Thermal transport in graphene and graphene-based composites

Jiuning Hu[1, 2], Wonjun Park[1, 2], Xiulin Ruan[3, 2], Yong P. Chen[4, 2, 1]
[1]School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907, U.S.A.
[2]Birck Nanotechnology Center, Purdue University, West Lafayette, IN 47907, U.S.A.
[3]School of Mechanical Engineering, Purdue University, West Lafayette, IN 47907, U.S.A.
[4]Department of Physics, Purdue University, West Lafayette, IN 47907, U.S.A.

Graphene has emerged as one of the most attractive materials in recent years and exhibits many unique and excellent properties, inviting a broad area of fundamental studies and applications. We theoretically and experimentally studied the thermal transport properties in various graphene-based systems. Firstly, we used molecular dynamics simulations to study the thermal transport in graphene nanoribbons (GNRs) that presented various properties such as chirality dependent thermal conductivity, thermal rectification in asymmetric GNRs, and defects and isotopic engineering of the thermal conductivity. These findings are useful for future applications of controlling heat at nanoscale using GNRs. We also obtained negative differential thermal conductance (NDTC) at large temperature biases in GNRs. We extended our study of NDTC in the diffusive limit into general one-dimensional thermal transport and found that NDTC is possible if a junction with temperature dependent thermal contact resistance is introduced. Secondly, we synthesized graphene-based composites with different graphene fillers (e.g., reduced graphene oxide and mechanically exfoliated graphene powder) and matrix materials (e.g., polystyrene and epoxy) and characterized their electric and thermal properties. Their electrical conductivity follows the percolation theory. We used 3-omega method to measure the thermal conductivity and found that their thermal conductivities can be tuned dramatically by the graphene filler concentration. Graphene-based composites are potentially promising as thermal interface materials, which have become increasingly important in modern heat management in many industrial applications. We acknowledge NRI, CTRC and DTRA for supporting our research.