Microstructural and phase evolution of Al-Cr-Fe-Mo-Nb-Ti-V refractory high-entropy alloys fabricated by mechanical alloying and spark plasma sintering

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ABSTRACT

The microstructural and phase evolution of a series of novel Al-Cr-Fe-Mo-Nb-Ti-V refractory high-entropy alloys (RHEAs) developed by mechanical alloying and spark plasma sintering was studied. The effect of milling time and Cr content over phase formation, particle size and powder morphology was also investigated. After 50 h of milling, the sample exhibited a bcc and a fcc solid solution, according to XRD analysis, and an average particle size of 6.62 μm. No significant changes were observed with further milling time nor Cr content. After consolidation, the XRD patterns exhibit two bcc phases and reflections of an unidentified phase; notwithstanding, the peaks associated with the fcc phase observed in the powder were no longer observed, suggesting the metastability of this phase. SEM-EDS analysis of the as-sintered sample (Figure 1.a) exhibits a matrix consisting of Nb-rich and Mo-rich phases, with ultrafine Ti-rich and Al-rich secondary phases homogeneously distributed throughout the microstructure. The effect of a homogenization treatment on the microstructure of the consolidated samples was also studied. The heat-treated sample exhibited the same four phases than the as-sintered sample, although a remarkable change in the size of the secondary phases was observed, as shown in Figure 1.b.

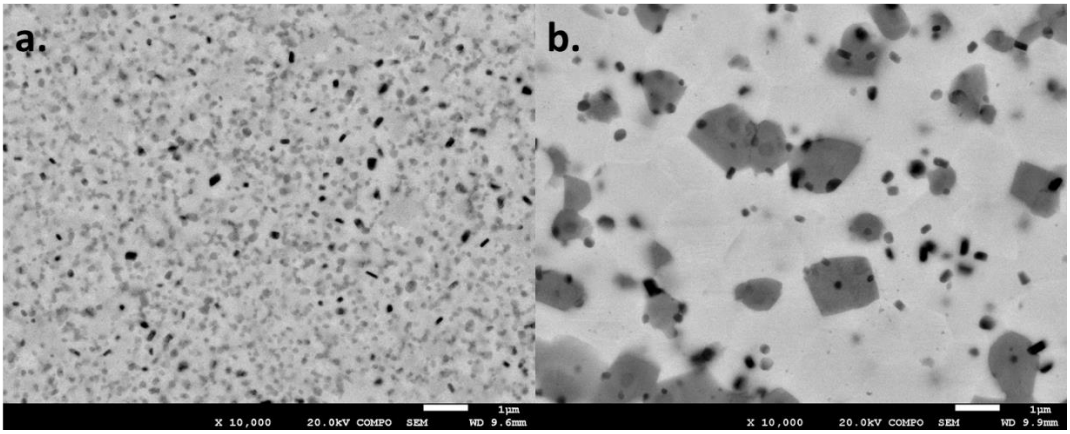

Figure 1: BSE-SEM images of a) as-sintered and b) heat-treated Al-Cr-Fe-Mo-Nb-Ti-V RHEA.