**Spectro-microscopy and Nano-tomography with Transmission X-ray Microscopy**

Johanna Nelson Weker
SLAC National Accelerator Laboratory, 2575 Sand Hill Rd, Menlo Park CA, 94025
jlnelson@slac.stanford.edu

Hard X-ray transmission X-ray microscopy (TXM) is an ideal tool for *in situ* and *operando* studies of functional materials and materials synthesis routes. The high energy X-rays provides relatively relaxed restrictions on *in situ* environments enabling high resolution 2D microscopy and tomography (3D microscopy)[1] across a large range of pressures and temperatures and in varying gas or liquid environments. The full field geometry of TXM allows imaging at the sub-second time scale, allowing relevant dynamics to be captured during; for example, battery cycling,[2,3] catalysis reactions,[4] electrochemical synthesis,[5] and corrosion.[6] Moreover, by tuning the incident X-ray energy to specific absorption edges, TXM can capture elemental and chemical (spectro-microscopy) changes at 30 nm resolution within a few minutes (Figure 1). Here we will present our latest *in situ* and *operando* X-ray microscopy results.

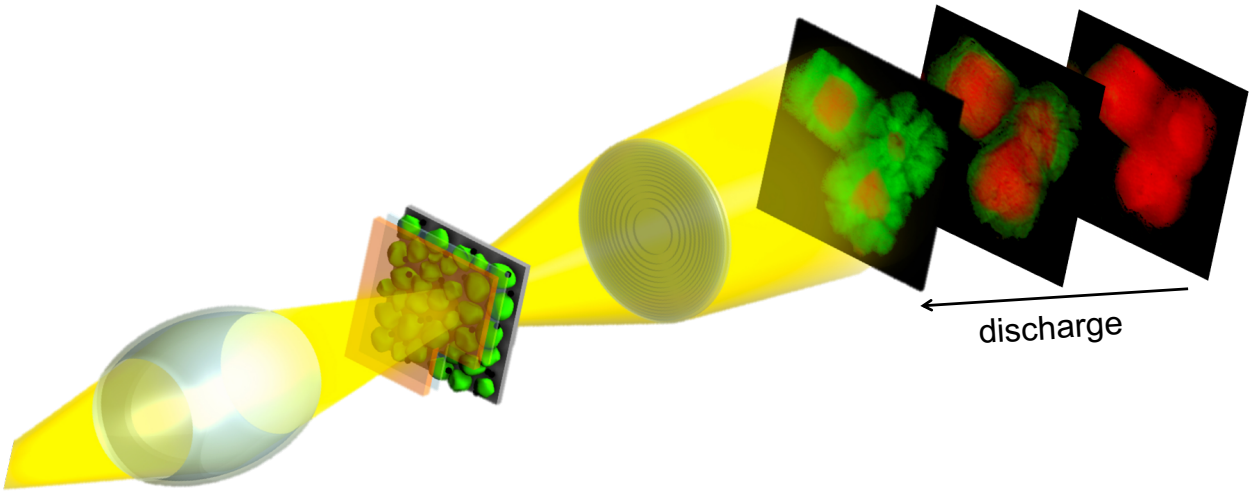


Figure 1. Spectro-microscopy of LiCoO2 battery electrode during deep discharge.[3]

1. J. N. Weker, N. Liu, S. Misra, J. C. Andrews, Y. Cui and M. F. Toney, *Energy Environ. Sci.* **2014**, *7*, 2771-2777.
2. J. Nelson Weker, Y. Li, R. Shanmugam, W. Lai and W. C. Chueh, *ChemElectroChem* **2015**, *2*, 1576-1581.
3. J. Nelson Weker, A. M. Wise, K. Lim, B. Shyam and M. F. Toney, *Electrochim. Acta* **2017**, *247*, 977-982.
4. I. D. Gonzalez-Jimenez, K. Cats, T. Davidian, M. Ruitenbeek, F. Meirer, Y. Liu, J. Nelson, J. C. Andrews, P. Pianetta, F. M. F. de Groot and B. M. Weckhuysen, *Angew. Chem. Int. Ed.* **2012**, *51*, 11986-11990.
5. S. E. R. Tay, A. E. Goode, J. Nelson Weker, A. A. Cruickshank, S. Heutz, A. E. Porter, M. P. Ryan and M. F. Toney, *Nanoscale* **2016**, *8*, 1849-1853.
6. M. A. Koronfel, A. E. Goode, J. Nelson Weker, S. E. R. Tay, C. A. Stitt, T. A. Simoes, J. F. W. Mosselmans, P. Quinn, R. Brydson, A.Hart, Michael F. Toney, A. E. Porter and M. P. Ryan accepted to *npj Mater. Degrad.*, **2018**, DOI: 10.1038/s41529-018-0029-2.