

Capturing metastable structures during high-rate cycling of nanoparticulate LiFePO_4 electrodes

Scientific Achievement

The non-equilibrium intermediate phases formed in a LiFePO_4 (LFP) nanoparticle electrode during high-rate charge and discharge have been captured by using time-resolved *in situ* synchrotron X-ray powder diffraction (XRD).

Significance and Impact

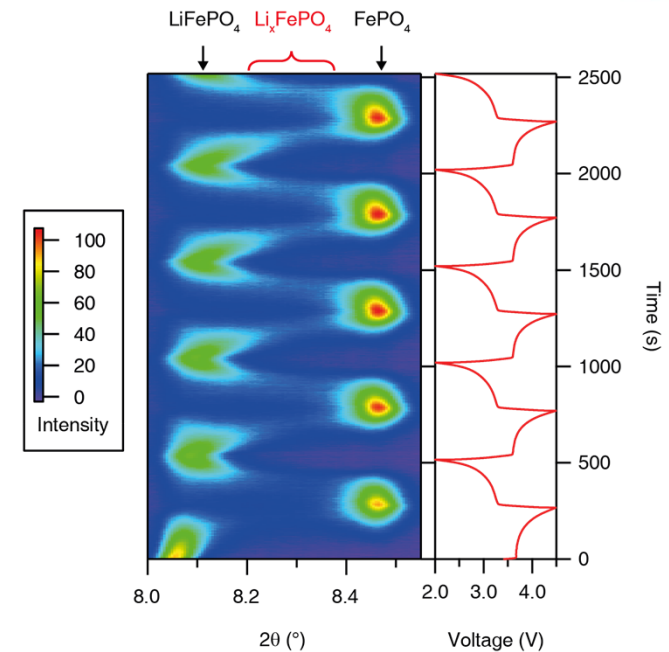
Our study provides experimental evidence that the high-rate capability of nano-sized LFP, a cathode material that reacts via a two phase reaction for large micron size particles and at slow rates, lies in its ability to form a series of non-equilibrium (solid solution) phases. These phases minimize the structural changes induced during charge and discharge and allow reaction to occur throughout the whole particle, not just at the interphase between LFP and FePO_4 . The results demonstrates the importance of *in situ* characterization and suggest strategies for the design of new high-rate electrodes.

Research Details

- Time-resolved *in situ* XRD patterns of LiFePO_4 nanoparticle electrode were collected during fast charge and discharge at beam line 17-BM, APS, Argonne National Lab. The use of a specially-designed (AMPIX) electrochemical cell ensures reproducible electrochemistry even at very high cycling rates.
- The existence of the non-equilibrium phases is manifested in the broadening and shifting of the diffraction peaks. Fitting across the entire diffraction pattern yields a quantitative distribution of the non-equilibrium phases.

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The non-equilibrium phases are evident in the continuous intensity observed between the Bragg reflections of LiFePO_4 and FePO_4 (red curly bracket)



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