Thermal and Electrical Transport Properties of Nano-Energy Materials

Thermal transport in nanoscale materials attracts increasing research attention because of both intriguing phonon physics at the nanoscale as well as growing importance of heat management in nanoscale devices. Active heat flow control is essential for broad applications of heating, cooling, and energy conversion. Like electronic devices developed for the control of electric power, it is very desirable to develop advanced all-thermal solid-state devices that actively control heat flow without consuming other forms of energy. However, experimental demonstration of thermal conductivity in the nanometer-scale or low-dimensional materials is lacking, due mostly to technical challenges in sample preparation and measurements. Here, I will introduce the method to measure the thermal properties of low-scale and low-dimensional materials, and present my recent research using the method: i) unusual behaviour of thermal conductivity in vanadium dioxide across the metal-insulator transition, ii) anisotropic in-plane thermal conductivity of black phosphorus nanoribbons, and iii) temperature-gated thermal rectifier for active heat flow control.