Preparation and Properties Study of Cu-$MoSi_2$ Composites

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Abstract

The particulate strengthened Cu-$MoSi_2$ composites were prepared by a PM process to develop novel copper based composites with reasonable strength, high thermal conductivity and low thermal expansion coefficient. Microstructure of the composites was investigated by SEM; the tensile strength, elongation, thermal conductivity and thermal expansion coefficient (CTE) of the composites were examined. A comparative analysis of mechanical and thermal properties of various Cu-matrix composites currently in use was given and the strengthening mechanisms for the Cu-$MoSi_2$ composites were discussed.

Keywords : particulate strengthening, Cu-$MoSi_2$ composites, thermal properties

1. Introduction

R&D efforts on advanced thermal materials are on a fast move, as critical heat dissipation problems keep arising from fields like the packaging of semiconductors and developments on high power devices. Cu-W and Cu-Mo alloys have been widely used as heat sink materials [1]. For higher performance demand, Cu-based composite reinforced by SiC[2] particles and carbon fiber have been developed because of their superior thermal property. In addition, some intermetallic compounds are also potential candidate reinforcements[3] in Cu-based composites developed for thermal management applications[4] at higher temperatures because of their excellent oxidation-resistance and very good electric and thermal conductivity. The objective of this paper is to prepare Cu-$MoSi_2$ composites and characterize their microstructure and properties. On the basis of experimental work, the potential of the novel composites as heat sink materials is evaluated.

2. Experimental and Results

The raw materials used in this investigation were electrolytic precipitation Cu powder (>99.5%) and ultra fine $MoSi_2$ powder of high purity (≈1μm).

Powders of $MoSi_2$ and Cu were mixed by planetary ball milling. Then, each mixture was cold pressed in a die at 200 MPa. To gain higher green strength, the die pressed samples were further compacted through cold isostatic pressing. The CIPed compacts were sintered in H_2. Final samples were fabricated by hot rolling, followed by a final annealing.

Samples of each composition were examined on properties tests of tensile strength, thermal-conductivity and thermal-expansion.

SEM micrograph of fracture surface in *Fig.1* illustrates a nearly uniform distribution of $MoSi_2$ particulates in the composites. During plastic deformation, voids eventually form dimples shown on the fracture surfaces[5]. The Cu-2%$MoSi_2$ composite exhibits better mechanical performance than that of other composites fabricated.

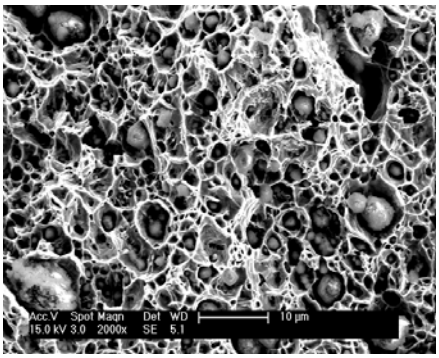

Fig. 1. Dimples and voids in a Cu-2% $MoSi_2$ sample.

Table 1 demonstrates the tensile properties tested. It can be drawn that the 2% $MoSi_2$ has the most favorable properties due to Orowan strengthening mechanism.

Table 1. Tensile property of copper based composites

Composition	σ (MPa)	$\sigma_{0.2}$(MPa)	Elong. (%)
0% $MoSi_2$	195.7	66.2	24.8
2% $MoSi_2$	226.6	75.6	40.4
4% $MoSi_2$	213.3	81.5	11.4
6% $MoSi_2$	181.7	80.2	-
8% $MoSi_2$	146.6	70.4	7.4

Fig.2 a) indicates pure copper and 2% $MoSi_2$ take a great lead in thermal conductive ability. As the vol% of $MoSi_2$ rises, thermal conductivity of the composites undergoes a

sharp drop due to electron scattering in the crystals.
Fig.2 b) is a summary on the relationship between vol% $MoSi_2$ and average CTE. The 2% $MoSi_2$ at 100 °C has the lowest CTE among all.

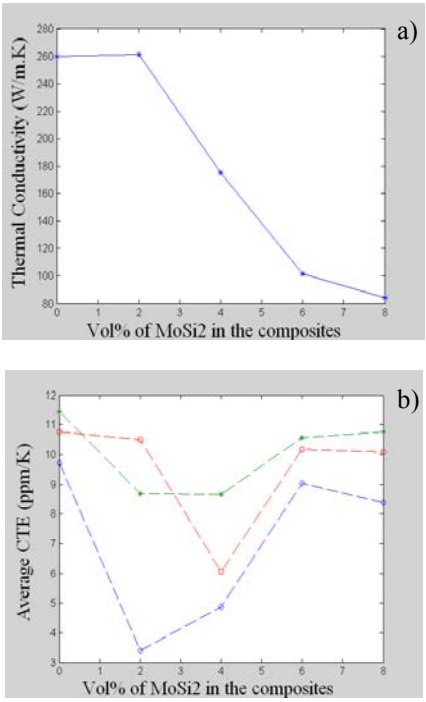

Fig. 2. Relationship between vol% $MoSi_2$ and the composite's thermal properties.
a) Thermal conductivity b) Thermal expansion

3. Summary

The main results from this work are summarized as follows:

1) Cu-$MoSi_2$ composites were prepared through a PM process[6]. A density of over 90% and nearly uniform distribution of $MoSi_2$ particulates in the copper matrix were obtained.
2) As compared to Cu samples, the composites with proper amount of $MoSi_2$ as reinforcement exhibit good thermal conductivity, smaller thermal expansion, and better tensile strength; in particular, the CTE of Cu-2%$MoSi_2$ is five times lower than that of pure Cu sample.
3) Further improvement in both purity and density of the materials is needed for evaluation.

4. References

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