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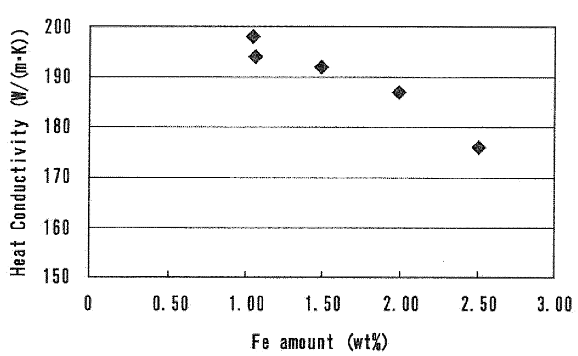
(54) HIGHLY HEAT CONDUCTIVE ALUMINUM ALLOY FOR DIE CASTING, ALUMINUM ALLOY DIE CAST PRODUCT USING SAME, AND HEATSINK USING SAME

(57) A highly heat conductive aluminum alloy for die casting, having excellent castability and capable of obtaining a heat conductivity not lower than 170 W/(m·K) without having heat treatment performed thereon, and an aluminum alloy die cast product using the same alloy have been developed. Specifically, the highly heat conductive aluminum alloy for die casting contains Cu by not more than 2.30 wt%, Si by not more than 1.50 wt%, and Fe by 1.20 to 2.60 wt%, and a remaining portion thereof is Al and unavoidable impurities.

FIG. 3



EP 2 871 250 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an aluminum alloy for die casting, which is used for computers and electronic devices and is optimal as a member requiring heat dissipation characteristic such as housings for housing electronic components, heat-receiving blocks, or heatsinks, and an aluminum alloy die cast product using the alloy.

BACKGROUND ART

[0002] In an electronic device of the present time, since more heat is generated from the electronic device because of miniaturization, acceleration, and densification thereof, it has become essential to cool electronic components themselves housed in the device in order to sustain the performance of the electronic device. Thus, high heat conductivity is required for heat dissipation members having the electronic components mounted thereon.

[0003] Conventionally, for this type of heat dissipation members such as, for example, a heat dissipation member having a large number of fins disposed on one surface or both surfaces thereof in a protruding manner, extrusion molding articles formed from aluminum alloys for wrought products or pure aluminum having excellent heat conduction (but having very inferior castability) have been used. Although users have been cutting those into required sizes and machining portions thereof corresponding to positions where electronic components are attached, the processing cost increases when the amount to be processed becomes enormous, generating a problem of high cost.

[0004] As a response, the usage of pressure casting technology such as die casting has been discussed for manufacturing the heat dissipation member. However, a conventional aluminum alloy for die casting such as, for example, ADC12 specified by Japanese Industrial Standards JIS H5302 has a very small heat conductivity of less than half of that of pure aluminum (approximately 250 W/(m·K)), and cannot satisfy the heat conducting property that is required.

[0005] As a solution for such problem, Patent Literature 1 described below discloses a technology of preparing main components of Si, Mn, Fe, and Mg in a chemical composition of an aluminum alloy to be in a predetermined range. With this technology, an aluminum alloy for pressure casting, which has a heat conductivity not lower than 150 W/(m·K) and can be used as a heat dissipation member instead of pure aluminum, and an aluminum alloy casting product using the same alloy are provided.

CITATION LIST

[PATENT LITERATURE]

[0006] [PTL 1] Japanese Patent No. 419370

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007] By using the aluminum alloy for heat casting set forth in Patent Literature 1 described above, heat dissipation members can be mass produced through pressure casting.

[0008] However, in recent years, for heat dissipation members manufactured through pressure casting described above, usage of an alloy having a higher heat conductivity of not lower than 170 W/(m·K) is desired for some parts. When die casting is performed using the alloy set forth in Patent Literature 1 described above, it has been difficult to obtain a heat conductivity not lower than 170 W/(m·K) without having heat treatment performed thereon.

[0009] Thus, a main object of the invention is to develop a highly heat conductive aluminum alloy for die casting having excellent castability and capable of obtaining a heat conductivity not lower than 170 W/(m·K) without having heat treatment performed thereon, and an aluminum alloy die cast product using the same alloy.

SOLUTION TO THE PROBLEMS

[0010] A first aspect of the present invention is a highly heat conductive aluminum alloy for die casting, having a feature of "containing Cu by not more than 2.30 wt%, Si by not more than 1.50 wt%, and Fe by 1.20 to 2.60 wt%, a remaining portion thereof being Al and unavoidable impurities."

