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Soft X-ray Absorption Spectroscopy – Chemical Analysis on nanoscale

T. Tyliszczak*

Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

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*e-mail: Tolek@lbl.gov

The soft X-ray scanning microscopes are used primary for utilization of X-ray absorption spectroscopy on nanoscale. Typically, the spatial resolution is being quoted using resolution of individual images. Presently, those images can be recorded with 15-25 nm resolution. Unfortunately, spatial resolution for spectroscopic analysis can be much worse. The reason for this reduction of resolution is a shape of the zone plate focused X-ray beam (Figure 1). Almost all soft X-ray microscopes are using zone plates as focusing elements thus most of the spectroscopic analysis can have limited resolution.

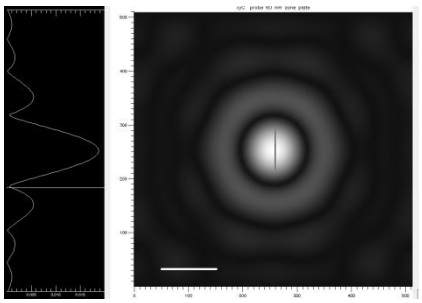

Figure 1. Typical focused beam profile. Up to 50% intensity can be in the beam wings.

Recent development of ptychography (Difraction Enchenced Scanning Transmission Microscopy) [1] can overcome the limitation in spatial resolution for spectroscopy because the beam shape is deconvoluted in the final reconstruction of images. While soft X-ray ptychography can be used for imaging with exceptional resolution of 2 nm, the application for the spectroscopic analysis is even more important because it favorable can compete with TEM/EELS analysis.

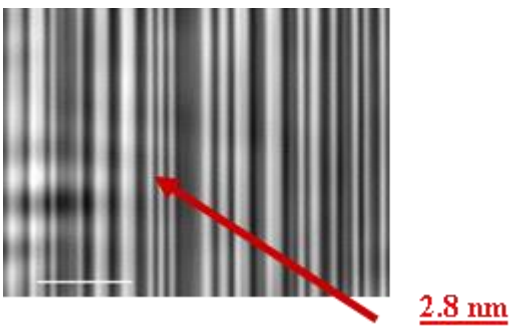

Figure 2. Test pattern image at 1500 eV.

Figure 3 illustrates example of a significant difference of quality of chemical analysis. A partially charged electrode of $LiFePO_4$ battery [2] was analyzed using the beamline 11.0.2 STXM in real space mode and calculated spatial resolution was about 70 nm while analysis of ptychographic measurements yielded component mapping with about 6 nm resolution.

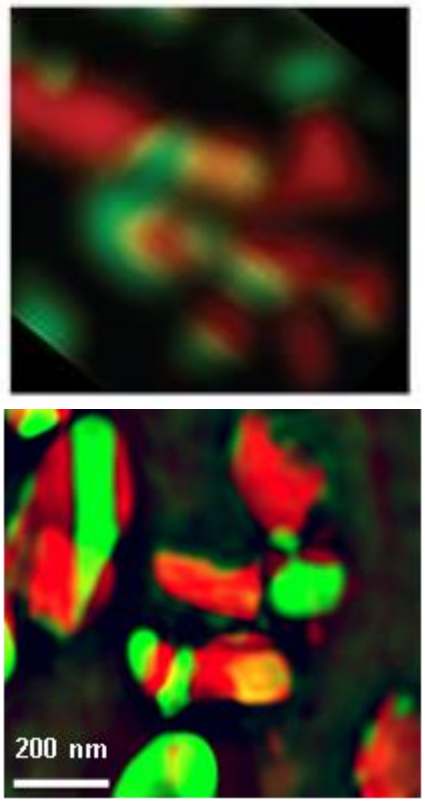

Figure 3. Maps of lithiated and delithiated components of partially charged $FeLiPO_4$ electrode from a stack of images recorded around Fe L3 absorption edge using real space imaging with 25 nm zone plate (top) and ptychography with 60 nm zone plate (bottom).

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