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Thermoelectric Transport in 2D structures

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Venue：31B, 3F Faculty of Engineering Bldg. 2

Abstract:

Thermoelectric modules have potential application in waste heat recovery, solar thermal energy conversion and radioisotope thermoelectric generators. These modules are also used for refrigeration, active cooling of hot spots of electronics, and thermal regulation. For more than a century, researchers have tried to increase the figure of merit, ZT. Perhaps one of the most important ideas in the thermoelectric field, was the pathway laid by Mildred Dresselhaus, to study low dimensional materials. Interfaces in two dimensional structures are associated with thermal and electrical resistance and Seebeck coefficient which adds to the responses of the bulk sample. In small samples and in structures with closely packed interfaces, the thermoelectric response of interfaces could dominate the overall response.

Silicon- F_4TCNQ Interface

A series of organic molecules were scanned computationally using first principles calculations to identify molecules that can create large surface doping in silicon. F_4TCNQ was identified as one that can heavily dope silicon. Silicon thin films were fabricated with thermometers for temperature measurements and electrical contacts. F_4TCNQ was thermally evaporated on the silicon surface. Interfacial thermoelectric responses were measured. Due to charge transfer at the interface of silicon-F_4TCNQ, electrical conductance increases by a factor of ten after F_4TCNQ deposition. Seebeck coefficient drops from 593 μV/K down to 243 μV/K confirming sample is p-doped after F_4TCNQ deposition.

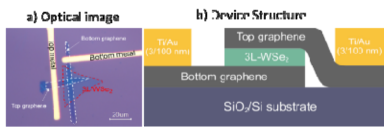

Figure 1. a) optical image and b) schematic of the device structure.

Thermionic Transport across WSe2 layers

Gold-graphene-few layers of WSe2-graphene-gold structures were fabricated as shown in figure 1. Thermoelectric responses of the structure were measured across the layers using a combination of thermal imaging and electrical measurements. A small ZT was estimated at room temperatures using cooling curve measurements. It is noted that despite the small value of ZT (0.002), it is orders of magnitude larger than previously reported ZTs for van der Waals heterostructures. It is also noted that higher ZT values are expected at elevated temperatures and better performances are expected when the substrate is replaced by a good heat sink.

Biography:

Mona Zebarjadi is a joint professor of Electrical and Computer Engineering and Materials Science and Engineering Departments at University of Virginia, where she is leading the Energy Science and Nanotechnology Lab (ESNL). Prior to her current appointment she was a professor of Mechanical Engineering Department at Rutgers University. Her research interests are in electron and phonon transport modeling; materials and device design, fabrication and characterization; with emphasis on energy conversion systems such as thermoelectric, thermionic, and thermomagnetic power generators, and heat management in high power electronics and optoelectronic devices. She received her Bachelor's and master's degree in physics from Sharif University and her PhD in EE from UCSC in 2009, after which she spent 3 years at MIT as a postdoctoral fellow working jointly with electrical and mechanical engineering departments. She is the recipient of 2017 NSF Career award, 2014 AFOSR career award, 2015 A.W. Tyson assistant professorship award, MRS graduate student gold medal, and SWE electronics for imaging scholarship.

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