MAR12-2011-005880

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

In-Situ TEM Electrochemistry of Individual Nanowire and Nanoparticle Electrodes in a Li-Ion Cell

JIANYU HUANG, Sandia National Lab.

Recently, we created the first Li-ion electrochemical cell inside a transmission electron microscope (TEM) and observed, in real time with atomic scale resolution, the lithiation/delithiation processes. This experiment opened the door for a suite of experimental studies involving in-situ TEM characterization of Li-ion battery materials. In this presentation, I'll first review our latest progress of using the in-situ electrochemical cell setup inside the TEM to reveal the intrinsic electrochemistry of several high energy density anode materials such as SnO_2, ZnO, Si, Ge, Al nanowires, Si nanoparticles, carbon nanotubes, and graphene. Several electrochemical mechanisms were observed and characterized in real-time, including lithiation induced stress, volume changes, phase transformations, pulverization, cracking, embrittlement, and mechanical failure in anode materials. These results indicate the strong material, size and crystallographic orientation dependent electrochemical behavior and degradation mechanisms that occur in Li-ion battery anodes. In the future, we will need further advancements in in-situ characterization for understanding important processes in Li-ion batteries. For example, liquid cells are required in order to examine the electrochemical reactions between battery materials and the standard battery electrolytes, which are ethylene carbonate-based. Furthermore, in-situ studies need to be correlated with electrochemical studies performed on bulk electrodes. I will present a comparison between our in-situ results and electrochemical studies on conventional battery electrodes and highlight how in-situ studies can have important impact on the design of Li-ion batteries. Finally I will discuss outstanding challenging issues and opportunities in the field of Li-ion battery research.

References: **Science** 330, 1515 (2010); 330, 1485 (2010); **Nano Lett**. Doi: 10.1021/nl200412p, 10.1021/nl2024118, 10.1021/nl201684d, 10.1021/nl202088h, **ACS Nano**, doi: 10.1021/nn200770p, 10.1021/nn202071y; **PRL** 106, 248302 (2011); **Eng. Env. Sci.** doi: 10.1039/c1ee01918j