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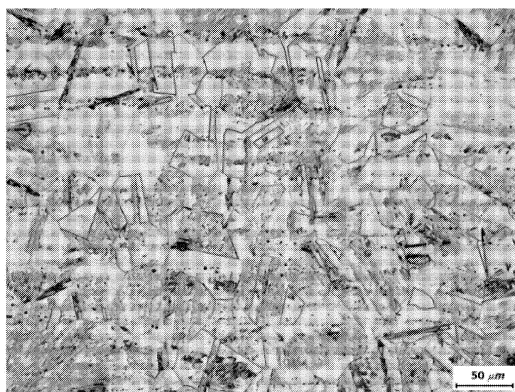
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(54) **LOW-ALLOY STEEL SHEET HAVING EXCELLENT STRENGTH AND DUCTILITY AND
MANUFACTURING METHOD THEREFOR**

(57) The disclosure is to provide a low alloy steel sheet with high strength, high yield strength and high ductility by minimizing the addition of alloying elements, and manufacturing method thereof. In accordance with an aspect of the disclosure, a low alloy steel sheet with excellent strength and ductility, includes: by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr:

13-15.0%, Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05% or less, the remainder of iron (Fe) and other inevitable impurities, and the microstructure of the low alloy steel sheet includes martensite phase at a volume fraction of 20% or less, and the remainder includes an austenite phase.

【FIGURE 1】



Description

[Technical Field]

[0001] The present disclosure relates to a high strength and high ductility steel sheet suitable for structural materials such as automobiles and railroad tracks and more particularly, the present disclosure relates to a low alloy steel sheet with excellent strength and ductility by minimizing alloying elements such as Ni and controlling a microstructure with Cr and Mn as main components, and a manufacturing method thereof.

[Background Art]

[0002] High strength and high ductility steel sheets have been used continuously to reduce the weight of automobile bodies. In recent years, transformed structure steel excellent in workability compared to existing precipitation strengthening or solid solution strengthening steels has been developed and used. The transformed structure steel is represented by DP (Dual Phase) steel, TRIP (TRansformation Induced Plasticity) steel and CP (Complex Phase) steel. The mechanical properties of the transformed structure steel such as the tensile strength and the elongation level are changed depending on the shape of the parent phase and the type and the fraction of the second phase, respectively.

[0003] The TRIP steel, which is one of the transformed structure steels, can control both the cooling rate and the cooling termination temperature during the cooling process after forming austenite during the annealing process, thereby partially improving the strength and ductility by partially retaining the austenite at room temperature. The metastable retained austenite is transformed into martensite by deformation, thereby increasing elongation by delaying local stress concentration relaxation and necking with increasing strength. Therefore, it is important that the TRIP steels retain austenite more than a certain fraction at room temperature. For this purpose, an austenite stabilizing element should be added together with a large amount of Mn to maintain a certain percentage of the retained austenite at room temperature.

[0004] On the other hand, there is TWIP (Twinning Induced Plasticity) steel which constitutes an austenite single phase by adding a large amount of C and Mn in the steel in addition to the above transformed textured steel. In the case of the TWIP steel, it exhibits excellent tensile strength and elongation. However, when the content of C in the TWIP steel is 0.4% by weight, the austenite causing a twinning phenomenon cannot be stably obtained unless the content of Mn is about 25% by weight or more. And also, when the content of C in the TWIP steel is 0.6% by weight, the austenite cannot be stably obtained unless the content of Mn is about 20% by weight or more. Also, a large amount of an austenite stabilizing element should be added so that austenite can stably exist at room temperature because epsilon martensite (ϵ) of an HCP structure and martensite (α') of a BCT structure are formed which are extremely detrimental to workability.

[0005] PCT Published Patent Application No. 2012/077150 relates to high Mn-containing TWIP steels having excellent mechanical properties and moldability, and includes cold rolled steel for cold-rolled annealing and recrystallization heat treatment. In this patent document, alloying elements such as C, Al and Si are additionally added to stabilize the austenite phase or to control the stacking defect energy (SFE).

[0006] As described above, the TRIP steel and the TWIP steel to which a large amount of the alloy component is added are solidified into an austenite single phase at the time of manufacture and hot workability is weakened, and a defect caused by inclusions such as Al easily occurs in hot rolling. There is a disadvantage in that manufacturing technology such as a casting and a rolling process is very difficult due to a problem, and the manufacturing cost is high due to a large increase in the alloy cost.

[0007] As described above, TRIP steel and TWIP steel to which a large amount of alloy components are added solidify in austenite single phase during manufacturing, resulting in inferior hot workability, and have a problem resulting from alloying components such as defects easily caused by inclusions such as Al during hot rolling. For this reason, TRIP steel and TWIP steel have a disadvantage in that the manufacturing technology such as casting and rolling process is very difficult and the manufacturing cost is high due to the large increase in alloy cost.

[0008] In addition, increasing the strength of automobile steel sheet inevitably leads to an increase in yield strength and a decrease in elongation and thus, there is a problem in that moldability is significantly reduced. In order to solve these problems and to manufacture high-strength automotive parts with tensile strength of 1470 MPa or more, a molding method called hot press molding or hot forming has been commercialized.

[0009] US Patent No. 6296805 proposes an aluminum steel sheet or an aluminum alloy plated steel sheet for suppressing an oxide film generated on a steel sheet surface during a heating process of a hot press forming process. In addition, a technique of using a zinc steel sheet or a zinc alloy plated steel sheet has been proposed for a portion requiring sacrificial protection properties such as a wet portion of an automobile body.

[0010] However, when the molded article is processed by the hot press as described above, sensitivity to crack generation and propagation of molded articles is increased, resulting in a problem of deterioration of bendability. In addition, the defects caused by the scale generated during reheating are removed in various ways, but there is a problem

in the economic part because the process is complicated and the process requires additional equipment. In addition, there is a disadvantage that the deformation of the final product is caused by the phase transformation and the cooling speed difference by position generated during cooling after high temperature molding.

[Disclosure]

[Technical Problem]

[0011] The disclosure is to provide a low alloy steel sheet having high strength and high ductility by implementing the TRIP shape by minimizing the addition of alloying elements.

[0012] In addition, the disclosure is to provide a low alloy steel sheet having a high strength and high ductility by implementing an annealing technique comprising a plurality of microstructure by the heat treatment process control.

