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TEM Characterization in Al-C-Cu-Al_2O_3 Composites Produced by MA.

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Aluminum-graphite-Copper-alumina (Al-C-Cu-Al_2O_3) novel micro-composites have been produced using the Mechanical Alloying process (MA). Graphite is a dispersoid element, the alumina is come from the oxide surface of aluminum powders and the Cu is an auxiliary element. The mechanics properties of the obtained composites have been evaluated. Al (99.9 % pure, -200 mesh in size) and previously graphite-disperse Cu (-300 mesh) powders were used as raw materials. Different compositions of graphite-disperse Cu were studied, 0.75%C/0%Cu, 0.75%C/0.25Cu, and 0.75%C/0.5%Cu. These were mechanically alloyed with pure Al to produce Al-based metal-matrix-composites (MMC). Each mixture was mechanically milled in a high energy shaker mill (SPEX-8000) during 4 h. The milling ball to powder weight ratio was 5 to 1. Consolidated products were obtained by pressing for 2 minutes at ~1200 MPa in Uniaxial load. Pressed samples were pressure-less sintered for 1 h at 823 K under high vacuum. Microstructural observations were performed by using transmission electron microscopy (TEM).

Figure 1 show the composite microhardness behavior as a function of the composition, before and after the sintering process. Notice the lower values after sintering process; however trend is kept. For quantities > 0.25%Cu, the microhardness increases considerably due probably to mixed effect between de C and Cu.
Figure 2 shows the broadening parameter for two condition of processing (Not sintering and sintering) as a function of composition. The broadening parameter B is due purely to change in crystalline size and strain. It is evident that grain grows and recrystallization processes are higher in the composites than in pure Al when the material is subjected to sintering process. Additionally, as the Cu content increases, the recrystallization - grain grow process is increasing too. However, composites keep high microhardness values; from this, we conclude that exist a strengthening effect due to particles dispersion into the Al matrix of the composites.
Analyses of TEM reveal the presence of dispersed nanofibers into the Al matrix (Figure 3); these nanofibers correspond to Al_2O_3-γ in agreement with high resolution analysis made in the nanofibers (Figure 4). The C has been found dispersed almost homogeneously into the Al-matrix, and highly related to the nanofiber according to high resolution in the nanofibers and composition analyses, one of them is illustrated in the mapping results of Figure 5. We consider that the size of the C is < 10 nm.

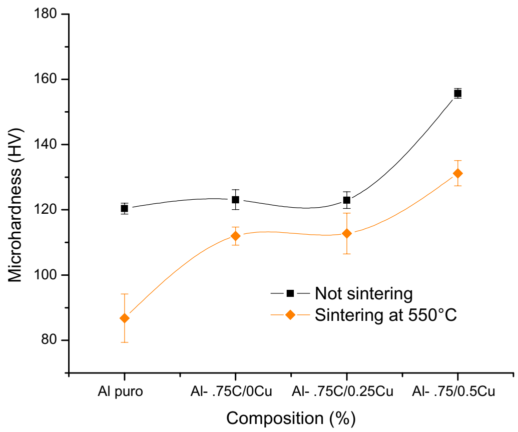

Fig. 1.- Microhardness vs Composition for sintering and not sintering condition.

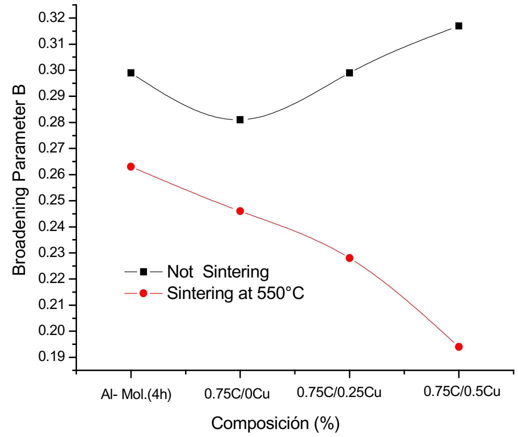

Fig. 2.- Broadening Parameter *B* vs composition for sintering and not sintering condition.

