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(54) **ALUMINUM ALLOY FOR DIE CASTING AND MANUFACTURING METHOD THEREOF**

(57) An aluminum alloy, comprising:4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01 to 1.0 weight % titanium (Ti), 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

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Description

[0001] Various embodiments of the present disclosure relate to an alloy for die casting and, for example, relate to an aluminum alloy for die casting and a manufacturing method thereof.

[0002] In general, aluminum, the second-most used metal after iron, is light and has excellent corrosion resistance and workability and high electrical and thermal conductivity, and may be used to manufacture various types of high-strength and high-corrosion-resistance alloys along with materials, such as Cu, Mg, Si, Zn, Mn, Ni, or the like. Accordingly, aluminum may be utilized in various applications, such as airplane manufacturing, household article manufacturing, architecture, vehicle manufacturing, and machinery manufacturing.

[0003] Aluminum alloys are classified according to the amount of aluminum they contain as well as the type of other metals that are present in them. For example, 1xxx series aluminum may be pure aluminum containing at least 99.00 wt % aluminum, 2xxx series alloys may include Al-Cu alloys, 3xxx series alloys may include Al-Mn alloys, 4xxx series alloys may include Al-Si alloys, 5xxx series alloys may include Al-Mg alloys, 6xxx series alloys may include Al-Mg-Si alloys, and 7xxx alloys may include Al-Zn alloys.

[0004] The biggest advantage aluminum alloys have over iron and steel is that they weigh nearly one third of the weight of iron and steel, while having mechanical properties equal of better than those of iron and steel. For this reason, aluminum alloys have been increasingly used in applications related to electronic device(e.g., mobile terminals) manufacturing in recent years.

[0005] An aluminum alloy is provided, comprising:4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01 to 1.0 weight % titanium (Ti), 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

[0006] A method, comprising die casting an electronic device component from an aluminum alloy, wherein the alloy comprises 4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01 to 1.0 weight % titanium (Ti), and 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

[0007] A method for manufacturing an aluminum alloy is provided comprising: melting aluminum (Al) by heating the aluminum (Al) up to a temperature of 700°C to 800°C; heating the melted aluminum to a temperature between 850°C and 900°C and adding silicon (Si) to the melted aluminum (Al) to produce a first intermediate alloy; heating up the first intermediate alloy to a temperature of 1200°C or less, and adding chromium (Cr), manganese (Mn), and titanium (Ti) to the first intermediate alloy to produce a second intermediate alloy; cooling the second intermediate alloy to a temperature between 700°C and 800°C and adding zinc (Zn), and tin (Sn) to the second intermediate alloy to produce the aluminum alloy, wherein the aluminum alloy comprises 4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01 to 1.0 weight % titanium (Ti), and 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above and other aspects, features, and advantages of the present disclosure will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a flowchart of a process for manufacturing an aluminum alloy according to various embodiments of the present disclosure;
FIG. 2 illustrates a graph and a table showing physical property test results of diverse specimens according to various embodiments of the present disclosure; and
FIG. 3 illustrates a comparative example of the corrosion of an aluminum alloy, according to various embodiments of the present disclosure.

DETAILED DESCRIPTION

[0009] Hereinafter, various embodiments of the present disclosure will be described in connection with the accompanying drawings. The present disclosure may be modified in various forms and include various embodiments, but specific examples are illustrated in the drawings and described in the description. However, it should be understood that there is no intent to limit the present disclosure to the particular forms disclosed herein; rather, the present disclosure should be construed to cover all modifications, equivalents, and/or alternatives falling within the spirit and scope of the disclosure. In the description of the drawings, identical or similar reference numerals are used to designate identical or similar elements.

[0010] The term "include" or "may include" refers to the existence of a corresponding disclosed function, operation or component which can be used in various embodiments of the present disclosure and does not limit one or more additional functions, operations, or components. In the present disclosure, the terms such as "include" or "have" may be construed to denote a certain characteristic, number, step, operation, constituent element, component or a combination thereof, but may not be construed to exclude the existence of or a possibility of addition of one or more other characteristics, numbers, steps, operations, constituent elements, components or combinations thereof.

[0011] The term "or" used in various embodiments of the present disclosure includes any or all of combinations of listed words. For example, the expression "A or B" may include A, may include B, or may include both A and B.

[0012] The expressions such as "first", "second", or the like used in various embodiments of the present disclosure may modify various component elements in the various embodiments but may not limit corresponding component elements. For example, the above expressions do not limit the sequence and/or importance of the elements. The expressions may be used to distinguish a component element from another component element. For example, a first user device and a second user device indicate different user devices although both of them are user devices. For example, a first element may be termed a second element, and similarly, a second element may be termed a first element without departing from the scope of the present disclosure.

