MICROSTRUCTURAL CHARACTERIZATION OF THIN FILM ELECTRODES FOR LITHIUM-ION BATTERIES

J.P.Maranchi[1], P.N.Kumta[1], A.F.Hepp[2]
[1]Materials Science and Engineering Department
Carnegie Mellon University, Pittsburgh, PA, USA
[2]NASA Glenn Research Center, Cleveland, OH, USA

Reduction in the size of electronic components (due to improved integrated circuit technology and fabrication processes) has led to the miniaturization of electronic devices and related peripherals.[1] This has resulted in a need for lightweight, compact power sources that would satisfy the demands of portable devices. One of the immediate consequences of this requirement is the emerging idea of integrating thin film power sources directly onto electronic devices called the "battery on a chip" concept.[2] Besides being lightweight and compact, these rechargeable thin film batteries (TFB's) offer several other advantages over bulky traditional power sources such as higher volumetric capacity and ability to mold them into any 2-D and 3-D forms.[3] Although there has been progress in the scientific understanding, the rechargeable battery technology and fabrication processes have not kept pace with the advances in device technology. There are still several important problems related to low cyclability, poor voltage regulation, and safety which need to be addressed. The fabrication of the thin film electrodes has therefore been the major source of problems in these cells.

Sputtering is the most popular method for the fabrication of thin film electrodes due to its simplicity.[4] Unfortunately, the process does not provide good compositional and microstructural control, which are critical to the properties of the electrodes and the overall battery performance. Composition and microstructure are very strongly dictated by the synthesis method and the processing conditions. It is therefore evident that novel, low cost deposition techniques which allow strict control over the composition and microstructural features of the films need to be investigated.

At Carnegie Mellon University, spin coating deposition methods based on sol-gel processes have been developed which allow precise control over the resultant composition and microstructure of the fabricated thin films. These processes have already been successfully used for synthesizing a variety of metal oxide, sulfide, and nitride materials.[5-8]

The present paper describes the microstructural study of sol-gel derived thin film electrodes using atomic force and scanning electron microscopy. The microstructural changes occurring in the electrodes before and after cycling were analyzed. The results of these characterization studies will be presented and discussed.

[1] Bates, J.B., G.R. Gruzalski, N.J. Dudney, F.F. Luck, X.H. Yu, *Solid State Tech.* **1993**, *36*, 59.
[2] Zuckerbrod, D., R.T. Giovannoni, and K.R. Grosman, Proc. 34th Intnl. Power Sources Symp., Cherry Hill, NJ, Sponsored by IEEE, *CH 2863-9*, **1990,**, 172.
[3] Solid State Batteries: Materials Design and Optimization, C. Julien and G.-A. Nazri, Kluwer, **1994**.
[4] Lithium Batteries: New Materials, Developments, and Perspectives, Ed. G. Pistoia, Elsevier, **1994**.
[5] Weil, K.S. and P.N. Kumta, *Mat. Sci. and Eng.*, **1996**, *B38*, 109.
[6] Sriram, M.S., K.S. Weil, and P.N. Kumta, *J. Appl. Organomet. Chem.*, **1997**, *11*, 163.
[7] Weil, K.S. and P.N. Kumta, *Materials and Design.*, **2001**, *22*, 605-615.
[8] Chang, C.C., N. Scarr, and P.N. Kumta, *Sol. St. Ionics* **1998**, *112*, 329.

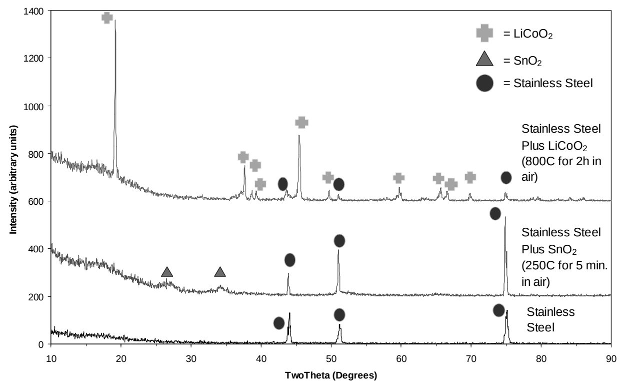

Figure 1 : XRD of the substrate and thin films prior to electrochemical cycling.

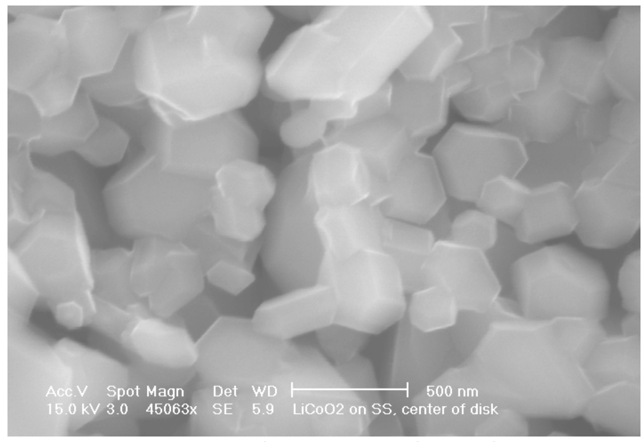

Figure 2: SEM image of $LiCoO_2$ thin film before electrochemical cycling.

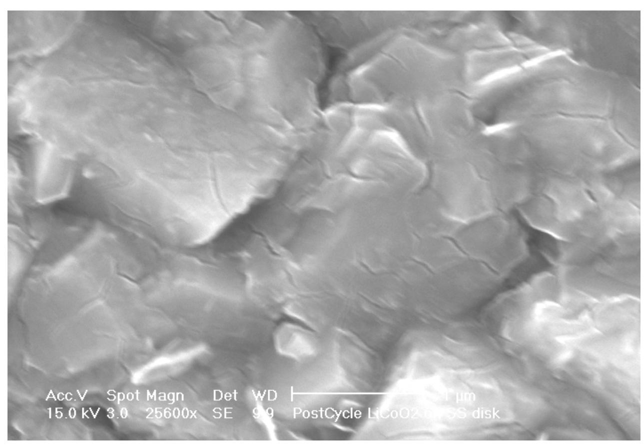

Figure 3: SEM image of $LiCoO_2$ thin film after electrochemical cycling.

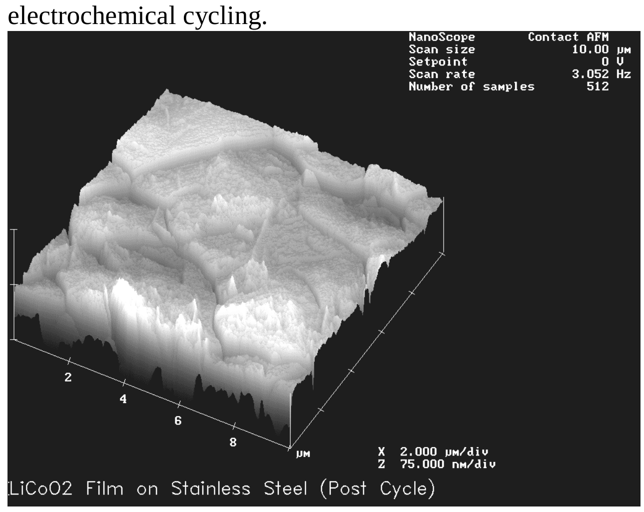

Figure 4: AFM image showing the surface of the $LiCoO_2$ thin film after 10 cycles (liquid electrolyte,Li metal counter-electrode).