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# Microstructure of Cu-Ni Matrix Nanocomposites Reinforced with $Al_2O_3$ Nanoparticles

M.I Ramos[1], N.M. Suguihiro[1], E. Brocchi[1] and I.G Solorzano[1].

[1.] Department of Chemical and Materials Engineering, PUC- Rio de Janeiro, Brazil.

Copper-based alloys and composites are widely used in engineering applications. The properties of alloys are exceptionally are improved when processed and structured at the nano-scale [1]. The present work focuses on the processing synthesis and microstructural characterization by transmission electron microscopy (TEM) of an 89wt%Cu-10wt%Ni/1%wt $Al_2O_3$ composite material. The synthesis procedure is reported elsewhere [2]. The metallic powder obtained was cold press into pellets under uniaxial pressure at 15 MPa and sintered at 600°C under pure $H_2$ for 30 minutes and cooling under the same atmosphere down to room temperature. The pellets were transformed into the ribbons by 80% cold-rolling followed to annealing at 600ºC for 30 minutes.

Microstructural characterization was conducted by transmission electron microscopy (TEM) using LaB6 Jeol 2010 instrument under 200 kV accelerating potential operating in diffraction contrast mode. TEM specimens were prepared by typical mechanical thinning down to about 100µm. The thickness of the thinned sample was decreased to 5 µm using a dimpling machine (South Bay Technology model 515) and, finally, submitted to ion milling at low incident angle (Gatan PIPS 691).

Typical microstructure of sintered heterogeneous composite is shown in Figure 1. Two pairs of typical TEM images show metallic particles. In Figure 1(a) is possible to observe the size distribution of the particles, about 50nm, some exhibiting twins, characteristic of thermal treatment. In the other pair of bright and dark field, Figure 1(b), the grains sizes are about 200nm in average; hence grain growth has occurred upon sintering. After 80% cold rolling and annealing recrystallization has taken place and the microstructure of the composite ribbon change completely. In Figure 2 (a) a typical bright field / dark field pair it is possible to observe the fully recrystallized microstructure, free of pores, with 200 nm average grain size. Figure 2(b), in bright and dark field, resolves a fine dispersion of $Al_2O_3$ nanoparticles inside the solid solution Cu-Ni matrix. It is well established the pinning effect of ceramic nanoparticles on metallic grain boundaries, thereby preventing grain growth. Current effort focuses on the detailed measurement of $Al_2O_3$ nanoparticles, their size distribution, morphologies and orientation relationships with the Cu-Ni matrix by means of analytical TEM [3].

References:

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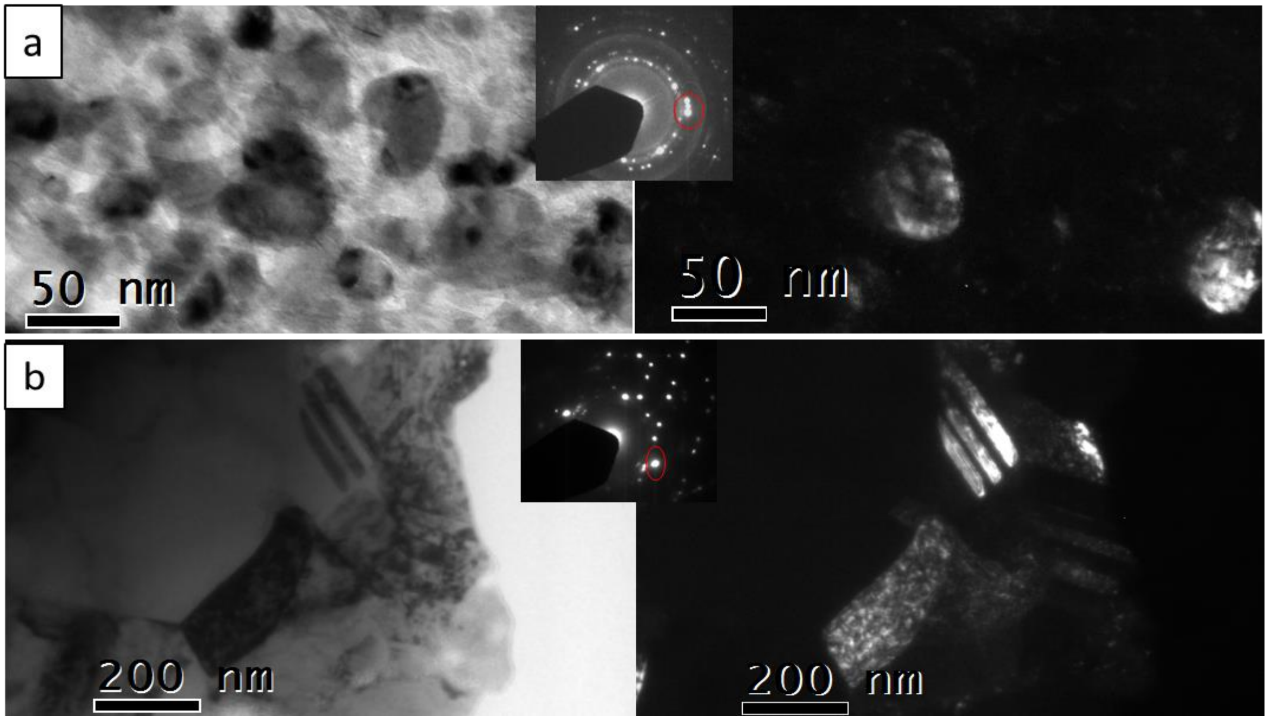