[0013] When it is described that a certain structural element "is connected to" or "is in contact with" another structural element, it should be understood that although the certain structural element is directly connected to or is in direct contact with another structural element, still another structural element may be interposed therebetween. Conversely, when one component element is "directly coupled" or "directly connected" to another component element, it may be construed that a third component element does not exist between the first component element and the second component element.

[0014] The terms in various embodiments of the present disclosure are used to describe a specific embodiment, and are not intended to limit the present disclosure. A singular expression may include a plural expression unless they are definitely different in a context.

[0015] Unless defined otherwise, all terms used herein, including technical and scientific terms, have the same meaning as commonly understood by those of skill in the art to which the present disclosure pertains. Such terms as those defined in a generally used dictionary are to be interpreted to have the meanings equal to the contextual meanings in the relevant field of art, and are not to be interpreted to have ideal or excessively formal meanings unless clearly defined in the present disclosure.

[0016] Aluminum alloys prepared by manufacturing methods, according to the various embodiments of the present disclosure, may be applied to case frames, bezels, and the like of electronic devices.

[0017] An electronic device according to the present disclosure may be a device including a communication function. For example, the electronic device may include at least one of a smart phone, a tablet Personal Computer (PC), a mobile phone, a video phone, an e-book reader, a desktop PC, a laptop PC, a netbook computer, a PDA, a Portable Multimedia Player (PMP), an MP3 player, a mobile medical device, a camera, a wearable device (for example, a Head-Mounted-Device (HMD) such as electronic glasses, electronic clothes, an electronic bracelet, an electronic necklace, an electronic appcessory, an electronic tattoo, and a smart watch.

[0018] According to some embodiments, the electronic device may be a smart home appliance with a communication function. The smart home appliances may include at least one of, for example, televisions, digital video disk (DVD) players, audio players, refrigerators, air conditioners, cleaners, ovens, microwaves, washing machines, air purifiers, set-top boxes, TV boxes (e.g., HomeSyncTM of Samsung, Apple TVTM, or Google TVTM), game consoles, electronic dictionaries, electronic keys, camcorders, or electronic frames.

[0019] According to some embodiments, the electronic device may include at least one of various medical devices such as a magnetic resonance angiography (MRA) scanner, a magnetic resonance imaging (MRI) scanner, a computed tomography (CT) scanner, a scanner, an ultrasonograph, or the like, a navigation device, a Global Positioning System (GPS) receiver, an Event Data Recoder (EDR), a Flight Data Recoder (FDR), a vehicle infotainment device, an electronic equipment for ship (for example a ship navigation device and gyro-compass and the like, avionics, a security device, a head unit for vehicle, an industrial or household robot, ATM(automatic teller machine) in banking facilities or POS(point of sales) in stores.

[0020] According to some embodiments, the electronic device may be integrated into furniture or be part of a building. Additionally or alternatively, the electronic device may include an electronic board, an electronic signature receiving device, a projector, and various types of measuring devices (for example, a water meter, an electric meter, a gas meter, a radio wave meter and the like) including a camera function. An electronic device according to various embodiments of the present disclosure may be a combination of one or more of above described various devices. Also, an electronic device according to various embodiments of the present disclosure may be a flexible device. Also, an electronic device according to various embodiments of the present disclosure is not limited to the above described devices.

[0021] According to aspects of the disclosure, an aluminum alloy is disclosed. The aluminum alloy may include at least some of Silicon (Si), Magnesium (Mg), chromium (Cr), Zinc (Zn), Manganese (Mn), titanium (Ti), and tin (Sn), Zirconium (Zn), Nickel (Ni), Magnesium (Mg), and iron (Fe). A discussion of each of these elements is now provided:

(1) Silicon (Si) content: 4.0 wt % to 10.0 wt %

[0022] According to various embodiments, the silicon (Si) content of the alloy may be between 4.0 weight percent (wt %) and 10.0 wt %. According to an embodiment, the silicon (Si) may function to enhance strength without degradation in corrosion resistance and may ensure a minimum fluidity, which is needed for the alloy to be usable for die casting. According to an embodiment, the silicon (Si) is for increasing fluidity of molten material, decreasing shrinkage thereof, and enhancing heat resistance.

[0023] According to various embodiments, the silicon is combined with magnesium (Mg) and separated as Mg_2Si through aging to affect mechanical properties, and the residual silicon (Si) left after the combination with the magnesium (Mg) is separated alone to enhance mechanical properties and effective in the fluidity improvement of molten metal.

[0024] According to various embodiments, when an amount of added silicon does not reach 4.0 wt %, desired strength and fluidity cannot be obtained, and in contrast, when an amount of added silicon exceeds 10.0 wt %, the forming efficiency and surface quality of a formed product can be deteriorated, and the satisfaction of an intended product specification of the formed product cannot be achieved due to the more brittle property of an aluminum alloy.

