Using Energy Dispersive X-Ray Diffraction to Map Li-Ion Batteries

One limitation of current lithium-ion battery technologies originate from the micromechanical fatigue degradation of the battery’s active materials. This damage to the microstructure results from mechanical strains and stresses induced by volume changes during the extraction and insertion of lithium ions. Also, structural changes that result from composition-induced phase changes and interfacial reactions with the electrolyte also contribute to the build-up of mechanical stresses. The specific challenge undertaken is the characterization of the spatial inhomogeneity within the battery cell electrodes during electrochemical cycling via energy dispersive x-ray diffraction.

The Li_{1+x}TM_{1-x}O_2 compounds are leading candidates for the next generation of lithium batteries. Due to constraints imposed by the complex electrode morphology, the mechanical stresses often lead to cracking within, and at the boundaries between, oxide particles. We have conducted a systematic experimental study to determine the evolution in these oxide materials as a function of electrode cycling, position in the battery cell, and aging conditions.

High-energy x-rays are able to penetrate through large amounts of material so that the diffraction signal probes the entire depth of the battery cells, including multiple layers of aluminum and copper current collectors and transition-metal laden electrodes. The diffraction signal provides information on the lattice parameters for the active materials, which changes as the battery cell is cycled. Results for a study of the spatial inhomogeneity that is present in a NMC523(+)/Graphite(-) battery with a prismatic form factor will be discussed.