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(54) **CREEP RESISTANT MAGNESIUM ALLOY**

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(57) **ABSTRACT**

The present invention relates to a creep resistant magnesium alloy, which includes aluminium (Al) in an amount of 5 to 20 percent by weight, carbon nanotubes (CNT) in an amount of 0.1 to 10 percent by weight, strontium (Sr) in an amount of 0 to 2 percent by weight, remainder being magnesium (Mg) and impurities commonly found in magnesium alloys.

CREEP RESISTANT MAGNESIUM ALLOY

FIELD OF THE INVENTION

[0001] The present invention relates to magnesium alloys, particularly to a magnesium alloy having good creep resistance and high strength.

DESCRIPTION OF RELATED ART

[0002] Magnesium alloys have been widely utilized in the automotive industry to reduce component weight while providing a high structural rigidity. Magnesium alloys are the lightest structural material among metals, with a specific gravity being merely 1.8, which is one-fourth of that of copper, two-thirds of that of aluminum, and is similar to that of plastic materials. In addition, magnesium alloys have good mechanical properties, such as good castability. Due to the above advantages, magnesium alloys are widely used in many fields, for example, electronic products, car industry, aerospace industry, etc.

[0003] However, conventional magnesium alloys exhibiting good castability also have poor creep resistance. Creep is a phenomenon that occurs when a material continues to deform under constant stress at a certain temperature. Generally, creep of magnesium alloys seldom occurs at room temperature, under stress below elasticity limitation. However, the creep phenomenon occurs when the temperature increases to a high degree, under stress below elasticity limitation. Therefore, creep resistant magnesium alloys are desired.

[0004] Generally, magnesium alloys capable of undergoing a temperature above 150 degrees centigrade without significant creep can be called creep resistant magnesium alloys. Creep resistance is a desirable characteristic for alloys under compressive load and high temperature. This characteristic is also important in maintaining bolt torque and dimensional stability of cast bodies during operation. However, compared with aluminum alloys, conventional magnesium alloys are disadvantageous in mechanical strength, toughness, and creep resistance.

[0005] Many efforts have been paid to solve the above problems. It has been suggested that grain refinement is a useful technology to improve the mechanical properties of magnesium alloys, such as creep resistance and toughness.

[0006] It is known to all that with the presence of aluminum component, magnesium-aluminum alloy exhibits improved strength, toughness and castability. However, an interphase of bulky $Mg_{17}Al_{12}$ grains is formed between magnesium phase and aluminum phase. With the presence of $Mg_{17}Al_{12}$ grains, the toughness and creep resistance of magnesium-aluminum alloys are reduced. Accordingly, optimizing the configuration and distribution of the interphase is considered another possible approach to improve the mechanical properties of magnesium alloys or magnesium-aluminum alloys.

[0007] For example, a magnesium-zinc-copper alloy has been provided. The magnesium-zinc-copper alloy contains a large amount of copper (about 5 percent by weight) for improvement of mechanical properties including toughness and creep resistance thereof. However, those mechanical properties can only be realized after aging treatment during fusing process. Furthermore, a large amount of copper can lead to a high melting point for the alloy, which leads to difficulties in casting, poor anti-corrosion properties and high cost. Moreover, the grain refinement of copper can only be realized in the absence of aluminum, this further restricts magnesium alloy's application.

[0008] Therefore, a heretofore-unaddressed need exists in the industry to address the aforementioned deficiencies and inadequacies.

SUMMARY OF THE INVENTION

[0009] In a preferred embodiment, a magnesium alloy is provided, which includes aluminum in an amount of 5 to 20 percent by weight, carbon nanotubes in an amount of 0.1 to 10 percent by weight, nano-sized strontium in an amount of 0 to 2 percent by weight, remainder being magnesium and impurities commonly found in magnesium alloys.

[0010] Compared with the conventional magnesium matrix materials, the magnesium alloy of the preferred embodiment has the following advantages. Firstly, the presence of aluminum leads to good intensity, toughness and castability for the alloy. Secondly, nanotube and nano-sized strontium can refine grain, thus leading to high fracture toughness of the alloy, and finally leads to good creep resistance.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0012] A magnesium alloy of a preferred embodiment contains, by weight, 5 to 20 percent aluminum, preferably 8 to 10 percent; 0.1 to 10 percent carbon nanotube, preferably 0.5 to 2 percent; 0 to 2 percent strontium, preferably 1 to 2 percent; with remainder being magnesium and impurities commonly found in magnesium alloys.

