Notice

DESCRIPTION CN120099600A

A method for preparing NiCu alloys with gradient nanostructures and their applications

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[0001]

Technical Field

[n0001]

This invention belongs to the field of materials science, specifically relating to a method for preparing NiCu alloys with gradient nanostructures and their applications.

[0003]

Background Technology

[n0002]

In the fields of nanotechnology, materials science, and metal manufacturing, metals with nanogradient structures have attracted widespread attention due to their unique physical and chemical properties.

Metals with nanogradient structures possess high strength, high hardness, and good corrosion resistance, making them promising candidates for applications in aerospace, electronics, and medical fields.

However, metals with nanogradient structures also face some challenges, such as thermal and mechanical instabilities, which can lead to significant grain growth.

Furthermore, although metals exhibit significant Hall-Petch strengthening, they tend to have low ductility and fracture toughness. Existing solutions mainly involve stabilizing nanogradient structures by adding alloying elements. For example, by adding a third element to form a solid solution or intermetallic compound, the thermal and mechanical stability of metals with nanogradient structures can be improved. In addition, there are other methods that use mechanical deformation, such as cold rolling and heat treatment, to adjust the microstructure of metals with nanogradient structures in order to improve their ductility and fracture toughness. Although existing solutions can improve the properties of metals with nanogradient structures to some extent, some problems still exist. First, adding alloying elements may alter the physical and chemical properties of a metal, thereby affecting its performance. Secondly, the mechanical deformation process may introduce severe mechanical stress, which can lead to the embrittlement of the metal. Furthermore, existing methods often require complex processes and high manufacturing costs, which is detrimental to large-scale production. Therefore, developing a new preparation method to overcome the shortcomings of existing technologies is a major challenge facing the field of nanotechnology.

[n0003]

NiCu alloys exhibit high strength and a certain degree of resistance to oxidation and corrosion at high temperatures.

This alloy has higher strength than pure nickel and exhibits excellent corrosion resistance in a variety of non-oxidizing acidic and alkaline environments, including rapidly flowing seawater. In addition, NiCu alloys have excellent oxidation resistance in high-oxygen environments and excellent mechanical properties at temperatures below zero and up to 550°C. Traditional NiCu alloys with nanogradient structures are often acquired through methods such as alloying and mechanical deformation, which presents challenges such as difficulty in preparation and the need for further performance improvement.

[0006]

Summary of the Invention

[n0004]

This method achieves a gradient distribution of composition and structure in NiCu alloys by precisely controlling the current density and potential gradient during the electrodeposition process.

Compared to traditional preparation methods, this method avoids the problems that may be caused by adding alloying elements or increasing mechanical deformation, which could alter the physical and chemical properties of the metal.

The NiCu alloy prepared by this method has good strength, toughness, wear resistance, shock absorption and high temperature performance.

[n0005]

The main objective of this invention is to prepare NiCu alloys with gradient nanostructures, comprising the following steps:

[n0006]

a) Pre-treat the substrate material, either a Ni or Cu plate, to ensure the smooth progress of the electrodeposition process;

[n0007]

b) Construct an electrodeposition system, which includes an electrolytic cell, an anode, a pretreated substrate material as a cathode, a constant current power supply, and an electroplating solution containing Ni and Cu ions.

[n0008]

c) The current density is precisely controlled by a constant current power supply, gradually increasing from an initial low current density to a final high current density, so as to form a gradient distribution with a gradually changing ratio of Ni and Cu on the substrate.

[n0009]

d) By utilizing the potential gradient between the electrode and the electrolytic solution interface, the electrodeposition rates of Ni and Cu can be further controlled to achieve a gradient distribution of alloy composition;

[n0010]

e) After electrodeposition, the deposits were characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) to confirm their surface morphology and chemical composition.

[n0011]

f) Based on the characterization results of SEM and EDX, the gradient nanostructure of NiCu alloy was optimized by adjusting electrodeposition parameters, such as current density range, potential gradient, composition and concentration of electroplating solution.

[n0012]

In step a), the pretreatment includes ultrasonication, rinsing, and drying steps.

[n0013]

In step b), the electroplating solution is a mixed solution of sulfate and/or chloride containing Ni and Cu ions.

The total concentration of Ni and Cu ions in the electroplating solution is 10-30 wt%, and the molar ratio of Ni to Cu ions is 1:1-1:1.

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[n0014]

In step b), the anode is a high-purity electrolytic nickel plate.

[n0015]

In step c), the current density is gradually increased from 10 mA/cm² to 100 mA /cm²; the electrodeposition time is 30-100 min.

[n0016]

The NiCu alloy with gradient nanostructure prepared by the above method has a continuously varying ratio of Ni and Cu components along its length or thickness, thus forming a gradient nanostructure.

[n0017]

The NiCu alloy with gradient nanostructure prepared by the above method is suitable for aerospace, nuclear industry, chemical industry and marine engineering, especially in the manufacture of components that require high strength, high toughness and good corrosion resistance.

[n0018]

The beneficial effects of this invention are as follows:

[n0019]

Compared with existing technologies, this technical solution mainly solves the following technical problems:

[n0020]

1) How to develop gradient nanostructured metals through chemical composition methods to overcome the problem that adding alloying elements may change the physical and chemical properties of metals with nanogradient structures in existing technologies.