[0011] Since the aluminum alloy of the present invention is to be used mainly as a heat dissipation member, it is important to have not only excellent castability and soldering resistance, but also excellent heat conductivity. Since the contain amount of the main components of Cu, Si, and Fe is in the above described range, the three requirements of castability, soldering resistance, and heat conductivity are satisfied.

[0012] Furthermore, a second aspect of the present invention is an aluminum alloy die cast product obtained through die casting the aluminum alloy according to the first aspect.

[0013] The aluminum alloy die cast product obtained through die casting the aluminum alloy of the first aspect has a heat conductivity of not lower than 170 W/(m·K) even without having heat treatment performed thereon.

[0014] Furthermore, a third aspect of the present invention is a heatsink obtained through die casting the aluminum alloy according to the first aspect.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0015] According to the present invention, since the main components of Cu, Si, and Fe are in required ranges; a highly heat conductive aluminum alloy for die casting satisfying the requirement of heat conductivity with a heat conductivity of not lower than 170 W/(m·K) without compromising castability and soldering resistance at the time of die casting molding, and an aluminum alloy die cast product can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

[FIG. 1] FIG. 1 is a graph showing a change in the heat conductivity with respect to the contained amount of Cu in Examples and Comparative Examples of the present invention.

[FIG. 2] FIG. 2 is a graph showing a change in the heat conductivity with respect to the contained amount of Si in Examples and Comparative Examples of the present invention.

[FIG. 3] FIG. 3 is a graph showing a change in the heat conductivity with respect to the contained amount of Fe in Examples and Comparative Examples of the present invention.

DESCRIPTION OF EMBODIMENTS

[0017] In the following, embodiments of the present invention will be described in detail by showing specific examples.

[0018] A highly heat conductive aluminum alloy for die casting (hereinafter, also referred to simply as "aluminum alloy" or "alloy") of the present invention mainly contains Cu (copper) by not more than 2.30 wt%, Si (silicon) by not more than 1.50 wt%, and Fe (iron) by 1.20 to 2.60 wt%, and a remaining portion thereof is Al (aluminum) and unavoidable impurities. In the following, characteristics of each of the elements will be described.

[0019] Cu (copper) improves tensile strength, 0.2%-yield strength, and hardness of an aluminum alloy, but slightly reduces the heat conductivity of the alloy. However, when the content ratio of Cu with respect to the whole aluminum alloy is not more than 2.30 wt%, a heat conductivity of not lower than 170 W/(m·K) can be obtained. Thus, in the aluminum alloy of the present invention, Cu is contained by 2.30 wt% at maximum in accordance with the required mechanical characteristics. It should be noted that when strength is not required for the aluminum alloy and heat conductivity is to be prioritized, the content ratio of Cu may be zero.

[0020] Si (silicon) is an element that improves tensile strength, 0.2%-yield strength, and hardness of an aluminum alloy, and improves fluidity when the aluminum alloy is melted and die-casted, but reduces the heat conductivity of the alloy. However, when the content ratio of Si with respect to the whole aluminum alloy is not more than 1.50 wt%, a heat conductivity of not lower than 170 W/(m·K) can be obtained. Thus, in the aluminum alloy of the present invention, Si is contained by 1.50 wt% at maximum in accordance with the required mechanical characteristics. It should be noted that when strength is not required for the aluminum alloy and heat conductivity is to be prioritized, the content ratio of Si may be zero.

[0021] Fe (iron) has an effect of preventing inferior release caused by soldering during die casting and contraction of a casting article in a mold. Thus, in order to die-cast the alloy without any trouble (with fine castability), Fe has to be contained by, with respect to the total weight of the aluminum alloy, not lower than 1.20 wt% and more preferably not lower than 1.40 wt%.

[0022] On the other hand, Fe is an element that reduces the heat conductivity of the alloy. However, when the content ratio of Fe with respect to the whole aluminum alloy is not more than 2.60 wt%, a heat conductivity of not lower than 170 W/(m·K) can be obtained. Thus, in the aluminum alloy of the present invention, Fe is contained in a range of 1.20 to 2.60 wt% in accordance with the required mechanical characteristics, heat conductivity, or castability.

