HRTEM Characterization of Nanoparticles Dispersed into Aluminum Nanocomposites Produced by Mechanical Milling

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Characterization of nanostructures down to the atomic scale is essential to understand some physical properties. This characterization is possible today using direct imaging methods such as aberration-corrected high-resolution transmission electron microscopy (HRTEM). HRTEM is extremely useful for investigating [1] because offers the unique ability to observe nanoparticles (or any solid material) directly in real space at or close to the atomic scale, i.e., the scale at which they are ultimately defined. With modern HRTEM instruments, lattice or structure images of very small particles can be obtained with 0.2-0.3 nm (2-3 Å) resolution [2]. Strong nanoparticles acting as a barrier on the dislocation movement improve the mechanical properties of the metal-based nanocomposites matrix. These materials can be produced by mechanical milling. The refining of the structure during mechanical treatment provides benefits such as small crystallite size, small reinforcing particle size, partial amorphization and homogenous distribution of the desired phase distribution.

In this work, aluminum nanocomposites produced by mechanical milling at different sintering times and composition were characterized by using HRTEM. Atomic structures, chemical composition and morphologies analyses of nanoparticles were carried out. A mixture of Al_4C_3 and C nanopowder were used as reinforcing phase to produced Al-base nanocomposites. The Fig. 1a shows a STEM bright-field image of the aluminum carbide nanoparticles uniformly distributed in the

Al matrix of the nanocomposite; the rod shaped particles are about 60 nm long and 10 nm wide. The HRTEM image of Figure 1b shows the interplanar distances which correspond to Al_4C_3 compound. An increase of microstrain with the heat treatment was detected by x-ray analysis and the results were corroborated with HRTEM images. The increment in the microstrain is caused mainly by the transformation of C in the Al_4C_3 reinforcing phase during the sintering process The Fig. 2 shows a STEM bright-field that shows Al_4C_3 distribution into the Al matrix of the nanocomposite where some particles are producing localized microstrain.

The phases found within this composite were: Al_4C_3, Al3O2-◌̋, and graphite (C).

Thanks to the HRTEM technique was possible identify the phases present in the material and proving to be an excellent tool for microstructural characterization of nanomaterials.

References

Halil Arik, Materials and Design 29 (2008) 1856–1861

G. Abouelmagd. Journal of Materials Processing Technology (2004).

A. Santos et al. Journal of Alloys and Compounds (2010). Microsc. Microanal. 18 (Suppl 2), 2012