[Technical Solution]

[0013] In accordance with an aspect of the disclosure, a low alloy steel sheet with excellent strength and ductility, includes: by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr: 13-15.0%, Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05% or less, the remainder of iron (Fe) and other inevitable impurities, and the microstructure of the low alloy steel sheet includes martensite phase at a volume fraction of 20% or less, and the remainder includes an austenite phase.

[0014] In addition, according to an embodiment of the disclosure, the low alloy steel sheet may further include, by weight percent, 0.2% or less of nickel (Ni).

[0015] In addition, according to an embodiment of the disclosure, the low alloy steel sheet may further include, by weight percent, less than 0.2% molybdenum (Mo).

[0016] In addition, according to an embodiment of the disclosure, the elongation of the low alloy steel sheet may be 30% or more.

[0017] In addition, according to an embodiment of the disclosure, the tensile strength of the low alloy steel sheet may be 1250 MPa or more.

[0018] In addition, according to an embodiment of the disclosure, the yield strength of the low alloy steel sheet may be 520 MPa or more.

[0019] In accordance with another aspect of the disclosure, a manufacturing method of a low alloy steel sheet with excellent strength and ductility, includes: manufacturing a slab comprising, by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr: 13-15.0%, Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05% or less, the remainder of iron (Fe) and other inevitable impurities; hot rolling the slab; hot-rolled annealing the hot rolled steel sheet; cold rolling the hot rolled steel sheet; and cold-rolled annealing the cold rolled steel sheet at 750 to 900°C.

[0020] In addition, according to an embodiment of the disclosure, in the cold-rolled annealing step, the microstructure of the low alloy steel sheet may include martensite phase at a volume fraction of 20% or less, and the remainder may include an austenite phase.

[0021] In addition, according to an embodiment of the disclosure, the cold-rolled annealing may perform air cooling after heat treatment at 750 to 900°C for 5 minutes.

[0022] In addition, according to an embodiment of the disclosure, the hot rolling may perform hot rolling by reheating to a temperature range of 1100 to 1200°C and may perform hot-rolled annealing in the temperature range from 900 to 1100°C, and the cold rolling may be performed at a reduction ratio of 70% or less.

[Advantageous Effects]

[0023] A low alloy steel sheet with excellent strength and ductility according to an embodiment of the disclosure can have a tensile strength of 1250MPa or more and 30% elongation and yield strength of 520MPa or more by implementing the TRIP or TWIP phenomenon. Accordingly, it is possible to manufacture a variety of molded articles, it can be used as automotive parts or other structural materials.

[Description of Drawings]

[0024]

FIG. 1 is a photograph showing a microstructure of a low alloy steel sheet according to an embodiment of the disclosure.

FIG. 2 is a photograph showing a microstructure of a low alloy steel sheet according to a comparative example.

FIG. 3 is a graph showing a change in mechanical properties according to cold-rolled annealing temperature in the manufacturing method of a low alloy steel sheet according to an embodiment of the disclosure.

FIG. 4 is a photograph taken with EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 750 °C.

FIG. 5 is a photograph taken by EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 800 °C.

FIG. 6 is a photograph taken by EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 900 °C.

[Modes of the Invention]

[0025] Hereinafter, with reference to the accompanying drawings an embodiment according to the present invention will be described in detail.

[0026] FIG. 1 is a view illustrating a state in which a plating layer is formed, a hairline is processed, and a coating layer is formed on a base material of a home appliance including a hairline according to an embodiment of the present disclosure.

[0027] As shown in FIG. 1, a copper (Cu) plating layer 110 is formed on an upper surface of the base material 100 of the home appliance 1 according to the disclosed embodiment. In addition, a nickel (Ni) plating layer 120 is formed on the copper plating layer 110. The chromium (Cr) plating layer 130 is formed on the nickel plating layer 120. Aluminum (Al) may be used as the base material 100. On the upper surface of the chromium plating layer 130, irregularities 130a for forming a pattern in the transverse direction are formed. The unevenness 130a may be formed by hairline processing. Here, the transverse direction means the transverse direction. More specifically, the lateral direction means that the hairline is formed parallel to the short side of the base material (100). Formation of a hairline is mentioned later. The coating layer 140 may be formed on the top surface of the chromium plating layer 130. The coating layer 140 may be formed using one of acrylic, fluorine, and silane paints.

[0028] That is, the copper plating layer 110, the nickel plating layer 120, and the chromium plating layer 130 may be formed in order from the base material 100. Unevenness (130a) is formed on the upper surface of the chromium plating layer 130, the coating layer 140 may be disposed on the upper surface of the chromium plating layer (130).

[0029] The thickness of the base metal 100 may be 10 to 30mm. The base material 100 may be manufactured using an extrusion technique. The copper plating layer 110 may have a thickness of 5 to 30 μm. The nickel plating layer 120 may have a thickness of 5 to 30 μm. The thickness of the chromium plating layer 130 may be 0.15 to 0.5 μm. This means the thickness of the chrome plating layer after the hairline processing, and means the maximum thickness of the chromium plating layer. The thickness of the chromium plating layer before the hairline processing may be 0.3 to 0.8 μm. This will be described in more detail in the following examples.

[0030] FIG. 2 is a diagram illustrating a manufacturing process of a home appliance according to one embodiment of the present disclosure.

[0031] As shown in FIG. 2, the home appliance 1 is formed by forming at least one plating layer (110, 120, 130) on the base material (100), processing the hairline 130a having irregularities in the transverse direction on the upper surfaces of the plating layers 110, 120, and 130, and forming a coating layer 140 on the hairline 130a. The coating layer may be coated using a silane-based, fluorine-based, or acrylic paint. According to the disclosed embodiments, it can be coated using a cycloalkoxy alkyl silane which is silane-based. Cycloalkoxy alkyl silane is (R10) 3- (CH) n-COONH- (CH2) 2-COO-CR2-CH2, where n is 2 to 12, R1 includes at least one of an alkoxy group, a cycloalkoxy group, and an alkyl group, R2 includes at least one of a hydrogen group (-H), a methyl group (-CH4), and a vinyl group (-CH = CH2).

[0032] The plating is performed on the upper surface of the base material 100 in the order of the copper plating layer 110, the nickel plating layer 120, and the chromium plating layer 130. Then, the hairline is processed on the upper surface of the chromium plating layer 130 to form the unevenness 130a. Thereafter, the coating is performed to be coated on the top surface of the uneven surface 130a so that the coating layer 140 is formed.

[0033] Hereinafter, the hairline processing of the disclosed embodiment will be described.