[0013] An average particle size (i.e. length) of the carbon nanotubes ranges from 5 to 500 nanometers, preferably 20 to 200 nanometers. Carbon nanotubes have a high Young's modulus, and a mechanical strength similar to that of diamond. Thus, carbon nanotubes have a good creep resistance and can prevent any micro cracks. In addition, carbon nanotubes have good electrical conductivity, therefore, when use in electronic customer products, carbon nanotubes can effectively prevent electro-magnetic interference (abbreviated as EMI). Furthermore, carbon nanotubes are good thermal conductors with a heat conductivity (k) of 6,000 W/m·K, which is 30 times to that of aluminum, 20 times to that of copper, and 2 times to that of diamond.

[0014] Strontium is widely used in many technical fields, such as metallurgy, chemical industry, photoelectric cell. When a little strontium particle is added into a magnesium alloy, refined structure will be produced. Accordingly, it can effectively prevent the occurrence of a micro crack caused by outer effect, and can further improve the creep resistant property of magnesium alloy.

[0015] For metal alloys or plastics, particle size is an important factor which can affect fracture toughness of the materials. Fracture toughness (K_{1c}) is one of main mechanical parameters for metal alloys and plastics. Fracture toughness indicates an ability of the material for preventing micro crack extension. Generally, when the fracture toughness is high, the material exhibits good mechanical properties. The fracture toughness satisfies the following formula:

$$K_{1c} \sim \sigma_y \cdot \left(\frac{3.14159c}{d}\right)^{0.5}$$

[0016] wherein K_{1c} represents fracture toughness; ay represents yield strength, also known as yield limit; c represents crack length; and d represents particle size. It can be deduced from the above formula that the smaller the particle size, the larger the fracture toughness. Due to the small size of carbon nanotubes and strontium particles, the fracture toughness of the magnesium alloy of the preferred embodiment is improved. Thus, the magnesium alloy has the advantages of preventing micro crack extension, high resistance to creep and improved mechanical properties.

[0017] A magnesium alloy of the first preferred example includes, by weight, 10 percent aluminum, 0.1 percent carbon nanotubes, 1 percent strontium, with the remainder being magnesium with an acceptable amount of impurities.

[0018] A magnesium alloy of the second preferred example includes, by weight, 8 percent aluminum, 10 percent carbon nanotubes, 2 percent strontium, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0019] A magnesium alloy of the third preferred example includes, by weight, 10 percent aluminum, 0.5 percent carbon nanotubes, 1 percent strontium, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0020] A magnesium alloy of the fourth preferred example includes, by weight, 9 percent aluminum, 2 percent carbon nanotubes, 1 percent strontium, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0021] A magnesium alloy of the fifth preferred example includes, by weight, 5 percent aluminum, 5 percent carbon nanotubes, 2 percent strontium, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0022] A magnesium alloy of the sixth preferred example includes, by weight, 20 percent aluminum, 5 percent carbon nanotubes, 2 percent strontium, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0023] A magnesium alloy of the seventh preferred example includes, by weight, 20 percent aluminum, 10 percent carbon nanotubes, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0024] A magnesium alloy of the eighth preferred example includes, by weight, 5 percent aluminum, 0.1 percent carbon nanotubes, with the remainder being magnesium with an acceptable amount of impurities commonly found in magnesium alloys.

[0025] The magnesium alloy provided hereinabove can be used as outer shells and nameplates for mobile phones, computer cases, personal digital assistants, DVDs, digital cameras, and the like.

[0026] It is believed that the present embodiments and their advantages will be understood from the foregoing description, and it will be apparent that various changes may be made thereto without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the examples hereinbefore described merely being preferred or exemplary embodiments of the invention.

What is claimed is:

1. A magnesium alloy comprising, by weight, aluminum in an amount of 5 to 20 percent, carbon nanotubes in an amount of 0.1 to 10 percent, strontium in an amount of 0 to 2 percent, remainder being magnesium and impurities commonly found in magnesium alloys.

2. The magnesium alloy as claimed in claim 1, wherein the aluminum is in an amount of 8 to 10 percent by weight.

3. The magnesium alloy as claimed in claim 1, wherein the carbon nanotube is in an amount of 0.5 to 2 percent by weight.

4. The magnesium alloy as claimed in claim 1, wherein an average length of the carbon nanotubes is in the range from 5 to 500 nanometers.

5. The magnesium alloy as claimed in claim 4, wherein the average length of the carbon nanotubes is in the range from 20 to 200 nanometers.

6. The magnesium alloy as claimed in claim 1, wherein strontium is in an amount by weight of 1 to 2 percent.

7. The magnesium alloy as claimed in claim 1, wherein the average size of the strontium is in the range from 20 to 500 nanometers.

8. The magnesium alloy as claimed in claim 7, wherein the average size of the strontium is in the range from 100 to 300 nanometers.

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