Emerging Thermal and Energy Nanomaterials for Rapid Transient Events

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Abstract:

The theory of energy and charge transport is a century old, yet classical and quantum size effects have been exploited usefully in practical materials only for the past two decades, and even then with a generally modest level of success in practice. With the increased prevalence of nanomaterials in advanced research, we must look deeper into fundamental aspects of interfacial transport in assemblies of nanomaterials in order to control their performance and engineer them for desired, useful properties in real applications. For example, individual carbon nanotubes possess extremely high axial thermal conductivity, yet when placed in a composite matrix, the effective thermal properties are quite ordinary. For high-performance applications, single-phase convection cooling is a limited option due to its inability to dissipate ultra-high thermal loads, thus constraining the performance of the host system. With these challenges in mind, this presentation will consider how nanomaterials can be exploited at appropriate engineering scales to improve the performance of realistic thermal and energy storage devices, particularly those requiring rapid transient response. The presentation will consider carbon nanomaterials for use in fast-charging and discharging supercapacitors, which are poised to replace traditional batteries in many applications. As another example, a tunable cooling technology befitting fast transient thermal events. In this system, the rapid depressurization of the working fluid triggers coincident flash boiling and desorption events, thereby achieving very high cooling rates for short periods of time. We anticipate that this combination of technologies will achieve instantaneous peak cooling rates surpassing those other advanced cooling systems in a manner appropriate for transient thermal events. The presentation will close with a discussion of opportunities in scalable manufacturing to enable cost-effective, large-scale production of these technologies.

Bio:

Timothy S. Fisher is the James G. Dwyer Professor of Mechanical Engineering at Purdue University. He received Ph.D. and B.S. degrees in Mechanical Engineering from Cornell University in 1998 and 1991, respectively, and joined the Purdue's School of Mechanical Engineering and Birck Nanotechnology Center in 2002 after several years at Vanderbilt University. In 2008 he was a Visiting Professor in the Chemistry and Physics of Materials Unit of the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR, Bangalore, India), and he now holds the position of Adjunct Professor in the International Centre for Materials Science at JNCASR and co-directs the JNCASR-Purdue Joint Networked Centre on Nanomaterials for Energy. From 2009 to 2011, he served as a Research Scientist at the Air Force Research Laboratory's newly formed Thermal Sciences and Materials Branch of the Materials and Manufacturing Directorate. Prior to his graduate studies, he was employed from 1991 to 1993 as a design engineer in Motorola's Automotive and Industrial Electronics Group. His research has included efforts in simulation and measurement of nanoscale heat transfer, coupled electrothermal effects in semiconductor and electron emission devices, nanoscale direct energy conversion, molecular electronics, microfluidic devices, hydrogen storage, and computational methods ranging from atomistic to continuum scales.

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Refreshments will be served at 3:15 p.m.