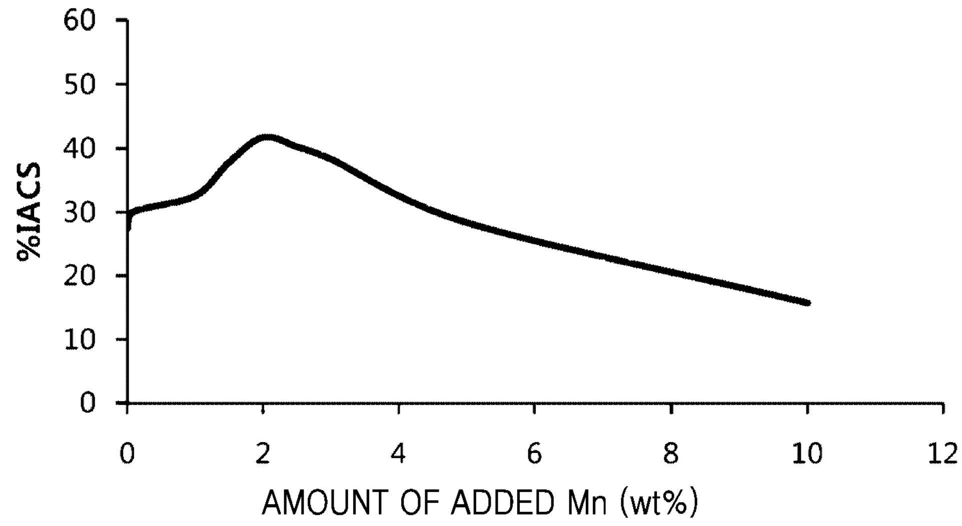


FIG. 9

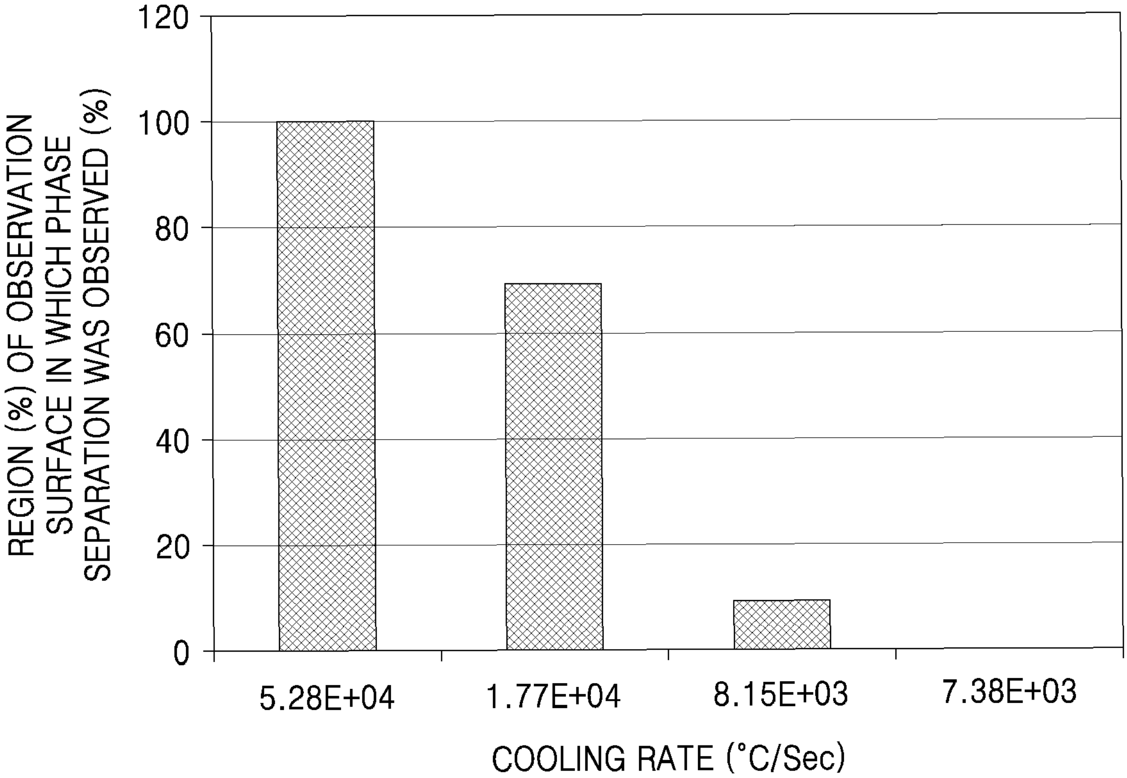
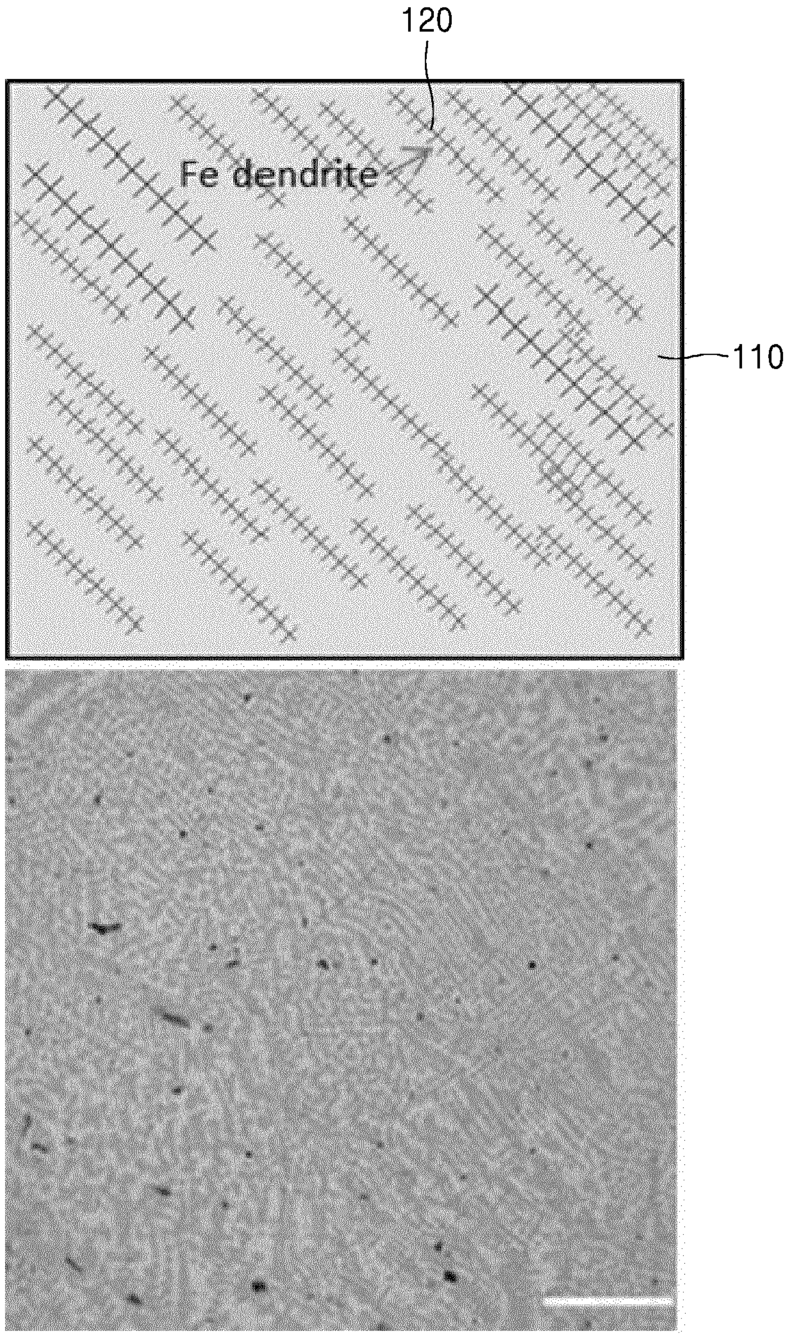

