1039
doi:10.1017/S1431927615005991 Paper No. 0520
Microsc. Microanal. 21 (Suppl 3), 2015

Microstructure and mechanical properties of Al-composites reinforcing with Gr/Ni nanoparticles processed by high-energy ball milling.

J.M. Mendoza-Duarte, R. Martínez-Sánchez, C. Carreño-Gallardo, I. Estrada-Guel.

Centro de Investigación en Materiales Avanzados (CIMAV). Laboratorio Nacional de Nanotecnología Miguel de Cervantes No. 120, 31109, Chihuahua, Chih., México.

Aluminum (Al) composites have been applied in the automotive and aerospace industry [1] due their low density and high strength. These materials can be produced with oxides, carbides or nitrides dispersed in the metallic matrix by mechanical milling. Recent studies show an increment in mechanical properties with different reinforcing materials as nanotubes [2-4], graphenes [5] and carbon [6]. These additives induce different reinforcement levels, depending how do they interact with material dislocations [7]. Graphite (Gr), an allotropic form of carbon, is used as reinforcing additive because it is cheap, abundant and can be easily comminuted. D. Yadav et al. [8] added nickel (Ni) particles to an Al matrix by friction stir processing, finding that Ni helps to obtain grain refinement and increase the mechanical properties of the prepared composites.

This work deals with the synthesis of some Al-based composites reinforced with Ni nanoparticles covered with Gr by mechanical milling. These composites were prepared and their morphology and mechanical properties were evaluated as a function of milling intensity. The first step was cover Ni particles with Gr by mechanical milling, this process was carried out using a SPEX-8000M mill using steel balls with a ratio (milling media to powder) of 5:1 (in wt.), mixtures of 90% Gr and 10% Ni were milled during 0, 1, 2, 3 and 8h periods. After, the Al composites were synthesized following same procedure using mixtures of pure Al powder and previously metallized 1%Gr-Ni particles (in wt.). The milled composites were compacted using a cylindrical die under 900MPa and sintered 4h at 623K in order to prepare samples for mechanical tests.

Micrographs in Fig. 1 show an important increment of the particle size of composite particles after milling, forming equiaxal particles due Al ductility and milling media impacts. In Fig. 1a some Gr/Ni particles embedded in the Al matrix are shown an attached EDS analysis confirms their composition.

The Fig. 2.1 presents the stress–strain curves of the studied Al-Ni/Gr composites compared with milled and un-milled pure Al sample used as a reference. Pure Al milled sample (Alp 2h) shows a notable increment on its mechanical response (compared with un-doped and un-milled Alp 0h), this is caused by the increment of the dislocations density and grain size reduction achieved by milling. On the other hand, with Gr/Ni addition, a more important increment is obtained, reaching a maximum value with Gr/Ni 4h addition. Hardness tests were also carried out and the results are detailed in the Fig. 2.2. In the graph, it is noticeable a higher hardness value of pure Al milled sample in comparison with the un-milled reference. Also, the highest increment was found with the composite milled by 2h with Gr/Ni 4h addition.

References:

[1] S. Hurley, Met. Bull. Mon. (1995) 54-56

[2] Y. Wu, G.-Y. Kim, A.M. Russell, Mater. Sci. Eng. A 538 (2012) 164-172.

[3] S. Salimi, H. Izadi, A.P. Gerlich, J. Mater. Sci. 46 (2011) 409-415.

[4] K. Hansang, L. Marc, Nanotechnology 23 (2012) 415701.

[5] R. Pérez-Bustamante, D. Bolaños-Morales, J. Bonilla-Martínez , I. Estrada-Guel, R. Martínez-Sánchez, J. Alloys Comp. (2014) 578-582.

[6] Halil Arik. Mat. Design (2004) 31-40.

[7] S. Goussous, W. Xu, X. Wu, K. Xia, Compos. Sci. Tech. 69 (2009) 1997-2001.

[8] Devinder Yadav, Ranjit Bauri Mat. Sci. Eng. A 528 (2011) 1326-1333.

[9] This research was supported by CONACYT (Project Nr. 169262) and the Redes Temáticas de Nanociencias y Nanotecnología (124886).