(2) Magnesium (Mg) content: 0.1 wt % to 4.0 wt %

[0025] According to various embodiments, the magnesium (Mg) content of the alloy may be between 0.1 wt % and 4.0 wt %.

[0026] According to various embodiments, the magnesium (Mg) may contribute to the enhancement of corrosion resistance, strength, ductility, weight, and machinability. When an amount of added magnesium is less than 0.1 wt %, the additive effect thereof is insufficient. In contrast, when an amount of added magnesium exceeds 4.0 wt %, the magnesium may foam with the start of ignition. In order to prevent it, another gas may be used, and it may be solved by content control.

[0027] According to various embodiments, the magnesium (Mg) is separated as a compound along with the above described silicon (Si) to enhance mechanical properties. However, when the Mg content does not reach 0.1 wt %, necessary strength cannot be obtained due to a small amount of Mg_2Si that is separated, and in contrast, when the Mg content exceeds 4.0 wt %, the presence of the magnesium may cause the degradation of various alloy characteristics. For example, the presence of the magnesium may lower the alloy's strength, and reduce its forming efficiency, thereby decreasing productivity, as in the case of the excessive silicon (Si). Further, the residual Mg, which does not form Mg_2Si, may prevent the solid solution of Mg_2Si to degrade strength.

[0028] According to various embodiments, the magnesium (Mg) may cause an oxidized layer (MgO) to form fast on the surface of a product that is made from the alloy, and the oxidized layer (MgO) may function as a coating film on the surface to enhance corrosion resistance.

(3) Chromium (Cr) content: 0.1 wt % to 1.0 wt %

[0029] According to various embodiments, the chromium content of the alloy may be between 0.1 wet % and 1.0 wt %.

[0030] According to various embodiments, the chromium (Cr) is for enhancing wear resistance through crystal grain refinement and may contribute to a certain amount of heat-resistance enhancement. According to an embodiment, the chromium (Cr) may restrain the creation and growth of a re-crystallized layer and may be distributed on grain boundaries while forming a compound along with aluminum (Al) to restrain precipitation during an aging process, thereby enhancing elongation. According to an embodiment, the chromium (Cr) may contribute to corrosion resistance enhancement by increasing the density of the oxidized layer (MgO) of the magnesium.

(4) Zinc (Zn) content: 0.05 wt % to 1.0 wt %

[0031] According to various embodiments, the zinc (Zn) content of the alloy may be between 0.05 wt % and 1.0 wt %. According to an embodiment, the zinc (Zn) is for enhancing corrosion resistance and strength. In cases where an amount of added zinc exceeds 1.0 wt %, physical properties, such as weldability, corrosion resistance, and the like, may be deteriorated. According to an embodiment, the zinc (Zn) may also contribute to strength enhancement through age-hardening.

(5) Manganese (Mn) content: 0.05 wt % to 1.0 wt %

[0032] According to various embodiments, the manganese (Mn) content of the alloy may be between 0.05 wt % and 1.0 wt %. According to an embodiment, the presence of manganese (Mn) may result in increased corrosion resistance, increased softening resistance, and improved surface-treatment characteristics at a predetermined high temperature.

[0033] According to an embodiment, a small amount of added manganese (Mn) may contribute to strength improvement through a solid-solution hardening effect and a fine-precipitate dispersion effect with a slight reduction in corrosion resistance.

(6) Titanium (Ti) content: 0.01 wt % to 1.0 wt %

[0034] The titanium (Ti) content of the alloy may be between 0.01 wt % and 1.0 wt %.

[0035] According to various embodiments, the titanium (Ti) is an effective element in grain refinement, and when an amount of added titanium exceeds 1.0 wt %, the titanium may produce a large amount of large and coarse intermetallic compounds, such as $TiAl_3$, thereby degrading mechanical characteristics of an alloy. According to an embodiment, the titanium may contribute to forming-efficiency and strength enhancement through grain refinement.

(7) Tin (Sn) content: 0.001 wt % to 0.5 wt %

[0036] According to various embodiments, the tin (Sn) content of the alloy may be between 0.001 wt % and 0.5 wt %. The addition of tin (Sn) to the alloy may enhance its forming efficiency and machinability. However, when the amount of tin added exceeds 0.5 wt %, the alloy's hot workability and cold workability may be impacted negatively.

(8) Zirconium (Zr): 0.01 wt % to 1.0 wt %

[0037] According to an embodiment, the zirconium (Zr) content of the alloy may be between 0.01 wt % and 1.0 wt %. According to an embodiment, the zirconium (Zr) may reinforce the strength of the aluminum alloy while also improving elongation.

