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(54) ALUMINUM ALLOY, PREPARATION METHOD THEREFOR AND APPLICATION THEREOF

(57) An aluminum alloy and a preparation method and application thereof are provided. The aluminum alloy includes, in percentages by weight: 9%-11% of Si, 0.001%-0.2% of Mg, 0.3%-0.7% of Fe, 0.003%-0.04% of Sr, 0.003%-0.03% of B, 0.001%-0.2% of Zn, 0.001%-0.1% of Cu, 0.001%-0.09% of Mn, less than 0.05% of Cr, 0.002%-0.05% of Ga, 0.001%-0.01% of Mo, and the balance of aluminum and other elements, wherein a total amount of the other elements is lower than 0.1%.

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Description

FIELD

[0001] The present disclosure relates to the field of aluminum alloy technologies, and specifically to an aluminum alloy and a preparation method and application thereof.

BACKGROUND

[0002] Die casting is a precision casting process that uses high pressure to force a metal molten fluid into a complexly shaped metal die. Die castings formed by die casting have a very small dimensional tolerance and high surface precision. In most cases, the die castings can be assembled and applied without the need for turning. Die casting of aluminum alloys has high requirements for mechanical properties of aluminum alloy materials, such as yield strength, tensile strength, elongation rate, flowability of the melt, etc.

[0003] For die casting of existing die-cast aluminum alloy materials, the thermal conductivity of the material often needs to be sacrificed under the conditions of comprehensively considering the properties of the material in various aspects, such as yield strength, tensile strength, elongation rate and other mechanical properties. As a result, the heat dissipation performance of existing die-cast aluminum alloys when used as a heat dissipating material decreases.

SUMMARY

[0004] To solve the problem that existing aluminum alloys cannot simultaneously meet the requirements on mechanical properties and heat dissipation, the present disclosure provides an aluminum alloy and a preparation method and application thereof.

[0005] To solve the above technical problems, the following technical schemes are employed in the present disclosure.

[0006] In one aspect, the present disclosure provides an aluminum alloy, including, in percentages by weight: 9%-11% of Si, 0.001%-0.2% of Mg, 0.3%-0.7% of Fe, 0.003%-0.04% of Sr, 0.003%-0.03% of B, 0.001%-0.2% of Zn, 0.001%-0.1% of Cu, 0.001%-0.09% of Mn, less than 0.05% of Cr, 0.002%-0.05% of Ga, 0.001%-0.01% of Mo, and the balance of aluminum and other elements, where a total amount of the other elements is lower than 0.1%.

[0007] Optionally, a content of Cr is $0.002\% \leq Cr < 0.05\%$.

[0008] Optionally, a weight ratio of Sr and B is (1-1.6):1.

[0009] Optionally, a weight ratio of Sr, B and Ga is (1-2):1:(1.5-2).

[0010] Optionally, a weight ratio of Si, Fe, Mn and Mg is (19-16):1:(0.1-0.13):(0.1-0.14).

[0011] Optionally, a weight ratio of Fe and Mo is 1:(0.002-0.008).

[0012] Optionally, the other elements include one or more of Pb, Bi, or Sb.

[0013] Optionally, a yield strength of the aluminum alloy is 140-170 MPa, a tensile strength of the aluminum alloy is 220-300 MPa, an elongation rate of the aluminum alloy is 7%-15%, and a thermal conductivity of the aluminum alloy is 170-177 W/(k*m).

[0014] In another aspect, the present disclosure further provides a method for preparing the aluminum alloy described above, including: weighing required amounts of raw materials according to a ratio of elements in the aluminum alloy; adding the raw materials to a smelting furnace for smelting to obtain a molten solution; casting the molten solution after slag removal and refinement and degassing treatment to obtain an aluminum alloy ingot; and die-casting the aluminum alloy ingot.

[0015] Optionally, the method further includes: performing artificial aging treatment on the aluminum alloy ingot.

[0016] Optionally, a treatment temperature of the artificial aging treatment is 320-330°C and a treatment time of the artificial aging treatment is 3-4 h.

[0017] Optionally, a yield strength of the aluminum alloy after the artificial aging treatment is 100-120 MPa, a tensile strength of the aluminum alloy after the artificial aging treatment is 220-241 MPa, an elongation rate of the aluminum alloy after the artificial aging treatment is 8%-15%, and a thermal conductivity of the aluminum alloy after the artificial aging treatment is 191-199 W/(k*m).

[0018] In another aspect, the present disclosure also provides an application of the aluminum alloy described above on a radiator.

[0019] In yet another aspect, the present disclosure also provides a radiator, where the radiator is at least partially formed of the aluminum alloy described above.

