Processing and Characterization of Advanced Composites for Resource-Efficient Applications and Technologies

"CREATe-Network"

Annual Report: Deliverable D5.3

Summary for publication

The activities carried out between 01.01.2015 and 31.12.2015 within the frame of the "Processing and characterization of advanced composites for resource-efficient applications and technologies" – CREATe-Network- (http://create-network.eu/) project are summarized in the following paragraphs.

From the planned studies of the first work package, related to design and materials processing, we have applied conventional routes to produce novel materials. Specifically, in topic 1 (development of electrical double-layer capacitors, EDLC), hydrothermal growth of manganese oxide on carbon onions and atomic layer deposition of titanium nitride also on carbon onions were used. In the former, the nanoscale implementation of manganese oxide domains in-between carbon onions accomplished a very high rate handling ability (high power performance) and high energy ratings. Regarding the latter, aqueous media did not yield a sufficient increase in Faradaic charge transferred during charging and discharging, a very significant redox reaction was seen in a protic ionic liquid.

The planned initial tasks for topics 2 and 3 are shared. We were able to correlate the different ultrasound exposure times to the final agglomerate size in the manufactured composites. It was observed that the best distribution within the metallic matrix was achieved for the nanodiamond-containing composites, followed by the composites reinforced with carbon onion and finally, the carbon nanotube-reinforced CNTs. This feature is related primarily to the hybridization of the C atoms in the nanoparticles (sp^3 is chemically more inert than sp^2, thus reducing the agglomeration). Within the sp^2 hybridized particles (OLCs and CNTs), the difference is related to their shape. The fiber-type shape of CNTs tends to enhance the possibility of an interlinking between them, resulting in larger agglomerates. Densification of the composites was achieved by conventional hot uniaxial pressing and spark plasma sintering. In both cases, very high (almost full density) was obtained, without compromising the structure of the reinforcement. This is important to retain the outstanding intrinsic properties of the reinforcement.

Finally, functionally graded cemented carbides with different binders have been produced by hot pressing consolidation techniques and by liquid phase sintering. The main objective has been to produce bi-layers consisting of different cemented carbide compositions, which have been pressed and sintered in sequential steps. The consolidated cemented carbides present a functionally graded microstructure regarding chemical composition, particle size of tungsten carbide and hardness profiles. The results look promising and their performance is being evaluated at an industrial lab test.

The acquired knowledge has been discussed and disseminated by the partners in international conferences and peer-reviewed journals. The current list of peer-reviewed publications is as follows:

1. K. Makgopa, P. M. Ejikeme, C. J. Jafta, K. Raju, M. Zeiger, V. Presser and K. I. Ozoemena, A high-rate aqueous symmetric pseudocapacitor based on highly graphitized onion-like carbon/birnessite-type manganese oxide nanohybrids, Journal of Materials Chemistry A, 2015, 3, 3480-3490.
2. M. Zeiger, N. Jäckel, V. Mochalin and V. Presser, Review: carbon onions for electrochemical energy storage, Journal of Materials Chemistry A, 2015, DOI: 10.1039/C5TA08295A.
3. M. Zeiger, D. Weingarth and V. Presser, Quinone-Decorated Onion-Like Carbon/Carbon Fiber Hybrid Electrodes for High-Rate Supercapacitor Applications, ChemElectroChem, 2015, 2, 1117-1127.
4. N. Souza, M. Zeiger, V. Presser and F. Mücklich, In situ tracking of defect healing and purification of single-wall carbon nanotubes with laser radiation by time-resolved Raman spectroscopy RSC Adv., 2015,5, 62149-62159.
5. José García, Thais Carvalho Miranda, Haroldo C. Pinto, Flavio Soldera and Frank Mücklich, 3D-FIB characterization of wear in WC-Co coated composites Materials Science Forum Vols., 2015, 825-826, 995-1000.
6. L. Reinert, M. Zeiger, S. Suárez, V. Presser and F. Mücklich, Dispersion analysis of carbon nanotubes, carbon onions, and nanodiamonds for their application as reinforcement phase in nickel metal matrix composites RSC Adv., 2015,5, 95149-95159.
7. Cucatti, S.; Ochoa, E.A.; Morales, M.; Droppa, R.; Garcia, J.; Pinto, H.C.; Zagonel, L.F.; Wisnivesky, D.; Figueroa, C.A.; Alvarez, F., Effect of bombarding steel with Xe+ ions on the surface nanostructure and on pulsed plasma nitriding process. Materials Chemistry and Physics, v. 149-150, p. 261-269, 2015. http://dx.doi.org/10.1016/j.matchemphys.2014.10.015.
8. Vales, Sandra Dos Santos; Becerra, Erika Abigail Ochoa; Brito, Pedro Paiva; Droppa Junior, Roosevelt; Garcia, Jose Luis; Alvarez, Fernando; Pinto, Haroldo Cavalcanti. Effect of Low Temperature Nitriding of 100Cr6 Substrates on TiN Coatings Deposited by IBAD. Materials Research (São Carlos. Impresso), v. 18, p. 54-58, 2015. http://dx.doi.org/10.1590/1516-1439.266514.

A network logo and website (http://create-network.eu/) were developed and are fully functional. There it can be found all the information related to the network activities and participants.

Additionally, a project kick-off meeting was carried out between March 19th and 20th 2015 at the Unviersidad Catolica del Uruguay, in Montevideo. In this meeting, the partners were able to present their research institutions and present their strategy to carry out the planned activities of the projects. All partners were represented by at least one researcher. The next project meeting will be carried out in September 2016 at the Universidad Politecnica de Catalunya, Spain.

Kick off meeting at Universidad Católica de Uruguay, Montevideo, March 2015.