(9) Nickel (Ni) content: 0.05 wt % or less

[0038] The nickel (Ni) may be present in the alloy as an impurity. The nickel (Ni) may introduced into the alloy with the aluminum that is used to manufacture the alloy. According to various embodiments, the nickel (Ni) content of the alloy may be no more than 0.05 wt %

[0039] Although the presence of nickel (Ni) may enhance the heat-resistance of the alloy, it may also have some negative consequences. For example, when 0.05 wt % or more nickel is contained in the alloy, the corrosion resistance of the alloy may decrease.

(10) Iron (Fe) content: 0.3 wt % or less

[0040] The iron (Fe) may be present in the alloy as an impurity. The iron (Fe) may introduced into the alloy with the aluminum that is used to manufacture the alloy. According to various embodiments, the iron (Fe) content of the alloy may be no more than 0.3 wt %.

[0041] According to various embodiments, the iron (Fe) is an element that can contribute to strength enhancement by increasing the density of an alloy and enhance form removal capability by decreasing viscosity. Although the iron is effective in preventing re-crystallized grains from being coarsened and refining grains during casting, the presence of iron may reduce the alloy's extruding efficiency and ductility. More particularly, when 0.3 wt % or more iron is contained in the alloy, the iron may cause the alloy to corrode.

(11) Copper (Cu) content: 0.05 wt % or less

[0042] The copper (Cu) may be present in the alloy as an impurity. The copper (Cu) may introduced into the alloy with the aluminum that is used to manufacture the alloy. According to various embodiments, the copper (Cu) content of the alloy may be no more than 0.005 wt %.

[0043] According to various embodiments, the presence of copper (Cu) in the alloy may enhance the alloy's strength, ductility (through precipitation hardening), corrosion resistance, as well as its fluidity when the alloy is in a molten state. However, the presence of copper may also decrease corrosion resistance, weldability, and extruding efficiency. Accordingly, when 0.05 wt % or more copper is contained in the alloy, the copper may cause the alloy to corrode faster.

(12) Aluminum (Al) content: 90 wt % or more

[0044] According to various embodiments, the aluminum (Al) content of the alloy may be 90 wt %.

[0045] According to various embodiments, the contents of nickel (Ni), iron (Fe), and copper (Cu), which are impurities in aluminum that may cause the corrosion of an alloy when they are contained in the alloy in excess of a predetermined wt %. For this reason, the amount of those metals in the alloy is maintained below 0.005 wt %, thereby making it possible to manufacture an aluminum ally for die casting with stable corrosion resistance, high strength, and excellent fluidity.

[0046] Hereinafter, a process of manufacturing an aluminum alloy, according to various embodiments of the present disclosure, will be described.

[0047] FIG. 1 is a flowchart of a process for manufacturing the aluminum alloy according to various embodiments of the present disclosure.

[0048] At task 101, 90 wt % or more of aluminum (Al) may be completely melted by heating it up to a temperature of 700°C to 800°C.

[0049] At task 103, a predetermined amount of silicon (Si) may be added to the completely molten aluminum (Al). According to an embodiment, the silicon (Si) may be added after the completely molten aluminum (Al) reaches a temperature of 850°C to 950°C. According to an embodiment, the silicon (Si) may be added in the range of 4.0 wt % to 10.0 wt %.

[0050] At task 105, the temperature may be raised to 1200°C after the aluminum (Al) and the silicon (Si) are added. According to an embodiment, titanium (Ti), chromium (Cr), and manganese (Mn) may be added to the heated molten material and then completely melted by heating at a corresponding temperature for a predetermined period of time. According to an embodiment, the heating may be conducted in the range of 4 to 5 hours. According to various embodiments, the titanium (Ti) may be added in the range of 0.01 wt % to 1.0 wt %, the chromium (Cr) may be added in the range of 0.1 wt % to 1.0 wt %, and the manganese (Mn) may be added in the range of 0.05 wt % to 1.0 wt %. According to an embodiment, zirconium (Zr) may also be added in addition to the titanium, manganese, and chromium. According to an embodiment, the zirconium (Zr) may be added in the range of 0.01 wt % to 1.0 wt %. According to an embodiment, the zirconium (Zr) may reinforce the strength of the aluminum alloy while also improving elongation.

[0051] At task 106, an ingredient analysis of the melt is performed.

[0052] At task 107, the amount of impurities present in the alloy is adjusted based on an outcome of the analysis.

[0053] At task 109, after the amount of impurities in the alloy is adjusted, the high-temperature melt may be cooled to a temperature of 700°C to 800°C through natural cooling, and then zinc (Zn) and magnesium (Mg) may be added and completely melted.

