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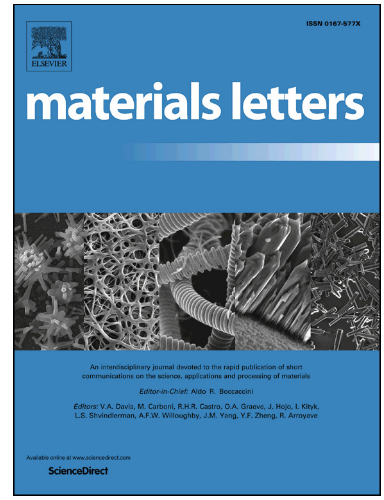

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G. Abrosimova, A. Aronin

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The increase of strength properties at nanocrystal formation

G. Abrosimova and A. Aronin

Institute of Solid State Physics RAS, Chernogolovka, Russia

To obtain a correct estimate of the microhardness dependence on the size of nanocrystals, the microhardness of amorphous-nanocrystalline samples with the same fraction of the crystalline phase and the same composition of the amorphous matrix but different sizes of nanocrystals was studied. It is shown that the dependence of microhardness on the nanocrystal size in the size range from 5 to 15 nm obeys the inverse Petch-Hall law and corresponds to different mechanisms of interaction nanocrystals with shear bands.

Keywords: functional properties, microstructure, nanocrystalline materials

1. Introduction

An important task of materials science is to develop the materials with high mechanical properties. Different treatments contributing to redistribution of structural components, formation of the particles of the second phase, etc., are used to increase the strength properties of known materials. One of the interesting objects – high-strength materials with low specific weight – are aluminum-based amorphous-nanocrystalline materials composed of nanocrystals and an amorphous phase [1-6]. The crystallization of amorphous Al-Ni-RE (RE – rare earth metals) alloys occurs by primary crystallization reaction; Al nanocrystals form in the amorphous phase and the residual amorphous phase changes its composition. Neither transition metals nor rare-earth elements dissolve in Al lattice [7]. It means that amorphous matrix enriches with Ni and RE components when Al nanocrystals form.

It is known that alloy strength increases at nanocrystal formation [2, 6, 8-10]. The formation of Al nanocrystals is accompanied by the change in amorphous phase composition. In this case strengthening can relate to both the amorphous matrix of the changed composition and nanocrystals, their interaction with shear bands during deformation. However, microhardness change with changing chemical composition of the amorphous phase was not yet analyzed. The dependence of strength properties on the nanocrystal size is non-monotonic [11]. In contrast to the conventional Hall-Petch relationship, it has the maximum at the critical nanoparticle size. At the subsequent nanocrystal size reduction microhardness decreases. As a rule, the increase of nanocrystal size at heat treatment is accompanied by the increase of nanocrystalline phase fraction. The dependence of yield strength on the nanocrystal size has not been identified correctly so far since one should have amorphous-nanocrystalline samples of the identical composition with the identical nanocrystalline phase fraction but with different nanocrystal size to determine this dependence. It is rather complicated to obtain such a material since at heat