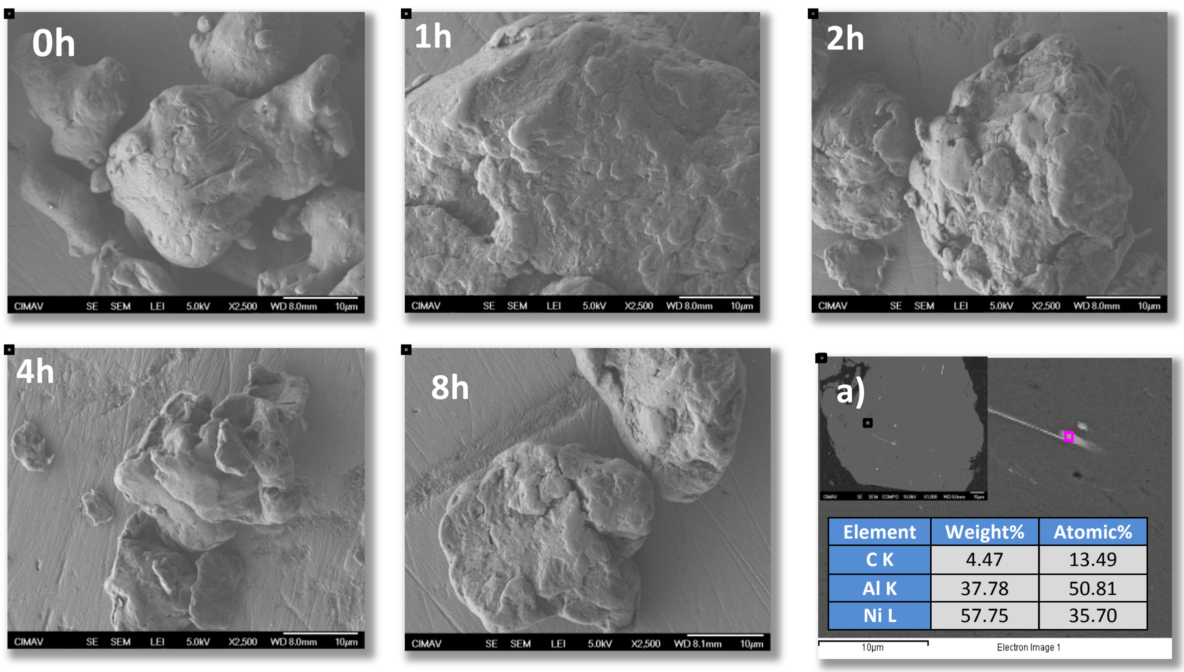

Figure 1. SEM micrographs (SE detector) of Al-Gr/Ni particles of milled composites. (a) Cross section image (RE detector) of Al Gr/Ni4h sample after 2h of milling.

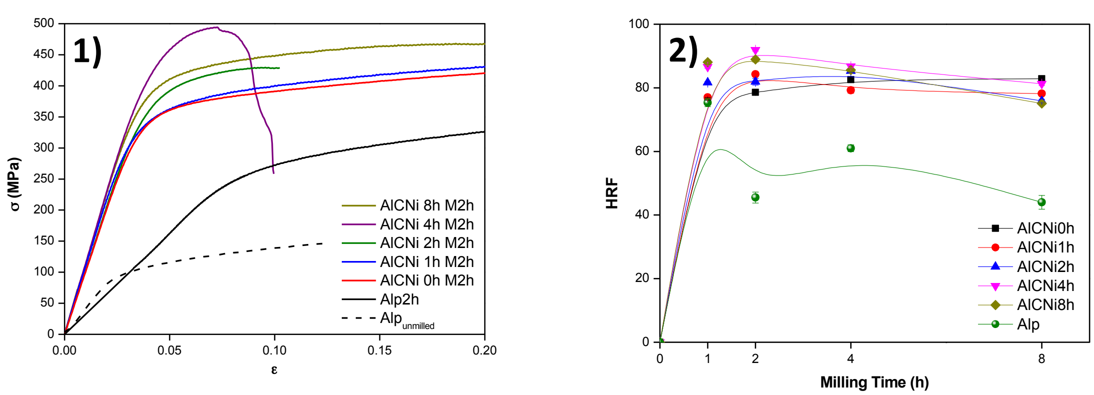

Figure 2. 1) Compressive test curves of samples milled 2h and 2) Plot of hardness results as a function of milling intensity and Gr/Ni addition.

https://doi.org/10.1017/S1431927615005991 Published online by Cambridge University Press