[0054] At task 111, an aluminum alloy pre-form may be formed. According to various embodiments, a casting pressure of 75 MPa may be applied to the pre-form during die casting. According to an embodiment, the pre-form may be formed to exhibit a tensile strength characteristic in the range of 250 MPa to 350 MPa during die casting. According to an embodiment, the pre-form may be formed to exhibit a yield strength characteristic in the range of 150 MPa to 250 MPa during die casting. According to an embodiment, the pre-form may be formed to exhibit a break elongation of 2.0% to 4.5%.

[0055] According to various embodiments, the ingredient analysis process may be conducted every a new element is added.

[0056] Table 1 and table 2 below show composition tables of properly prepared aluminum alloys according to various embodiments of the present disclosure.

[Table 1]

Classification	Chemical composition (%)											
	Total	Al	Cu	Si	Mg	Zn	Fe	Mn	Ti	Ni	Sn	Cr
Representative composition	100	90.12	0.0	7.0	2.0	0.1	0.0	0.1	0.1	0.05	0.03	0.5
Range	100	B al.	0.0-0.3	4-10.0	0.1-4.0	0.01-1. 0	0.0-0.5	0.01-1. 0	0.01-1. 0	0.001-1.0	0.001-0.5	0.01-1. 0

[Table 2]

Example	Chemical composition (%)											
	Total	Al	Cu	Si	Mg	Zn	Fe	Mn	Ti	Ni	Sn	Cr	Zr
1	100	Bal.	0.0	7.0	2.0	0.1	0.0	0.1	0.1	0.05	0.03	0.5	0.0
2	100	Bal.	0.0	9.0	2.0	0.1	0.0	0.1	0.1	0.05	0.03	0.5	0.0
3	100	Bal.	0.0	9.0	2.0	0.1	0.0	0.1	0.7	0.05	0.03	0.5	0.0
4	100	Bal.	0.0	9.0	2.0	0.1	0.0	0.1	0.5	0.0	0.03	0.5	0.0
5	100	Bal.	0.0	7.0	2.0	0.1	0.0	0.1	0.5	0.0	0.03	0.5	0.0
6	100	Bal.	0.0	6.5	1.5	0.05	0.0	0.05	0.15	0.0	0.01	0.4	0.0
7	100	Bal.	0.0	6.5	1.5	0.1	0.0	0.1	0.25	0.0	0.03	0.4	0.0
8	100	Bal.	0.0	6.0	1.0	0.1	0.0	0.1	0.25	0.0	0.03	0.4	0.0
9	100	Bal.	0.0	5.0	1.0	0.1	0.0	0.1	0.25	0.0	0.03	0.35	0.0
10	100	Bal.	0.0	5.0	1.0	1.0	0.0	0.1	0.25	0.0	0.03	0.4	0.3
11	100	Bal.	0.0	6.0	1.0	0.1	0.0	0.5	0.25	0.0	0.03	0.4	0.3
12	100	Bal.	0.0	6.5	1.5	0.1	0.0	0.1	0.25	0.0	0.06	0.4	0.1
13	100	Bal.	0.0	6.5	1.5	0.1	0.0	0.1	0.25	0.0	0.03	0.4	0.3
14	100	Bal.	0.0	6.5	1.5	0.1	0.0	0.1	0.25	0.0	0.03	0.4	0.5
15	100	Bal.	0.0	6.5	1.5	0.1	0.0	0.1	0.25	0.0	0.03	0.4	0.8

[0057] According to various embodiments, the copper (Cu), the iron (Fe), and the nickel (Ni), which are unavoidable impurities capable of affecting corrosion resistance, may not be intentionally added to the alloy. According to an embodiment, the copper (Cu), the iron (Fe), and the nickel (Ni), which may be contained in aluminum, may be identified through an ingredient analysis during the melting process of each element, and the copper (Cu) and the nickel (Ni) may be controlled to be 0.05 wt % or less on the basis of the entire weight. According to an embodiment, the iron (Fe) may be controlled to be 0.3 wt % or less on the basis of the entire weight.

[0058] FIG. 2 illustrates a graph and a table showing physical property test results of diverse specimens according to various embodiments of the present disclosure.

[0059] As illustrated in FIG. 2, aluminum alloys having desired physical properties may be manufactured by controlling wt % of compositions thereof. For example, an alloy having increased strength may be obtained by increasing the contents of silicon (Si) and magnesium (Mg). However, since the elongation of the alloy may be degraded, the proper composition of elements has to be made in order to obtain an alloy having desired physical properties (e.g., tensile strength, yield strength, elongation, etc.).

[0060] FIG. 3 illustrates a comparative example of the corrosion of an aluminum alloy, according to various embodiments of the present disclosure, and a general aluminum alloy.

[0061] Referring to FIG. 3, it can be seen that the aluminum alloy (the left specimen in the drawing) manufactured according to the various embodiments of the present disclosure has more excellent corrosion resistance than an aluminum alloy known in the art (the right specimen in the drawing).

