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MICROSTRUCTURAL CHARACTERIZATION OF Al-Fe-Cr-Ce ALLOYS

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Abstract – Great efforts have been directed to understand the formation, structure, mechanical and physical properties of alloys containing icosahedral phases, as well as the stability of such phases at high temperatures. The high strength, typical of quasicrystalline phases, can be useful in Al-based alloys for example in a structure containing quasicrystalline nanoparticles dispersed in an aluminium-matrix. The objective of the present work was to evaluate the formation of quasicrystalline phases in $Al_{92}Fe_3Cr_2Ce_3$ and $Al_{93}Fe_3Cr_2Ce_2$ (at.%) alloys using two different rapid solidification processes; centrifugal force casting in copper mould and injection casting into cooper mould of cylindrical section with different diameters. Samples were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM) and differential scanning calorimetry (DSC).

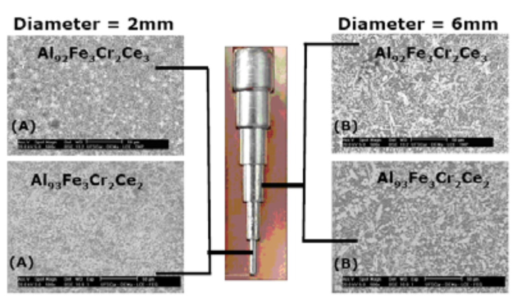
It is well known that the rapidly solidification process causes important microstructural modification frequently associated with the production of metastable phases. Such possibility to design new microstructures is in phase with the rapid progress observed in the world of materials, which must respond to new and trendiest technologies, and obviously novel applications. Better control and understanding of the performance of new materials requires knowledge and control of the microstructure since important changes in properties can be often associated with small changes in composition, presence of equilibrium and / or metastable phases and phases distribution. This is even more important when we take into consideration the presence of nanometer scale phases, which now play an important role in materials science and solid-state physics.

In the case of aluminum based alloys, a variety of metastable, amorphous, nanostructured or quasicrystallline phases is observed in multicomponent compositions containing transition metals and rare-earth as alloying elements

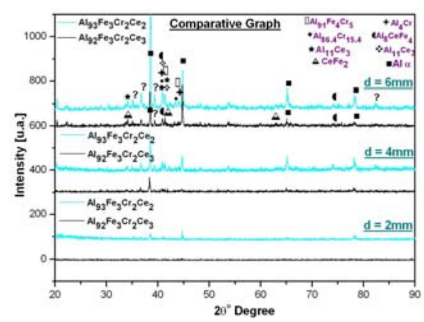
In the present work we have used two different rapidly solidification processes to produce a high volumetric fraction of α-Al phase with refined grains in addition to aggregates of phases with varied morphologies including intermetallic phases radiating from grains with quasycristalline morphologies. These microstructures, which can be classified as a nanophase composite can be observed in the SEM micrographs showed in fig. 1A. The x-ray diffraction patterns presented in fig. 1B were taken from the transversal section of the cylindrical samples in diameters of 2mm, 4mm and 6mm and the results reveal the presence of the metastable phases $Al_{91}Fe_4Cr_5$, $Al_{80}Cr_{13.5}Fe_{6.5}$ and $Al_{95}Fe_4Cr$ for the $Al_{92}Fe_3Cr_2Ce_3$ alloy, and $Al_{11}Ce_3$, Al_4Cr, $Al_{86,4}Cr_{15,4}$ and $Al_{91}Fe_4Cr_5$ phases for the $Al_{93}Fe_3Cr_2Ce_2$ alloy.

Thermal analysis confirms the presence, in both alloys, of quasycristalline phases stable up to 560ºC, indicated in the DSC curves of fig. 1C. In the paper, we discuss the microstructure evolution and its consequences in terms of mechanical properties

(A)



(B)



(C)

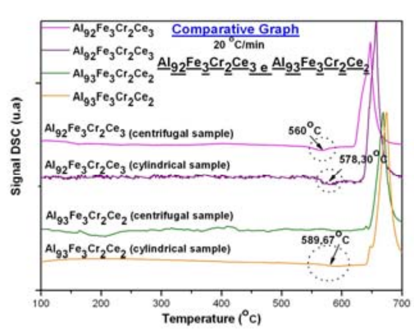


Figure 1: (A)SEM images showing different morphologies of cylindrical samples with 2mm and 6mm diameter; (B) XRD patterns of 2mm, 4mm and 6mm diameter samples obtained by casting in cylindrical section copper mold, and (C) DSC analysis showing for 2mm diameter sample with a heating rate of 20°C /min