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(54) HIGH THERMAL CONDUCTIVITY MAGNESIUM ALLOY, INVERTER HOUSING, INVERTER AND AUTOMOBILE

(57) A magnesium alloy with high thermal conductivity, an inverter housing, an inverter and a vehicle are provided. Based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity includes: 2.0-4.0 wt% of Al, 0.1-0.3 wt% of Mn, 1.0-2.0 wt% of La, 2.0-4.0 wt% of Ce, 0.1-1.0 wt% of Nd, 0.5-2.0 wt% of Zn, 0.1-0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

EP 3 640 356 A1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and benefits of Chinese Patent Application Serial No. 201710453134.2, filed on June 15, 2017. The entire content of the above-referenced application is incorporated herein by reference.

FIELD

[0002] This application relates to the field of materials technologies, and specifically, to a magnesium alloy with high thermal conductivity and application thereof, and more specifically, to a magnesium alloy with high thermal conductivity, an inverter housing of which at least a part is formed by the magnesium alloy with high thermal conductivity, an inverter including the inverter housing, and a vehicle including the inverter.

BACKGROUND

[0003] A conventional die casting magnesium alloy on the current market is AZ91D, including main components as follows: Al: 8.5~9.5%, Zn: 0.45~0.90%, Mn: 0.17~0.4%, Si: ≤0.05%, Cu: 0.025%, Ni: ≤0.001%, Fe: ≤0.004%, and magnesium. This material has good fluidity and formability, low costs, and relatively high mechanical properties. However, the thermal conductivity of this material is relatively low, which is less than 60 W/m·K, thereby limiting broad application of magnesium alloys.

[0004] Therefore, current research on magnesium alloys remains to be improved.

SUMMARY

[0005] This application is directed to solve one of the technical problems in the related technology at least to some extent. To this end, an objective of this application is to provide a die casting magnesium alloy having good thermal conductivity or having ideal mechanical properties as well.

[0006] According to an aspect of this application, this application provides a magnesium alloy with high thermal conductivity. According to embodiments of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity includes: 2.0-4.0 wt% of Al, 0.1-0.3 wt% of Mn, 1.0-2.0 wt% of La, 2.0-4.0 wt% of Ce, 0.1-1.0 wt% of Nd, 0.5-2.0 wt% of Zn, 0.1-0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium. It is found that the magnesium alloy including the foregoing components has extremely high thermal conductivity and ideal mechanical properties at the same time, and can be effectively applied to conditions and environments that require high thermal conductivity and a light weight, for example, being used to manufacture an inverter housing of a vehicle, thereby greatly expanding the application scope of magnesium alloys.

[0007] According to another aspect of this application, this application provides an inverter housing. According to an embodiment of this application, at least a part of the inverter housing is formed by the foregoing magnesium alloy with high thermal conductivity. In this way, the inverter housing has extremely high thermal conductivity and good heat-dissipation performance, so that the safety and service life of an inverter using the inverter housing are improved significantly.

[0008] According to still another aspect of this application, this application provides an inverter. According to an embodiment of this application, the inverter includes the foregoing inverter housing. It is found that the inverter has good heat-dissipation performance, so that the safety is greatly improved and the service life is significantly increased.

[0009] According to yet another aspect of this application, this application provides a vehicle. According to an embodiment of this application, the vehicle includes the foregoing inverter. The vehicle has all the foregoing features and advantages of the inverter, which are not described herein again.

DETAILED DESCRIPTION

[0010] The following describes embodiments of this application in detail. The embodiments described below are exemplary and are only used to interpret this application, instead of limiting this application. Technologies or conditions that are not explicitly specified in the embodiments are technologies or conditions described in documents in the art or as described in product specifications. All agents and instruments used in the embodiments whose manufacturers are not explicitly specified are conventional products available on the market.

[0011] According to an aspect of this application, this application provides a magnesium alloy with high thermal conductivity. According to the embodiments of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity includes: 2.0-4.0 wt% of Al, 0.1-0.3 wt% of Mn, 1.0-2.0 wt% of La, 2.0-4.0 wt% of Ce, 0.1-1.0 wt% of Nd, 0.5-2.0 wt% of Zn, 0.1-0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium. It is found that the magnesium alloy including the foregoing components has extremely high thermal conductivity and ideal mechanical performance at the same time, and can be effectively applied to conditions and scenarios that require high thermal conductivity and a light weight, for example, being used to manufacture an inverter housing of a vehicle, thereby greatly expanding the application scope of magnesium alloys.