[0034] FIG. 3 is a view illustrating a state in which a shaft of a hairline processing wheel for processing a hairline on a base material is tilted according to the disclosed embodiment.

[0035] The hairline processing of one disclosed embodiment proceeds using the hairline processing wheel 2. The polishing brush 3 for processing the hairline of the hairline processing wheel 2 uses a polishing brush (3) in which high-purity alumina (Al₂O₃: more than 90% purity) is adhered to the actual surface of nylon 6.6 or polyester with an adhesive.

[0036] The hairline processing wheel 2 according to the disclosed embodiment processes the hairline in a tilted state at an angle. The rotating shaft 4 of the hairline processing wheel 2 is installed to be tilted at a predetermined angle with respect to the short side of the base material 100. Thus, the polishing brush 3 of the hairline processing wheel 2 is also tilted at a predetermined angle. The polishing brush 3 of the hairline processing wheel 2 can be tilted 4 to 10 degrees with respect to the horizontal plane. That is, θ described in FIG. 3 may be 4 to 10 degrees. As in the disclosed embodiment,

since the hairline is generated in the transverse direction, the centrifugal force acts on the base material 100 because the processing of the hairline proceeds at the same time as the base material moves. Accordingly, the centrifugal force of the hairline machining wheel 2 acted on the base material 100 to form a hairline in the transverse direction. Conventionally, the hairline was processed without tilting the hairline processing wheel, and thus the hairline was formed in an oblique direction.

[0037] Hereinafter, the embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. The following embodiments are provided to transfer the technical concepts of the present disclosure to those of ordinary skill in the art. However, the present disclosure is not limited to these embodiments, and may be embodied in another form. In the drawings, parts that are irrelevant to the descriptions may be not shown in order to clarify the present disclosure, and also, for easy understanding, the sizes of components are more or less exaggeratedly shown.

[0038] In accordance with an aspect of the disclosure, a low alloy steel sheet with excellent strength and ductility, includes, by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr: 13-15.0%, Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05% or less, the remainder of iron (Fe) and other inevitable impurities.

[0039] In addition, according to an embodiment of the disclosure, the low alloy steel sheet may further include, by weight percent, 0.2% or less of nickel (Ni).

[0040] In addition, according to an embodiment of the disclosure, the low alloy steel sheet may further include, by weight percent, less than 0.2% molybdenum (Mo).

[0041] Description of the role and content of each component included in the low alloy steel sheet with excellent strength and ductility according to the present disclosure is as follows. % for the following components means weight %.

C: 0.05 to 0.15 %

[0042] Carbon is an austenite-forming element and is an effective element for increasing the strength of materials by solid solution strengthening. Although it is advantageous to add a large amount of C in order to secure yield strength, the corrosion resistance is lowered when it is added in excess, thus the upper limit is limited to 0.15%. On the other hand, the lower limit is limited to 0.05% in order to take into consideration the decarburization load during smelting and to obtain the effect of increasing the strength by the minimum amount of C. It is preferable to add C in the range of 0.05 to 0.15% in order to ensure stable production and strength by the addition of C.

Si: 0.7 to 2.5 %

[0043] Silicon is partially added because it has a deoxidizing effect and is a ferrite stabilizing element. However, if it is excessive, the mechanical properties related to corrosion resistance and impact toughness will be deteriorated. When a large amount of Si is added, the ferrite content is increased to cause surface cracking during hot rolling, and there is a problem that the rolling load is increased during manufacture, thus the upper limit is limited to 2.5%. On the other hand, the lower limit is limited to 0.7% in order to control the stability of the austenite phase by the addition of Si, control strain-induced martensite formation, and ease production. For controlling the phase fraction by the addition of Si and controlling the deformation mechanism during the austenite phase transformation, it is preferable to limit the range of Si to 0.7 to 2.5%.

Mn: 8 to 9.9 %

[0044] Manganese is an austenite-forming element and is a major element constituting the austenite phase in the Cr-added steel. In particular, Cu is used as a substitute element for Ni. When Mn is contained in a large amount at the time of production, oxide-based inclusions cause defects in production or deterioration in corrosion resistance. An additional technique such as special refining to reduce the dissolved oxygen, is required for the inclusion reduction, and the manufacturing cost is increased. Therefore, the upper limit is limited to 9.9%. The minimum amount for the addition of Ni and the minimum amount for securing the austenite single phase or some of the ferrite or martensite structure is about 8%. Therefore, the range of Mn is preferably limited to 8 to 9.9%.

Cr: 13.0 to 15.5 %

[0045] Chromium is a representative ferrite-forming element and is an element that increases corrosion resistance. In particular, it is an element that greatly affects nitrogen solubility. In order to minimize surface cracking during hot rolling, it is preferable to control the initial phase at the time of solidification with ferrite so as not to control the trace elements, particularly S and P which are intergranular segregated elements, at a very low level. When the amount of ferrite exceeds a certain amount, it is present in two phases of ferrite and austenite at a high temperature, resulting in

deterioration of hot workability and a large amount of cracks are generated in hot rolling. In addition, some of the ferrite phases are present more than necessary in the manufacture of the final product, resulting in deterioration of mechanical properties. Therefore, the upper limit of Cr is limited to 15.0%. On the other hand, when the content of Cr is too low, there is a problem of controlling the amount of P and S which are intergranular segregation sources by solidification at the austenite initial phase at the time of solidification at high temperature. If the above-mentioned control is insufficient, a large amount of surface cracks will occur during manufacture. In addition, at least 13.0% of chromium is required to have the minimum corrosion resistance and superior corrosion resistance to carbon steel. Therefore, it is preferable that the content of Cr is limited to 13.0 to 15.0% in order to solidify the initial phase into ferrite within the range of the desired alloying element and to maintain the corrosion resistance of the minimum stainless steel level.

Cu: more than 0 and 1.0% or less

[0046] Copper is an austenite-forming element similar to Mn and Ni. Cu is an element to be added in place of Ni, and when it is added in excess, it is precipitated in Cu in excess of solubility, resulting in grain boundary embrittlement upon heating. Therefore, the maximum content of Cu that can control the stability of austenite without exceeding the solubility is 1.0%. Therefore, it is preferable that Cu is limited to more than 0 and 1.0% or less.