[0020] According to the aluminum alloy provided in the present disclosure, by adjusting and controlling the ratio of elements in the aluminum alloy, the aluminum alloy has a high yield strength, tensile strength and elongation rate, and has a high thermal conductivity and excellent flowability without sacrificing various mechanical properties. In addition, the aluminum alloy has low process requirements and good process adaptability.

DETAILED DESCRIPTION

[0021] To make the technical problem to be solved, the technical solution, and the beneficial effects of the present disclosure clearer, the present disclosure is described in further detail with reference to examples. It should be understood that the specific embodiments described herein are merely used for explaining the present disclosure, and are not intended to limit the present disclosure.

[0022] In one aspect, the present disclosure provides an aluminum alloy, including, in percentages by weight: 9%-11% of Si, 0.001%-0.2% of Mg, 0.3%-0.7% of Fe, 0.003%-0.04% of Sr, 0.003%-0.03% of B, 0.001%-0.2% of Zn, 0.001%-0.1% of Cu, 0.001%-0.09% of Mn, less than 0.05% of Cr, 0.002%-0.05% of Ga, 0.001%-0.01% of Mo, and the balance of aluminum and other elements, where a total amount of the other elements is lower than 0.1%. In other words, the composition of the aluminum alloy is as follows in percentages by weight: the content of Si is 9%-11%, the content of Mg is 0.001%-0.2%, the content of Fe is 0.3%-0.7%, the content of Sr is 0.003%-0.04%, the content of B is 0.003%-0.03%, the content of Zn is 0.001%-0.2%, the content of Cu is 0.001%-0.1%, the content of Mn is 0.001%-0.09%, the content of Cr is <0.05%, the content of Ga is 0.002%-0.05%, the content of Mo is 0.001%-0.01%, and the balance is aluminum and other elements, where a total amount of the other elements is lower than 0.1%.

[0023] In some embodiments, the content of Si is 9.4%, 9.5%, 9.7%, or 9.8%, the content of Mg is 0.05%, 0.07%, 0.09%, 0.11%, 0.15%, or 0.19%, the content of Fe is 0.3%, 0.32%, 0.43%, or 0.52%, the content of Sr is 0.005%, 0.01%, 0.011%, 0.015%, 0.021%, or 0.025%, the content of B is 0.005%, 0.01%, 0.011%, 0.015%, 0.016%, or 0.019%, the content of Zn is 0.005%, 0.01%, 0.02%, 0.05%, 0.09%, 0.12%, or 0.17%, the content of Cu is 0.005%, 0.01%, 0.02%, 0.05%, or 0.09%, the content of Mn is 0.005%, 0.01%, 0.02%, 0.05%, or 0.09%, the content of Cr is 0.01%, 0.02%, 0.03%, or 0.05%, the content of Ga is 0.005%, 0.01%, 0.02%, or 0.03%, and the content of Mo is 0.003%, 0.005%, 0.006%, or 0.009%.

[0024] In some embodiments, in the aluminum alloy, the content of Cu is 0.001%-0.1%, and the content of Mn is 0.001%-0.09%. A small amount of Cu and Mn in the aluminum alloy results in an improvement in the yield strength and thermal conductivity of the aluminum alloy material.

[0025] In some embodiments, the content of Cr is 0.002% ≤ Cr < 0.05%, for example, 0.002%, 0.01%, 0.02%, 0.03%, 0.04%, 0.05%, etc.

[0026] In some embodiments, a weight ratio of Sr and B is (1-1.6):1, for example, 1:1, 1.1:1, 1.2:1, 1.3:1, 1.4:1, 1.5:1, 1.6:1, etc.

[0027] The addition of Sr and B has a great improvement on the internal structure of the aluminum alloy, and has a good effect on the improvement of casting quality. The detailed mechanism is mainly as follows: Sr and B promote the formation of fine grains in the aluminum alloy, so that the coarse eutectic silicon becomes smaller and fibrous, the reaction between Al and B to generate AlB_2 can reduce the solid solubility of impurity elements, and the element B promotes the refinement of grains and optimizes the grains structure. When Sr > 0.04% and B > 0.03%, the mechanical properties of the aluminum alloy increase significantly, but the thermal conductivity decreases seriously. When Sr < 0.003% and B < 0.003%, the coarse eutectic silicon leads to a serious decrease in intercrystalline thermal conductivity, a decrease in the thermal conductivity of the aluminum alloy, and low mechanical properties. When Sr > 0.04% but B < 0.003% in the aluminum alloy, the mechanical properties of the aluminum alloy increase significantly and the thermal conductivity decreases significantly. Through adjustment and testing, the aluminum alloy has good performance when the contents of Sr and B added in the aluminum alloy satisfy 0.003% < Sr < 0.04%, 0.003% < B < 0.03%, and Sr:B = 1:1-1.6:1.

