UC San Diego
JACOBS SCHOOL OF ENGINEERING
NanoEngineering

UC SAN DIEGO NANOENGINEERING SEMINAR

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Seminar Presentation: 11:00am – 12:00pm
SME 248

"Nanostructured Materials for Application in Electrochemical Energy Storage"

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Abstract: In this talk, we examine ways that solution processed nanostructured materials can be used to address both fundamental and practical issues relevant to electrochemical energy storage. Materials with nanoporous architectures can be synthesized using a range of solution phase methods, including polymer templating, nanoparticle assembly, and selective dealloying of mixed metal precursors. We begin with fast charging energy storage systems referred to as pseudocapacitors. Here we aim both to produce practical new fast charging material, and to clarify how pseudocapacitive charge storage differs from traditional battery behavior. We find that in optimized materials, the nanoscale porosity can produce a very desirable combination of electrical connectivity, electrolyte access to the interior of the material, ample surface redox sites, and very short solid-state diffusion lengths for lithium ions, all of which facilitate fast charge and discharge. Perhaps more importantly, many nanoscale materials appear to show suppression of the intercalation induced phase transitions that can cause kinetic limitations in bulk materials. The result is a new family of fast charging nanostructured energy-storage materials. A combination of electrochemical kinetics and *operando* X-ray diffraction allows us to correlate phase transition behavior with electrochemical kinetics. Similar porous architectures can also be used to increase stability and cycle life in high capacity alloy-type anode materials. These alloy anodes generally suffer from short lifetimes due to large volume changes during lithiation or sodiation, but we find that nanoscale porosity helps accommodate those volume changes. Using transmission X-ray microscopy (TXM), we are able to directly image changes in both individual grains, and in the pore structure itself upon cycling. We find that porous materials expand much less than bulk materials, because the pores help accommodate the strain. Direct pore imaging also allows us to follow pore fracture and determine how it can be avoided. Taken together, these two families of materials emphasize the key role that can be played by nanoscale porosity in optimizing the properties of next generation energy-storage materials.

Biosketch: Sarah H. Tolbert is a professor in the Departments of Chemistry and Biochemistry and Materials Science and Engineering at UCLA. Prior to joining the faculty at UCLA, she received a B.S. from Yale University, a Ph.D. from U.C. Berkeley as an NSF graduate fellow, and was an NSF postdoctoral fellow at U.C. Santa Barbara. Her research focuses on controlling nanometer-scale architecture in solution-processed nanomaterials to generate unique optical, electronic, magnetic, structural, and electrochemical properties. She has published over 175 scholarly research article. Her group specifically focuses on electrochemical energy storage (including both pseudocapacitors and batteries), solar energy harvesting, electrocatalysis, nanomagnetics, and new ultra-hard materials. She also leads a program aimed at bringing nano-concepts to schools throughout the greater LA area. Professor Tolbert is the recipient of a number of awards and honors including Fellow of the Royal Society of Chemistry, the UCLA Diversity, Equity, and Inclusion Award, an NSF Special Creativity Award, the American Chemical Society R.A. Glen Award, Closs and Barrer Lectureships at the University of Chicago and Penn. State, respectively, an Office of Naval Research Young Investigator Award, an NSF CAREER Award, a Beckman Young Investigator Award, and a Sloan Foundation Research Fellowship. She serves on the advisory boards of *Nanoscale Horizons*, *ACS Applied Materials and Interfaces*, and the Advance Light Source at Laurence Berkeley National Laboratory.