120
100
80
60
40
20
0
REGION (%) OF OBSERVATION SURFACE IN WHICH PHASE SEPARATION WAS OBSERVED (%)
5.28E+04
1.77E+04
8.15E+03
7.38E+03
COOLING RATE (°C/Sec)

FIG. 10



INTERNATIONAL SEARCH REPORT

International application No. **PCT/KR2020/004335**

A. CLASSIFICATION OF SUBJECT MATTER

C22C 38/16(2006.01)i; **C22C 38/08**(2006.01)i; **C22C 38/14**(2006.01)i

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)

C22C 38/16; B01J 21/02; B01J 23/89; C01B 3/40; C07B 33/00; C22C 30/06; C22C 38/00; C22C 9/00; C22C 38/08; C22C 38/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 덴드라이트(dendrite), 주조(casting), 균질(homogeneity), 합금(alloy) 및 미세조직 (microstructure)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 05-331572 A (TOSHIBA CORP.) 14 December 1993. See paragraphs [0006]-[0012] and claims 1-2.	1-8
A	JP 2012-207286 A (KOBE STEEL LTD.) 25 October 2012. See claim 1.	1-8
A	JP 62-263931 A (NIPPON STEEL CORP.) 16 November 1987. See claim 1.	1-8
A	US 2016-0090331 A1 (IFP ENERGIES NOUVELLES) 31 March 2016. See claim 1.	1-8
A	CN 107108206 A (SABIC GLOBAL TECHNOLOGIES BV.) 29 August 2017. See claim 1.	1-8

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 October 2020	**07 October 2020**

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2020/004335

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 05-331572 A	14 December 1993	JP 3333247 B2	15 October 2002
JP 2012-207286 A	25 October 2012	None	
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		US 9809504 B2	07 November 2017
CN 107108206 A	29 August 2017	EP 3227020 A1	11 October 2017
		US 2017-0354962 A1	14 December 2017
		WO 2016-087976 A1	09 June 2016

Form PCT/ISA/210 (patent family annex) (July 2019)