**Figure 1.** TEM bright field/dark field pairs of cold pressed and annealed pellets a) from a porous material region with small grain size and b) coarsened region exhibiting grain growth and annealing twins.

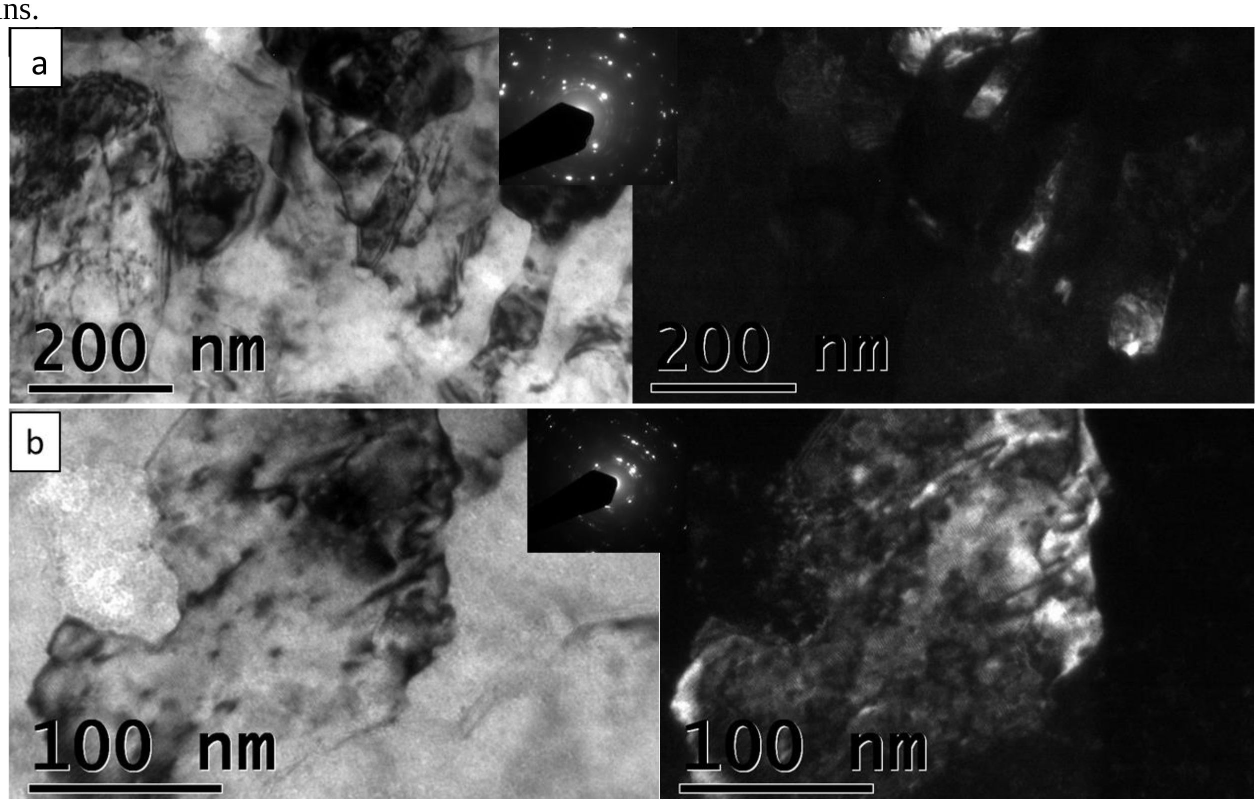


**Figure 2.**TEM bright field/ dark field pair images of cold rolled and annealed composite a) showing a fully recrystallized nano-scale grain size and b) individual grain with fine dispersion of $Al_2O_3$ particles.

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