N: 0.1 to 0.2 %

[0047] Nitrogen is a representative austenite forming element together with Ni and it is an element which improves the corrosion resistance of the material together with Cr and Mo. The minimum N content of which the effect of the addition of N is shown and improves the strength of the material with interstitial elements together with C is 0.1%. In general, pressure is applied to increase the solubility of N in order to dissolve a large amount of N in the material. Even if Cr and Mn, which are representative elements for increasing the solubility of N, are present in a large amount, the amount that can maximally dissolve N without applying atmospheric pressure is 0.2%. Therefore, it is preferable that the appropriate amount of N is limited within the range of 0.1 to 0.2%.

Al: 0 to 0.25 % or less

[0048] Aluminum is a ferrite-forming element in Cr-added stainless steel and is a useful element for deoxidation in steelmaking. At the same time, it is known that Al increases the stacking defect energy of the austenite phase to form strain-induced martensite or mechanical twinning at the time of modification, and improves a delayed fracture resistance, which is a crack generated after molding. If the Al content exceeds 0.25%, large Al-based inclusions are generated and cause surface defects. In addition, when Al is added excessively, it contains a large amount of ferrite phase at high temperature, which causes cracking during hot rolling. Therefore, the content of Al is limited to 0.25%. According to one embodiment of the present disclosure, Al may be contained in 0.13% or less.

Sn: 0 to 0.05%

[0049] Tin is known as an element improving the corrosion resistance of the material and improving the pickling property by controlling the thickness of the annealing scale during annealing. That is, when Sn is added, the effect of suppressing the formation of SiO₂ oxide on a scale surface layer generated in the cold rolling or hot rolling annealing process can be increased and the efficiency of the cold rolling annealing process can be increased. However, the excessive addition of Sn causes deterioration in hot workability and a reduction in the production process, thus the upper limit is limited to 0.05%. In addition, in the case of the corrosion resistance, when Sn is added, Sn is added to the surface of a passivation layer of the stainless steel to increase the resistance of the coating. Therefore, the content of Sn is limited within the range of 0.05% or less.

[0050] According to an embodiment of the present disclosure, the steel sheet may further contain 0.2% or less of Ni in % by weight.

[0051] Nickel is an austenite-forming element and plays the same role as Mn. Most of Ni is replaced with Mn, and some of nickel is present as impurities such as scrap. The residual amount of Ni is limited to 0.2% or less.

[0052] According to an embodiment of the present disclosure, the steel sheet may further contain less than 0.2% Mo in % by weight.

[0053] Molybdenum is an expensive element that increases the corrosion resistance and forms ferrite. The content of Mo is limited to 0.2% or less.

[0054] A steel sheet according to the present disclosure that satisfies the above-described alloying element composition range, include the martensite phase as a microstructure at a volume fraction of 20% or less, the remainder includes an austenite phase.

[0055] In accordance with the conventional manufacturing method for the molten steel that satisfies the above component, the low alloy steel sheet according to the present disclosure is produced through a process such as reheating the slab, hot rolling, hot-rolled annealing, cold rolling, cold-rolled annealing, pickling, etc.

[0056] For example, the slab may be hot rolled at a temperature of 1100 to 1200°C, which is a typical rolling temperature, and the hot rolled steel sheet may be hot-rolled annealing at a temperature range of 900 to 1,100°C. Hot-rolled annealing can proceed for 10 to 60 minutes. Thereafter, the hot rolled steel sheet may be manufactured into a thin sheet through cold rolling. Cold rolling can be carried out with a reduction ratio of 70% or less. Cold-rolled annealing according to an embodiment of the present disclosure may be carried out at a temperature of 750 to 900°C. In addition, cold-rolled annealing according to an embodiment of the present disclosure may be subjected to air cooling after the heat treatment for 5 minutes at a temperature of 750 to 900°C. The low alloy steel sheet with excellent strength and ductility according to an embodiment of the present disclosure can be used, for example, in a general product for molding, and can be used as a strip, a bar, a plate, a sheet, a pipe, or a tube.

[0057] Hereinafter, the present invention will be described in detail with reference to the following examples. However, the following examples are intended to illustrate the present invention in more detail, but the scope of the present invention is not limited to these examples.

Example

[0058] The specimens of the steels corresponding to the composition range of the component according to the present disclosure were prepared and the elongation, yield strength and tensile strength of the material after hot rolling, hot-rolled annealing, cold rolling and cold-rolled annealing were measured. Table 1 below shows the alloy composition (wt%) for the experimental steel grades.

<Table 1>

	C	Si	Mn	Cr	Cu	N	Ni	Mo	Al	Sn
Inventive Steel	0.081	2.0	9.7	14.1	0.43	0.14	0.15	0.05	0.11	0.035
Comparative Steel	0.084	1.98	10.3	13.4	2.1	0.15	0.3	0.2	0	0

[0059] After hot-rolling the material manufactured as described above at the usual rolling temperature, the hot rolled steel sheet was hot-rolled annealing and cold rolling and cold-rolled annealing were performed at various temperatures to evaluate the microstructure and related strength and elongation. Table 2 below shows the yield strength, tensile strength and elongation obtained after heat treatment of the inventive steel during about 5 minutes at each cold-rolled annealing temperature.

<Table 2>

cold-rolled annealing temperature (°C)	yield strength(Mpa)	tensile strength(Mpa)	elongation(%)
700	962	1205	19.0
750	910	1286	30.9
800	734	1342	34.0
850	684	1428	41.0
900	530	1383	45.2
950	516	1442	44.3
1000	449	1408	44.6
1100	372	1313	42.9

[0060] Table 3 below shows the yield strength, tensile strength and elongation obtained after heat treatment of the comparative steel during about 5 minutes at each cold-rolled annealing temperature.

<Table 3>

annealing temperature (°C)	yield strength(Mpa)	tensile strength(Mpa)	elongation(%)
700	795	1203	26.3
750	784	1214	39.6
800	691	1136	41.9
850	689	1112	46.1
900	515	962	52.2
950	495	1013	54.6
1000	471	1014	55.8
1100	414	944	59.2

[0061] FIG. 3 is a graph showing a change in mechanical properties according to cold-rolled annealing temperature in the manufacturing method of a low alloy steel sheet according to an embodiment of the disclosure. As can be seen in FIG. 3, as the cold-rolled annealing temperature decreases, yield strength increases, tensile strength decreases. Especially in the case of elongation, the decrease in annealing temperature may adversely affect workability. As shown in FIG. 3 and Table 2, it can be seen that the desired mechanical properties such as yield strength 520MPa or more, tensile strength 1250MPa or more, elongation 30% or more in the cold-rolled annealing temperature range of 750 to 900°C. As can be seen in Table 2, when the cold-rolled annealing temperature is 850°C, it can be confirmed that the yield strength of the inventive steel is 684MPa, the tensile strength of the inventive steel is 1428MPa, and the elongation of the inventive steel is 41%. However, when the cold-rolled annealing temperature is 700°C, yield strength of 962MPa and tensile strength of 1205MPa can be obtained, but elongation is 19% thus molding is considered difficult. In the cold-rolled annealing temperature 750 to 900°C of the inventive steel, it can be confirmed that the yield strength 520MPa, tensile strength 1250MPa, 30% elongation are all satisfied.

