IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Heat Transfer in Li-ion Batteries – Interfaces, Imaginary Eigenvalues and Thermal Runaway

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Faculty host: Todd Kingston

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Abstract

Li-ion cells offer high-efficiency electrochemical energy storage, and therefore, may play a central role in meeting the energy challenges of the future. Unfortunately, Li-ion cells suffer from several thermal safety problems, as evidenced by recent product recalls and incidents of fires in electric cars and aircraft. Understanding and optimizing the nature of multiscale heat transfer in Li-ion cell materials, components and systems is critical for overcoming such challenges.

This talk will summarize ongoing experimental and theoretical research on heat transfer in Li-ion cells. Thermal conduction measurements at multiple length scales that identify poor thermal transport across the cathode-separator interface as the fundamental root cause of the low thermal conductivity of Li-ion cells will be discussed. A molecular bridging approach that improves this interfacial thermal transport by 4X will be discussed. System-level multiphysics simulations that capture the highly non-linear thermal runaway phenomenon will be discussed. Finally, theoretical analysis of diffusion-reaction problems in multilayer systems for predicting thermal runaway in Li-ion cells will be discussed. Key outcomes of this theoretical work include the derivation of a new non-dimensional number to predict the occurrence of thermal runaway, and analysis of the existence of multiple but finite number of imaginary eigenvalues in such problems.

Dr. Ankur Jain is an Associate Professor in the Mechanical and Aerospace Engineering Department at the University of Texas, Arlington. His research interests include heat transfer in Li-ion batteries, microscale thermal transport, additive manufacturing and applied mathematics. He has published 111 journal papers, and given 59 invited talks, seminars and tutorials. He received the UT Arlington President's Award for Excellence in Teaching (2022), UT Arlington College of Engineering Lockheed Martin Excellence in Teaching Award (2018), UT Arlington College of Engineering Outstanding Early Career Award (2017), NSF CAREER Award (2016) and the ASME EPP Division Young Engineer of the Year Award (2013). He received his Ph.D. (2007) and M.S. (2003) in Mechanical Engineering from Stanford University, and B.Tech. (2001) in Mechanical Engineering from Indian Institute of Technology, Delhi with top honors.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.

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