DEPOSITION OF GRAPHITE/SnO_2 COMPOSITE ANODE THIN FILMS FOR Li ION BATTERIES

Marcus Jahn and Kwang-Leong Choy*

Department of Materials, Mechanical and Manufacturing Engineering, The University of Nottingham, Nottingham,

University Park, NG7 2RD, United Kingdom
(*corresponding author; email: Kwang-Leong.Choy@nottingham.ac.uk, Tel.: +44(0)115 951 4031)

Lithium based rechargeable batteries have received considerable attention in research and industry during the last decades due to the limitations in energy density of previous rechargeable batteries. Technological demands in consumer electronics, medical applications and on-chip devices for increased performance with minimized space requirements have driven research in high energy density materials for Li ion electrodes and miniaturized battery design. Furthermore the increased safety requirements for modern day applications have caused concern over the traditional use of Li metal as counter electrode in Li ion batteries as well as the use of liquid electrolytes which are generally flammable. Graphite and carbonaceous compounds have been commonly used as Li metal substitute. It exhibits a much lower volume expansion of only up to 12% during Li (de-)intercalation and has therefore a significantly enhanced cycle life. This however comes at the cost of lower specific capacity, which is only ~370mAhg^{-1}. This rather low specific capacity has drawn the focus of research to replacement of graphite electrodes with metal oxides, mainly in the form of nano-structures since these have been found to help overcome the volume expansion problem significantly. One of such metal oxides is SnO_2 which has received much attention due to its good availability and a good theoretical specific capacity of 790mAh/g [1]. These attributes are overshadowed by the large intrinsic volume change during Li^+ insertion of up to 300% similar to silicon as mentioned above [2-4]. There have been several attempts to reduce this volume change of which nano-structuring has proofed most successful

In this paper the fabrication of graphite/SnO_2 composite anode thin films is presented. Thin films of graphite/SnO_2 have been prepared using an Aerosol Assisted Chemical Vapour Deposition (AACVD) based method (see Figure 1). Ink like spray solutions have been prepared using various ratios of graphite powder and SnO_2 nano particles in addition to PVdF polymer binder. Powder mixtures have been dissolved in N,N-methyl-2-pyrrolidnone (NMP). Scanning electron microscopy (SEM), Energy dispersive X-ray analysis (EDX) and cyclic voltammetry have been used to characterize the material's surface morphology and potentiodynamic electrochemical properties respectively. The cyclic performance of the composite anodes has been monitored over several cycles at various currents in order to investigate the influence of charge/discharge rate on the film's performance. Various ratios of graphite and SnO_2 nano-particles have been analysed with the aim to optimise the cyclic stability and specific capacity of the composite anode. In currently available results it has been found that the concentration of SnO_2 nano particles with respect to graphite plays a crucial role to the surface morphology of the deposited anodes as well as the resulting electrochemical performance. A ratio of graphite to SnO_2 of 2:1 (w/w) has been found to result in the highest initial specific capacity of 800mAhg^{-1} and over 1000mAhg-1 with respect to the active material only (see Figure 2). A larger SnO_2 content results in a lower initial specific capacity, but better cyclic stability. All tested films to date have been shown to exceed the specific capacity of commercially available graphite alone.

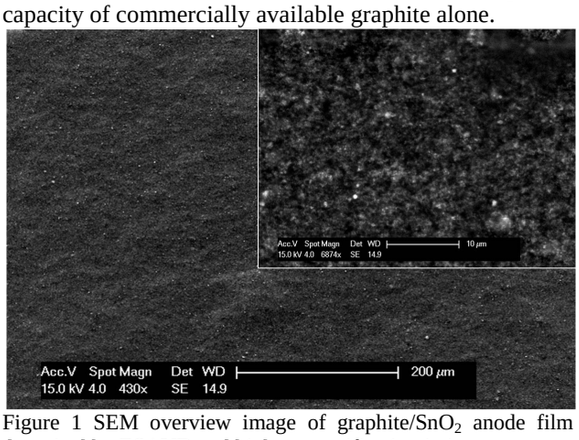

Figure 1 SEM overview image of graphite/SnO_2 anode film deposited by ESAVD and higher magnification in inset.

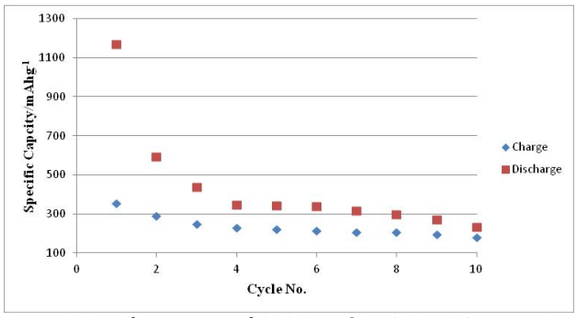

Figure 2 Specific capacity of SnO_2/graphite (2:1 w/w) composite anode active material over first 10 cycles.

References

1. Li, N.C., C.R. Martin, and B. Scrosati, *A high-rate, high-capacity, nanostructured tin oxide electrode.* Electrochemical and Solid State Letters, 2000. **3**(7): p. 316-318.
2. Li, N.C. and C.R. Martin, *A high-rate, high-capacity, nanostructured Sn-based anode prepared using sol-gel template synthesis.* Journal of the Electrochemical Society, 2001. **148**(2): p. A164-A170.
3. Idota, Y., et al., *Tin-based amorphous oxide: A high-capacity lithium-ion-storage material.* Science, 1997. **276**(5317): p. 1395-1397.
4. Yu, Y., et al., *Three-dimensional porous amorphous SnO2 thin films as anodes for Li-ion batteries.* Electrochimica Acta, 2009. **54**(28): p. 7227-7230.