COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
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ME Department Seminar

Piezoelectrochemistry in Li-ion Batteries: Coupling Mechanics and Electrochemistry

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Abstract

Because of their high energy densities and high working voltages, lithium-ion batteries are the most suitable energy storage choice for a variety of applications from large scale battery electric vehicles to small scale implantable medical devices. These systems are well-known to experience both mechanical and electrochemical phenomena and in this presentation, we discuss how the evolution of internal and external mechanical stress affects the electrochemical performance over the lifetime and how the electrochemical state of the system influences its mechanical properties. Starting with the internal stress state of the battery, we identify the dynamic nature of this quantity, fluctuating with charge/discharge and gradually increasing irreversibly over long times with electrochemical cycling. Further probing of the system behavior reveals that not only the stress state, but regions of stress localization within the cell can lead to electrochemical phenomena which further accentuate performance degradation. Based on a detailed understanding of mechanical and electrochemical coupling, we demonstrate how it is possible using standard li-ion batteries to construct a thermodynamic process for harvesting mechanical energy at low frequencies. Such a mechanism exhibits certain benefits over more traditional piezoelectric energy harvesting that will be discussed.

Bio

Craig Arnold is a Professor of Mechanical and Aerospace Engineering at Princeton University, and Director of the Princeton Institute for the Science and Technology of Materials (PRISM). Research in the Arnold group primarily focuses on laser processing and transport in materials with particular emphasis on shaping laser-material interactions. We strive to develop a deep understanding of the fundamental materials and optical physics, in order to have a direct impact on applications at the frontiers of technology in fields ranging from energy to biology and imaging to nanoscience. Key examples of our work in this area include the research and development of optical trap assisted direct-write nanopatterning (Trap and Zap), the tunable acoustic gradient index of refraction (TAG) lens for high-speed varifocal imaging and materials processing, laser direct-write printing for complex materials in biological and energy applications, and solution based printing methods of chalcogenide glass for mid-infrared photonic applications. The research is primarily experimental in nature with a mix of fundamental and applied projects. Prof. Arnold is the recipient of the ONR Young Investigators Award (2005) and NSF Career Award (2006).