[0028] In some embodiments, a weight ratio of Sr, B, and Ga is (1-2):1:(1.5-2), for example, 1:1:1.5, 1.5:1:1.5, 2:1:1.5, 1:1:2, 1.5:1:2, 2:1:2, etc.

[0029] On the basis of adding Sr and B, the addition of the element Ga can increase the nucleation rate and decrease the speed of nucleus growth, promoting grain refinement, improving mechanical properties, optimizing the intercrystalline structure, improving the thermal conductivity, and improving the strength. When Ga > 0.05%, the mechanical properties of the aluminum alloy drop sharply. The addition of the element Ga can significantly improve the mechanical properties of the aluminum alloy after thermal treatment. When the content of Ga is 0.002%-0.05%, the yield strength of the aluminum alloy after thermal treatment at 320°C may be maintained between 100-120 Mpa. The yield strength of the aluminum alloy after thermal treatment under the same conditions is only 95 Mpa by relying on the deteriorating agents Sr and B alone.

[0030] Through adjustment, the aluminum alloy exhibits good performance, when the content of Sr is 0.003%-0.04%, the content of B is 0.003%-0.03%, the content of Ga is 0.002%-0.05%, and the contents of the elements have a relationship of Sr:B:Ga = (1-2):1:(1.5-2). Therefore, a high thermal conductivity is ensured while ensuring the mechanical properties in the F state. After artificial aging at 320°C for 3 h, the thermal conductivity of the aluminum alloy is greatly increased, meanwhile, the mechanical properties do not decrease too much, and can be kept between 100-120 Mpa.

[0031] In some embodiments, a weight ratio of Si, Fe, Mn, and Mg is (19-16):1:(0.1-0.13):(0.1-0.14), for example, 19:1:0.1:0.1, 18:1:0.1:0.1, 17:1:0.1:0.1, 16:1:0.1:0.1, 16:1:0.12:0.1, 16:1:0.13:0.1, 16:1:0.1:0.12, 16:1:0.1:0.14, etc.

[0032] The addition of Si in the above ratio range not only ensures good flowability and moldability of the aluminum alloy, but also ensures good mechanical properties without sacrificing the thermal conductivity of the aluminum alloy. After artificial aging, the thermal conductivity may reach 198 W/(m*K). When the Si content is too low, the flowability of the aluminum alloy is poor, making it not easy to form complex thin-walled members, and the mechanical properties are low. When the Si content is too high, the thermal conductivity of the aluminum alloy is low. The thermal conductivity of the aluminum alloy is low when the Fe content exceeds the above range. Under the condition that the aluminum alloy has good flowability and anti-sticking performance and excellent mechanical properties, the weight ratio of Si and Fe is (19-16):1, and in this case, the Fe content is strictly controlled to be within the range of 0.3%-0.7%.

[0033] A small amount of Mg and Fe in the aluminum alloy can react with Si to form Mg_2Si and $Al_{12}Fe_3Si$, not only increases the strength of the aluminum alloy, but also has a positive effect on the thermal treatment, i.e., it also can improve the thermal conductivity of the aluminum alloy. The thermal conductivity of the aluminum alloy after artificial aging is greatly improved, without reducing the mechanical properties too much.

[0034] The relationship between the contents of Fe and Mn also affects the thermal conductivity and anti-sticking performance of the aluminum alloy. When the content of Fe is in the range of 0.3%-0.7%, the content of Mn satisfies $0.001\% < Mn < 0.09\%$, and the weight ratio of Fe and Mn satisfies 1:(0.1-0.13), the elements Fe and Mn can reduce the reaction of the aluminum alloy with the mold during die casting, and reduce the anti-sticking performance of the aluminum alloy, allowing the aluminum alloy to be used to form more complex and precision devices. When the content of Mn is too high, the joint effect of Mn and Fe has great impact on the thermal conductivity of the aluminum alloy, and the anti-sticking performance of the aluminum alloy is not improved.

[0035] On the other hand, although adding an appropriate amount of Fe and Mn can reduce the mold sticking phenomenon during die casting of the aluminum alloy, the needle-shaped ferrite will block the motion such as slippage of the material on the crystal surface, which not only affects the flowability of the aluminum alloy, but also reduces the intercrystalline thermal conductivity. The reaction of Mn with Al to form Al_6Mn also reduces the machining performance of the aluminum alloy. Therefore, when Mg, Fe, Si and Mn are added together in the above ratio, the granular $Al_{15}(FeMn)_3Si_2$ formed in the aluminum alloy can serve as a heterogeneous nucleation substrate for the aging-strengthened phase Mg_2Si, promoting Mg_2Si phase precipitation, and also improving the solid solubility of Fe, so that the aluminum alloy has a good plasticity.