[0062] As shown in Table 3, in the case of comparative steel, the yield strength may be 520 MPa or more at cold-rolled annealing temperature of 750 to 900°C, but since the tensile strength is less than 1250MPa, it can be confirmed that the desired mechanical properties can not be secured.

[0063] FIG. 4 is a photograph taken with EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 750 °C. FIG. 5 is a photograph taken by EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 800 °C. FIG. 6 is a photograph taken by EBSD (Electron Backscatter Diffraction) of the microstructure of the invention steel according to an embodiment of the disclosure when cold-rolled annealing at 900 °C. In FIGS. 4 to 6, the grain size and phase composition of austenite according to cold-rolled annealing temperature can be confirmed.

[0064] When the cold-rolled annealing temperature shown in FIG. 4, FIG. 5 is 750°C, 800°C, the crystal size of austenite is very fine, it can be seen that a significant amount of martensite other than austenite exists. These martensite and fine grains are important to secure a yield strength of 520MPa or more.

[0065] When the cold-rolled annealing temperature shown in Figure 6 is 900°C, it can be seen that the grain consists of coarse austenite and a small amount of martensite. Accordingly, it can be seen that the yield strength is lowered when the cold-rolled annealing temperature exceeds 900°C.

[0066] As such, in the case of the inventive steel according to one embodiment of the present disclosure, yield strength 520MPa, tensile strength 1250MPa, and elongation of 30% or more may be secured within a range of cold-rolled annealing temperature of 750 to 900°C.

[0067] As described above, while the disclosure has been described with reference to embodiments of the disclosure, the disclosure is not limited thereto, and it will be understood by those of ordinary skill in the art that various modifications and alternations can be made without departing from the concept and scope of the accompanying claims.

Claims

1. A low alloy steel sheet with excellent strength and ductility, comprising:

by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr: 13-15.0%, Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05% or less, the remainder of iron (Fe)

and other inevitable impurities,

wherein the microstructure of the low alloy steel sheet comprises martensite phase at a volume fraction of 20% or less, and the remainder comprises an austenite phase.

- 5 **2.** The low alloy steel sheet according to claim 1, further comprising, by weight percent, 0.2% or less of nickel (Ni).
- 3.** The low alloy steel sheet according to claim 1 or 2, further comprising, by weight percent, less than 0.2% molybdenum (Mo).
- 10 **4.** The low alloy steel sheet according to claim 1, wherein the elongation of the low alloy steel sheet is 30% or more.
- 5.** The low alloy steel sheet according to claim 1, wherein the tensile strength of the low alloy steel sheet is 1250 MPa or more.
- 15 **6.** The low alloy steel sheet according to claim 1, wherein the yield strength of the low alloy steel sheet is 520 MPa or more.
- 7.** A manufacturing method of a low alloy steel sheet with excellent strength and ductility, comprising:
20 manufacturing a slab comprising, by weight percent, C: 0.05-0.15%, Si: 0.7-2.5%, Mn: 8-9.9%, Cr: 13-15.0%,
 Cu: more than 0 and 1.0% or less, N: 0.1-0.2%, Al: more than 0 and 0.25% or less, Sn: more than 0 and 0.05%
 or less, the remainder of iron (Fe) and other inevitable impurities;
 hot rolling the slab;
 hot-rolled annealing the hot rolled steel sheet;
25 cold rolling the hot rolled steel sheet; and
 cold-rolled annealing the cold rolled steel sheet at 750 to 900°C.
- 8.** The manufacturing method according to claim 7, wherein in the cold-rolled annealing step, the microstructure of the
30 low alloy steel sheet comprises martensite phase at a volume fraction of 20% or less, and the remainder comprises
 an austenite phase.
- 9.** The manufacturing method according to claim 7, wherein the cold-rolled annealing performs air cooling after heat
 treatment at 750 to 900°C for 5 minutes.
- 35 **10.** The manufacturing method according to claim 7, wherein the hot rolling performs hot rolling by reheating to a
 temperature range of 1100 to 1200°C and performs hot-rolled annealing in the temperature range from 900 to
 1100°C, and the cold rolling is performed at a reduction ratio of 70% or less.

