Scalable Manufacturing of Copper Nanocomposites with Tunable Properties

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SUMMARY

UCLA researchers in the Department of Mechanical and Aerospace Engineering have developed a cost-effective method to produce copper-based nanocomposites with excellent mechanical, electrical and thermal properties.

BACKGROUND

High performance copper-based materials are needed for a wide range of applications, spanning industries as diverse as aerospace, energy, transportation, and electronics. The current methods of modifying pure copper to achieve these high-performance characteristics all have significant drawbacks. Alloying cannot achieve tensile strengths above 600 MPa with good ductility and reasonable thermal and electrical conductivity, and alloys soften at high temperature. Severe plastic deformation can increase the strength of copper, but significantly decreases its ductility and thermal stanility. Other approaches present challenges in scaling to industrial production levels. Copper-based nanocomposites show promise, but uniform dispersion of nanoparticles within the metal matrix is required and has proven difficult to achieve.

INNOVATION

UCLA researchers have developed a scalable method to produce copper-based nanocomposites with desirable mechanical, electrical and thermal properties. The process uses a salt-assisted method to uniformly distribute the nanoparticles in copper and copper alloys, and can be readily applied to industry-scale production. By varying the amount of nanoparticles used, the functional properties of the resultant material can be tuned to desired specifications. Ingots of cast copper nanocomposites made with this method can be processed with standard methods such as hot rolling, cold rolling, and extrusion. Lab tests produced the following results: an average yield strength of 1020.7±244.3 MPa, with a uniform plasticity of more than 8%; microhardness exceeding 478 HV; and a Young's Modulus of 254.4±11.2 GPa (compared to ~115 GPa for copper and copper alloys). By varying the composition of nanoparticles, the resultant material can be tuned for a range of thermal and electrical conductivities. For example, Cu/12.5 vol.% WC nanocomposite offers a thermal conductivity of 304.1±2.3 W/(mK) and similarly impressive conductivities were noted for copper alloys produced with this method.

APPLICATIONS

- Terminals and connectors for electrical, electronic and automotive applications
- Rotors for electric motors
- High-speed railway contract wires
- Electric resistance welding electrodes
- Integrated circuit leadframes
- Heavy electrical switchgear

ADVANTAGES

- Scalable, cost-effective manufacturing process
- Tunable, high-performance mechanical properties
- Tunable, high thermal and electrical conductivity

RELATED MATERIALS

- S Pan, M Sokoluk, C Cao, Z Guan, X Li. Facile fabrication and enhanced properties of Cu-40 wt% Zn/WC nanocomposite. Journal of Alloys and Compounds, 2019.

STATE OF DEVELOPMENT

Copper-based nanocomposites have been successfully synthesized with varying amounts of other elements demonstrating tunable, high-performance properties.

PATENT STATUS

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OTHER INFORMATION

KEYWORDS

copper, nanocomposites, aerospace, conductive materials, copper alloys, nanoparticles, copper alloys, tunable properties, electronics

CATEGORIZED AS

- **Energy**
  - Transmission
- **Materials & Chemicals**
  - Composites
  - Nanomaterials
  - Superconductors
- **Nanotechnology**
  - Electronics
  - Materials
- **Semiconductors**
  - Design and Fabrication
- **Transportation**
  - Aerospace

RELATED CASES

2019-317-0

Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Concentration Of Nanoparticles By Zone Heating Method
- Evaporation-Based Method For Manufacturing And Recycling Of Metal Matrix Nanocomposites
- Super Ceramics With Self-Dispersed Nanoparticles Via Casting

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