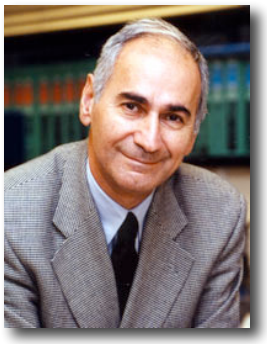
Mechanical Engineering Department Seminar



3:35pm January 30, 2013
402 Walter Library

2013 Eckert Lecture: "Heat Transfer Physics"

Massoud Kaviany

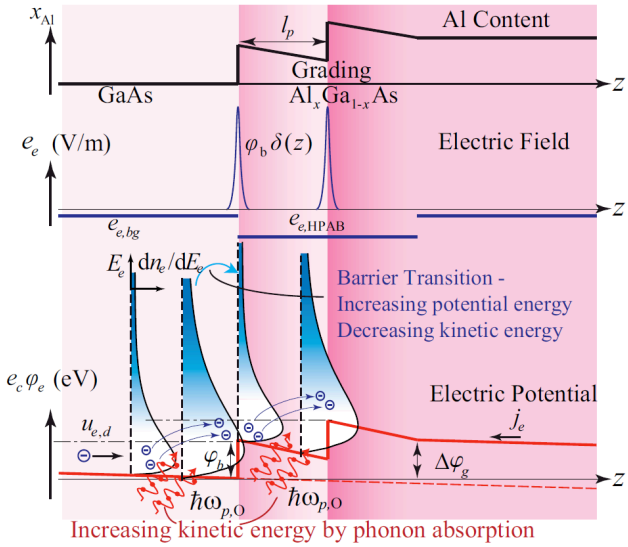
Professor, Department of Mechanical Engineering and Applied Physics Program; University of Michigan

We discuss atomic-level heat transfer in solids, with examples of phonon recycling (local reabsorption of emitted phonons, especially before their inter-phonon interactions leading to equilibrium occupancy) in devices and the roles of phonons in thermoelectricity.

Phonons are emitted in all resistive and energy conversion processes in solids and are generally called waste heat, representing efficiency loss. We discuss in-situ (at/adjacent to the emission site) recycling of optical phonons to improve thermal management (lowering operating temperature and/or reducing heat generation) and increase efficiency. We consider phonon emissions in non-radiative decay in lasers and in integrated electric circuits. The first is photon-assisted phonon absorption, while the second is unassisted phonon absorption, and we discuss phonon-recycling layered structures for each. These layers are placed adjust to the phonon emission sites, with thickness and composition matching their assisted and unassisted phonon absorption function.

Phonons generally play a negative role in thermoelectric figure of merit, but we show phonon softening (phonon mode red-shifting with temperature) in boron carbides increases the Seebeck coefficient. We also discuss the roles of thermal disorder (off-center displacement of atoms with temperature) in enhancing the figure of merit (e.g., electronic band convergence and suppression of long-range acoustic phonon transport).

These examples are inspired by and in evolutionary steps with the Ernst Eckert heat transfer science tradition/stewardship at the University of Minnesota, aimed at advancing the education/research of this field.



Bio: Massoud Kaviany is a Professor in the University of Michigan Department of Mechanical Engineering and in the Applied Physics Program. His interests are focused in heat transfer education and research. He has authored *Heat Transfer Physics 2008* and *Essentials of Heat Transfer 2011*, by Cambridge University Press. He was Chair of ASME Committee on *Theory and Fundamental Research in Heat Transfer (1995-1998)*, is an ASME Fellow (1992) and an APS Fellow (2011), and has received the University of Michigan Engineering 2003 Education Excellence Award, the 2002 ASME Heat Transfer Memorial Award (Science), and the 2010 ASME James Harry Potter Gold Medal (Thermodynamics Science). His Ph.D. is from the University of California at Berkeley, awarded in 1979.