Thermal Transport in Low-dimensional Materials

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With the continuous reduction of dimension and increase in the use of low-dimensional materials in electronic and photonic devices, there is a greater need for the understanding of thermal transport and thermophysical properties in these materials and devices. It has been discovered that nanomaterials such as quantum dots, nanowires, and ultra-thin films often provide unique transport properties that can improve the performance of devices. The goal of nanoscale thermal transport research is to discover unique energy coupling channels to facilitate or inhibit energy transport for energy conversion and utilization. On the horizon are newly discovered or synthesized 2-dimensional materials that promise novel applications ranging from electronics to health care devices. In this talk we will discuss a number of nanoscale thermal transport problems in emerging technologies of energy harvesting/conversion, information storage, and next generation electronic devices. Unique experimental tools are developed for these studies. In addition to the need of investigating thermal transport with high spatial resolution, high temporal resolution is often required as the time scale involved in the energy transport through nanoscale devices is usually very short. Moreover, from a microscopic viewpoint, energy transport and conversion are determined by interactions among basic energy carriers such as electrons, photons, and phonons, which often occur at a time scale of femtoseconds to picoseconds. A number of examples will be discussed, including investigating energy transfer at the ultrafast time scale to help to develop photovoltaic materials and to develop thermoelectric materials for converting waste heat to useful power, complex thermal transport problems involved in the next generation data storage devices, and the intriguing thermal transport processes in a few atomic layer-thick ultra-thin materials.