[0012] According to the embodiments of this application, in the foregoing magnesium alloy: aluminum can improve the strength and anti-corrosion performance of the magnesium alloy and manganese can improve the elongation and toughness of the magnesium alloy. Adding rare earth elements such as La, Ce and Nd can obviously enhance the high-temperature performance of the magnesium alloy and refine particles of the magnesium alloy during the casting process. In addition, magnesium can form a solid solution with the foregoing rare earth elements, a zone rich in magnesium is a simple eutectic zone with a low melting point, and magnesium is distributed in the shape of a net at the grain boundary to prohibit the formation of micro pores, thereby improving the casting performance and thermal conductivity of the magnesium alloy. Nd has relatively large impact on fine-grain strengthening of the magnesium alloy. The refining effect of Ce on micro structures helps to improve the mechanical properties and anti-corrosion performance of the magnesium alloy. Zinc can achieve solution strengthening and form a strengthening phase. Both a small amount of Ca and a small amount of Sr can prevent the magnesium alloy from oxidation during the process of smelting. These components are mixed according to the foregoing proportions to form the magnesium alloy. Due to the synergistic effect of these components, the obtained magnesium alloy has high thermal conductivity and mechanical properties at the same time, and can be effectively applied to multiple fields, especially to scenarios that require relatively high thermal conductivity.

[0013] According to the embodiments of this application, to further improve usage performance of the magnesium alloy, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy may include: 0.15-0.3 wt% of Mn and 2.5-4.0 wt% of Ce. In this way, it is ensured that the magnesium alloy has ideal thermal conductivity and high mechanical properties at the same time, to better satisfy usage requirements of different operating environments and conditions.

[0014] According to a specific embodiment of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy may include: 3.0 wt% of Al, 0.25 wt% of Mn, 1.55 wt% of La, 3.0 wt% of Ce, 0.13 wt% of Nd, 0.6 wt% of Zn, 0.15 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0015] According to another specific embodiment of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy may include: 2.0 wt% of Al, 0.15 wt% of Mn, 2.0 wt% of La, 2.5 wt% of Ce, 0.1 wt% of Nd, 2.0 wt% of Zn, 0.1 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0016] According to another specific embodiment of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy may include: 4.0 wt% of Al, 0.1 wt% of Mn, 1.0 wt% of La, 2.0 wt% of Ce, 1.0 wt% of Nd, 0.5 wt% of Zn, 0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0017] According to another specific embodiment of this application, based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy may include: 2.5 wt% of Al, 0.3 wt% of Mn, 1.0 wt% of La, 4.0 wt% of Ce, 0.5 wt% of Nd, 1.5 wt% of Zn, 0.3 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0018] It is found that the magnesium alloy including the foregoing components has high thermal conductivity and ideal mechanical properties at the same time.

[0019] Through a large number of experiments, it is verified that the magnesium alloy according to the embodiments of this application has thermal conductivity obviously higher than that of an existing magnesium alloy. Experimental results show that the thermal conductivity of the magnesium alloy including the foregoing components with the corresponding proportions may be greater than 110 w/m·K. In this way, the magnesium alloy can be effectively applied to scenarios that require relatively high thermal conductivity. In addition, the magnesium alloy has advantages such as a low density, a high specific strength, a high specific modulus, a high property of tremble elimination, and high resistance to corrosion caused by organic matter and alkali.

[0020] In addition, the magnesium alloy according to the embodiments of this application may further satisfy at least one of the following conditions: a tensile strength is greater than 220 MPa; a yield strength is greater than 150 MPa; and an elongation is greater than 4%. Specifically, the magnesium alloy may satisfy only one of the foregoing conditions. For example, the magnesium alloy may only satisfy the condition that the tensile strength is greater than 220 MPa, or may only satisfy the condition that the yield strength is greater than 150 MPa, or may only satisfy the condition that the elongation is greater than 4%. Alternatively, the magnesium alloy may satisfy two of the foregoing conditions. For example, the magnesium alloy may satisfy the condition that the tensile strength is greater than 220 MPa and the condition that the yield strength is greater than 150 MPa, or may satisfy the condition that the tensile strength is greater than 220 MPa and the condition that the elongation is greater than 4%, or may satisfy the condition that the yield strength is greater than 150 MPa and the condition that the elongation is greater than 4%. Alternatively, the magnesium alloy may also satisfy the three conditions that the tensile strength is greater than 220 MPa, the yield strength is greater than 150 MPa and the elongation is greater than 4%. In this way, it is ensured that the magnesium alloy has ideal thermal conductivity and better mechanical properties at the same time, and can satisfy usage requirements in different fields as well as different operating environments and conditions.

