Electrochemical Characteristics of Sn-Mo Anodes for Lithium Batteries

R.L. Turner, B. Amick, L.J. Krause, L. Christensen and J.R. Dahn[a]

3M Co., 3M Center, St. Paul, MN, 55144-1000, USA
a - Depts. of Physics and Chemistry, Dalhousie University, Halifax, N.S., Canada B3H 3J5

Lithium alloys have been used for many years as anodes in lithium batteries. The well know problem with these alloys has been their poor cycle life due to electrical isolation of the active material that is a result of the poor mechanical stability of the materials during large volume expansions (1). Several years ago there was renewed interest in the lithium alloys when the Fuju tin oxide material demonstrated significantly improved cycle life (2). During the past several years there have been many publications in this area (3). A clear technical direction to extend cycle life has been to make nanostructures or nanocomposites of the lithium alloy materials with active and inactive regions. We prepare Sn-Mo nanostructural compositions that have nanocrystalline regions of Sn and Mo phases.

Sequential sputtering of tin and molybdenum was used to prepare thin films with and without layers. The films were sputtered onto a 25 micron copper substrate. Typically it took from 1 to 2 hours to prepare 4 to 10 micron thick films. The composition ranged from 45 to 65 wt% tin. The typical deposition rate for each element or layer ranged from 0.3 to 15 nm thick. Details of the deposition rates used and the relationship between the deposition rates and the resulting film structure are given in a previous talk. The layered Sn-Mo films are compositionally modulated through the material with no distinct grain boundaries between the layers. Films with no layers have less than 1 nm crystalline phases.

The electrochemical performance in this talk will be confined to 1225 and 2325 coin cells that were cycled between a C/2 and C/5 rate. Typical irreversible capacities were 100 mAh/g or approximately 25 %. The cycle life of a compositionally modulated layered Sn-Mo film is shown in Figure 1 and the voltage vs. capacity plot is in Figure 2. The reversible specific and volumetric capacities are remarkable in the cycle life shown. Some Sn-Mo films, 54 wt% Sn, that were not layered and that had less than 1 nm crystalline phases were highly active, 350 mAh/g. Sn-Mo films with 54 wt% tin have better cycle life when the film is layered. We will present further details on the relationship between the Sn-Mo film structure and the capacity and cycle life. These types of structures may be critical to extending the cycle life from 200 to 500 cycles with nanocrystalline lithium alloy anodes.

A further talk will describe the safety and performance of 18650 Li-ion cells using Mo-Sn anodes.

References

1. J. O. Besenhard, J. Yang, and M. Winter, *J. Power Sources*, **68**, 87 (1997).
2. Y. Idota, T. Kubota, A. Matsufuji, Y. Maekawa, and T. Miyasaka, *Science*, **276**, 1395 (1997).
3. Y. Xia, T. Sakai, T. Fujieda, M. Wada, and H. Yoshinaga, *Electrochem. Solid-State Lett*., **4** (2) A9-A11 (2001); H. Morimoto, M. Tatsumisago, and T. Minami, *Electrochem. Solid-State Lett*., **4** (2) A16-A18 (2001); Il-seok Kim, P. N. Kumta, and G. E. Blomgren, *Electrochem. Solid-State Lett*., **3** (11) 493-496 (2000); N. Li, C. R. Martin, and B. Scrosati, *Electrochem. Solid-State Lett*., **3** (7) 316-318 (2000); J. T. Vaughey, J. O'Hara, and M. M. Thackeray, *Electrochem. Solid-State Lett*., **3** (1) 13-16 (2000); K. D. Kepler, J. T. Vaughey, and M. M. Thackeray, *Electrochem. Solid-State Lett*., **2**, 307 (1999); O. Mao and J. R. Dahn, *J. Electrochem. Soc*., **146**, 423 (1999).

Figure 1. Cycle life of a 7 micron Sn-Mo co-sputtered film. The composition is about 50 wt. % tin. Layers of 15 Å Sn and 10 Å Mo were deposited sequentially.

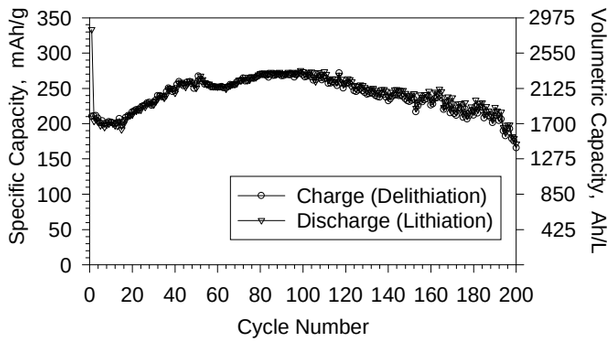

Figure 2. Voltage vs. capacity plot for a 7 micron Sn-Mo co-sputtered film. The composition is about 50 wt. % tin. Layers of 15 Å Sn and 10 Å Mo were deposited sequentially