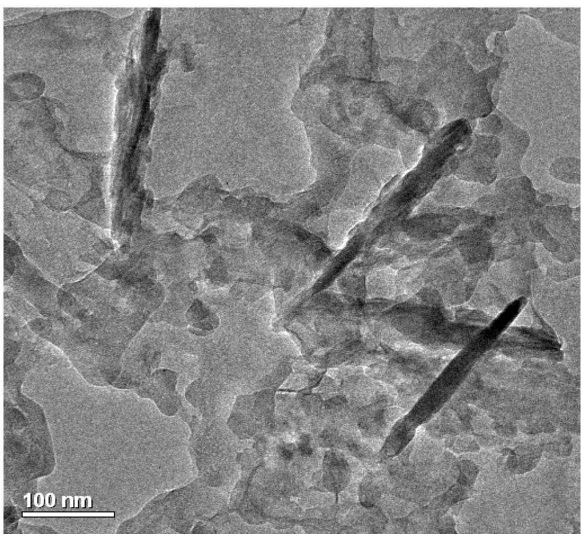

FIG. 3.- TEM micrograph from Al-C-Cu-Al_2O_3 micro composite showing the nanofibers.

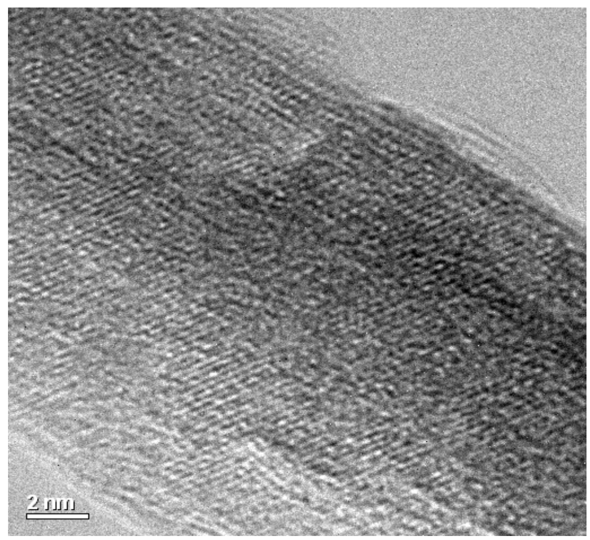

FIG. 4.- HRTEM micrograph from nano-fibers.

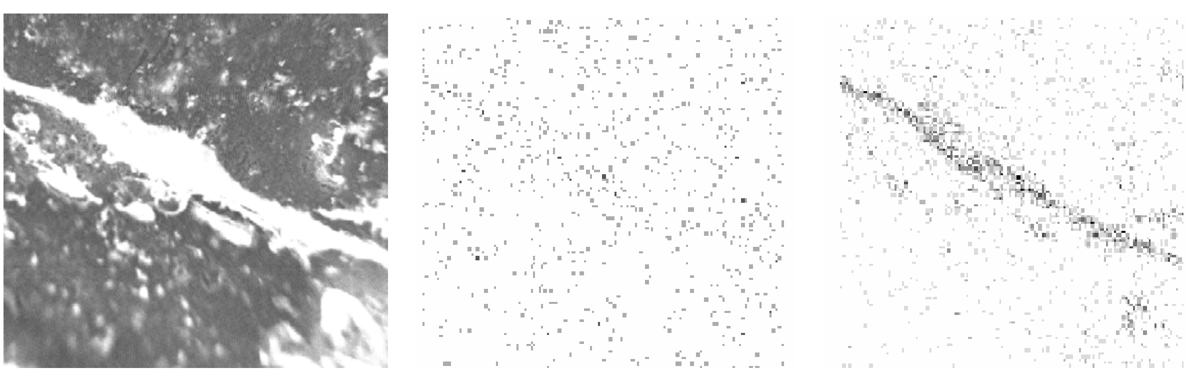

FIG. 5.- TEM micrograph and mapping of a nanofiber from Al-C-Cu-Al_2O_3 micro composite.

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