[0062] According to various embodiments, an aluminum alloy for die casting can have stable corrosion resistance in a saline-water environment, in water, and in air due to a stable and dense surface oxidation layer formed thereon compared to commercial alloys and general alloys. According to an embodiment, an aluminum alloy can provide high-quality external and internal die-cast components having complex shapes and structures due to high strength and excellent fluidity thereof.

[0063] FIGS. 1-3 are provided as an example only. At least some of the steps discussed with respect to these figures can be performed concurrently, performed in a different order, and/or altogether omitted. It will be understood that the provision of the examples described herein, as well as clauses phrased as "such as," "e.g.", "including", "in some aspects," "in some implementations," and the like should not be interpreted as limiting the claimed subject matter to the specific examples. No claim element herein is to be construed under the provisions of 35 U.S.C. 112, sixth paragraph, unless the element is expressly recited using the phrase "means for".

[0064] While the present disclosure has been particularly shown and described with reference to the examples provided therein, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the appended claims.

Claims

1. An aluminum alloy, comprising:

   4.0 to 10.0 weight % silicon (Si),
   0.1 to 4.0 weight % magnesium (Mg),
   0.1 to 1.0 weight % chromium (Cr),
   0.05 to 1.0 weight % zinc (Zn),
   0.05 to 1.0 weight % manganese (Mn),
   0.01 to 1.0 weight % titanium (Ti),
   0.001 to 0.5 weight % tin (Sn), and
   81.5 to 95.689 weight % aluminum and at least one impurity.

2. The aluminum alloy of claim 1, wherein the at least one impurity includes at least one of copper (Cu), nickel (Ni), and iron (Fe).

3. The aluminum alloy of claim 2, wherein the copper (Cu) makes up at most 0.05 weight % of the alloy and the nickel (Ni) makes up at most 0.05 weight % of the alloy.

4. The aluminum alloy of claim 2 or 3, wherein the iron (Fe) makes up at most 0.3 weight % of the alloy.

5. The aluminum alloy of any of claims 1-4, further comprising 0.01 to 1.0 weight % zirconium (Zr).

6. A method, comprising die casting an electronic device component from an aluminum alloy, wherein the alloy comprises 4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01 to 1.0 weight % titanium (Ti), and 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

7. The method of claim 6, wherein the aluminum alloy is subjected to a casting temperature of 680 to 750°C during the die casting.

8. The method of claim 6 or 7, wherein the aluminum alloy is subjected to a casting pressure of 75 MPa during the die casting.

9. The method of claim 6, 7 or 8, wherein the aluminum alloy exhibits a tensile strength of 250 to 350 MPa.

10. The method of any of claims 6-9, wherein the aluminum alloy exhibits a yield strength of 150 to 250 MPa.

11. The method of any of claims 6-10, wherein the aluminum alloy is exhibits a break elongation of 2.0 to 4.5%.

12. The method of any of claims 6-11, wherein the electronic device component includes at least one of an external housing, an internal housing, and a bezel of the electronic device.

13. A method for manufacturing an aluminum alloy comprising:

   melting aluminum (Al) by heating the aluminum up to a temperature of 700°C to 800°C ;
   heating the melted aluminum (Al) to a temperature between 850°C and 900°C and adding silicon (Si) to the melted aluminum (Al) to produce a first intermediate alloy;
   heating up the first intermediate alloy to a temperature of 1200°C or less, and adding chromium (Cr), manganese (Mn), and titanium (Ti) to the first intermediate alloy to produce a second intermediate alloy;
   cooling the second intermediate alloy to a temperature between 700°C and 800°C and adding zinc (Zn), and tin (Sn) to the second intermediate alloy to produce the aluminum alloy,
   wherein the aluminum alloy comprises 4.0 to 10.0 weight % silicon (Si), 0.1 to 4.0 weight % magnesium (Mg), 0.1 to 1.0 weight % chromium (Cr), 0.05 to 1.0 weight % zinc (Zn), 0.05 to 1.0 weight % manganese (Mn), 0.01

to 1.0 weight % titanium (Ti), and 0.001 to 0.5 weight % tin (Sn), and 81.5 to 95.689 weight % aluminum and at least one impurity.

14. The method of claim 13, further comprising adjusting the amount of the at least one impurity that is present in the alloy, wherein the at least one impurity includes at least one of copper (Cu), nickel (Ni), and iron (Fe),
wherein the copper (Cu) makes up at most 0.05 weight % of the alloy and the nickel (Ni) makes up at most .005 weight % of the alloy,
wherein the iron (Fe) makes up at most 0.3 weight % of the alloy.

15. The method of claim 13 or 14, further comprising adding zirconium (Zn) to the first intermediate alloy, wherein the aluminum alloy further comprises 0.01 to 1.0 weight % zirconium (Zr).

