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Graphene as reinforcement agent in aluminum alloy 7075 matrix composite by using mechanical milling

E. Cuadros-Lugo[1], I. Estrada-Guel[1], M. Herrera-Ramírez[1], C. López-Meléndez[2] and C. Carreño-Gallardo[1].

[1.] Centro de Investigación en Materiales Avanzados (CIMAV). Laboratorio Nacional de Nanotecnología. Miguel de Cervantes No. 120, 31136, Chihuahua, Chih., México.
[2.] Universidad La Salle Chihuahua, Prol. Lomas de Majalca No. 11201, C.P. 31020 Chihuahua, México.

Metal Matrix Composites (MMCs) have made their ways into various applications in electronic packaging, aerospace, and automotive industries [1, 2]. Recently, MMCs reinforced with nano-elements have attracted the interest of many researchers. Nanoscience and nanotechnology primarily deal with the synthesis, characterization, exploration, and exploitation of nanomaterials. Carbon, one of the most common atoms on Earth, occurs naturally in many forms and as a component in countless substances which are called allotropes of carbon. Graphene, a "wonder material" is the world's thinnest, strongest, and stiffest material, as well as being an excellent conductor of heat and electricity. It is the basic building block of other important allotropes. Graphene oxide (GO) is of great interest due to its low cost, easy access, and widespread ability to convert to graphene. Scalability is also a much desired feature [3].

Aluminum alloy 7075 (Al7075) was used as the matrix phase and graphene (GNP) as reinforcement, both components were used as the starting materials to produce GNP/Al7075 composites. Initial Al7075 burhs were produced by machining a commercial solid bar, and the GNPs were synthesized by dry ice method. The coarse powders were mixed with GNP in different concentrations (0.3wt.% and 1.0wt.%). The mechanical milling of powder mixture was performed in a high-energy mill (SPEX 8000), under an inert atmosphere of pure argon gas. The milling container was made of stainless steel and milling media was made of hardened chrome steel, 5 drops of methanol were used as a process control agent to avoid excessive cold-welding of the powder particles. The GNP/Al7075 composite powders used to prepare compression samples; the milling time was constant (2 hours). A blank (reference) sample without any reinforcement addition was produced under the same conditions for comparison purposes. The milling ball-to-powder weight ratio was set at 5:1.

In Figure 1, the addition of graphene has an immediate effect in Al7075 matrix, this effect in on the mechanical properties, mainly on yield strength. With the introduction of 0.3wt.% of GNP, the yield strength is increased from 239 MPa to 351 MPa, however, the composite with 1.0wt.% of GNP present a considerable decrease on the same property, this behavior can be attribute, High concentrations of GNP, generate agglomerations, causing a reduction in mechanical properties. With the increasing on GNP content, the GNP/Al7075 composite shows significant improvements on mechanical performances.

Figure 2(a) shows the physical characteristic of GNP as well as the distinction of the number of layers, figure 2(b) present bright-field TEM images of large GNP in the fabricated 0.3wt.%GNP/Al7075 composite. It can be found that the GNP, which has distinctly wrinkled, folding and multilayer features and the GNP covers a large area of the Al7075 surface. GNP became an effective reinforcement with deposition of GNP are closely embedded on the Al7075 matrix. Good dispersion of reinforcement is seen through along the particles of Al7075.