[0023] The aluminum alloy of the present invention contains, other than each of the main elements described above, Al, which forms a matrix, and unavoidable impurities. Among these, although containing a smaller amount of the unavoidable impurities improves heat conductivity, increasing purity by reducing impurities is costly. Thus, it is necessary to accept impurities at a level not compromising the target heat conductivity, and one example of the type and amount of the impurities is Zn by not more than 0.1 wt%, Ti by not more than 0.05 wt%, Pb by not more than 0.06 wt%, Sn by not more than 0.05 wt%, Cr by not more than 0.10 wt%, and Ni by not more than 0.05 wt%.

[0024] When the content ratio of Cu, Si, and Fe is adjusted in accordance with the elemental composition described above, soldering and inferior release between the aluminum alloy and the mold when die casting can be prevented, and an aluminum alloy base metal having excellent heat conductivity can be obtained.

[0025] When producing the aluminum alloy of the present invention, first, a material obtained by blending each of the elemental components of Al, Cu, Si, and Fe in the above described predetermined ratio is prepared. Next, the material is added in a melting furnace such as a melting furnace with a fore hearth and a sealed melting furnace to melt the material. With respect to the melted material, i.e., a molten metal of an aluminum alloy, refinement treatments such as dehydrogenation treatment and inclusion removal treatment are performed if necessary. Then, the refined molten metal is poured in a predetermined mold and solidified to mold the molten metal of the aluminum alloy into an alloy base metal ingot.

[0026] Die casting is mainly used when casting an aluminum alloy casting product (casting article) using the aluminum alloy of the present invention. The casting article can be efficiently mass produced by using die casting.

[0027] With respect to the aluminum alloy casting product (aluminum alloy die cast product) obtained through die casting, solution treatment and aging treatment are performed if necessary. By performing solution treatment and aging treatment on the aluminum alloy casting product, mechanical characteristics of the aluminum alloy casting product can be improved.

[0028] Since the aluminum alloy die cast product using the alloy of the present invention has a heat conductivity of not lower than 170 W/(m·K) even without having heat treatment performed thereon, the aluminum alloy die cast product is particularly suitable in usage as a heat dissipation member such as a heatsink. Here, "heatsink" refers to a component that is attached to a mechanical/electrical component that generates heat and whose purpose is to lower the temperature through dissipation of heat, and may take thousand different sizes and shapes depending on the use application.

Examples

[0029] In the following, although the present invention will be described specifically using Examples, the present invention is not limited to the Examples. The mechanical characteristics (tensile strength, stretch, 0.2%-yield strength) in the Examples and the Comparative Examples were each measured using a universal testing machine (AG-IS 100kN) manufactured by Shimadzu Corp. The heat conductivity was measured with a laser flash method using a thermal constant measuring device (TC-7000) manufactured by ULVAC-Riko (Co., Ltd.). Brinell hardness was measured in compliance with JIS Z 2243. Regarding castability, die casting was performed using a common die casting machine (DC250JMT manufactured by Toshiba Machine Co., Ltd.) with a clamping force of 250 ton at an injection speed 2.0 m/s and a casting pressure of 80 MPa, and the castability was visually examined. One that did not present any trouble in castability was represented as "○," and one that did present trouble in castability was represented as "x."

[0030] Table 1 shows the elemental composition, the heat conductivity, physical property measurement results, and castability of aluminum alloys, which are the object of the present invention, in Examples 1 to 11 and Comparative Examples 1 to 3.

[Table 1]

	Elemental composition (wt%)			Heat conductivity W/(m·K)	Physical property measurement result				Castability
	Cu	Si	Fe		Tensile strength (MPa)	Stretch (%)	0.2%-yield strength (MPa)	Brinell hardness (HBW10/500)	
Example 1	0.22	0.18	1.49	192	142	16.9	72.3	34.7	○
Example 2	0.21	0.18	1.99	187	157	15.4	81.4	37.8	○
Example 3	0.02	0.44	2.07	176	161	16.0	84.1	37.2	○
Example 4	0.02	0.94	2.06	175	165	13.0	89.2	41.3	○
Example 5	0.02	1.10	2.06	176	172	13.0	91.4	41.0	○
Example 6	0.02	1.40	2.05	171	176	11.9	94.7	43.3	○
Example 7	0.01	0.11	2.50	176	159	16.6	89.7	36.7	○
Example 8	0.78	0.11	2.02	181	173	15.4	83.3	41.3	○
Example 9	1.12	0.11	2.03	186	181	13.0	82.3	43.3	○
Example 10	1.50	0.11	2.02	174	192	14.3	85.6	43.9	○
Example 11	2.25	0.11	2.02	170	210	13.1	91.9	48.9	○
Comparative Example 1	0.03	0.18	1.07	194	122	20.1	63.3	29.1	×
Comparative Example 2	0.23	0.18	1.05	198	131	17.3	67.5	31.1	×
Comparative Example 3	0.02	1.96	2.05	158	190	11.9	97.0	46.1	○

[0031] The aluminum alloy of the present invention is required to have three excellent characteristics of castability, soldering resistance, and heat conductivity as described above. Regarding heat conductivity, as described above, pure aluminum exhibits the best value of approximately 250 W/(m·K), and heat conductivity is reduced as various elements are added thereto (as in the case of each alloy shown in Table 1).