[0036] In some embodiments, a weight ratio of Fe and Mo is 1:(0.002-0.008), for example, 1:0.002, 1:0.003, 1:0.004, 1:0.005, 1:0.006, 1:0.007, 1:0.008, etc.

[0037] When the content of Mo is 0.001%-0.01%, the hardness and mechanical properties of the aluminum alloy are significantly improved. The binding of Fe to Mo effectively improves the strength and hardness of the Al-Fe matrix. A too high Mo content leads to a decrease in the toughness of the aluminum alloy. In addition, the element Mo effectively improves the number of solute atoms of the solid solution, and improves the stability of the beta tissue in the aluminum alloy tissue. The resistance of the misalignment motion is increased due to the solute atom-dislocation interaction, so that the microhardness of the aluminum alloy increases with the increase of the content of the element Mo.

[0038] In some embodiments, the other elements include one or more of Pb, Bi, or Sb.

[0039] In some embodiments, a yield strength of the aluminum alloy is 140-170 MPa (for example, 140 MPa, 145 MPa, 150 MPa, 155 MPa, 160 MPa, 165 MPa, 170 MPa, etc.), a tensile strength of the aluminum alloy is 220-280 MPa (for example, 220 MPa, 230 MPa, 240 MPa, 250 MPa, 260 MPa, 270 MPa, 280 MPa, etc.), an elongation rate of the aluminum alloy is 7%-15% (for example, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, etc.), and a thermal conductivity of the aluminum alloy is 170-177 W/(k*m) (for example, 170 W/(k*m), 171 W/(k*m), 172 W/(k*m), 173 W/(k*m), 174 W/(k*m), 175 W/(k*m), 176 W/(k*m), 177 W/(k*m), etc.).

[0040] It should be noted that, the above properties of the aluminum alloy are test parameters of the aluminum alloy before artificial aging.

[0041] In another aspect, the present disclosure further provides a method for preparing the aluminum alloy described above, including:

weighing required amounts of raw materials according to a ratio of elements in the aluminum alloy; adding the raw materials to a smelting furnace for smelting to obtain a molten solution; casting the molten solution after slag removal and refinement and degassing treatment to obtain an aluminum alloy ingot; and die-casting the aluminum alloy ingot. In other words, the method may include the following steps: weighing required amounts of raw materials according to a ratio of elements in the aluminum alloy, melting the raw materials in a smelting furnace, performing slag removal and refinement and degassing treatment and then casting to obtain an aluminum alloy ingot, and then die-casting the aluminum alloy ingot.

[0042] The raw materials include an aluminum-containing material, a Si-containing material, a Mg-containing material, a Fe-containing material, a Sr-containing material, a B-containing material, a Zn-containing material, a Cu-containing material, a Mn-containing material, a Cr-containing material, a Ga-containing material, and a Mo-containing material. In the present disclosure, the aluminum-containing material, the Si-containing material, the Mg-containing material, the Fe-containing material, the Sr-containing material, the B-containing material, the Zn-containing material, the Cu-containing material, the Mn-containing material, the Cr-containing material, the Ga-containing material, and the Mo-containing material may be materials capable of providing the various elements required for preparing the die-cast aluminum alloy of the present disclosure, and may be alloys containing the above elements or simple substances, as long as the components in the aluminum alloy obtained after smelting the added aluminum alloy raw materials are within the above ranges.

[0043] In some embodiments, the method further includes: performing artificial aging treatment on the aluminum alloy ingot. In some embodiments, a treatment temperature of the artificial aging treatment is 320-330°C (for example, 320°C, 321°C, 322°C, 323°C, 324°C, 325°C, 326°C, 327°C, 328°C, 329°C, 330°C, etc.), and a treatment time of the artificial aging treatment is 3-4 h (for example, 3 h, 3.5 h, 4 h, etc.).

[0044] In some embodiments, a yield strength of the aluminum alloy after the artificial aging treatment is 100-120 MPa (for example, 100 MPa, 105 MPa, 110 MPa, 115 MPa, 120 MPa, etc.), a tensile strength of the aluminum alloy after the artificial aging treatment is 220-241 MPa (220 MPa, 225 MPa, 230 MPa, 235 MPa, 240 MPa, etc.), an elongation rate of the aluminum alloy after the artificial aging treatment is 8%-15% (for example, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, etc.), and a thermal conductivity of the aluminum alloy after the artificial aging treatment is 191-199 W/(k*m) (for example, 191 W/(k*m), 192 W/(k*m), 193 W/(k*m), 194 W/(k*m), 195 W/(k*m), 196 W/(k*m), 197 W/(k*m), 198 W/(k*m), 199 W/(k*m), etc.).