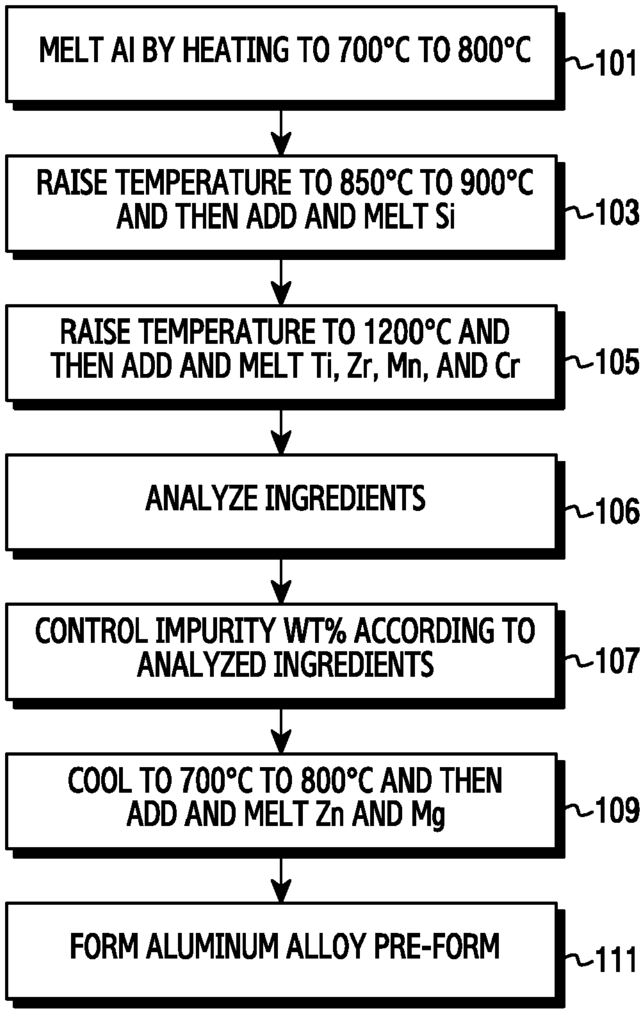
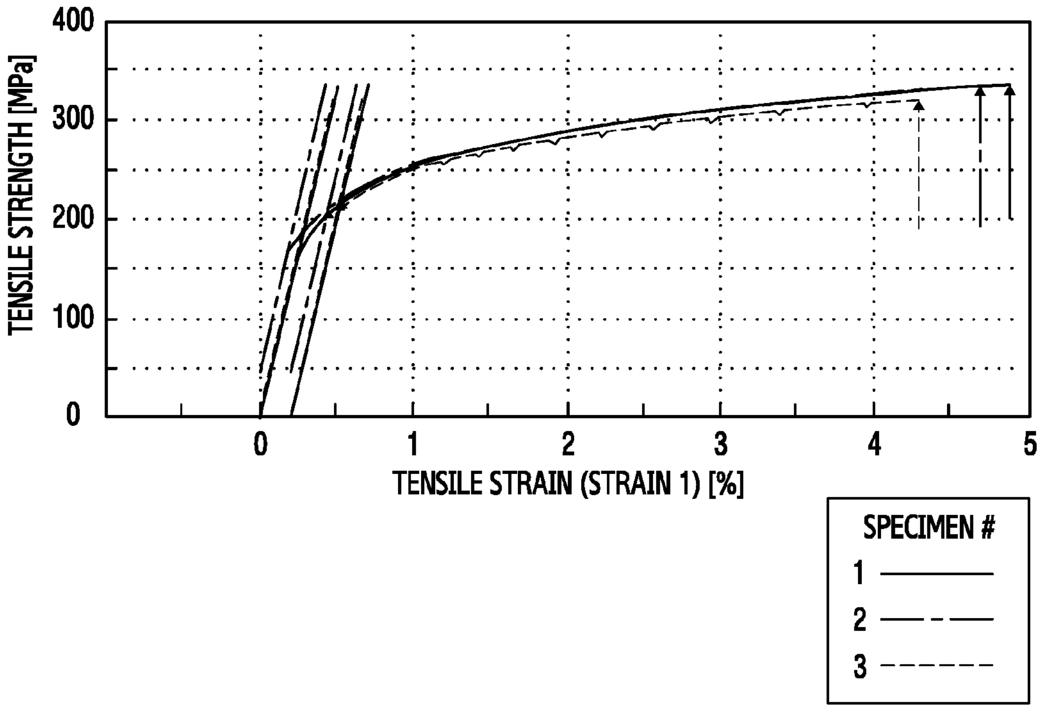