[0021] According to another aspect of this application, this application provides an inverter housing. According to an embodiment of this application, at least a part of the inverter housing is formed by the foregoing magnesium alloy with high thermal conductivity. In this way, the inverter housing has extremely high thermal conductivity and high heat-dissipation performance, so that the safety and service life of an inverter using the inverter housing are improved significantly.

[0022] According to the embodiments of this application, the specific structure of the inverter housing is not particularly limited and may be any existing structure of an inverter housing in the field. A person skilled in the art may choose flexibly according to an actual demand. Moreover, a part of the inverter housing, such as a part that requires higher thermal conductivity, may be prepared by using the magnesium alloy in this application. Alternatively, the entire inverter housing may be prepared by using the magnesium alloy in this application. A person skilled in the art may also choose flexibly according to costs and usage requirements.

[0023] According to another aspect of this application, this application provides an inverter. According to an embodiment of this application, the inverter includes the foregoing inverter housing. It is found that the inverter has good heat-dissipation performance, so that the safety is greatly improved and the service life is significantly increased. Moreover, a person skilled in the art may understand that the inverter has all the features and advantages of the foregoing inverter housing, which are not described herein again.

[0024] According to the embodiments of this application, apart from the inverter housing, the inverter further includes necessary structures and parts of a conventional inverter, such as an inverter bridge, control logic and a filter circuit, which are not described in further detail herein.

[0025] According to another aspect of this application, this application provides a vehicle. According to an embodiment of this application, the vehicle includes the foregoing inverter. In this way, the inverter of the vehicle has good thermal conductivity and mechanical properties, thereby greatly improving the safety. In addition, the inverter housing is prepared by using a magnesium alloy, which helps to reduce the weight of the vehicle and improve user experience. The vehicle has all the features and advantages of the foregoing inverter, which are not described herein again.

[0026] According to the embodiments of this application, apart from the inverter, the vehicle has necessary structures and parts of a conventional vehicle, such as a body, an engine, wheels and interior decoration items, which are not described in further detail herein.

Embodiment 1

[0027] Components of the magnesium alloy: 3.0 wt% of Al, 0.25 wt% of Mn, 1.55 wt% of La, 3.0 wt% of Ce, 0.13 wt% of Nd, 0.6 wt% of Zn, 0.15 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0028] Preparation procedure: put a pure magnesium ingot and a pure aluminum ingot into a smelting furnace, where the smelting temperature is 700-750°C; add an Mg-Ca master alloy, an Mg-Mn master alloy and an Mg-Zn master alloy into the smelting furnace and completely melt down the master alloys, where the smelting temperature is 700-750°C; add an Mg-La master alloy, an Mg-Ce master alloy and an Mg-Nd master alloy into the smelting furnace, where the smelting temperature is 700-750°C, and at the same time add a covering agent onto the surface of the melt; perform a 15-minute refining treatment on the melt using an RJ-5 flux, where the refining temperature is 730-760°C, and then let the melt stand for 80-120 minutes, where the temperature is 650-730°C. Sr and Cu may be introduced using impurities of the foregoing raw materials, and therefore, it is unnecessary to add Sr and Cu separately.

Embodiment 2

[0029] Components of the magnesium alloy: 2.0 wt% of Al, 0.15 wt% of Mn, 2.0 wt% of La, 2.5 wt% of Ce, 0.1 wt% of Nd, 2.0 wt% of Zn, 0.1 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0030] Preparation procedure: same as the preparation procedure in Embodiment 1.

Embodiment 3

[0031] Components of the magnesium alloy: 4.0 wt% of Al, 0.1 wt% of Mn, 1.0 wt% of La, 2.0 wt% of Ce, 1.0 wt% of Nd, 0.5 wt% of Zn, 0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0032] Preparation procedure: same as the preparation procedure in Embodiment 1.

Embodiment 4

[0033] Components of the magnesium alloy: 2.5 wt% of Al, 0.3 wt% of Mn, 1.0 wt% of La, 4.0 wt% of Ce, 0.5 wt% of Nd, 0.5 wt% of Zn, 0.3 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0034] Preparation procedure: same as the preparation procedure in Embodiment 1.

