

### 3D model and experiments for understanding carbon additive behavior in primary alkaline cells

Yuan Wen, Cameron Chubbuck, Josh Flygare, Doug Nevers, and Dean R. Wheeler  
Department of Chemical Engineering  
Brigham Young University  
Provo, UT 84602 USA

The goal of this work is to investigate, by means of experimentation and modeling, volumetrically efficient conductive carbon additives in primary alkaline battery cathodes based on electrolytic manganese dioxide (EMD). Understanding carbon additive behavior can lead to optimization of electrode performance under desired rates of discharge. For instance, a combination of different morphology carbon additives may be used to produce a battery with better performance through more effective pathways for electrons and ions in the microstructure [1].

This work is built on previously developed analytical tools in our group, such as FIB/SEM images, transport property measurements and 3D microstructure modeling [2, 3]. Fig. 1 is a FIB/SEM image, which is employed to analysis the microstructure of alkaline battery cathodes under different compositions of additive materials. From a particular cross section, the morphology of carbon additives and interaction between particles can be identified. A preliminary 3D microstructure model for alkaline battery cathodes was developed to understand the trade-offs among electronic and ionic resistances. As with our previous work, the model is partially parameterized from information gained from the FIB/SEM cross sections [2].

We will present the results of the following work: (1) development of experimental apparatuses to measure transport properties (electronic and ionic conductivity), (2) analysis of experimental results and FIB/SEM images for carbon additive effects under different compositions of additive materials, and (3) development of a stochastic 3D model to imitate carbon additive effects in terms of microstructure of MnO<sub>2</sub>-based cathodes.

Acknowledgments: This work is funded by Procter & Gamble.

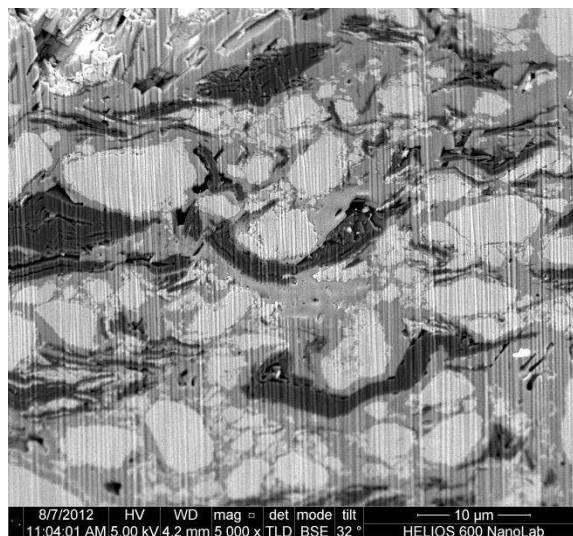


Figure 1. FIB/SEM image of alkaline battery cathode cross section. Black areas are graphite, white areas are EMD, and gray areas are mixtures of KOH and smaller particles of graphite and EMD.

#### References:

- [1] A. Urfer, G.A. Lawrance, D.A.J. Swinkels, *Journal of Applied Electrochemistry* 31 (2001) 341-347.
- [2] D.E. Stephenson, B.C. Walker, C.B. Skelton, E.P. Gorzkowski, D.J. Rowenhorst, D.R. Wheeler, *Journal of the Electrochemical Society* 158 (2011) A781-A789.
- [3] I.V. Thorat, D.E. Stephenson, N.A. Zacharias, K. Zaghib, J.N. Harb, D.R. Wheeler, *Journal of Power Sources* 188 (2009) 592-600.