# “Hard X-ray Photoelectron Spectroscopy Investigations of Lithium Ion Batteries”

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**Abstract:**

Lithium ion batteries (LIBs) currently fulfill a very useful role as the power sources for many portable electronics. For more demanding applications such as in electric vehicles they are less than ideal and a considerable amount of R+D is being carried out in attempts to improve their performance.

A key element affecting the performance of LIBs is the solid electrolyte interface (SEI), which grows at the anode-electrolyte interface once the battery has been run through several charge/discharge cycles (and the corresponding SEI on the cathode side, also known as the cathode electrolyte interface (CEI)). It is important that the SEI be stable during the course of many charging cycles and not so thick as to prevent the movement of Li ions during battery operation.

One of many approaches to improve the cyclability of these alternate anodes is to cycle the electrodes with new and different electrolytes, salts, and/or electrolyte additives. The goal is to improve the stability of the SEI and extend the life of the LIB's. We have cycled graphite, tin, silicon, and lithium anodes using a variety of electrolyte-salt-additive-binder combinations. Following cycling, the batteries are opened and the electrodes are examined by a variety of *ex situ* techniques, including hard X-ray photoelectron spectroscopy (HAXPES) as discussed here.

Using beamline X24A at the National Synchrotron Light Source (NSLS) and beamline 06B1-1 at the Canadian Light Source (CLS), we have utilized the HAXPES technique to extend the probing depths well into and in some cases through the SEI's and CEI's. Specific issues we address include the following.

- The composition of the SEI/CEI for different electrode materials, additives, electrolytes, and binders.
- The composition of the SEI/CEI as a function of depth (using HAXPES at several photon energies.) Are the interfaces homogeneous vs. depth or not?
- The composition of the SEI/CEI as a function of charging cycle. How many cycles are required to obtain a stable SEI/CEI?

**Biography:**

David Heskett is a Professor of Physics at the University of Rhode Island. He received his B.S. in Physics from Brown University and his Ph.D. in Physics from the University of Pennsylvania. His graduate research advisor was Professor E. Ward Plummer, and the topic of his thesis was *Photoemission Investigations of the Bonding and Interactions of Simple Molecules*

*on Metal Surfaces*. His current research interests include experimental investigations of the electronic, structural, and dynamic properties of clean and adsorbate-covered metal and semiconductor surfaces and thin films using a variety of surface sensitive probes.