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Synthesis of AlCoNi-SiC Composite Prepared by Mechanical Alloying

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Extensive researches have been carried out geared towards the ongoing improvement of the properties and performance of materials. Chemical modification and thermo-mechanical processing methods have been able to improve the physical properties of these materials. However, ever increasing demands for better materials that exceed the traditional physical characteristics have led to the design and development of advanced materials. Aluminum based composite materials are leading ones in this area; they are fabricated using various methods, including powder metallurgy processes [1]. Mechanical alloying (MA) is a solid-state powder processing technique involving repeating welding, fracturing, and re-welding of powder particles in a ball mill. Mechanical alloying is a unique process for fabrication of several alloys and advanced materials at room temperature. The traditional materials commonly used SiC, Al_2O_3 or B_4C particles incorporated into the matrix by a variety of processes including powder metallurgy. The properties that are trying to improve are the elastic modulus, enhanced heat and wear resistance [2], and for the case of materials processed properly, improved high cycle fatigue performance [3] relative to the unreinforced matrix. Carbides are interesting materials as reinforcement capability to be applied in several fields in materials science, because their excellent chemical, physical and mechanical properties, they are widely applied in electronic, automotive and aircraft industry. In the field of materials, metal-based composites reinforced with carbides offer the possibility of increasing the mechanical performance of novel materials produced by a wide variety of techniques.

In this work, Al, Co and Ni powders were used to make the matrix alloy. SiC particles were added as reinforcement. The dispersion of particles was carried out by milling in a high-energy Spex 8000M device, with a milling time of 3 h. The reinforcement particles were added to the equiatomic AlCoNi matrix in a 2.5 wt.% concentration. The millings were performed under an argon atmosphere. Methanol was added as process control agent in order to avoid the excessive agglomeration of particles. Powders were cold consolidated under a pressure of 1.5 GPa. Consolidated samples were sintered at 1200°C under vacuum atmosphere during 3 h. Raw materials and composites were characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM) with energy dispersive spectrometer (EDS). The mechanical behavior of the composites was evaluated in the as-milled and sintering condition through Vickers microhardness.

Figure 1 shows secondary electron (SE) SEM micrograph of the SiC nanoparticles, with an average particle size of 43 nm, which were used for reinforcing the AlCoNi alloy. Figure 2 displays a mixture of powder particles of different materials and a homogeneous morphology after alloying process. This is achieved with the continuous competition between plastic deformation, agglomeration and size reduction.
Microstructure representative micrographs of the sintered sample are shown in Figure 3, where a microporous microstructure of mechanically alloyed and sintered materials can be appreciated. Furthermore, two main phases can be seen, where a continuous dark area having a chemical composition

close to the equiatomic ratio, a discontinuous bright area having low aluminum content, and submicron precipitates are observed. Figure 4 presents a micrograph of AlCoNi alloy reinforced with SiC, in which a decrease of size and density of pores, as well as the presence of Al_2O_3 and SiC particles can be seen. The two main phases observed in the micrograph of Figure 3 still prevail in the sintered sample reinforced with SiC (see Figure 4); Figure 5 shows the abundant elements (Co and Ni) in each phase (detected by EDS technique). The results of microhardness tests are given in table 1. The highest hardness value was reached for the sintered AlCoNi-SiC sample (556.10 HV).

In the present work, an effort has been made to study hardness and microstructural properties of the AlCoNi alloy reinforced with SiC particles developed through mechanical alloying method of powder metallurgy technique. The results from the present investigation show that: a) mechanical alloying processing has its drawbacks as: decreased ability of powders to deform plastically, an increase of pores on the consolidated elements; b) a relatively homogeneous distribution of SiC particles reinforcement in the matrix could be produced by mechanical alloying; and c) SiC particles are a good candidate for use as reinforcing materials in a metal matrix.

References:

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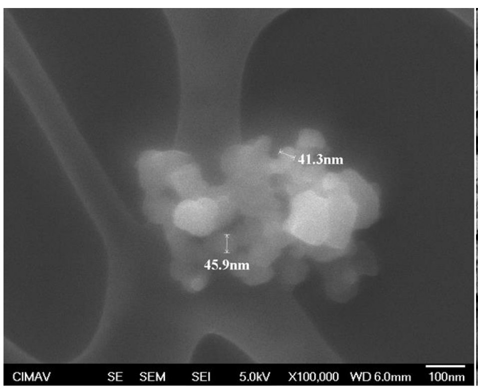

Figure 1. SE-SEM micrographs of SiC nanoparticles.

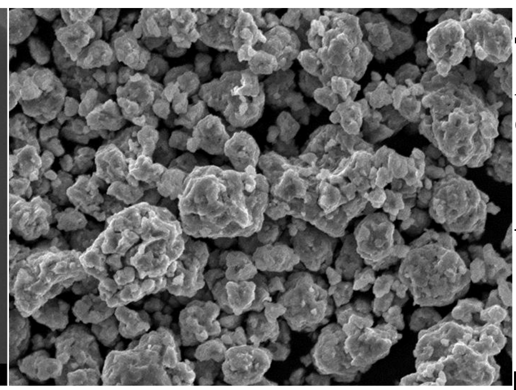

Figure 2. SE-SEM of AlCoNi powders with 10 h of milling.

Table 1. Microhardness of AlCoNi alloy sintered and doped with powder SiC.

Sample	Hardness (HV)
AlCoNi	491.92
AlCoNi-SiC	556.10

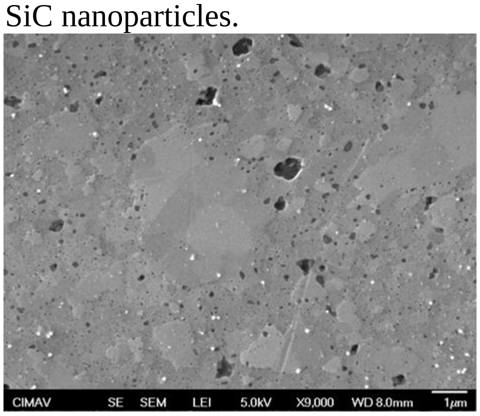

Figure 3. SE-SEM of AlCoNi samples sintered at 1200°C.

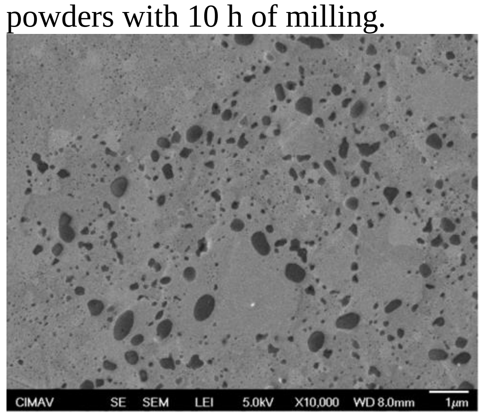

Figure 4. SE-SEM of AlCoNi reinforced with SiC.

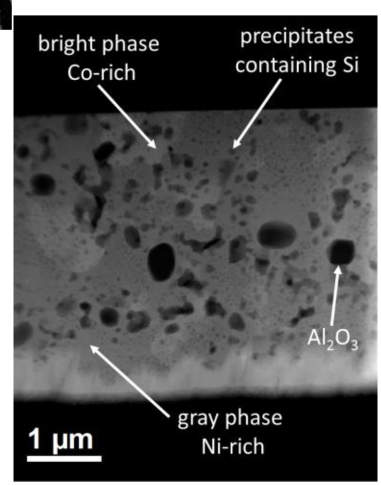

Figure 5. TEM of AlCoNi reinforced with SiC.