

Roughness Analysis of Electrode Materials for Lithium Ion Batteries[†].

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[†]-A copy of this presentation will be available for download at www.physics.dal.ca/~dahn/Luc.html

A system using an AFM has been built to study the morphology of electrode materials as they react with lithium *in situ* [1-2]. Figure 1 shows the AFM images collected on a SiSn film cycled against Li metal during the first discharge. Apart from in-plane drift, it appears that the electrode is unchanged by the insertion of Li into the electrode. However, when a statistical analysis is performed, it is found that the roughness of the electrode increases proportionally with the addition of lithium.

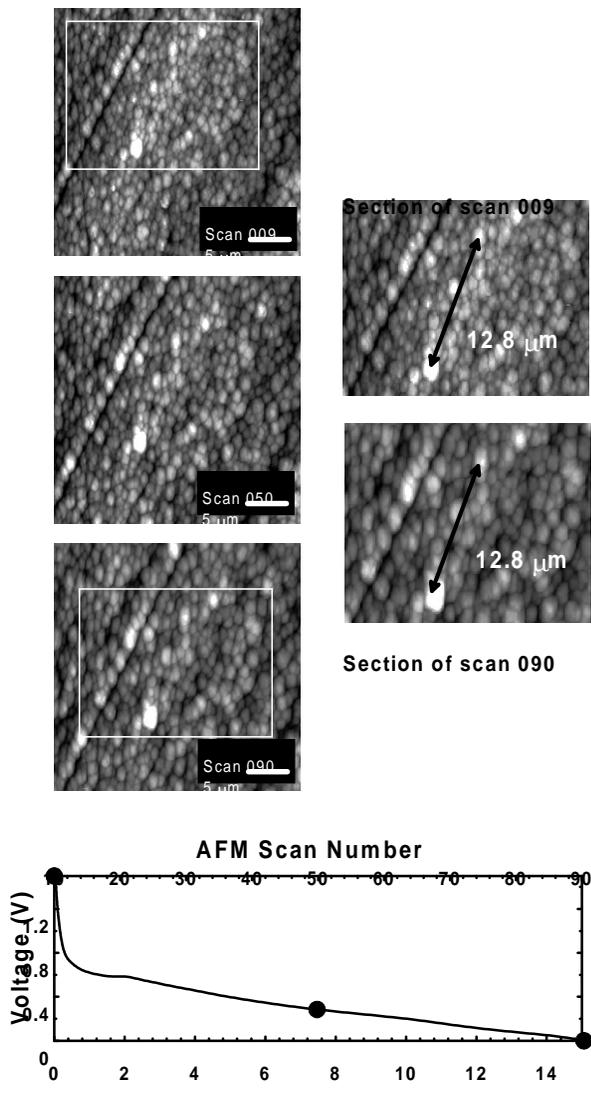


Figure 1: Selection of AFM topographs (scan 9, 50, and 90) taken during the first discharge of the SiSn electrode cycled against pure Li.

Typically, the RMS roughness is defined by the standard deviation,

$$RMS = \sqrt{\frac{\sum_{i=1}^N (z_i - z_\mu)^2}{N}} \quad (1)$$

where, z_i is the coordinate of the electrode surface, z_μ is mean value, and N is total number of data points. If each value of z_i increases by α ($z_i \rightarrow \alpha z_i$) then the mean value would also increase by the same amount ($z_\mu \rightarrow \alpha z_\mu$). Substituting these values into equation 1 shows the RMS value also increases by α ($RMS \rightarrow \alpha RMS$) making it possible to infer the thickness change of the electrode from the change in the RMS roughness.

Figure 2 shows the increase in RMS roughness (2a) and the thickness change of the electrode as measured directly (2b) both compared to the voltage curve (2c) collected for the first discharge. Analysis of the RMS roughness measurements indicates that the film expanded from 1.2 to 2.6 μm whereas the direct measurements of the piezo in the AFM scanner gives a final film thickness of 2.7 μm.

In this talk we will show how AFM roughness measurements can be used to infer film thickness changes, in cases where the film thickness changes proportionally at all points of the film. Also we will discuss how the roughness of the substrate on which the film is initially deposited influences the experimental results.

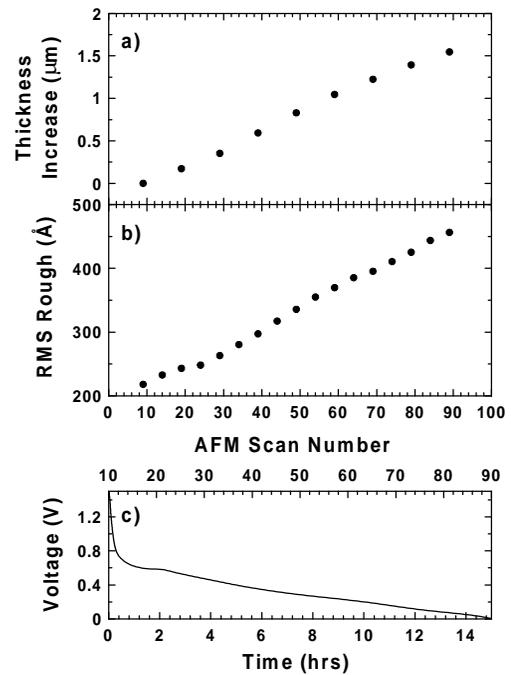


Figure 2: Change in height of the electrode occurring during the first discharge measured using a) the raw data, b) the change in surface RMS roughness compared to c) the voltage curve collected during the experiment.

Reference:

- [1] L.Y. Beaulieu, K.W. Eberman, R.L. Turner, L.J. Krause and J.R.Dahn, *Submitted to ECS Letters (2001)*
- [2] L.Y. Beaulieu, V.K. Cumyn, K.W. Eberman, L.J. Krause, and J.R. Dahn, *Submitted to Rev. Sci. Ins. (2001)*