Materials Science Forum Vols. 730-732 (2013) pp 925-930
Online available since 2012/Nov/12 at www.scientific.net

doi:10.4028/www.scientific.net/MSF.730-732.925

Multiscale Copper-μDiamond Nanostructured Composites

D. Nunes[1,2,3,a], V. Livramento[1,2,b], H. Fernandes[1,d], C. Silva[1,e], N. Shohoji[2,c], J.B. Correia[2,f], P.A. Carvalho[1,3,4,g]

[1]Associação Euratom/IST, Instituto de Plasmas e Fusão Nuclear - Laboratório Associado, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

[2]LNEG, Estrada do Paço do Lumiar, 1649-038 Lisboa, Portugal

[3]ICEMS-Instituto de Materials and Surfaces Science and Engineering, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

[4]Department of Bioengineering, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

[a]daniela.nunes@ist.utl.pt, [b]vanessa.livramento@ineti.pt, [c]nobumitsus@ineti.pt, [d]hf@ipfn.ist.utl.pt, [e]csilva@ipfn.ist.utl.pt, [f]brito.correia@ineti.pt, [g]pac@ist.utl.pt,

Keywords: Composites, Extrusion, High Energy Milling, Microdiamond, Nanodiamond.

Abstract

Nanostructured copper-diamond composites can be tailored for thermal management applications at high temperature. A novel approach based on multiscale diamond dispersions is proposed for the production of this type of materials: a Cu-nDiamond composite produced by high-energy milling is used as a nanostructured matrix for further dispersion of micrometer sized diamond. The former offers strength and microstructural thermal stability while the latter provides high thermal conductivity. A series of Cu-nDiamond mixtures have been milled to define the minimum nanodiamond fraction suitable for matrix refinement and thermal stabilization. A refined matrix with homogenously dispersed nanoparticles could be obtained with 4 at.% nanodiamond for posterior mixture with μDiamond and subsequent consolidation. In order to define optimal processing parameters, consolidation by hot extrusion has been carried out for a Cu-nDiamond composite and, in parallel, for a mixture of pure copper and μDiamond. The materials produced were characterized by X-ray diffraction, scanning and transmission electron microscopy and microhardness measurements.

Introduction

Diamond has the highest thermal conductivity, 2000 W/mK at 20°C, whereas copper presents 400 W/mK [1]. However, the high thermal expansion mismatch between diamond films and metallic substrates is a severe drawback of diamond use in thermal management applications. Yet, diamond dispersions in copper matrices can result in enhanced thermal conductivity and tailored thermal expansion matching. Indeed, a copper-diamond composite produced by a patent-pending process, which presents up to a 3-fold increase in thermal conductivity in relation to pure copper, has been introduced in the market [2]. Nonetheless, reduced strength and limited thermal stability remain as unsolved issues, impairing the use of these materials under high temperature conditions.