Microstructural and Hot Extrusion Evaluation of Aluminum Alloy Al2024 During Mechanical Milling

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Aluminum-based metal matrix composites (MMCs) offer potential for advanced structural applications when high specific strength and modulus, as well as good elevated-temperature resistance, are important. Most of the commercial work on MMCs has focused on aluminum as the matrix metal.

The aim of the present work was to characterize the microstructural in an aluminum alloy Al_{2024} synthesized by Mechanical milling (MM) and compacted by subsequent hot extrusion. Metal shavings of aluminum alloy Al_{2024} and carbon coated-silver nanoparticles (Ag-C NP) were mixed in a container under argon atmosphere. The machined metal shavings were mixed with Ag-C NP in different concentrations (0.00, 0.50, 1.00, 1.50, 2.00, 2.50 wt. % Ag-C NP), next mechanically milled (MM'ed) in a high-energy CM01 Simoloyer mill.

In order to avoid excessive welding of the powders, 38 drops of methanol were added to the powder mixtures, previous to milling runs. Milling time was set to 10 h. MM'ed powders were cold compacted under a uniaxial pressure of ~60 tons, sintering at 773 K and finally the nanocomposite was consolidated by hot extrusion at 808 K. After milling, nanostructures in the range 50-200 nm were obtained. The mechanically milled and extruded composites show finer and homogenous distribution of reinforcement nanoparticles that increase the mechanical properties of obtained products.

Microstructural characterization was carried out by optical microscopy, SEM and TEM. Fig. 1 shows a TEM micrograph from as-milled Al- based composite. After milling process, crystal size range was 50-200 nm. SEM image in back scattered (BE) mode from as-milled Al_{2024}-1wt% Ag-C NP is presented in Fig. 2. Bright spots correspond to Ag-C NP, notice the homogeneous dispersion of NP. Fig. 3 shows a representative view of an Ag-C NP dispersed into aluminum matrix, notice the size lower than 20 nm. Because of high ductility of Al matrix Ag-C NP not suffers high deformation during MM, keeping the equiaxed morphology. Fig. 4 shows a typical microstructure after hot extrusion.

Fig.5. shows the Brinell hardness of different composites. The data are presented as a function of Ag-C NP. The increase in hardness as a function of the nanoparticles content is important. From 0.0 to 2.5 wt. % of Ag-C NP the increase is on the order of 30 Brinell units.

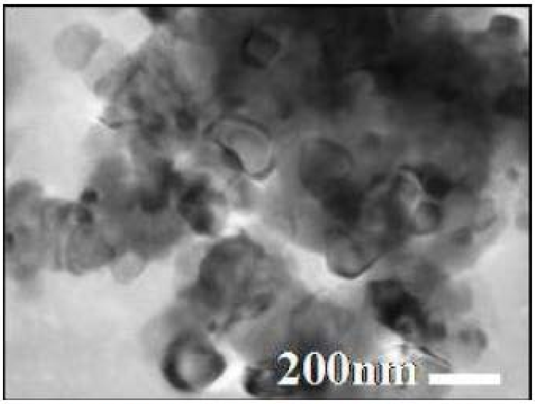

Fig. 1. TEM bright field image of an Al-based composite, showing the crystal size.

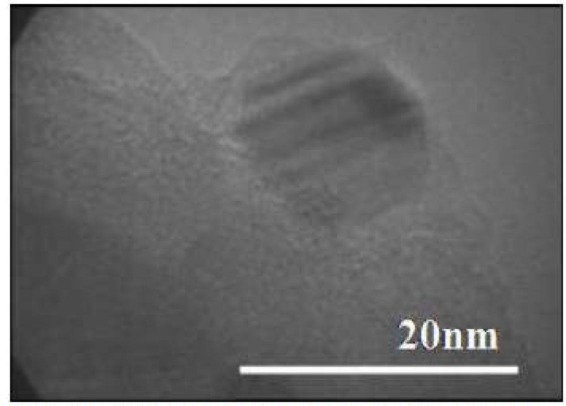

Fig.3. TEM image from Ag-C NP dispersed into Al_{2024} alloy.

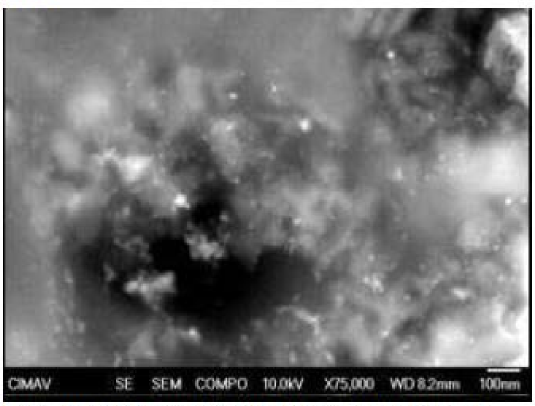

Fig. 2. SEM image in BE mode bright spot correspond to Ag-C NP, notice the nanometric size.

Fig. 4. Optical micrographs of Al_{2024} 1.0 wt % in as-extruded condition.

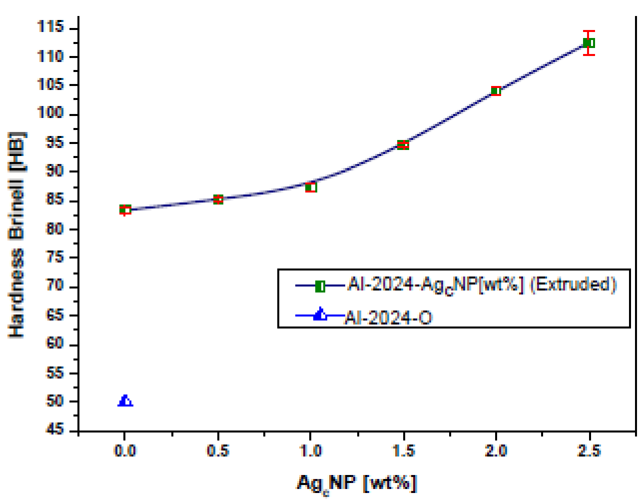

Fig. 5. Brinell hardness as a function of Ag-C NP content.