THE MATERIALS AND DEVICES AREA SEMINAR

(EE 500 GRADUATE COLLOQUIUM)

Fall 2009

You are cordially invited to

The Materials and Devices Area Seminar

Entitled

"Electrochemical Modeling, Estimation & Control of Lithium Ion Batteries"

By

Prof. Christopher D. Rahn

Department of Mechanical Engineering
Penn State University Park Campus

The talk will take place on

October 8, 2009
4:00 pm

At

225 EE West Building

Talk Abstract:

Batteries directly contribute to the advancement of technologies ranging from portable electronics to fuel-efficient vehicles to the Smart Grid. In high power applications such as hybrid electric vehicles, monitoring algorithms use current and voltage measurements to estimate battery state of charge (SOC) and available power. Despite increased cost, these systems commonly employ conservative, oversized batteries due to poor prediction of current/voltage dynamics and imprecise real-time estimation. This seminar introduces an electrochemical model-based approach for safe and efficient integration of Li-ion batteries into transient, pulse power-type systems. Development of a fast, stable, and accurate model is difficult given the infinite-dimensional, distributed nonlinear processes governing battery dynamics. An impedance model is derived from the electrochemical kinetic, species and charge transport equations and, using a novel model order reduction technique, the high order transfer functions/matrices are numerically reduced to an observable/controllable state variable model in modal form. Open circuit potential and electrode surface concentration nonlinearities are explicitly approximated in the model output equation on a local and electrode-averaged basis, respectively. Validated against a 313th order CFD model, the 12th order state variable model accurately predicts terminal voltage over a 0-10 Hz bandwidth. A linear observer is designed for real-time estimation of internal potentials, concentration gradients, and SOC. A reference current governor predicts operating margin with respect to electrode side reactions and surface depletion/saturation conditions responsible for damage and sudden loss of power.

Speaker's Bio:

Christopher D. Rahn obtained his Ph.D. from the University of California, Berkeley in 1992 and is currently a Professor of Mechanical Engineering and Director of the Mechatronics Research Laboratory at The Pennsylvania State University. His research work on the modeling, analysis, design, and control of mechatronic systems has resulted in one book, over one hundred and twenty refereed publications, and several patents. He was an Associate Editor of the *ASME Journal of Dynamic Systems, Measurement, and Control* and is currently an Associate Editor of the *ASME Journal of Vibration and Acoustics*, the Chair of the *ASME Technical Committee on Vibration and Sound*, and a Fellow of ASME.