MELT Al BY HEATING TO 700°C TO 800°C
101
RAISE TEMPERATURE TO 850°C TO 900°C AND THEN ADD AND MELT Si
103
RAISE TEMPERATURE TO 1200°C AND THEN ADD AND MELT Ti, Zr, Mn, AND Cr
105
ANALYZE INGREDIENTS
106
CONTROL IMPURITY WT% ACCORDING TO ANALYZED INGREDIENTS
107
COOL TO 700°C TO 800°C AND THEN ADD AND MELT Zn AND Mg
109
FORM ALUMINUM ALLOY PRE-FORM
111

FIG.1



	S33	YIELD STRENGTH (offset 0.2%) [MPa]	TENSILE STRENGTH (MAXIMUM LOAD) [MPa]	SPECIFIC GRAVITY	TENSILE STRAIN (MAXIMUM LOAD) [%]	TENSILE STRENGTH (AT FAILURE) [MPa]	TENSILE STRAIN(AT FAILURE) (%)
1	S33	210.98	333.15		4.67	333.15	4.67
2	S33	211.12	320.66		4.26	320.59	4.27
3	S33	216.29	335.22		4.88	335.22	4.88
MAXIMUM VALUE		216.29	335.22		4.88	335.22	4.88
MINIMUM VALUE		210.98	320.66		4.26	320.59	4.27
MEAN		212.80	329.68		4.60	329.65	4.61
STANDARD DEVIATION		3.02486	7.87902		0.31226	7.91459	0.30702

	FAILURE LOAD [kN]	MAXIMUM LOAD [kN]	YIELD STRAIN (offset 0.2%) [%]	ELONGATION POSITION MAXIMUM LOAD [mm]	YOUNG'S MODULUS (METAL MATRIX) [MPa]	YOUNG'S MODULUS (AUTOMATIC) [MPa]	NOTE
1	6.35	6.35	0.45	1.97052	68002.85462	22795.92705	
2	6.11	6.11	0.51	1.85978	67330.30689	30310.38607	
3	6.39	6.39	0.53	2.00052	66702.73757	27809.17713	
MAXIMUM VALUE	6.39	6.39	0.53	2.00052	68002.85462	30310.38607	
MINIMUM VALUE	6.11	6.11	0.45	1.85978	66702.73757	22795.92705	
MEAN	6.28	6.28	0.49	1.94361	67345.29969	26971.83008	
STANDARD DEVIATION	0.15084	0.15016	0.04	0.07413	650.18818	3826.56976	

FIG.2

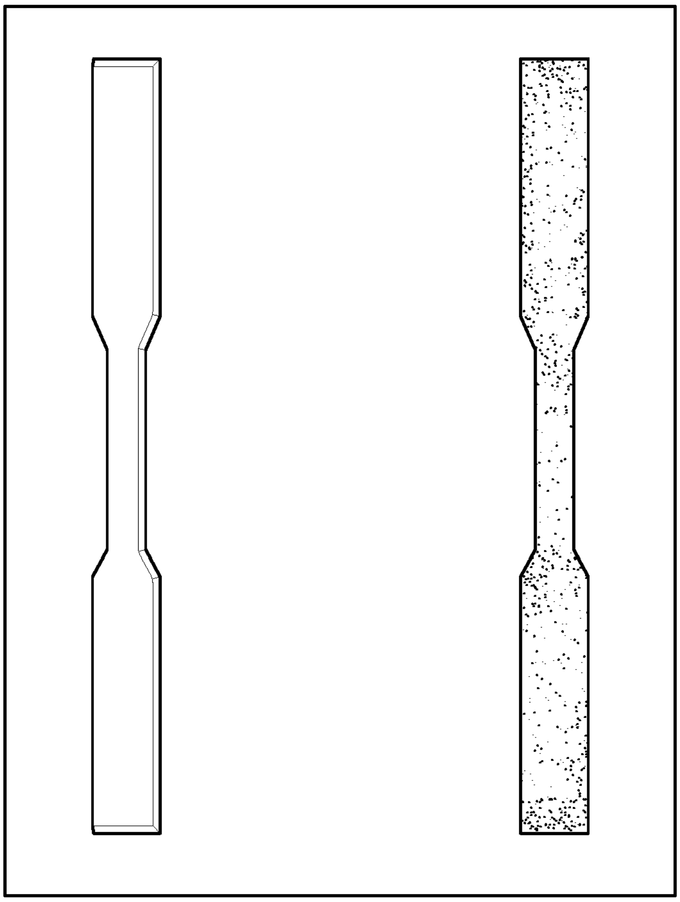


FIG.3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3486

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 2012/138767 A2 (EMERSON CLIMATE TECHNOLOGIES [US]; WILLIAMSON WARREN G [US]) 11 October 2012 (2012-10-11) * paragraph [0034] - paragraph [0046] *	1-15	
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	20 January 2016	Liu, Yonghe

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons
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