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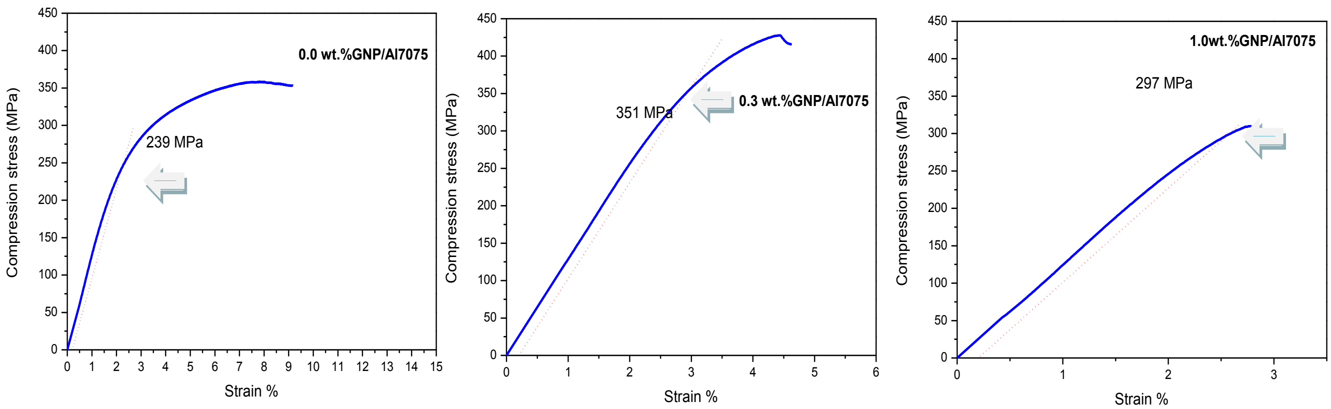

Figure 1. Room temperature compression stress strain compression curves of samples containing 0.0wt.%, 0.3 wt.%, and 1.0 wt.% GNP.

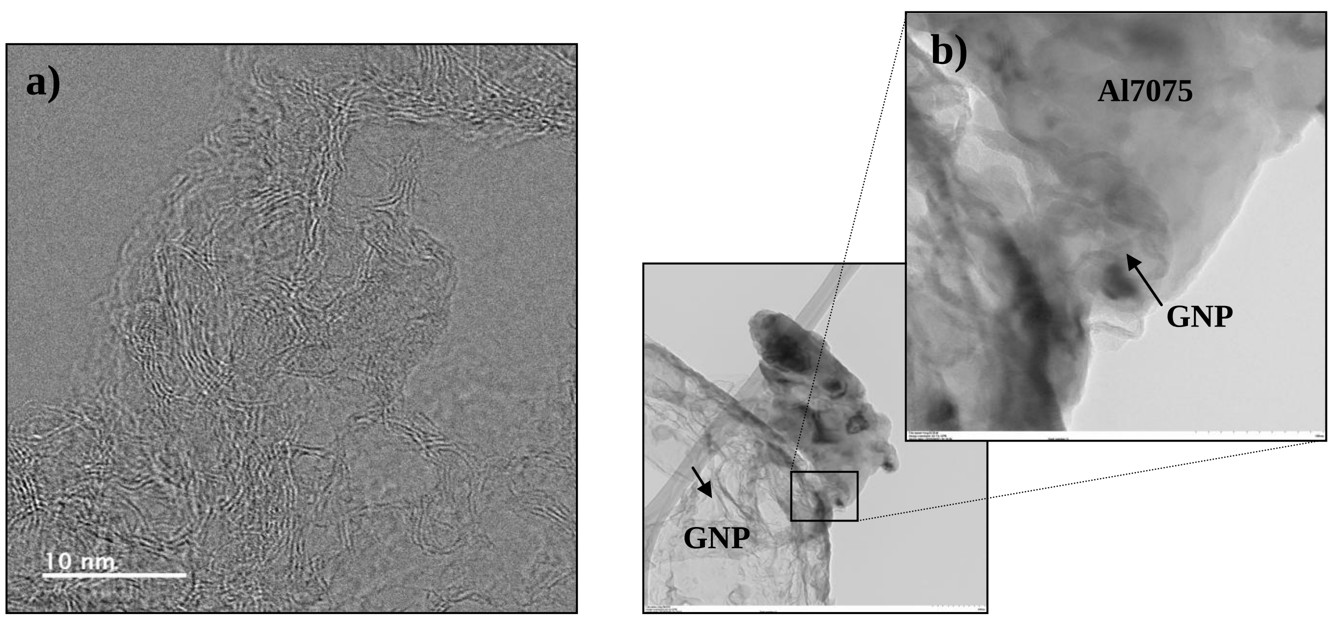

Figure 2. Bright-field TEM images of GNP (a) and (b) low-magnification images showing large GNP in composites, and (c) a high magnification image showing GNP fragments embedded in the composites.

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