[n0021]

2) How to manufacture gradient nanostructured metals through compositional methods to avoid the shortcomings of existing technologies where mechanical deformation processes may introduce severe mechanical stress.

[n0022]

3) How to combine gradient nanostructuring into a single process strategy to improve the thermal and mechanical stability of metals with nanogradient structures, while overcoming the problems of complex process flow and high manufacturing costs in existing technologies.

[0026]

Attached Figure Description

[n0023]

Figure 1 is an SEM image of the product obtained in Example 1.

[0028]

Detailed Implementation

[n0024]

Example 1

[n0025]

The main objective of this invention is to prepare NiCu alloys with gradient nanostructures, comprising the following steps:

[n0026]

a) Pre-treatment of the Ni substrate mainly includes ultrasonication, rinsing, and drying to ensure the smooth progress of the electrodeposition process;

[n0027]

b) Construct an electrodeposition system, which includes an electrolytic cell, an anode, a pretreated substrate material as a cathode, and a constant current power supply. The electrolytic cell is filled with a solution containing 20 wt% nickel sulfate and copper sulfate.

[n0028]

c) As a metal, the molar ratio of Ni/Cu in the solution is 1:1;

[n0029]

d) The current density is precisely controlled by a constant current power supply, gradually increasing from an initial low current density of 10mA/cm² to a final high current density of 100mA/cm².

[n0030]

e) Electrodeposition time is 30 min;

[n0031]

f) The NiCu alloy with gradient nanostructure prepared has a continuously varying ratio of Ni and Cu components along its length or thickness direction, forming a gradient nanostructure.

[n0032]

The NiCu alloy prepared in this embodiment has a hardness of 7.08 GPa and a modulus of 168.4 GPa.

[n0033]

As shown in Figure 1, the product obtained in this embodiment has a distinct gradient nanostructure, gradually transitioning from larger Ni metal particles at the bottom to smaller Cu metal particles at the bottom.

[n0034]

Example 2

[n0035]

The main objective of this invention is to prepare NiCu alloys with gradient nanostructures, comprising the following steps:

[n0036]

a) Pre-treatment of the Ni substrate mainly includes ultrasonication, rinsing, and drying to ensure the smooth progress of the electrodeposition process;

[n0037]

b) Construct an electrodeposition system, which includes an electrolytic cell, an anode, a pretreated substrate material as a cathode, and a constant current power supply. The electrolytic cell is filled with a solution containing 20 wt% nickel sulfate and copper sulfate.

[n0038]

c) As a metal, the molar ratio of Ni/Cu in the solution is 1:2;

[n0039]

d) The current density is precisely controlled by a constant current power supply, gradually increasing from an initial low current density of 10mA/cm² to a final high current density of 100mA/cm².

[n0040]

e) Electrodeposition time is 30 min;

[n0041]

f) The NiCu alloy with gradient nanostructure prepared has a continuously varying ratio of Ni and Cu components along its length or thickness direction, forming a gradient nanostructure.

[n0042]

The NiCu alloy prepared in this embodiment has a hardness of 7.58 GPa and a modulus of 172.4 GPa.

[n0043]

Example 3

[n0044]

The main objective of this invention is to prepare NiCu alloys with gradient nanostructures, comprising the following steps:

[n0045]

a) Pretreatment of the Cu substrate mainly includes ultrasonic treatment, rinsing, and drying to ensure the smooth progress of the electrodeposition process;

[n0046]

b) Construct an electrodeposition system, which includes an electrolytic cell, an anode, a pretreated substrate material as a cathode, and a constant current power supply. The electrolytic cell is filled with a solution containing 20 wt% nickel sulfate and copper sulfate.

[n0047]

c) As a metal, the molar ratio of Ni/Cu in the solution is 1:1;

[n0048]

d) The current density is precisely controlled by a constant current power supply, gradually increasing from an initial low current density of 10mA/cm² to a final high current density of 100mA/cm².

[n0049]

e) Electrodeposition time is 60 min;

[n0050]

f) The NiCu alloy with gradient nanostructure prepared has a continuously varying ratio of Ni and Cu components along its length or thickness direction, forming a gradient nanostructure.

[n0051]

The NiCu alloy prepared in this embodiment has a hardness of 8.01 GPa and a modulus of 189.2 GPa.

[n0052]

Example 4

[n0053]

The main objective of this invention is to prepare NiCu alloys with gradient nanostructures, comprising the following steps:

[n0054]

a) Pretreatment of the Cu substrate mainly includes ultrasonic treatment, rinsing, and drying to ensure the smooth progress of the electrodeposition process;

[n0055]

b) Construct an electrodeposition system, which includes an electrolytic cell, an anode, a pretreated substrate material as a cathode, and a constant current power supply. The electrolytic cell is filled with a solution containing 20 wt% nickel chloride and copper chloride.

[n0056]

c) As a metal, the molar ratio of Ni/Cu in the solution is 1:1;

[n0057]

d) The current density is precisely controlled by a constant current power supply, gradually increasing from an initial low current density of 10mA/cm² to a final high current density of 100mA/cm².

[n0058]

e) Electrodeposition time is 60 min;

[n0059]

f) The NiCu alloy with gradient nanostructure prepared has a continuously varying ratio of Ni and Cu components along its length or thickness direction, forming a gradient nanostructure.

[n0060]

The NiCu alloy prepared in this embodiment has a hardness of 8.23 GPa and a modulus of 184.2 GPa.