[0032] FIG. 1 is a graph created based on data in Table 1 and shows the relationship between the heat conductivity and the percentage content of Cu. As shown in this graph, although the heat conductivity of an alloy gradually decreases associated with an increase in the content ratio of Cu with respect to the whole aluminum alloy, a heat conductivity of not lower than 170 W/(m·K) is maintained up to a content ratio of Cu of about 2.30 wt%. Thus, the heat conductivity can be considered satisfactory when the content ratio of Cu is in a range of not more than 2.30 wt%.

[0033] FIG. 2 is a graph created based on the data in Table 1 and shows the relationship between the heat conductivity and the percentage content of Si. As shown in this graph, although the heat conductivity of an alloy decreases associated with an increase in the content ratio of Si with respect to the whole aluminum alloy, a heat conductivity of not lower than 170 W/(m·K) is maintained up to a content ratio of Si of about 1.50 wt%. Thus, the heat conductivity can be considered satisfactory when the content ratio of Si is in a range of not more than 1.50 wt%.

[0034] FIG. 3 is a graph created based on the data in Table 1 and shows the relationship between the heat conductivity and the percentage content of Fe. As shown in this graph, although the heat conductivity of an alloy gradually decreases associated with an increase in the content ratio of Fe with respect to the whole aluminum alloy, a heat conductivity of not lower than 170 W/(m·K) is maintained up to a content ratio of Fe of about 2.60 wt%. Thus, the heat conductivity can be considered satisfactory when the content ratio of Fe is in a range of not more than 2.60 wt%.

[0035] However, regarding Fe, as shown in Comparative Examples 1 and 2 in Table 1, when the content ratio of Fe with respect to the whole aluminum alloy was less than 1.20 wt%, a problem related to castability had occurred. Specifically, when opening a mold of the die casting machine, the casted aluminum alloy die cast product was adhered to the mold and could not be removed. Such a phenomenon is speculated to be caused by contraction of the aluminum alloy die cast product due to insufficient Fe.

[0036] Thus, when considering both heat conductivity and castability of an alloy, a range of 1.20 to 2.60 wt% can be considered suitable for the content ratio of Fe with respect to the whole aluminum alloy.

Claims

1. A highly heat conductive aluminum alloy for die casting, the alloy comprising Cu by not more than 2.30 wt%, Si by not more than 1.50 wt%, and Fe by 1.20 to 2.60 wt%, a remaining portion thereof being Al and unavoidable impurities.

2. An aluminum alloy die cast product obtained through die casting the aluminum alloy according to claim 1.

3. A heatsink obtained through die casting the aluminum alloy according to claim 1.

FIG. 1

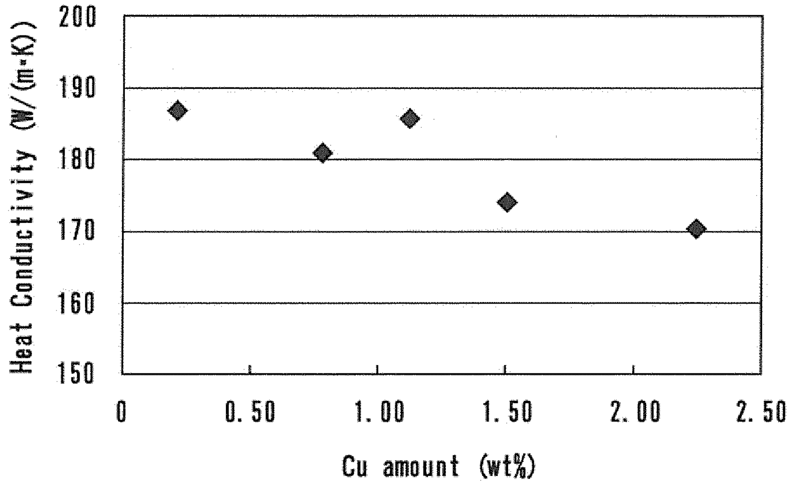

200
190
180
170
160
150
Heat Conductivity (W/(m·K))
0
0.50
1.00
1.50
2.00
2.50
Cu amount (wt%)