[0045] Although the aluminum alloy after the artificial aging have a certain degree of decrease in yield strength and tensile strength, however its thermal conductivity increases with the increase of the treatment temperature.

[0046] In another aspect, the present disclosure also provides an application of the aluminum alloy described above on a radiator. In other words, the present disclosure provides a radiator. The radiator includes the aluminum alloy described above, or in other words, the radiator is at least partially formed of the aluminum alloy described above.

[0047] The application of the aluminum alloy on the radiator can effectively improve the heat dissipation effect of the radiator, and ensures that the radiator has good mechanical properties and can meet the various requirements of the die casting process.

[0048] The present disclosure is further described below with reference to examples.

Table 1

	Si	Mg	Fe	Sr	B	Zn	Cu	Mn	Cr	Ga	Mo	Inevitable impurities and Al
Example 1	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 2	9.6	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 3	11	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 4	10	0.06	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 5	10	0.08 4	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 6	9.5	0.07	0.5	0.015	0.01	0.02	0.05	0.05	0.002	0.018	0.003	Other impurities < 0.1
Example 7	10.4	0.07	0.65	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 8	10	0.07	0.6	0.01	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 9	10	0.07	0.6	0.02	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 10	10	0.07	0.6	0.01	0.005	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 11	10	0.07	0.6	0.02	0.02	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 12	10	0.07	0.6	0.015	0.01	0.002	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 13	10	0.07	0.6	0.015	0.01	0.2	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 14	10	0.07	0.6	0.015	0.01	0.02	0.003	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 15	10	0.07	0.6	0.015	0.01	0.02	0.09	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 16	10	0.07	0.6	0.015	0.01	0.02	0.05	0.06	0.002	0.018	0.003	Other impurities < 0.1
Example 17	10	0.07	0.6	0.015	0.01	0.02	0.05	0.078	0.002	0.018	0.003	Other impurities < 0.1
Example 18	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.001	0.018	0.003	Other impurities < 0.1
Example 19	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.03	0.018	0.003	Other impurities < 0.1
Example 20	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.015	0.003	Other impurities < 0.1
Example 21	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.02	0.003	Other impurities < 0.1
Example 22	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.0012	Other impurities < 0.1
Example 23	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.0048	Other impurities < 0.1
Example 24	10	0.07	0.6	0.005	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 25	10	0.07	0.6	0.03	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1

(continued)

	Si	Mg	Fe	Sr	B	Zn	Cu	Mn	Cr	Ga	Mo	Inevitable impurities and Al
Example 26	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.01	0.003	Other impurities < 0.1
Example 27	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.03	0.003	Other impurities < 0.1
Example 28	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0	0.018	0.003	Other impurities < 0.1
Example 29	9	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 30	10	0.07	0.5	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 31	10	0.07	0.6	0.015	0.01	0.02	0.05	0.04	0.002	0.018	0.003	Other impurities < 0.1
Example 32	10	0.07	0.6	0.015	0.01	0.02	0.05	0.09	0.002	0.018	0.003	Other impurities < 0.1
Example 33	10	0.04	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 34	10	0.1	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Example 35	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.006	Other impurities < 0.1
Example 36	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.001	Other impurities < 0.1
Comparative Example 1	7	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 2	11.5	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 3	10	0	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 4	10	0.6	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 5	10	0.07	0.05	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 6	10	0.07	0.8	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 7	10	0.07	0.6	0.001	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 8	10	0.07	0.6	0.05	0.01	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 9	10	0.07	0.6	0.015	0.001	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 10	10	0.07	0.6	0.015	0.04	0.02	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 11	10	0.07	0.6	0.015	0.01	0	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 12	10	0.07	0.6	0.015	0.01	0.3	0.05	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 13	10	0.07	0.6	0.015	0.01	0.02	0.3	0.07	0.002	0.018	0.003	Other impurities < 0.1
Comparative Example 14	10	0.07	0.6	0.015	0.01	0.02	0.05	0.25	0.002	0.018	0.003	Other impurities < 0.1

(continued)

	Si	Mg	Fe	Sr	B	Zn	Cu	Mn	Cr	Ga	Mo	Inevitable impurities and Al
Comparative Example 15	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.1	0.018	0.003	Other impurities < 0.1
Comparative Example 16	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.001	0.003	Other impurities < 0.1
Comparative Example 17	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.1	0.003	Other impurities < 0.1
Comparative Example 18	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0	Other impurities < 0.1
Comparative Example 19	10	0.07	0.6	0.015	0.01	0.02	0.05	0.07	0.002	0.018	0.03	Other impurities < 0.1

Example 1

[0049] This example is used to describe the aluminum alloy and the preparation method thereof disclosed in the present disclosure, including the following steps.

