Purdue
School of Materials Engineering

Presents

Peter G. Winchell Distinguished Lecture Series

Seminar

Date: Friday,

Oct. 26, 2012

Time: 3:30 – Seminar

Place: ARMS 1010

4:45 – Refreshments

Armstrong Atrium

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Infinite Possibilities

Doctor Stephen J. Harris

Visiting Scientist
Lawrence Berkeley National Laboratory

Improved Electrode Architectures for High Energy Density and Long Life Lithium-Ion Batteries

ABSTRACT

A long-term goal of DOE is the development of batteries that could power a commercially successful all-electric vehicle, probably requiring a range near 200 miles (at least double that of a Nissan Leaf). In order to achieve higher energy densities, current research focuses on new electrode chemistries with higher capacities and higher voltages (volumetric energy density = charge capacity voltage mass density) that could provide a >50% increase in energy density—still insufficient for a 200 mile range. (Volumetric energy density is more critical to auto companies than gravimetric energy density.) Improvement in the mass density term has been stymied because low electrode porosities always seem to lead to high tortuosities and low power densities. We note, however, that the inverse relationship between porosity and tortuosity applies only to electrodes with random microstructures, which inevitably have large local inhomogeneities.

At the same time, failure in materials almost always begins at local inhomogeneities. Yet, current analyses of lithium-ion batteries are based on a porous electrode model that assumes a homogeneous mixture of flawless, isotropic particles. Our work suggests that variability in local microstructure and in internal particle morphology plays a critical role in reducing both performance and durability of Li-ion batteries. Prof. Edwin Garcia's models lead to similar conclusions.

Following this reasoning, and in collaboration with Garcia, we are developing a new approach for electrode architectures. We suggest that with designed (*i.e.,* non-random) microstructures and particles, we can create electrodes with a high density of active material, to maximize capacity; a low tortuosity, to maximize power; and improved uniformity (no weak spots), to maximize battery life.

SHORT BIO

Steve Harris received a BS degree in chemistry from UCLA in 1971 and a PhD degree in physical chemistry from Harvard University in 1975. He was a Miller Institute post doctoral fellow at UC Berkeley for 2 years and began working in the Physical Chemistry Department at General Motors Research Labs in 1977. He switched to the Chemistry Department at Ford Research Labs from 1998 until 2007, after which he returned to General Motors as a Technical Fellow in the Electrochemical Energy Research department. He was a Miller Institute Visiting Professor at UC Berkeley in 2012 and is currently a visiting scientist at LBNL.

During his more than 30 year career at GM and Ford, Steve has worked in a variety of different fields, including: Laser diagnostics of combustion and laser-induced chemistry, Soot formation, aerosol dynamics, and the chemistry of rich combustion systems; Modeling and experiment; Chemical vapor deposition of diamond and boron-containing films; Modeling and experiment; Development of tribological coatings. Contact mechanics modeling and prediction of fatigue lifetimes; Microscopic basis for ductility and fracture in cast aluminum; Microscopic bases for transport and degradation in lithium-ion batteries.

Steve's work in Li-ion batteries commenced in 2006 and has focused on developing new diagnostic techniques that provide detailed information about Li transport in new and aged cells. These include (1) direct *in-situ* spatial maps showing Li transport in the electrolyte and within particles; (2) 3D tomographic reconstructions of electrodes and 3D reconstructions of the interiors of particle electrode particles; (3) and transport mechanisms through thin (~ 20 nm) SEI films that control many of the performance and life issues in Li-ion batteries. Some of his work (and that of others) is shown at his web site, www.LithiumBatteryResearch.com.