

The Department of Mechanical Engineering
College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar



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Thermal Transport Phenomena in Nanomaterials: Applications of Quantum Kinetic Theory and Electrodynamics

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Abstract

As future electronics shrink toward the atomic size scale, challenges arise in controlling thermal energy and characterizing temperatures in few atom-confined bodies. Besides the classical heat transfer sense, we must consider quantum size effects and ultrafast transport processes, to fully understand energetic transport mechanisms in these nanomaterials. Dr. Zhang and his group at UNT are working on modeling and validating transport phenomena within and in between nanomaterials, such as carbon nanotubes, semiconductor nanowires, 2D materials, and photonic metamaterial gratings. The first part of the presentation discusses the efforts to understand photon-to-nanomaterial interactions at thermal equilibrium. Examples include far-field optical and infrared spectra of nanowire/tube arrays and sub-micron thick layered heterostructures for heat-absorbing/rejecting coatings. On the other hand, nanomaterials can modulate photon energy transmission (near-field tunneling) across nanoscale vacuum gaps, which contribute to interfacial energy losses and thermophotovoltaic conservation. The second topic in this presentation discusses non-equilibrium thermal conditions in quantum-confined materials, such as semiconductor nanowire arrays. In these materials, it is especially difficult to resolve thermophysical properties during ultrafast femtosecond-scale laser interactions, in which electron carrier transport and phonon vibration modes become anharmonic. Modeling these non-linear coupled quantum kinetic interactions give perspective on locally transient electric current and lattice temperature, key to the thermoelectric effect.

Biography

Dr. Zihao (Richard) Zhang is an Assistant Professor in the Department of Mechanical & Energy Engineering at University of North Texas in Denton, TX. His degrees are from the Massachusetts Institute of Technology (B.S., 2010), and Georgia Institute of Technology (M.S., 2013, and Ph.D., 2015), all in Mechanical Engineering. Dr. Zhang was a Member of the Technical Staff at the Aerospace Corporation in El Segundo, CA from 2015 to 2017. Professor Zhang's research interest principally cover heat transfer, from fundamental nanoscopic transport phenomena to mesoscale thermal characteristics of materials and devices. Forward engineering applications include optical/infrared sensors, passive thermal radiative coatings, thermophotovoltaics, and aerospace materials. Dr. Zhang's works have been featured in international peer-reviewed journals, such as Journal of Heat Transfer, Applied Physics Letters, ACS Photonics, and more. He is also a holder of a patent. Dr. Zhang is an active member of American Society of Mechanical Engineers (ASME) Nanoscale Heat Transfer committee. He was recently granted a fellowship with the US Air Force Research Laboratory.



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