[0050] As shown in Table 1, the composition of the aluminum alloy is as follows in percentages by weight: The content of Si is 10%, the content of Mg is 0.05%, the content of Fe is 0.6%, the content of Sr is 0.015%, the content of B is 0.01%, the content of Zn is 0.02%, the content of Cu is 0.05%, the content of Mn is 0.07%, the content of Cr is 0.002%, the content of Ga is 0.02%, the content of Mo is 0.003%, and the balance is Al and inevitable impurities, where the content of the inevitable impurities is less than 0.1%. Weights of various intermediate alloys or elemental metals required were calculated according to the percentages by weight of the components of the aluminum alloy. Then the intermediate alloys or elemental metals were added to a smelting furnace for smelting. A slag removal agent was added to the molten metal for slag removal. A refining agent was added to the molten metal for refinement and degassing, followed by casting to obtain an aluminum alloy ingot.

Examples 2-36

[0051] Examples 2-36 are used to describe the aluminum alloy and the preparation method thereof disclosed in the present disclosure, and include most of the operations in Example 1. Differences are as follows:

Based on the aluminum alloy compositions corresponding to the Examples 2-36 shown in Table 1, weights of various intermediate alloys or elemental metals required were calculated according to the percentages by weight of the components of the aluminum alloy. Then the intermediate alloys or elemental metals were added to a smelting furnace for smelting. A slag removal agent was added to the molten metal for slag removal. A refining agent was added to the molten metal for refinement and degassing, followed by casting to obtain an aluminum alloy ingot.

Comparative Example 1

[0052] This comparative example is used to describe the aluminum alloy and the preparation method thereof disclosed in the present disclosure through comparison, including the following operations.

[0053] As shown in Table 1, the composition of the aluminum alloy is as follows in percentages by weight: The content of Si is 10%, the content of Mg is 0.07%, the content of Fe is 0.6%, the content of Sr is 0.015%, the content of B is 0.01%, the content of Zn is 0.02%, the content of Cu is 0.05%, the content of Mn is 0.07%, the content of Cr is 0.002%, the content of Ga is 0.018%, the content of Mo is 0.003%, and the balance is Al and inevitable impurities, where the content of the inevitable impurities is less than 0.1%. Weights of various intermediate alloys or elemental metals required were calculated according to the percentages by weight of the components of the aluminum alloy. Then the intermediate alloys or elemental metals were added to a smelting furnace for smelting. A slag removal agent was added to the molten metal for slag removal. A refining agent was added to the molten metal for refinement and degassing, followed by casting to obtain an aluminum alloy ingot.

Comparative Examples 2-19

[0054] Comparative Examples 2-19 are used to describe the aluminum alloy and the preparation method thereof disclosed in the present disclosure through comparison, and include most of the operations in Example 1. Differences are as follows:

Based on the aluminum alloy compositions corresponding to the Comparative Examples 2-19 shown in Table 1, weights of various intermediate alloys or elemental metals required were calculated according to the percentages by weight of the components of the aluminum alloy. Then the intermediate alloys or elemental metals were added to a smelting furnace for smelting. A slag removal agent was added to the molten metal for slag removal. A refining agent was added to the molten metal for refinement and degassing, followed by casting to obtain an aluminum alloy ingot.

Performance test

[0055] The following performance tests were performed on the aluminum alloys prepared in Examples 1-36 and Comparative Examples 1-19:

Tensile strength test:

[0056] The tensile strength, yield strength and elongation rate of the material were tested with reference to "GB/T 228.1-2010 Metallic materials - Tensile testing - Part 1: Method of test at room temperature".

Thermal conductivity test:

[0057] The aluminum alloy was made into a cast thermally conductive round sheet of ϕ 12.7*3 mm. A graphite coating is uniformly sprayed on both sides of the sample to be tested. The treated sample was placed into a laser flash apparatus for testing. A laser thermal conductivity test was carried out in accordance with ASTM E1461 "Standard Test Method for Thermal Diffusivity of Solids by the Flash Method".

[0058] The aluminum alloys prepared in Examples 1-36 and Comparative Examples 1-19 were subjected to artificial aging treatment at 320°C for 3 h. The above performance tests were carried out on the aluminum alloys after the artificial aging treatment.

[0059] The test results obtained are shown in Table 2.

