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Microstructural analysis of master alloys processed by mechanical alloying

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Aluminum and its alloy offer attractive characteristics related with weight and mechanical strength that make them ideal metals to disperse a wide range of reinforcements with promising physical and chemical properties [1]. Nowadays, rare earths are intensively investigated due to their potential in the manufacturing of components tough for structural applications at room and hot working conditions [2]. However, the dispersion of reinforcement agents implies difficulties by casting routes, when considering high concentrations and differences in nature between the reinforcement and the matrix. An alternative route to overcome this problem, implies the use of mechanical milling [3], which offer promising results for homogeneous dispersion and fragmentation of secondary phases due that is a materials-processing method where fracture and welding events take place, forming alloys and composites with a controlled microstructure.

In this work, rare earths were processed by means of powder metallurgy routes and mechanical milling in order to produce a refinement of secondary phases present in master alloys. A commercial master alloy composed by 6.0 wt.% of Ce, and 3.0 wt.% of La, was mechanically milled for 5 and 10 h. All runs were carried out under an inert atmosphere with a high energy mill. For microstructural characterization the preparation of the cross-section of milled powders were carried out by cold mounting in epoxy resin and subsequently analyzed by scanning electron microscopy.

Fig. 1 shows backscattered electron SEM micrographs of the cross-section of the as-received 6.0 wt.% of Ce, and 3.0 wt.% of La. The images display large needles phases; which length exceeds 50 micrometers. Fig. 2 shows the fragmentation behavior of the master alloy as function of the milling time. Figs. 2a,c display the powder morphology of the samples milled during 5 h, whilst Figs. 2 b,d present the effect of milling time on the powder morphology and particle size reduction after 10 h of milling. The cross-section of the micrographs reveals a dramatic effect of milling time on the fragmentation of secondary phases composed by Ce and La. Particles appears with a equiaxed and irregular shape, where a narrow particle size distribution can be observed. These observations suggest that the increase in the milling time favors the reduction in particle size and the fragmentation of secondary phases.

The microstructural analysis of the processed alloys suggests that extending the milling time a complete solid solution of Ce and La phases can be formed due to the continuous fragment and refinement generation of particles and secondary phases that constitutes their microstructures [4]. This behavior has been observed in the dispersion of nanotubes in aluminum alloys, achieving a solid solution after 30 h of milling [5]. The dispersion and processing of secondary phases in order to reduce their original size is viable way to produce master alloys. This is due to the high solid solubility limits that mechanical alloying and milling offer when considering non equilibrium conditions in the synthesis and processing of advanced materials.

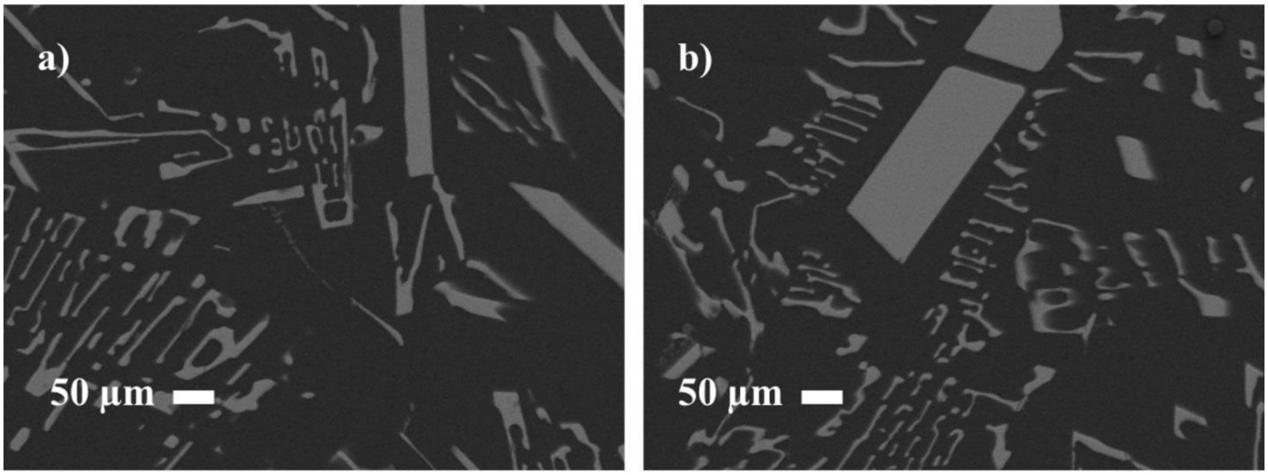

Figure 1. (a,b) Backscattered electron SEM micrographs of the as-received master alloy

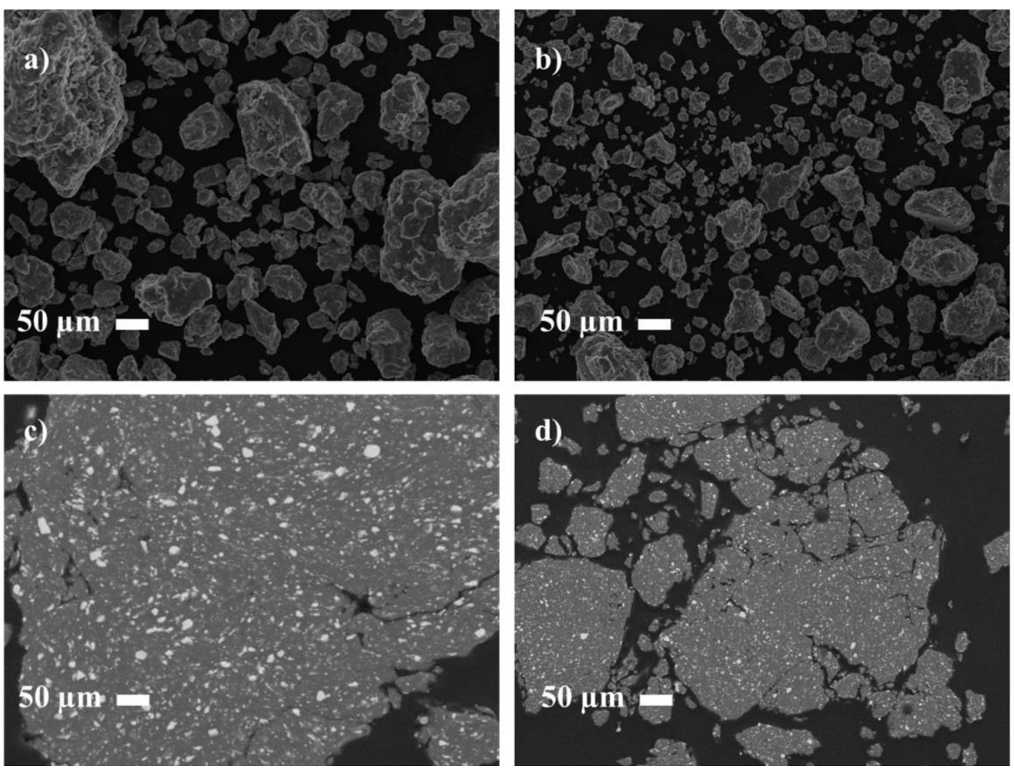

Figure 2. (a,b) Secondary electron SEM micrographs of powder morphology corresponding to the master alloy after mechanical milling of 5 and 10 h respectively. (c,d) Backscattered electron SEM micrographs of the cross-section corresponding to the master alloy after mechanical milling of 5 and 10 h respectively.

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