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Thermal Transport at Nanostructure Interfaces

Thermal transport in nanotubes, nanowires, ultrathin films, and other structures with nanometer-scale characteristic dimensions differs dramatically from that in bulk materials. Nanocomposite 'metamaterials' formed of these nanostructure building blocks have recently gained much attention for their potential to exploit these unusual properties and achieve the extreme values of thermal conductivity demanded by many current and future applications. For example, ultrahigh thermal conductivity materials are required to meet the escalating heat sinking demands of next-generation high power density electronics, and ultralow thermal conductivity materials are required to make thermoelectric alternative energy systems competitive with conventional energy systems. A crucial consideration when building such 'materials-by-design' is the transport of thermal energy across the interfaces between the constituent nanostructures and their surroundings. Presented here is recent molecular dynamics simulation work that illustrates how interfaces can be tailored to modify thermal transport in such materials. Specifically, thermal transport between carbon nanotubes, around nanoparticles embedded in a host material, and within superlattices will be discussed. Key results observed include a four order of magnitude reduction in nanotube-nanotube thermal resistance as nanotube spacing decreases, a distortion of phonon scattering arising from host material crystal structure, and a clear thermal conductivity minimum in lattice matched superlattices. Additionally, other ongoing computational and experimental projects addressing the unusual fluid and mass transport behavior occurring at the nanoscale will be briefly discussed.

Jennifer R. Lukes is currently William K. Gemmill Assistant Professor in the Department of Mechanical Engineering and Applied Mechanics at the University of Pennsylvania. Professor Lukes received her B.S. in Mechanical Engineering *magna cum laude* from Rice University in 1994 and was elected to Phi Beta Kappa that same year. Following her undergraduate studies, she worked in industry as a facility engineer at Amoco Production Company. A National Science Foundation Fellow, she returned to academia and joined Professor Chang-Lin Tien's Microscale Heat Transfer Laboratory at the University of California, Berkeley, earning her M.S. and Ph.D. degrees in Mechanical Engineering in 1998 and 2001. She began teaching at the University of Pennsylvania in 2002. Professor Lukes received the National Science Foundation CAREER Award in 2006, and in 2007 she was selected to participate in the National Academy of Engineering's U.S. Frontiers of Engineering Symposium. A member of the American Society of Mechanical Engineers, the Materials Research Society, and the American Physical Society, Professor Lukes is active in the ASME K-8 Committee on Theory and Fundamentals of Heat Transfer. She has chaired/co-chaired several technical sessions in the past few years on micro/nanoscale thermal transport simulations, carbon nanotubes, and novel nanostructured materials.

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