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Ultrafast heat transfer in nanoscale materials

Professor **David Cahill**

*Department of Materials Science and Engineering and
Materials Research Laboratory, University of Illinois,*

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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} .



主催:

東京大学大学院工学系研究科「機械システム・イノベーション」プログラム (GMSI)
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本件連絡先:

東京大学大学院工学系研究科機械工学専攻 准教授 塩見 淳一郎

GMSIプログラム事務局 E-mail: office@gmsi.t.u-tokyo.ac.jp Phone: 03-5841-0696