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Addressing the scale and complexity of the global energy challenge.

Keeping up with the increasing demands for electrochemical energy storage:
Ceramic oxide electrolytes enabling a new class of safe, high energy density batteries

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Date: Thursday, February 21, 2013 at 3:30 PM
Location: Engineering Building, ECCR room 1B40

Abstract:

The interest in vehicle electrification is unprecedented. Several automotive manufacturers are producing or planning to produce hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fully or battery electric vehicles (BEVs). Lithium-ion (Li-ion) battery technology is the current leading candidate to meet the near and medium-term needs for electric vehicles. Leveraging considerable growth and development from the manufacturing of batteries for microelectronics, Li-ion technology has advanced significantly in the last decade. However, the leap from small-scale microelectronic batteries (tens of watt hours) to electric vehicle battery packs (tens of kilowatt hours) is not trivial. Performance metrics such as cost/kilowatt hour, specific energy (Wh/kg), specific power (kW/kg), safety, and cycle life are considerably more demanding for electric vehicles than for laptops and cell phones. Electric vehicles (EVs) show promise in minimizing reliance on fossil fuels, but their widespread use will likely require a revolutionary advance in energy storage technology. This presentation will provide an overview of energy storage technology for vehicle electrification, highlight challenges, and discusses opportunities at the frontiers of battery research. Specifically, this work will focus on a novel approach to enable new battery technologies through the development of solid oxide electrolytes.

While the primary strategy for improving performance has focused on electrode materials, the development of new electrolytes has been overlooked as a potential means to revolutionize electrochemical energy storage. This presentation will discuss recent work on a new class of electrolyte based on a ceramic oxide with the garnet structure ($Li_7La_3Zr_2O_{12}$) exhibiting the unprecedented combination of high ionic conductivity (~1mS/cm at 298 K) and chemical stability against metallic lithium and air. However, with new approaches come new challenges. Specifically, establishing high density, polycrystalline, thin, bulk-scale ceramic membranes that can withstand the rigors of processing and integration present the need for advanced materials and materials processing. Additionally, I foresee a need for advanced densification technology and engineering solutions to enable integration with electrode powders and to optimize the mechanical properties. Examples of technologies that could be enabled by this class of electrolyte include: solid-state lithium ion batteries that are non-flammable and do not require hermetic packaging, lithium-air semi fuel cells, redox and lithium-sulfur batteries.

Biosketch:

Jeff Sakamoto is an Associate Professor in the Department of Chemical Engineering and Materials Science at Michigan State University. Prior to joining the MSU faculty he was a Senior Engineer at the California Institute of Technology, Jet Propulsion Laboratory for 6 years. He worked on the Li-ion batteries for the twin Mars Exploration Rovers and thermoelectric generators for deep space exploration missions. He earned his PhD (2001) in Materials Science and Engineering from UCLA. His research focuses on the synthesis of micro-meso-macro porous materials as well as high density complex ceramic oxides, transition metal pnictides, and hydrogels for electrochemical energy storage, thermoelectric energy conversion, and biomedicine, respectively.

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