Table 2

	F state				320°C/3 h			
	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)
Example 1	143	296	11.25	175	117	240	13.68	198
Example 2	147	294	11.5	173	107	236	12.6	195
Example 3	144	288	12.04	172	118	240	13.5	198.4
Example 4	141	284	14.52	172	110	228	13.89	195
Example 5	144	285	9.7	170	117	229	14	194
Example 6	140	297	10.32	170	116	238	11.95	194
Example 7	150	299	11.02	173	118	241	12.93	195
Example 8	140	296	11.31	170	109	237	13.1	193
Example 9	148	294	11.95	174	116	239	12.1	196
Example 10	141	296	11.31	173	110	237	13.1	191
Example 11	148	293	11.95	174	116	239	12.1	196
Example 12	135	278	9	171	105	233	9.3	193
Example 13	150	300	10.75	170	118	240	12.1	188
Example 14	141	293	9.25	172	106	235	14.1	193
Example 15	147	297	10.35	170	107	240	13.68	194
Example 16	148	289	10.6	170	112	236	9.69	193
Example 17	145	300	12.26	171	117	238	11.63	193
Example 18	140	277	10.23	174	109	223	12.3	191
Example 19	149	290	14.13	173	118	240	13.9	194
Example 20	135	279	15	172	104	220	14	191
Example 21	143	280	12.68	170	115	230	10.2	193
Example 22	138	273	13	170	114	230	14.7	196
Example 23	143	296	11	173	118	240	13.68	195

(continued)

	F state				320°C/3 h			
	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)
Example 24	142	296	11.11	170	110	237	13.05	191
Example 25	150	298	12.3	171	118	238	9.96	191
Example 26	145	287	13.1	172	110	233	10.26	192
Example 27	146	286	11.5	170	109	223	10.5	191
Example 28	142	280	9.97	170	104	221	11.5	193
Example 29	144	293	10.31	172	109	224	12.9	191
Example 30	140	285	9.77	171	106	226	12.45	191
Example 31	146	283	13.2	173	111	227	12.12	191
Example 32	143	288	10.8	170	110	223	9.9	191
Example 33	148	289	12.56	173	109	220	10.1	192
Example 34	147	299	9.9	170	119	234	12.1	191
Example 35	143	289	9.8	173	117	238	9.75	192
Example 36	149	300	12.24	172	114	221	14.3	192
Comparative Example 1	127	270	10.95	168	95	210	13.68	185
Comparative Example 2	149	299	11.9	166	119	241	12.69	187
Comparative Example 3	137	268	11.25	168	97	203	10.2	180
Comparative Example 4	140	287	8.56	155	130	244	9.75	170
Comparative Example 5	156	312	10	145	130	245	9.87	179

(continued)

	F state				320°C/3 h			
	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)
Comparative Example 6	161	311	9.22	160	121	246	11.16	181
Comparative Example 7	142	293	10.1	147	110	242	13.05	178
Comparative Example 8	145	300	12.36	168	117	241	11.63	186
Comparative Example 9	140	296	10.8	166	112	236	10.1	179
Comparative Example 10	145	302	12.36	170	120	241	11.63	186
Comparative Example 11	135	278	9	140	105	233	9.3	178
Comparative Example 12	160	319	12.32	145	129	242	12.7	179
Comparative Example 13	144	296	10.65	158	109	231	13.7	183
Comparative Example 14	150	307	10.7	155	120	240	11.12	177
Comparative Example 15	153	311	11.27	169	128	238	10.19	179
Comparative Example 16	133	279	15.1	168	96	217	14	182
Comparative Example 17	128	273	12.4	166	109	213	10.5	183
Comparative Example 18	139	268	12.4	170	106	212	11.53	187

(continued)

	F state				320°C/3 h			
	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)	Yield strength (MPa)	Tensile strength (MPa)	Elongation rate	Thermal conductivity of ingot W/(m*K)
Comparative Example 19	146	311	9.86	167	127	229	11.19	183

[0060] From the test results in Table 1, it can be seen that compared with the aluminum alloys of which the element contents are not within the ranges provided in the present disclosure, the aluminum alloy provided in the present disclosure has better mechanical strength, can meet the requirements of the die casting process, and has a better thermal conductivity, elongation rate, and die-casting formability. In particular, the aluminum alloy provided in the present disclosure has an excellent thermal conductivity and is especially suitable for use in heat dissipation materials.

[0061] The foregoing descriptions are merely optional embodiments of the present disclosure, but are not intended to limit the present disclosure. Any modification, equivalent replacement, or improvement made within the spirit and principle of the present disclosure shall fall within the protection scope of the present disclosure.

Claims

1. An aluminum alloy, comprising, in percentages by weight:
9%-11% of Si, 0.001%-0.2% of Mg, 0.3%-0.7% of Fe, 0.003%-0.04% of Sr, 0.003%-0.03% of B, 0.001%-0.2% of Zn, 0.001%-0.1% of Cu, 0.001%-0.09% of Mn, less than 0.05% of Cr, 0.002%-0.05% of Ga, 0.001%-0.01% of Mo, and the balance of aluminum and other elements, wherein a total amount of the other elements is lower than 0.1%.

