DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Fall Seminar Series

Ultrafast heat transfer in nanoscale materials

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On the macroscopic lengths scales of conventional engineering systems, heat transfer by conduction is generally a slow process well-described by the heat diffusion equation. The characteristic time-scale of diffusion scales with the square of length; therefore, at nanometer length scales, heat conduction can involve processes that occur on time-scales of picoseconds, i.e., a few trillionth of a second. We use ultrafast pump-probe optical techniques to directly study a variety of unconventional heat transfer mechanisms that are critical in nanoscale devices and nanoscale materials. Our studies encompass a diverse variety of systems (metallic nanoparticles for photothermal medical therapies, phase change materials for solid-state memory, and heat-assisted magnetic recording) and physical mechanisms (the thermal conductance of interfaces between dissimilar materials, the non-equilibrium between thermal excitations of electrons, phonons, and magnons, and the cross-terms in the transport of heat, charge, and spin). In this talk I will highlight three recent examples: i) ultrafast thermal transport in the surroundings of plasmonic nanostructures; ii) limitations on ultrafast heating of metallic multilayers imposed by electron-phonon coupling; and iii) the generation of currents of magnetization by the spin-dependent Seebeck effect and extreme heat fluxes exceeding 100 GW m^{-2}.

Professor Cahill received his BS in engineering physics from Ohio State University (summa cum laude) and his PhD in physics from Cornell University in 1989. His PhD work concerned lattice vibrations of disordered solids. Before joining the faculty at UIUC, he worked at IBM Watson Research Center where he conducted research on metal-semiconductor interfaces. His current research program focuses on developing a microscopic understanding of thermal transport at the nanoscale; the development of new methods of materials processing and analysis using ultrafast optical techniques; and advancing fundamental understanding of interfaces between materials and water. David Cahill is the 1998 winner of the Peter Mark Memorial Award, the outstanding young investigator award of the AVS. Cahill was named a University Scholar by the University of Illinois in 2001, and a Willett Professor of Engineering by the College of Engineering in 2005. He is a fellow of the American Vacuum Society, the American Physical Society, and the Materials Research Society. He is on the editorial boards of *Applied Physics Letters* and *Journal of Applied Physics*.