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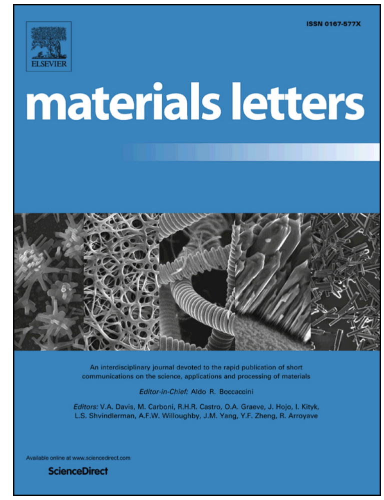

An approach for fabrication of Al-Cu composite by high pressure torsion

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An approach for fabrication of Al-Cu composite by high pressure torsion

V.N. Danilenko[a], S.N. Sergeev[a], J.A. Baimova[a,b,*], G.F. Korznikova[a], K.S. Nazarov[a], R. Kh. Khisamov[a], A.M. Glezer[c], R.R. Mulyukov[a,b]

[a] *Institute for Metals Superplasticity Problems of the Russian Academy of Sciences, 39 Khalturina Street, 450001 Ufa, Russia*
[b] *Bashkir State University, 32 Zaki Validi Street, 450076 Ufa, Russia*
[c] *National University of Science and Technology MISIS, 4 Leninskiy Ave., 119049 Moscow, Russia*

Abstract

The method utilizing high-pressure torsion (HPT) processing followed by annealing to fabricate Cu-Al in-situ composite with enhanced mechanical properties is presented. The initial sample consists of three metal discs Cu/Al/Cu was processed by HPT (5GPa, 5 turns). The analyses of the microstructure after HPT carried out by transmission electron microscopy and scanning electron microscopy equipped with energy dispersive spectrometry (EDS). After HPT, the development of nanostructure with the mean crystallite size of about 100 nm in the produced sample was revealed with the small presence of the intermetallic phases. Investigation of the kinetics during subsequent annealing at 450 ^{o}C/30 min showed the in-situ formation of intermetallic Al_2Cu, AlCu, Al_3Cu_4, Al_2Cu_3 and Al_4Cu_9 phases in the copper matrix which was detected by EDS. The formation of intermetallic phases after annealing was also confirmed by X-ray diffraction. The results showed that microhardness of the composite considerably increases from an initial value of ∼380 for HPT sample to a saturation value of ∼900 after annealing.

Keywords: nano-crystalline materials, phase transformations, in-situ composite, kinetics, microstructure, CuAl intermetallics, high pressure torsion

1. Introduction

Cu-Al composites own excellent thermal properties and electric resistances, for example, Al-Cu clad composite system demonstrates high thermal and electrical conductivity by competitive price in comparison with single Cu [1, 2, 3]. Cu-Al composites seem to possibly substitute pure copper in automotive and aerospace industry. Thus, many efforts in alloying and processing have been performed on this system to obtain composites with improved properties. From this point of view, various in-situ composites, which are a class of composite materials in which the reinforcement is formed within the matrix by reaction during the processing, has attracted much attention in the past decade for their outstanding mechanical and physical properties [4, 5].

Among various methods to fabricate Al-Cu composites are stir-casting technique [6], rotary swaging [1], explosive welding [7], etc. Plastic deformation represents a favourable solution for production of composites which can be produced by conventional forming technologies, as well as by severe plastic deformation (SPD) processes resulting in grain size refinement to the nanoscale [8, 9, 10, 11, 12]. High pressure torsion (HPT), as a kind of SPD technique, was shown to be not so effective method of fabrication of nanostructured materials in comparison with other well-known methods [13]. However, it was shown that HPT is a promising route to fabricate ultra-fine or nanostructured bulk materials [8, 9, 14, 10, 15, 16, 17]. This technique has been applied to Cu-Cr [18], Cu-Mo [19], Cu-Sn [20], Al-Mg [21, 22], Al-Cu [23] composites. It was found, that it is possible to form ultrafine composite via HPT. Formation of the composite structure for the bi-metallic laminate after HPT can be facilitated by a vortex-like folding instabilities of layers [24]. Moreover, SPD by HPT changes the composition of alloys [25]. Solid-state reactions occur by the application of HPT to the AlCu system even at low homologous temperature was found in [23] so that the formation of Al_2Cu, AlCu and Al_4Cu_9 intermetallic phases occurs, as well as the dissolution of Al and Cu in each matrix. However, to date limited reports on synthesis of in-situ Al-Cu composite by HPT have been presented.

This work sets out to provide a consideration of the microstructural evolution of Cu-Al composite during room-temperature HPT deformation followed by annealing. In particular, the extent of microstructural refinement, the formation and decomposition of composite microstructures during deformation and after annealing are examined and analysed.

2. Experimental material and procedures

The starting materials used in this study are coarse grained commercial Al (purity: 99.1%, mean size: 35 μm)

*Corresponding author
Email address: julia.a.baimova@gmail.com (J.A. Baimova)