Morphological analysis for the evaluation of electrode structures

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Knowledge of electrode structure and morphology is a key driving force for the optimization of electrode performance in many electrochemical systems. Among the factors influencing morphology are the size and composition of active material, the interaction between electrode components and the extent to which a given formulation have been calendared. Changes in electrode morphology can be drivers in reductions in electrode performance.

It is well known that Si is an electrode material which undergoes significant changes during cycling. A key issue with the Si system is the rupture of the stabilizing SEI and eventual fracturing of the primary particles during cycling. One route which has been proposed to alleviate some of the issues with Si and other alloying anodes is the use of new binder systems including polyacrylate salts (PAA).[1, 2] Due to the performance improvement achieved using PAA systems a host of different alkaline metal salts and more traditional PVDF systems have been investigated to follow electrode performance and to also follow changes which occur in the morphology of the electrode during cycling. Presented in Figure 1 are data associated with a K-PAA binder system which undergoes capacity fade during cycling. The corresponding SEM images show that through the formation of the SEI and other processes that significant change in surface topology occurs.

This presentation will discuss capacity fade issues and how advanced mathematical morphology computational methods can be used to identify changes which occur in electrode systems. A key advantage to using the advanced morphological analysis is the ability to monitor changes which occur, but which are not directly discernible to the eye allowing complex processes to be better visualized. In addition the present method allows complex changes to be identified, while also allowing models to be applied to materials which have not undergone cycling to predict how morphology will change for a given electrode (Figure 2).

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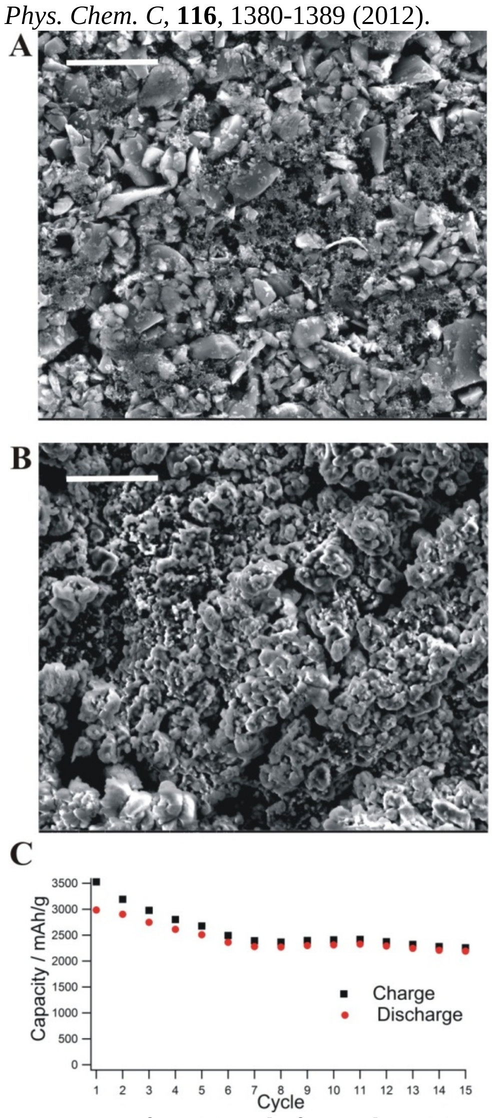

Figure 1: Before (A) and after cycling (B) SEM images for a Si-based composite electrode using a K-PAA binder and C/3 half-cell cycling data for the system (C). Scale bar represents 10 µm.

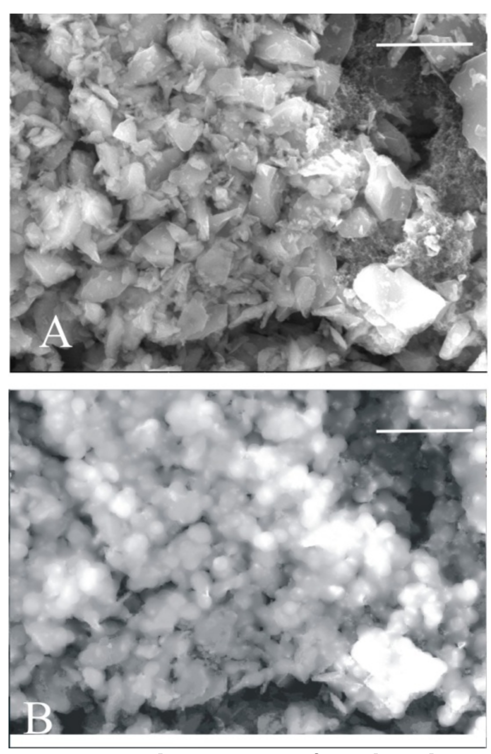

Figure 2. Predictive aging of a Si-based composite electrode A) As prepared B) Predictive model following cycling. Scale bar represents 5 µm.