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Effect of the homogenization treatment on the microstructure and the electrical conductivity of 3YTZP/graphene nanoplatelet composites

R. Poyato[1], C. López-Pernía[1,2], C. Muñoz-Ferreiro[2], C. González-Orellana, A. Morales-Rodríguez[2] and **A. Gallardo-López[2]**
[1]Instituto de Ciencia de Materiales de Sevilla, ICMS, CSIC-Universidad de Sevilla, Spain
[2]Departamento de Física de la Materia Condensada, Universidad de Sevilla-ICMS (CSIC), Spain

Nowadays, graphene nanoplatelets (GNPs) are being considered as an emerging class of nanomaterials. GNPs are composed of ten or more graphene layers, with thickness up to 100 nm, and present unusual mechanical and electrical properties1,2. These characteristics have motivated a great interest in incorporating these nanostructures as second phase in a ceramic matrix, in order to enhance the mechanical and functional properties of the final composite3-5. However, one of the main obstacles to be overcome is obtaining a good dispersion of the GNPs into the ceramic matrix.

In this work, 3YTZP based composites with different GNP contents were prepared using different powder homogenization methods and electric pulsed discharge sintering (also called spark Plasma Sintering or SPS). Composite powders were prepared by tip-sonication in isopropanol and/or by planetary ball milling under dry or wet conditions. The effect of milling and ultrasonic agitation on GNP integrity and particle size has been evaluated by Raman spectroscopy and laser granulometry. Microstructure of the composites has been analysed by electron microscopy, X-ray diffraction and Raman spectroscopy to assess the integrity of the GNPs, their degree of dispersion or agglomeration in the ceramic matrix and the stabilization of the tetragonal phase in the 3YTZP matrix. The relationships between GNP content and dimensions, microstructure and electrical conductivity, as well as the conduction mechanisms of the composites, have been analysed and discussed.

Recent Publications

1. Jang BZ, Zhamu A (2008) Processing of nanographene platelets (NGPs) and NGP nanocomposites: a review. J Mater Sci 43:5092-5101.
2. Kaiser AB, Gómez-Navarro C, Sundaram RS, Burghard M, Kern K (2009) Electrical conduction mechanism in chemically derived grapheme monolayers. Nano Letters 9:1787-1792.
3. Ramirez C, Miranzo P, Belmonte M, Osendi MI, Poza P, Vega-Diaz SM, Terrones M (2014) Extraordinary toughening enhancement and flexural strength in Si3N4 composites using graphene sheets. Journal of the European Ceramic Society 34:161-169.
4. Román-Manso B, Domingues E, Figueiredo FM, Belmonte M, Miranzo P (2015) Enhanced electrical conductivity of silicon carbide ceramics by addition of graphene nanoplatelets. Journal of the European Ceramic Society 35: 2723–2731.
5. Gallardo-López A, Márquez-Abril I, Morales-Rodríguez A, Muñoz A, Poyato R (2017) Dense graphene nanoplatelet/yttria tetragonal zirconia composites: Processing, hardness and electrical conductivity. Ceramics International 43: 11743–11752.

Biography

Dr. Rosalía Poyato completed her B.Sc. in Physics at the University of Seville and received her PhD in Applied Physics at the Autonoma University of Madrid. After obtaining PhD, she developed her research at University of Connecticut and Ohio State University (USA), as a postdoctoral research Fulbright fellow. At this moment, she is a Tenured Researcher at the Materials Science Institute of Seville and her current research interests include processing and characterization of ceramic composites including carbon nanostructures (carbon nanotubes and multi-layered graphene structures). She has co-authored over 50 papers in international journals. Dr. Poyato is now co-leader of a research project funded by the Spanish National Science Foundation and the European Feder Funding: Processing and microstructural, mechanical and electrical characterization of ceramic-graphene composites (MAT2015-67889-P).

rosalia.poyato@icmse.csic.es