Fast charging high-capacity anodes for lithium-ion batteries based on antimony doped tin oxide/graphene nanocomposites

Florian Zoller [a, b], Kristina Peters [a], Peter M. Zehetmaier [a], Patrick Zeller [a], Markus Döblinger [a], Thomas Bein [a], Zdeněk Sofer [c], Dina Fattakhova-Rohlfing [b, d]

[a] *Department of Chemistry and Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München (LMU Munich), Butenandtstrasse 5-13 (E), 81377 Munich, Germany*

[b] *Faculty of Engineering and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany*

[c] *Department of Inorganic Chemistry, University of Chemistry and Technology, Technická 5, 166 28 Prague, Czech Republic*

[d] *Forschungszentrum Jülich GmbH, Institute of Energy and Climate Research (IEK-1) Materials Synthesis and Processing, Wilhelm-Johnen-Straße, 52425 Jülich, Germany*

E-mail: florian.zoller@cup.uni-muenchen.de

Lithium-ion batteries (LIBs) are one of the most advanced electrochemical energy-storage systems with superior energy and power densities. Nevertheless, there is an ever increasing need for LIBs with significantly higher energy densities and faster charging rates able to meet the growing demands of new consumer electronics, stationary power storage systems, and especially long-range electric vehicles.

State-of-the-art LIBs are based on insertion-type electrode materials such as graphite based anodes and transition metal oxide cathodes, for example $LiCoO_2$. The redox transformations of these materials involve the reversible incorporation of lithium ions without major structural changes, resulting in high cycling stability combined, however, with only moderate specific capacity. The use of electrode materials with different charge storage chemistry, such as alloying/de-alloying or conversion mechanisms, is a promising way to increase the storage capacity.

Among numerous candidates belonging to these two materials classes, tin dioxide (SnO_2) is a very attractive candidate as anode material due to its very high lithium insertion capacity and low working potential. Nevertheless, huge volume changes during the structural conversion and the irreversibility of the conversion step are major drawbacks of this auspicious anode material. In order to overcome these problems, a promising approach is nanostructuring of SnO_2 and incorporating it into a carbonaceous matrix.

Here, we describe the fabrication of antimony-doped tin oxide (ATO)/graphene hybrid nanocomposites using a microwave assisted *in-situ* synthesis in *tert*-butyl alcohol. This reaction enables the growth of ultra-small ATO nanoparticles with sizes below 3 nm on the surface of graphene, providing a composite anode material with a high electric conductivity and high structural stability. Antimony doping results in high reversible capacity and superior rate performance. The nanocomposites feature a gravimetric capacity of 1226 mAh g^{-1} at the charging rate 1C and still a high capacity of 577 mAh g^{-1} at very high charging rates of up to 60C, as compared to 93 mAh g^{-1} at 60C for the undoped composite synthesized in a similar way. At the same time, the antimony-doped anodes demonstrate excellent stability with a capacity retention of 77% after 1000 cycles.[1]

References:

[1] F. Zoller, K. Peters, P. M. Zehetmaier, P. Zeller, M. Döblinger, T. Bein, Z. Sofer, D. Fattakhova-Rohlfing, Adv. Funct. Mater (2018), DOI: 10.1002/adfm.201706529.