Comparative Example 1

[0035] Components of the magnesium alloy: 6 wt% of Al, 0.4 wt% of Mn, 0.48 wt% of Zn, 1.2 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0036] Preparation procedure: same as the preparation procedure in Embodiment 1.

Comparative Example 2

[0037] Components of the magnesium alloy: 6.0 wt% of Al, 0.25 wt% of Mn, 1.55 wt% of La, 3.0 wt% of Ce, 0.013 wt% of Nd, 0.6 wt% of Zn, 0.15 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

[0038] Preparation procedure: same as the preparation procedure in Embodiment 1.

Embodiment 5

[0039] Mechanical properties and the coefficient of thermal conductivity of magnesium alloys prepared in Embodiments 1 to 4 and Comparative Examples 1 and 2 are tested:

[0040] (1) Experiment on the coefficient of thermal conductivity: According to the test method of ASTM E 1461-07, a laser flash method is used to test the coefficient of thermal conductivity of a magnesium alloy wafer having a diameter of 12.7 mm and a thickness of 3 mm.

[0041] (2) Experiment on tensile properties: According to the test method of ISO 6892-1, the smelted magnesium alloy melt is injected into a mold cavity by using pressure casting equipment to obtain a tensile casting with a wall thickness of 3 mm. A universal mechanical testing machine is used to perform the experiment on tensile properties to obtain a yield strength and an elongation. The yield strength is a yield limit when a 0.2% residual deformation is produced. The elongation is elongation at break.

[0042] Experimental results of Embodiments 1 to 4 and Comparative Examples 1 and 2 are shown in Table 1.

Table 1

	Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4	Comparative Example 1	Comparative Example 2
Tensile strength/MPa	223	222	224	223	190	230
Yield strength/MPa	155	153	154	152	140	160
Elongation/%	5	5	5	5	3	4
Coefficient of thermal conductivity/W/(m·K)	114	112	110	113	70	75

[0043] It can be learned from the data in Table 1 that the magnesium alloys obtained in Embodiments 1 to 4 have substantially the same mechanical properties as those of the magnesium alloys in Comparative Examples 1 and 2 and much higher coefficients of thermal conductivity than those of the magnesium alloys in Comparative Examples 1 and 2. It indicates that the magnesium alloy in this application has high thermal conductivity while mechanical properties meeting requirements are ensured.

[0044] The mechanical properties and material molding fluidity of the magnesium alloy prepared in Embodiment 1 and an AZ91D magnesium alloy are tested. The test standard for mechanical properties is ISO 6892-1. A sample for testing the material molding fluidity is die-cast at atmospheric pressure by using a mosquito-repellent incense mold, where the mold temperature is 200°C and the die-casting temperature is 700°C. An injection speed is 3 circles per second. A second-speed starting position is 140 mm. The length of the injected mosquito-repellent incense mold is recorded as an analogy of the material fluidity. Results are respectively shown in Table 2 and Table 3.

Table 2

Alloy	Tensile strength/MPa	Yield strength/MPa	Elongation/%	Formability
Embodiment 1	>220	>150	>4	High
AZ91D	>200	>150	>3.0	High

Table 3

Alloy	Length 1	Length 2	Length 3	Length 4	Length 5	Average value mm
Embodiment 1	1100	1090	1120	1180	1100	1118
AZ91D	1050	980	1030	1020	980	1012

[0045] It can be learned from the data in Table 2 and Table 3 that, compared with the AZ91D magnesium alloy, the magnesium alloy with high thermal conductivity in this application has extremely high thermal conductivity and heat-dissipation capability, as well as a relatively high tensile strength, yield strength and elongation, and also has high formability and recovery capability.

[0046] In the description of the specification, the description of reference terms such as "one embodiment", "some embodiments", "example", "specific example" or "some examples" means that specific features, structures, materials, or features described with reference to the embodiment or example are included in at least one embodiment or example of this application. In the specification, schematic descriptions of the foregoing terms are not necessarily specific to the same embodiment or example. In addition, the described specific features, structures, materials, or characteristics may be combined in a proper manner in any one or more of the embodiments or examples. In addition, a person skilled in the art may integrate or combine different embodiments or examples and characteristics of different embodiments or examples described in the specification, as long as they do not conflict each other.

