doi: 10.1017/S1431927609097700
Microsc Microanal 15(Suppl 2), 2009

Aluminum Carbide Nanoparticles Produced By Mechanical Milling

A. Santos-Beltrán*, M. Miki-Yoshida**, F. Alvarado-Hernández,* S. Haro-Rodríguez*, V. Gallegos-Orozco*

*Unidad académica de Ingeniería. Universidad Autónoma de Zacatecas, Av. López Velarde 801, C. P. 98000. Zacatecas, Zac. México.
** Centro de Investigación en Materiales Avanzados (CIMAV), Miguel de Cervantes No. 120, C.P. 31109, Chihuahua, Chih., México·

The reinforcing particles Al_4C_3 have become an interesting reinforcing material because their high level of physical and mechanical properties, e.g. high temperature strength, thermal cyclic resistance, wear resistance and low linear expansion coefficient. Therefore, the reinforcement of the aluminum using Al_4C_3 has recently become the subject of many studies and widely used for products and structures [1]. Mechanical milling (MM) technique, such high energy ball milling process, is suitable for producing composite metal powders with a fine controlled microstructure. This method is crucial for obtaining homogeneous distribution of nano-sized dispersoids in a more ductile matrix (e.g. aluminum- or copper based alloys) [2]. Over last two decades high resolution transmission electron microscopy (HRTEM) has become a technique for direct structural and analytical investigation of ultrafine particles.

In this work, Al_4C_3 nanoparticles were synthesized using Al powders (99.5% pure) and C as raw materials. A mixture of Al powders at 75 wt. % and C powder at 25 wt. % was used to produce the compound. The mixture was mechanically processed in a high energy mill (Symoloyer) for 8h and the product was compacted at ~200 MPa of pressure. The consolidated samples were sintered for 2h at 550°C. The characterization was carried out by X-ray diffractometry, scanning electron microscopy (SEM) and HRTEM.

The X-ray diffraction pattern of the Al-C sintered powder shown in Figure 1 reveals the Al_4C_3 formation and Al and C as residual elements. As we can see, a high fraction of Al remains without reacting. The morphology of a particle of the Al-C sintered powder is observed in the secondary electron SEM image (see Figure 2). The image reveals also a homogenous mixture and a nanocrystalline state. The TEM dark field image of Figure 3 shows the size and dispersion of Al_4C_3 nanoparticles in the Al matrix and the selected area diffraction pattern (SADP) inset, shows also the existence of C and Al_2O_3-γ. These results are in agreement with the HRTEM analyses carried out on the Al-C sintered powder particle surface (see Figure 4). According with the results, aluminum carbide nanoparticles are formed and dispersed into the Al matrix during the MM and subsequent sintering. A certain quantity of residual graphite (without reacting) remain adhered to the aluminum particle surface [3] and the alumina type Al_2O_3-γ (Al_2O_3-α comes from oxide layers of Al powder which is transformed to Al_2O_3-γ during the sintering processes) is dispersed on the particle surface given an appearance of shell structure [4].

References
[1] G. Abouelmagd, J. Mat. Proc. Tech. 155–156 (2004) 1395–1401.
[2] M. Besterci1, O. Velgosová, L. Kováč, F. Lofaj, Mat. Sci. 9 (2003) 22-26.
[3] H.T. Son, T.S. Kim, C. Suryanarayana, B.S. Chun. Materials Science and Engineering. A348 (2003) 163-169.
[4] A. Santos et al. Journal of Alloys and Compounds (2007) 434-435.

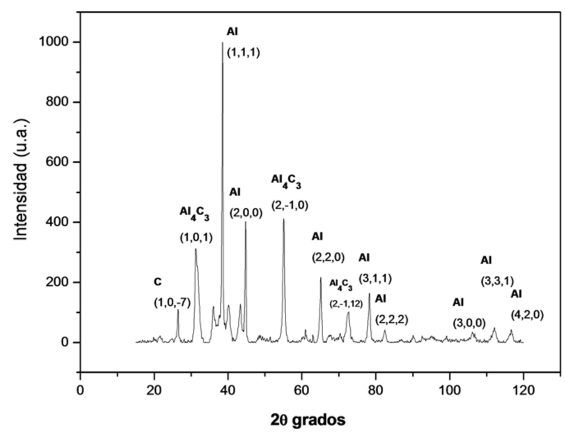

Figure 1. X-Ray diffraction pattern from the Al-C sintered powder. (4h MM and 2h sintering).

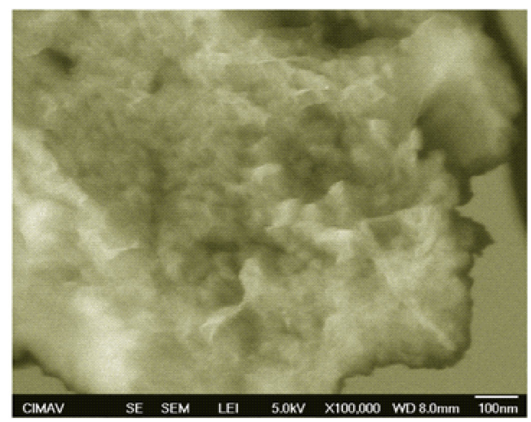

Figure 2. Secondary electron SEM image from the Al-C sintered powder particle.

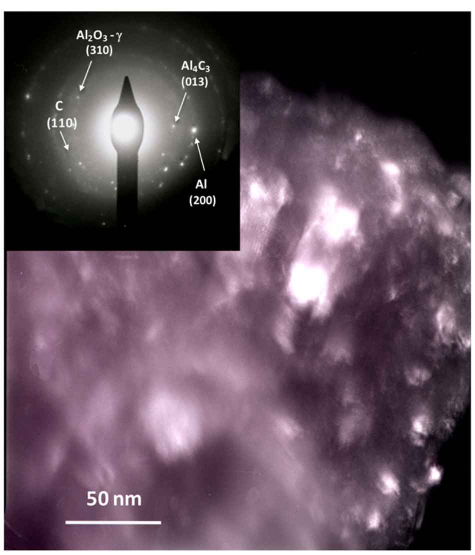

Figure 3. TEM dark field image and SADP from the Al-C sintered powder particle.

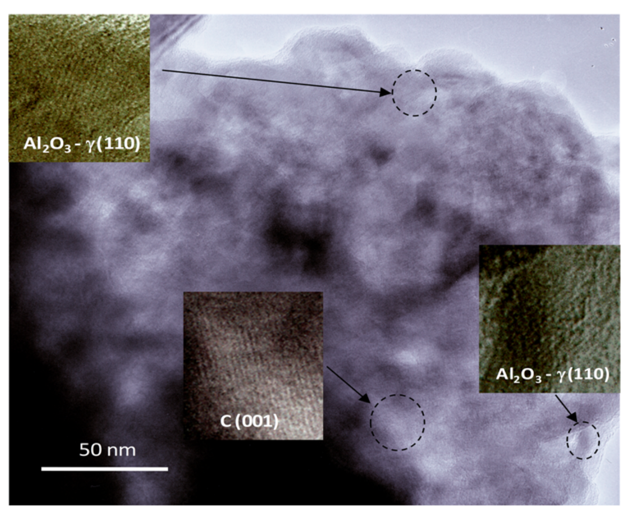

Figure 4. HRTEM image from Al-C sintered powder particle.

https://doi.org/10.1017/S1431927609097700 Published online by Cambridge University Press