Physics & Astronomy Colloquium – Spring 2020

Tuesday, Feb 25th at 3:30 pm in SC 234

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Thermoelectric and Photocatalytic Energy Conversion using Atomically-thin 2D Materials and Plasmon Resonant Nanostructures

In this talk, our latest work will be presented on thermal and thermoelectric transport characteristics of nanoscale materials and devices, including MoS_2 and $SnSe_2$.[1,2] Here, the thermal conductivity between the layers of these rotationally-disordered 2D crystals provides a promising strategy for improving the thermoelectric figure of merit in the cross-plane direction. We also report photocatalytic energy conversion (i.e., generation of solar fuels) using atomically thin 2D materials, including WSe_2 and $MoSe_2$. In these systems, we observe plasmon-resonant enhancement of photocatalysis on monolayer WSe_2 and resonant excitation of interlayer excitons in monolayer $WSe_2/MoSe_2$ heterostructures.[3,4] We probe photocatalytic and electrocatalytic processes using various forms of surface spectroscopy, including sum frequency generation (SFG) spectroscopy, surface enhanced Raman scattering (SERS) spectroscopy, graphene enhanced Raman scattering (GERS) spectroscopy, transient absorption (TAS) spectroscopy, and vibrational Stark-shift spectroscopy.[5,6] Plasmon resonant grating structures provide an effective platform for distinguishing between the effects of plasmon resonant excitation and bulk metal absorption via interband transitions. By simply rotating the polarization of the incident light, we can switch between resonant excitation and non-resonant excitation, while keeping all other parameters of the measurement constant. With light polarized perpendicular to the lines in the grating (i.e., TE-polarization), the photocatalytic reaction rate (i.e., photocurrent) is measured as the angle of the incident laser light is tuned through the resonance with the grating. The spectral responses of grating structures fabricated with Ag, Al, and Cu are also presented.[7, 8, 9]

1. Nano Letters, DOI: 10.1021/acs.nanolett.8b02744 (2018).
2. Nano Letters, 17, 1978-1986 (2017).
2. ACS Photonics, 6, 787 (2019).
4. ACS Applied Nano Materials, DOI:10.1021/acsanm.9b01898 (2020).
5. ACS Applied Materials & Interfaces, 11, 36252-36258 (2019).
6. ACS Photonics, 6, 2295 (2019).
7. Faraday Discussions 214, 325 DOI:10.1039/C8FD00141C (2019).
8. Applied Physics Letters 113, 083904 DOI: 10.1063/1.5030674 (2018).
9. Applied Physics Letters, DOI: 10.1063/1.5048582 (2018).

Refreshments at 3:00 pm in SC 103