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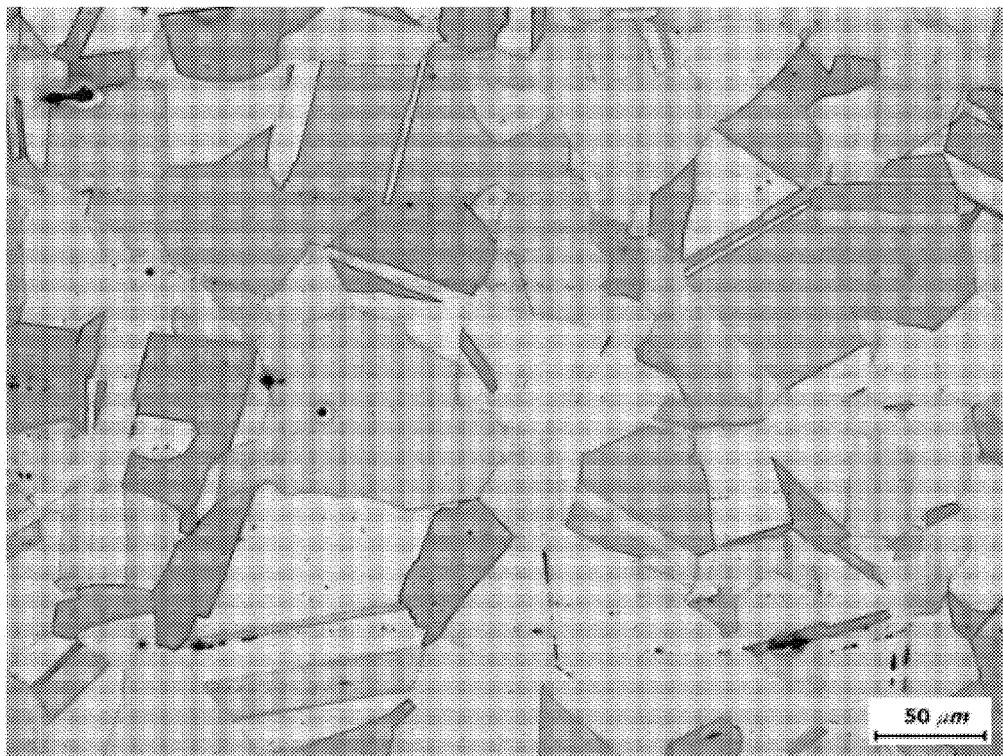
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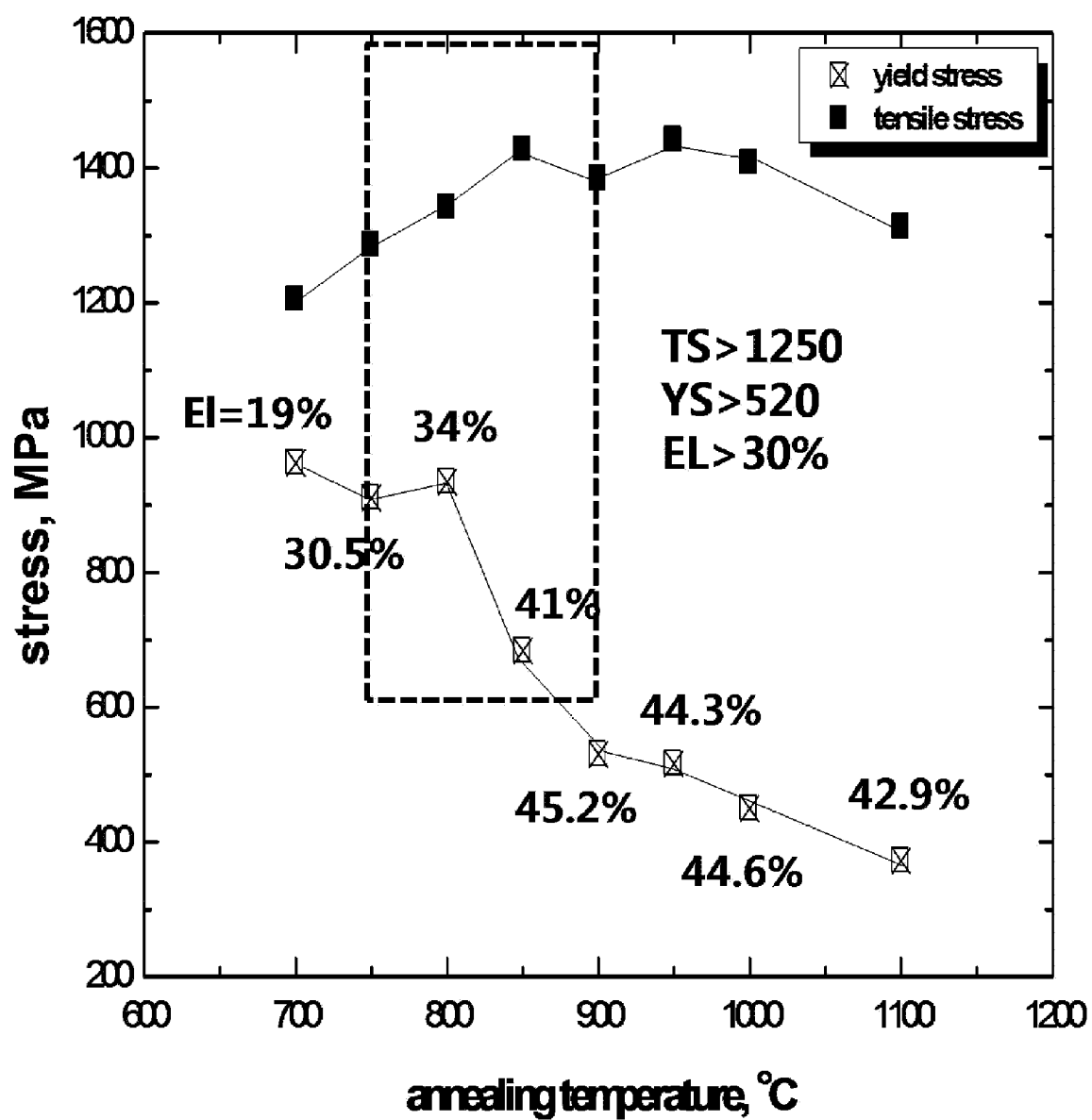
【FIGURE 1】



