Mechanical Engineering Department Seminar

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1130 Mechanical Engineering
111 Church Street SE, Minneapolis, MN 55455

Ultrafast Heat Transfer in Nanoscale Materials

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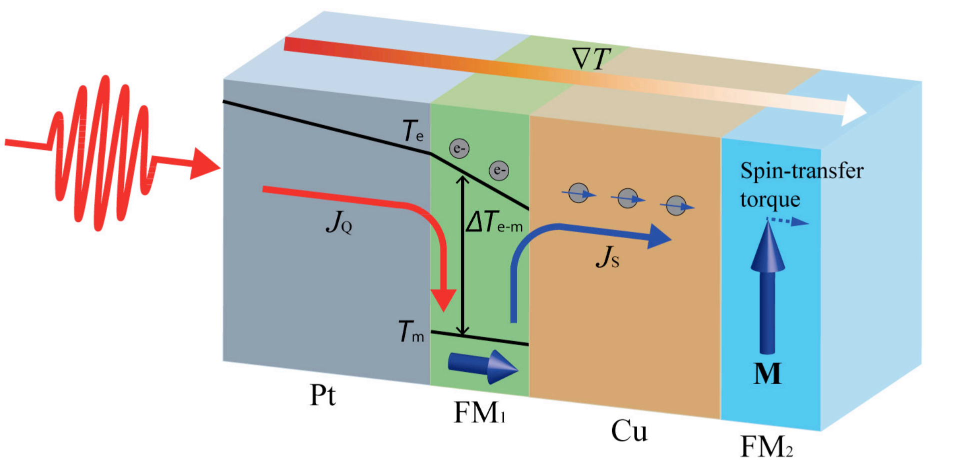
On the macroscopic lengths scales of conventional engineering systems, heat transfer by conduction is generally a slow process well-described by the heat diffusion equation. The characteristic time-scale of diffusion scales with the square of length; therefore, at nanometer length scales, heat conduction 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 K-1.



Bio: Dr. David Cahill joined the faculty of the University of Illinois at Urbana-Champaign in 1991 after earning his Ph.D. in condensed matter physics from Cornell University, and working as a postdoctoral research associate at the IBM Watson Research Center. In 2005, he was named Willett Professor of Engineering and was appointed Head of the Department of Materials Science and Engineering in 2010. His 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. He received the Peter Mark Memorial Award from the American Vacuum Society (AVS); is a fellow of the AVS, American Physical Society (APS) and Materials Research Society (MRS); and currently serves as past-chair of the Division of Materials Physics of the APS.