FIG. 2

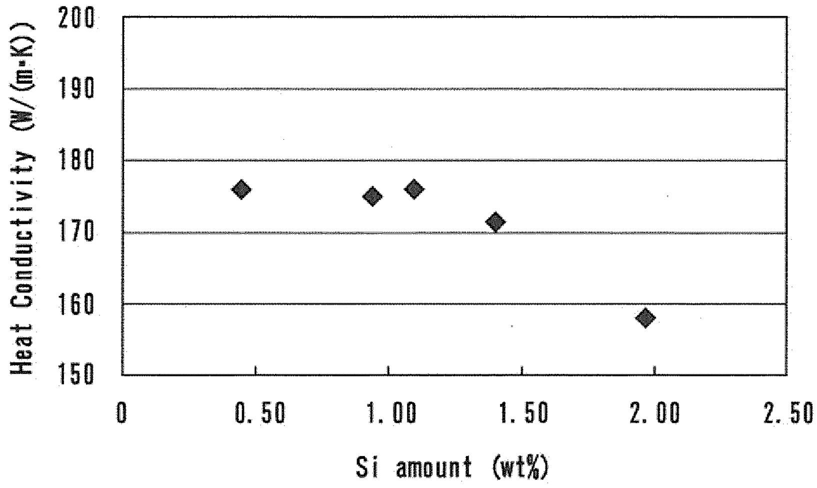
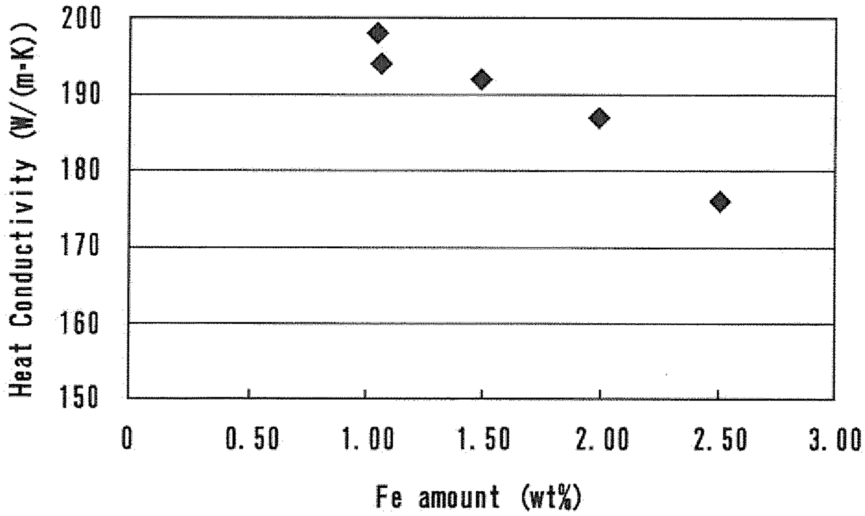

200
190
180
170
160
150
Heat Conductivity (W/(m·K))
0
0.50
1.00
1.50
2.00
2.50
Si amount (wt%)

FIG. 3


Heat Conductivity (W/(m·K))
200
190
180
170
160
150
0
0.50
1.00
1.50
2.00
2.50
3.00
Fe amount (wt%)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2012/005531

A. CLASSIFICATION OF SUBJECT MATTER
C22C21/00(2006.01)i, *C22C21/12*(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)
C22C21/00-21/18

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-226931 A (Ryoka Macs Kabushiki Kaisha), 14 August 2002 (14.08.2002), claims 1, 2; paragraph [0005]; table 1 (Family: none)	1-3
A	JP 57-2857 A (Ryobi Ltd.), 08 January 1982 (08.01.1982), claims; tables 1, 2, no.10 (Family: none)	1,2
A	JP 56-166359 A (Nippon Light Metal Research Laboratory, Ltd.), 21 December 1981 (21.12.1981), claims; table 2 (Family: none)	1,2

☒ 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
26 September, 2012 (26.09.12)	09 October, 2012 (09.10.12)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/005531

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-121164 A (Nippon Light Metal Co., Ltd.), 03 June 2010 (03.06.2010), claim 1; table 1 (Family: none)	1,2

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 419370 A **[0006]**