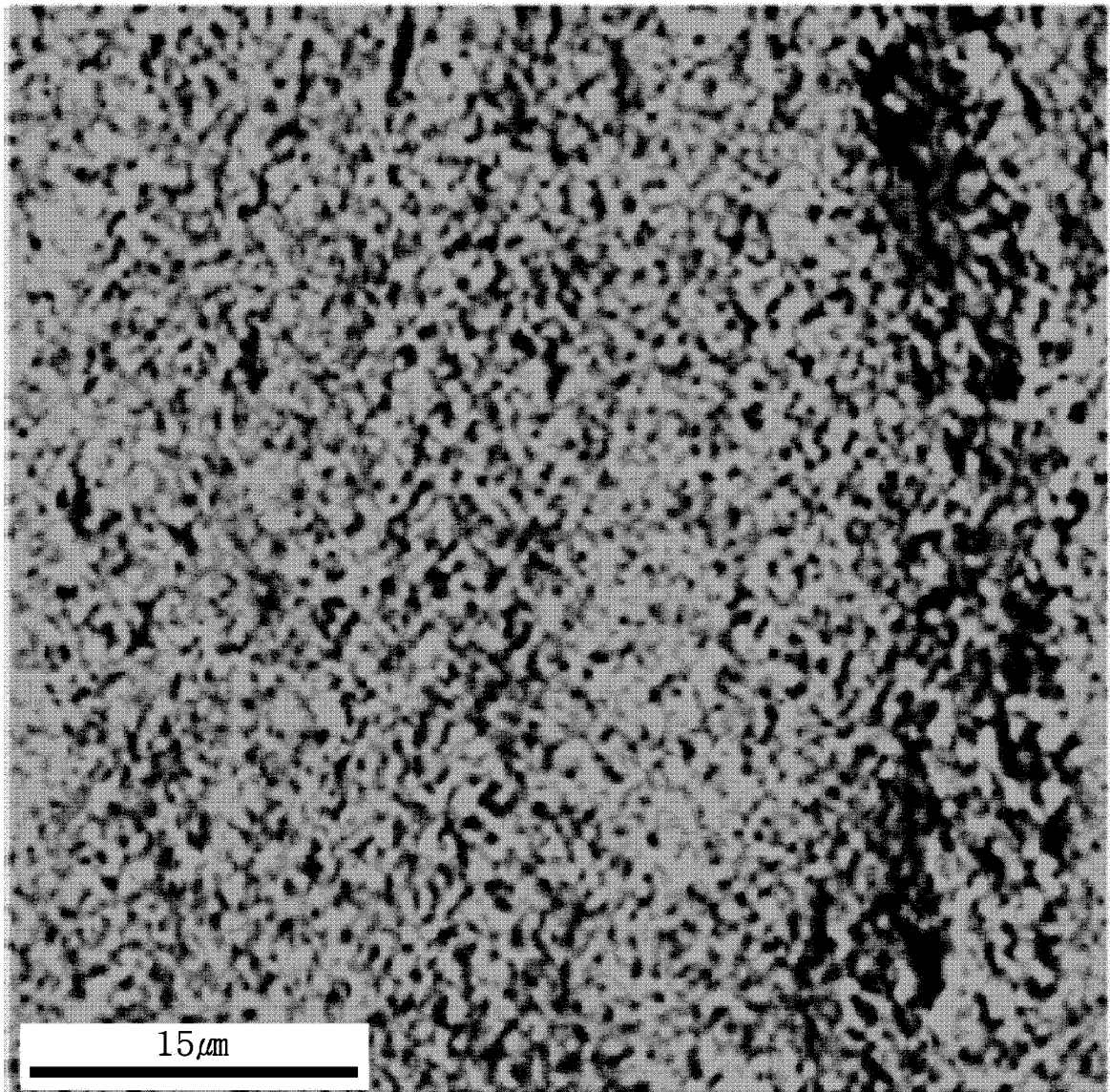
【FIGURE 2】



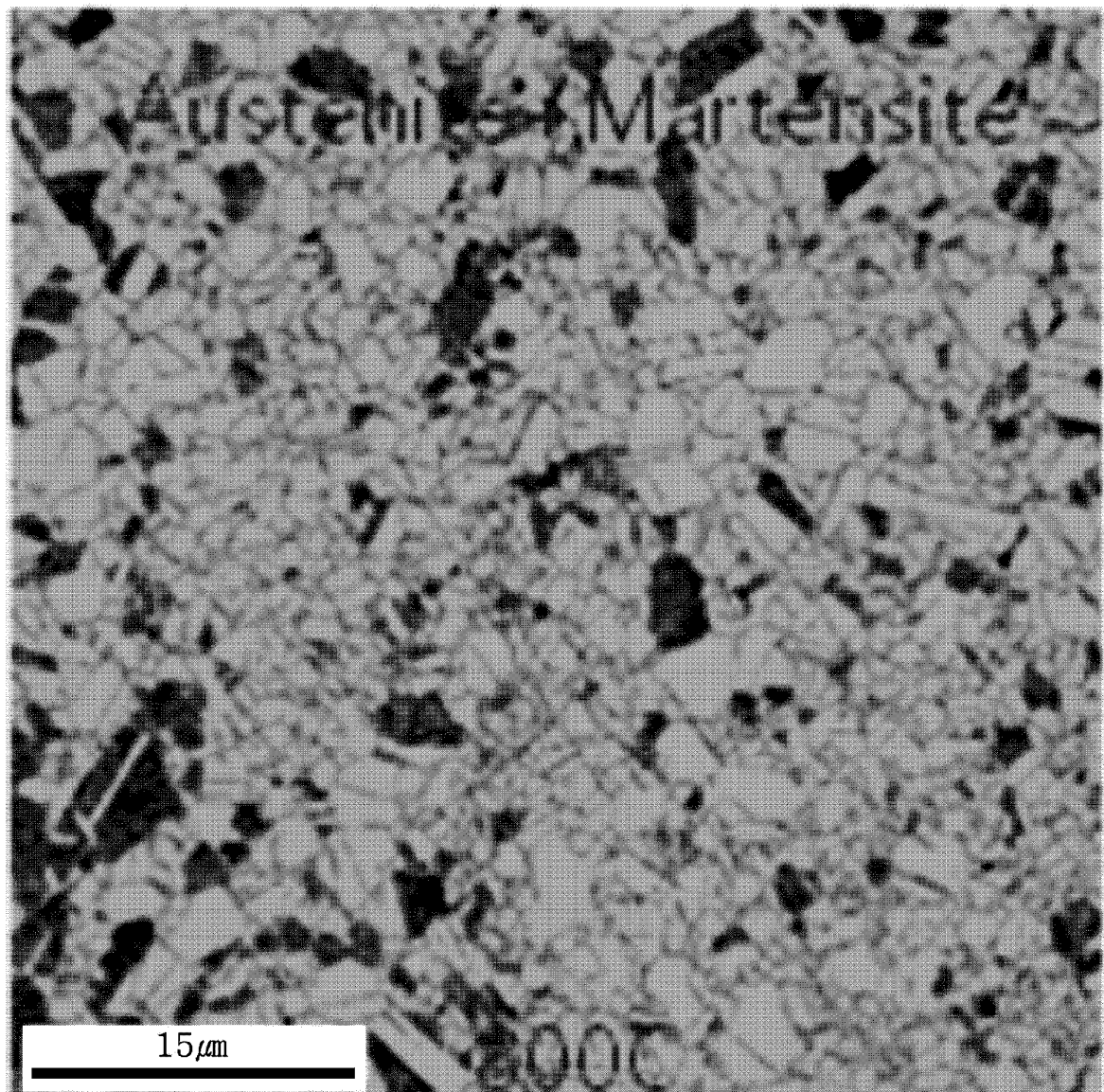
【FIGURE 3】



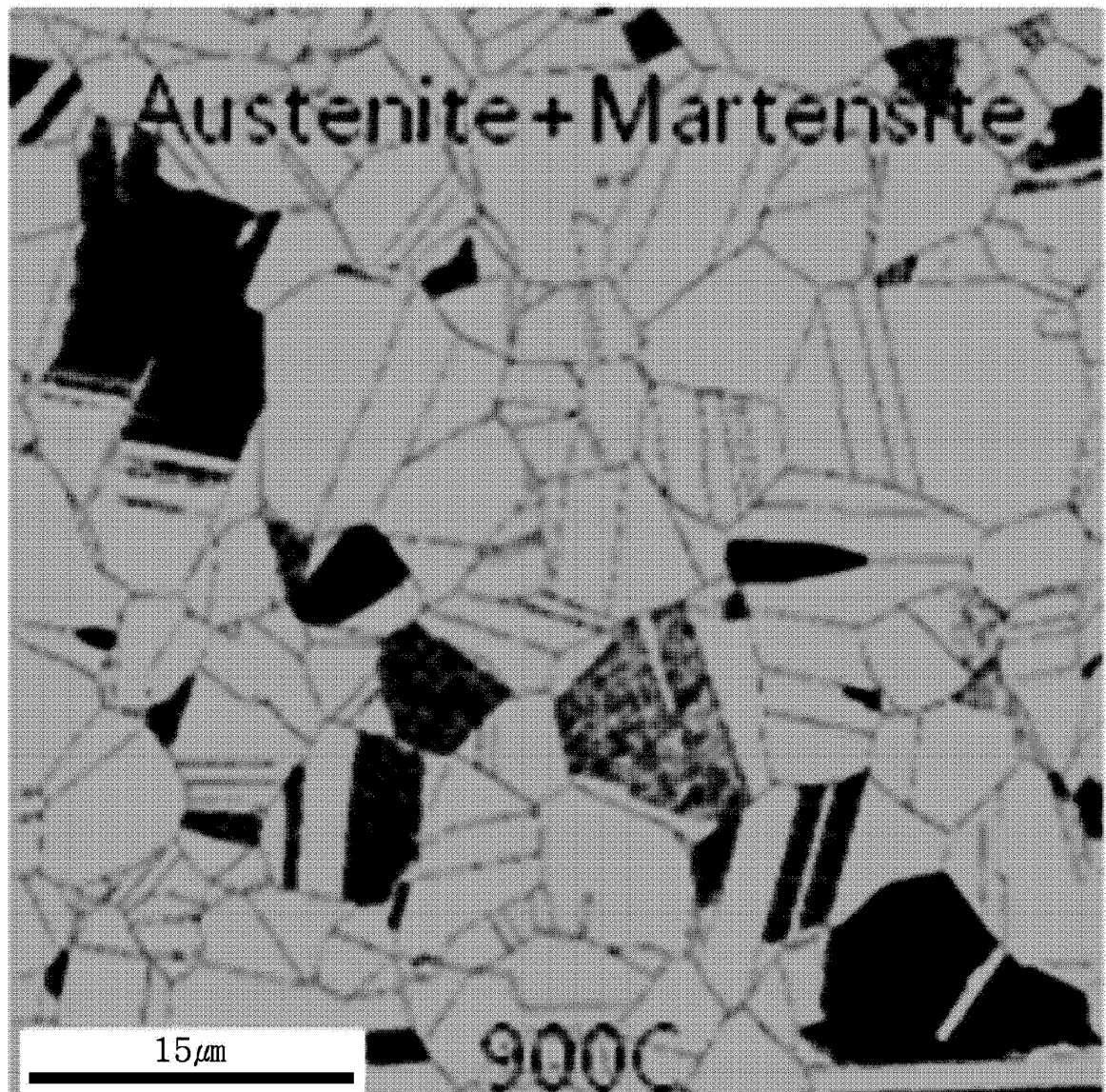
【FIGURE 4】



【FIGURE 5】






【FIGURE 6】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2018/011097

<p>A. CLASSIFICATION OF SUBJECT MATTER <i>C22C 38/60(2006.01)i, C22C 38/34(2006.01)i, C22C 38/58(2006.01)i, C22C 38/42(2006.01)i, C22C 38/44(2006.01)i, C21D 8/02(2006.01)i, C21D 9/46(2006.01)i</i> According to International Patent Classification (IPC) or to both national classification and IPC</p>																					
<p>B. FIELDS SEARCHED</p>																					
<p>Minimum documentation searched (classification system followed by classification symbols) C22C 38/60; C22C 38/00; C22C 38/02; C22C 38/04; C22C 38/18; C22C 38/38; C22C 38/40; C22C 38/50; C22C 38/58; C22C 38/34; C22C 38/42; C22C 38/44; C21D 8/02; C21D 9/46</p>																					
<p>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</p>																					
<p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & Key words: micro structure, martensite, volume fraction, austenite, strength, flexibility, cold annealing</p>																					
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p>																					
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>KR 10-2014-0105849 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 02 September 2014 See paragraphs [0081]-[0083] and claims 1, 2.</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>KR 10-2011-0052749 A (THYSSENKRUPP NIROSTA GMBH.) 18 May 2011 See paragraphs [0077]-[0082] and claim 1.