THE EFFECT OF INTERFACE LAYER THICKNESS ON THERMAL CONDUCTIVITY OF DIAMOND PARTICLES DISPERSED CR-ALLOYED CU MATRIX COMPOSITES

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ABSTRACT

Diamond particles dispersed Cu matrix (diamond/Cu) composites are attracting much attention as a promising thermal management material. In this paper, diamond/Cu composites were produced at 1150 ℃ for 30 min under a pressure of 1.0 MPa by a gas pressure infiltration route. In order to overcome the inherently poor interfacial bonding between diamond and Cu, before infiltration, 0.1-1.0 wt.% Cr were added to Cu matrix to modify the interfacial bonding. The X-ray diffraction (XRD) results demonstrated the existence of Cr carbide in the produced diamond/Cu-Cr composites. The transmission electron microscopy (TEM) characterizations further confirmed that a thin layer of carbide was formed at interface of diamond/Cu. This layer is believed to connect diamond reinforcements and Cu matrix closely. As a result, the diamond/Cu composites with Cr-alloyed Cu matrix exhibited much higher thermal conductivity than the unmodified diamond/Cu composite. In the compositional range of 0.1-1.0 wt.% Cr, the thermal conductivity first increased and then decreased with increasing Cr content, and a maximum thermal conductivity of 810 W/mK was obtained at 0.5 wt.% Cr. The thermal conductivity values were also compared with theoretical values predicted by the differential effective medium (DEM) model. The results manifest the role of Cr alloying to Cu matrix in enhancing the thermal conducting properties of diamond/Cu composites.

1 INTRODUCTION

With the dramatic decrease in component size, highly powered devices like laser diodes and large-scale integrated circuits are demanding electronic packaging materials with excellent thermal conductivity. Diamond particles dispersed Cu matrix composites (diamond/Cu) are a promising candidate due to their high thermal conductivity and tailorable coefficient of thermal expansion [1]. Nevertheless, the inherently poor interfacial bonding between diamond and Cu make it difficult to obtain high thermal conductivity in the Cu/diamond composites. Metal matrix alloying and diamond particle coating are applied to solve this problem [2].

2 EXPERIMENTAL

The 0.1-1.0 wt.% Cr were alloyed to the Cu matrix using a vacuum arc melting route and some of the diamond particles were coated with a Cr layer using a vacuum vapor deposition method. The diamond/Cu composites were produced at 1150 ℃ under 1.0 MPa for 30 min by a gas pressure infiltration route.

3 RESULTS

The x-ray diffraction (XRD) patterns suggest that Cr_3C_2 and Cr_7C_3 are formed on the diamond particles in the diamond/Cu composites. The transmission electron microscopy (TEM) observations show that the thickness of the Cr carbide layer increases from 150 to 500 and 700 nm with increasing Cr content from 0.3 to 0.5 and 1.0 wt.%, as show in figure 1.

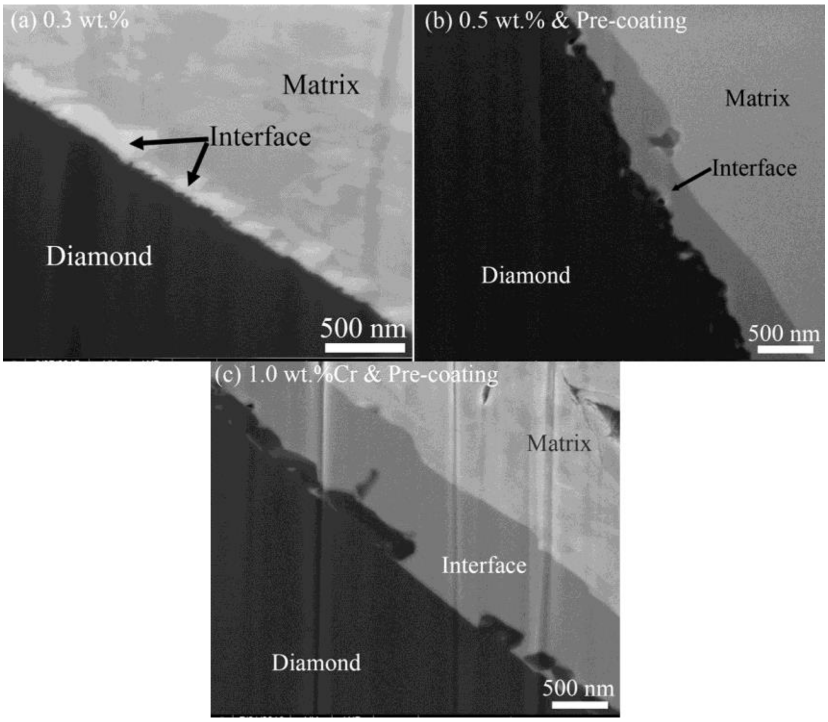

Figure 1: TEM images of the diamond/Cu-*x*Cr composites.

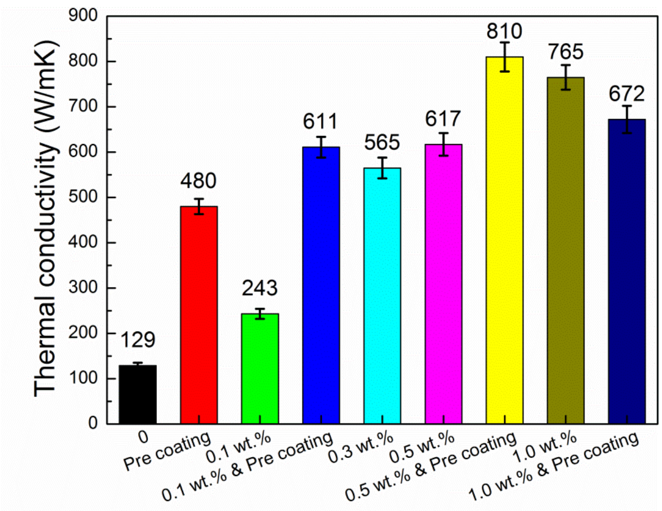

Figure 2: Thermal conductivity of the diamond/Cu-*x*Cr composites.

As shown in figure 2, the thermal conductivity of the diamond/Cu composites first increases and then decreases with increasing Cr content, attaining a maximum thermal conductivity of 810 W/mK at 0.5 wt.% Cr. The thermal conductivity is also compared with theoretical values predicted by the differential effective medium (DEM) model

4 CONCLUSIONS

The diamond/Cu composites with a high thermal conductivity of 810 W/mK were produced by the gas pressure infiltration route. The Cr addition is effective in improving the interfacial bonding and enhancing the thermal conductivity. The finding manifests the role of Cr carbide thickness in tailoring the thermal conductivity of the diamond/Cu composites.

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