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Preparation of 2-D Sections of Li-ion Battery Electrode Architectures with a Focused Ion Beam and Modeling

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Li-ion batteries are widely being developed for applications requiring continuous high rate discharge. One key factor to producing such batteries is the electrode architecture. Therefore, in an integrated effort to tune the morphologies of Li-ion battery electrodes, a dual beam Focused Ion Beam (FIB) was used with porous electrode modeling. Rather than empirically optimize film thickness for rate capability, we investigate possible tradeoffs between controlling resistances through a strategy involving innovations in 3D electrode imaging and mathematical modeling which can be used to tailor electrode fabrication techniques for favorable performance. Advances in automation have rendered serial sectioning a viable solution for determining the 3D structure of complex microstructures. Using the ion beam, thin sections were milled from a Li-ion battery electrode while the electron beam was used for high- resolution imaging of the cross section. We use 2D techniques to quantitatively determine and understand pore structure, overall porosity, particle size and shape distributions. An example of such an image for lithium cobalt oxide ($LiCoO_2$) electrodes can be found in Figure 1. The information from the images obtained with the FIB can then be entered into a model that describes the processes within the electrodes. For instance, the complex interactions of solid materials and liquid-filled pores can be modeled with effective transport properties and averaged inter-phase surface areas. An example of the output from such a model can be seen in Figure 2.

The possibility of using 3D reconstruction to understand processing, microstructure and electrochemical characteristics has been demonstrated for solid-oxide fuel-cell anodes [1]. The use of this tool can further understanding of porous Li-ion battery electrode microstructures and opens up possibilities to develop more rigorous models to understand the structure-performance relationships pertaining to ion and electron transport and surface reactions.
The development of these techniques is envisioned for implementation into the design cycle for battery electrodes.

References

[1] J.R. Wilson, et al., *Nature Materials*, 5 (2006) 541.

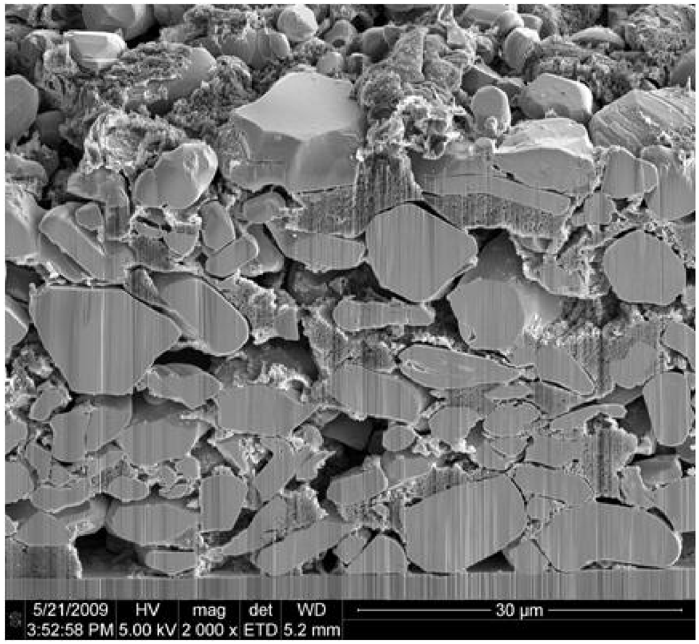

FIG 1. A sample FIB image of $LiCoO_2$ electrodes that were milled for this study.

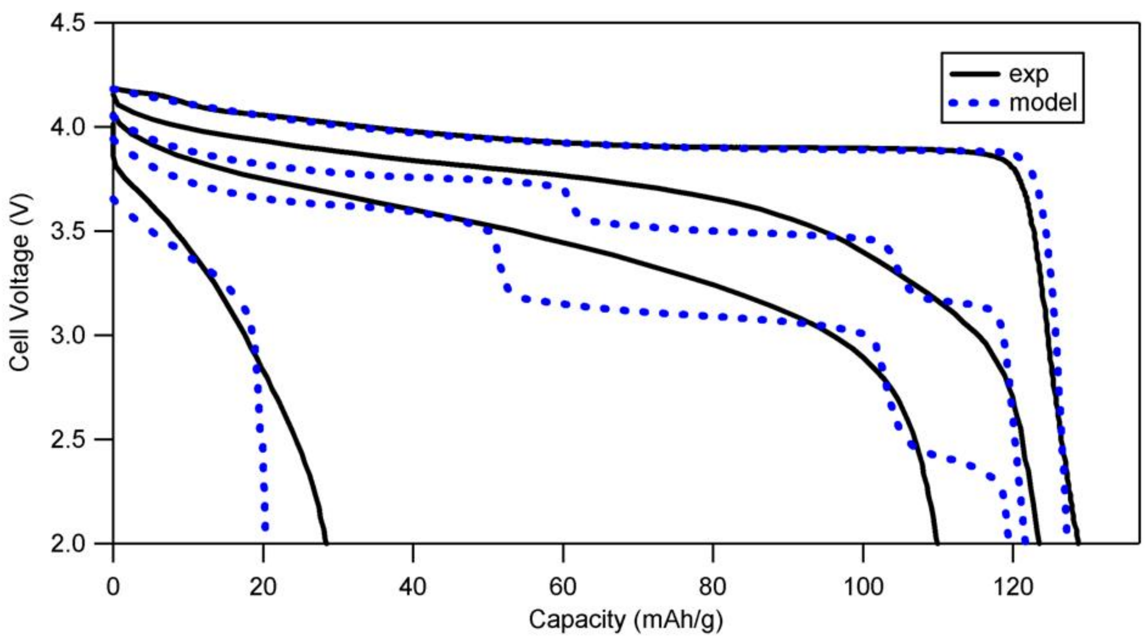

FIG 2. Cell Voltage versus capacity plot showing the model versus experimental values of a thick $LiCoO_2$ electrode.

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