[0047] Although the embodiments of this application are shown and described above, it can be understood that, the foregoing embodiments are exemplary, and cannot be construed as a limitation to this application. Within the scope of the present invention, a person of ordinary skill in the art may make changes, modifications, replacement, and variations to the foregoing embodiments.

Claims

1. A magnesium alloy with high thermal conductivity, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises: 2.0-4.0 wt% of Al, 0.1-0.3 wt% of Mn, 1.0-2.0 wt% of La, 2.0-4.0 wt% of Ce, 0.1-1.0 wt% of Nd, 0.5-2.0 wt% of Zn, 0.1-0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

2. The magnesium alloy with high thermal conductivity according to claim 1, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises: 0.15-0.3 wt% of Mn and 2.5-4.0 wt% of Ce.

3. The magnesium alloy with high thermal conductivity according to claim 1 or 2, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises:

3.0 wt% of Al, 0.25 wt% of Mn, 1.55 wt% of La, 3.0 wt% of Ce, 0.13 wt% of Nd, 0.6 wt% of Zn, 0.15 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

4. The magnesium alloy with high thermal conductivity according to claim 1 or 2, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises: 2.0 wt% of Al, 0.15 wt% of Mn, 2.0 wt% of La, 2.5 wt% of Ce, 0.1 wt% of Nd, 2.0 wt% of Zn, 0.1 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

5. The magnesium alloy with high thermal conductivity according to claim 1 or 2, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises: 4.0 wt% of Al, 0.1 wt% of Mn, 1.0 wt% of La, 2.0 wt% of Ce, 1.0 wt% of Nd, 0.5 wt% of Zn, 0.5 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

6. The magnesium alloy with high thermal conductivity according to claim 1 or 2, wherein based on the total mass of the magnesium alloy with high thermal conductivity, the magnesium alloy with high thermal conductivity comprises: 2.5 wt% of Al, 0.3 wt% of Mn, 1.0 wt% of La, 4.0 wt% of Ce, 0.5 wt% of Nd, 0.5 wt% of Zn, 0.3 wt% of Ca, less than 0.1 wt% of Sr, less than 0.1 wt% of Cu, and magnesium.

7. The magnesium alloy with high thermal conductivity according to any one of claims 1 to 6, wherein the thermal conductivity is greater than 110 w/m·K.

8. The magnesium alloy with high thermal conductivity according to any one of claims 1 to 7, wherein at least one of the following conditions is met:

a tensile strength is greater than 220 MPa;
a yield strength is greater than 150 MPa; and
an elongation is greater than 4%.

9. An inverter housing, wherein at least a part of the inverter housing is formed by the magnesium alloy with high thermal conductivity according to any one of claims 1 to 8.

10. An inverter, comprising the inverter housing according to claim 9.

11. A vehicle, comprising the inverter according to claim 10.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/084488

A. CLASSIFICATION OF SUBJECT MATTER

C22C 23/06 (2006.01) i; C22C 23/02 (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 23/-

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)

EPODOC, JPABS, CNABS, CNKI: 镁, 铝, 锰, 锌, 钙, 稀土, 镧, 铈, 钕, magnesium, Mg, alumium, Al, manganese, Mn, Zinc, Zn, calcium, Ca, RE, La, lanthanum, Ce, cerium, Nd, neodymium

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H07331375 A (TOYOTA CHUO KENKYUSHO KK et al.), 19 December 1995 (19.12.1995), claim 1, and description, paragraph 0022	1-8
Y	JP H07331375 A (TOYOTA CHUO KENKYUSHO KK et al.), 19 December 1995 (19.12.1995), claim 1, and description, paragraph 0022	9-11
Y	CN 102776427 A (LINJIANG DONGFENG NON-FERROUS METALS CO., LTD.), 14 November 2012 (14.11.2012), abstract, and description, paragraph 0002	9-11
A	CN 106609331 A (SHANGHAI JIAO TONG UNIVERSITY), 03 May 2017 (03.05.2017), entire document	1-11
A	JP 2009120883 A (MITSUBISHI ALUMINIUM CO., LTD.), 04 June 2009 (04.06.2009), entire document	1-11

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

* Special categories of cited documents:

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2018	03 July 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer PENG, Min Telephone No. 86-010-62084744

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/084488

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP H07331375 A	19 December 1995	None	
CN 102776427 A	14 November 2012	None	
CN 106609331 A	03 May 2017	None	
JP 2009120883 A	04 June 2009	None	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201710453134 **[0001]**