2. The aluminum alloy according to claim 1, wherein a content of Cr is $0.002\% \leq Cr < 0.05\%$.

3. The aluminum alloy according to claim 1 or 2, wherein a weight ratio of Sr and B is (1-1.6):1.

4. The aluminum alloy according to any one of claims 1 to 3, wherein a weight ratio of Sr, B and Ga is (1-2):1:(1.5-2).

5. The aluminum alloy according to any one of claims 1 to 4, wherein a weight ratio of Si, Fe, Mn and Mg is (19-16):1:(0.1-0.13):(0.1-0.14).

6. The aluminum alloy according to any one of claims 1 to 5, wherein a weight ratio of Fe and Mo is 1:(0.002-0.008).

7. The aluminum alloy according to any one of claims 1 to 6, wherein the other elements comprise one or more of Pb, Bi, or Sb.

8. The aluminum alloy according to any one of claims 1 to 7, wherein a yield strength of the aluminum alloy is 140-170 MPa, a tensile strength of the aluminum alloy is 220-300 MPa, an elongation rate of the aluminum alloy is 7%-15%, and a thermal conductivity of the aluminum alloy is 170-177 W/(k*m).

9. A method for preparing the aluminum alloy according to any one of claims 1 to 8, comprising:

   weighing required amounts of raw materials according to a ratio of elements in the aluminum alloy;
   adding the raw materials to a smelting furnace for smelting to obtain a molten solution;
   casting the molten solution after slag removal and refinement and degassing treatment to obtain an aluminum alloy ingot; and
   die-casting the aluminum alloy ingot.

10. The method for preparing the aluminum alloy according to claim 9, wherein the method further comprises: performing artificial aging treatment on the aluminum alloy ingot.

11. The method for preparing the aluminum alloy according to claim 10, wherein a treatment temperature of the artificial aging treatment is 320-330°C and a treatment time of the artificial aging treatment is 3-4 h.

12. The method for preparing the aluminum alloy according to claim 10 or 11, wherein a yield strength of the aluminum alloy after the artificial aging treatment is 100-120 MPa, a tensile strength of the aluminum alloy after the artificial aging treatment is 220-241 MPa, an elongation rate of the aluminum alloy after the artificial aging treatment is 8%-15%, and a thermal conductivity of the aluminum alloy after the artificial aging treatment is 191-199 W/(k*m).

13. An application of the aluminum alloy according to any one of claims 1 to 8 on a radiator.

14. A radiator, wherein the radiator is at least partially formed of the aluminum alloy according to any one of claims 1 to 8.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/097984

A. CLASSIFICATION OF SUBJECT MATTER

C22C 21/02(2006.01)i； C22C 1/02(2006.01)i； C22F 1/043(2006.01)i； F28F 21/08(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; C22F; F28F

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

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

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT: 铝合金, 硅, 镁, 铜, 锶, 镓, 铬, 硼, 钼, 锰, 散热, 人工时效, 硬度, 熔炼, 除渣, 压铸, 浇铸, 除气, aluminium alloy, Si, silicon, magnesium, Mg, cuprum, copper, Cu, strontium, Sr, chrom+, Cr, boron, B, molybdenum, Mo, manganese, Mn, heat dissipation, artificial seasoning, rigidity, fusion, clinker removal, die casting, mould, degassing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 111101029 A (FNA GROUP INC.) 05 May 2020 (2020-05-05) description paragraphs 0004, 0006	1-8, 13, 14
X	CN 104616897 A (SHOWA DENKO K. K.) 13 May 2015 (2015-05-13) description, paragraphs 0010-0013	1-8, 13, 14
Y	CN 111101029 A (FNA GROUP INC.) 05 May 2020 (2020-05-05) description paragraphs 0004, 0006	9-12
Y	CN 104616897 A (SHOWA DENKO K. K.) 13 May 2015 (2015-05-13) description, paragraphs 0010-0013	9-12
Y	CN 103572111 A (JIANGSU JIANGXU CASTING GROUP) 12 February 2014 (2014-02-12) description, paragraph 0003	9-12
A	CN 111041302 A (ZHANG, Zingyi) 21 April 2020 (2020-04-21) entire document	1-14
A	CN 106282702 A (MAANSHAN SHUNFA MACHINERY MANUFACTURING CO., LTD.) 04 January 2017 (2017-01-04) entire document	1-14

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

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Date of the actual completion of the international search	Date of mailing of the international search report
29 July 2021	**19 August 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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		HK 1208956 A1	08 June 2018
		HK 1208956 A0	18 March 2016
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Form PCT/ISA/210 (patent family annex) (January 2015)