Joint seminar between MSE and
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Creating Pseudocapacitive Materials for High Rate Energy Storage

The prospect of developing materials with the energy density of batteries and the power density and cycle life of electrical double-layer capacitors (EDLCs, also known as supercapacitors) is an exciting direction that has yet to be realized. With these materials there is the promise of achieving charging in minutes (much faster than batteries) with charge storage levels comparable to battery electrode materials (much higher than EDLCs). In recent years there has been widespread interest in pseudocapacitance, a faradaic process involving surface or near -surface redox reactions, that can lead to high energy density at high charge-discharge rates. This paper will review our work on identifying Li^+ conducting materials which exhibit pseudocapacitive behavior. Our research on Li^+ insertion in Nb_2O_5 has established a basis for intercalation pseudocapacitance in which the rate of charge storage is determined by surface-like kinetics rather than semi-infinite diffusion as occurs with battery materials. Another key feature with this mechanism is that the structure does not undergo a phase transformation upon Li^+ insertion. In addition, when materials are reduced to nanoscale dimensions, they may begin to exhibit pseudocapacitive characteristics because of the large number of surface sites or because phase transitions are suppressed. In research to date, we have identified several electrode materials that retain high capacity for lithium at charging rates of 1 to 2 minutes. These results indicate our improved understanding of the electrochemical and structural characteristics that lead to materials and devices that exhibit both high energy density and high power density.

Biosketch

Bruce Dunn is the Nippon Sheet Glass Professor of Materials Science and Engineering at UCLA. Prior to joining UCLA, he was a staff scientist at the General Electric Research and Development Center. His research interests concern the synthesis of inorganic and organic/inorganic materials, and characterization of their electrical, optical, biological and electrochemical properties. A continuing theme in his research is the use of sol-gel methods to synthesize materials with designed microstructures and properties. His recent work on electrochemical energy storage includes three-dimensional batteries and pseudocapacitor materials. Among the honors he has received are a Fulbright research fellowship, the Orton Lectureship from the American Ceramic Society, awards from the Department of Energy and invited professorships in France, Japan and Singapore. He is a Fellow of the Materials Research Society, the American Ceramic Society, and a member of the World Academy of Ceramics. In addition to the Board of Reviewing Editors at *Science*, he is a member of the editorial boards of the *Journal of the American Ceramic Society, Advanced Energy Materials, Solid State Ionics,* and *Energy Storage Materials*.

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