</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>KR 10-2008-0106200 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 04 December 2008 See paragraph [0049] and claim 1.</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>KR 10-2008-0034839 A (SCHELLER, Piotr, R.) 22 April 2008 See claims 1, 2.</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>KR 10-2009-0035710 A (ACTECH GMBH.) 10 April 2009 See claims 1-4.</td> <td>1-10</td> </tr> <tr> <td>PX</td> <td>KR 10-2018-0068088 A (POSCO) 21 June 2018 See claims 1-5.</td> <td>1-5</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	KR 10-2014-0105849 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 02 September 2014 See paragraphs [0081]-[0083] and claims 1, 2.	1-10	A	KR 10-2011-0052749 A (THYSSENKRUPP NIROSTA GMBH.) 18 May 2011 See paragraphs [0077]-[0082] and claim 1.	1-10	A	KR 10-2008-0106200 A (NIPPON STEEL & SUMIKIN STAINLESS STEEL CORPORATION) 04 December 2008 See paragraph [0049] and claim 1.	1-10	A	KR 10-2008-0034839 A (SCHELLER, Piotr, R.) 22 April 2008 See claims 1, 2.	1-10	A	KR 10-2009-0035710 A (ACTECH GMBH.) 10 April 2009 See claims 1-4.	1-10	PX	KR 10-2018-0068088 A (POSCO) 21 June 2018 See claims 1-5.	1-5
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<table border="1"> <tr> <td> Name and mailing address of the ISA/KR  Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsu-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578 </td> <td> Authorized officer Telephone No. </td> </tr> </table>	Name and mailing address of the ISA/KR  Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsu-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.																			
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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