College of Engineering
Department of
Mechanical & Industrial Engineering

The Sidney E. Fuchs Seminar Series

3:00-4:00pm, Friday, November 16, 2018
1200 Patrick F Taylor Hall

Plasmonic Hot-Carrier Devices: Infrared Photodetectors and Solar Water Disinfection

by Kevin McPeak*

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Plasmonic hot-carrier devices offer tunable absorption, below-the-band-gap charge generation, and ultrafast response times. These features could result in transformative advances in photon detection, photocatalysis and photovoltaic devices. Unfortunately, state-of-the-art devices suffer from low efficiency (~1%) due to their ultrafast lifetimes and non-ideal energy distributions. In this talk, I will discuss two different methods my group at LSU is exploring to increase the hot-carrier lifetime and tune their energy distribution for applications in solar water disinfection and infrared photodetection.

Solar energy can disinfect water through the generation of reactive oxygen species (ROS), but current methods utilize ultraviolet (UV) light—only 5% of the solar spectrum—and make use of particulate suspensions which must be separated from the water post-disinfection. I will present a visible light driven hot-carrier device which utilizes a metal-semiconductor-metal geometry to improve the absorption of solar energy and increase the lifetime of the hot electron. Furthermore, I will discuss a proposed mechanism for ROS generation, and present results on E. coli disinfection under UV filtered AM1.5 light.

Silicon photodetectors allow the integration of both optical and electrical functionality in a single device. However, silicon photodetectors are unworkable above 1.10 μm wavelengths due to the low infrared absorption in silicon. Plasmon-assisted silicon photodetectors offer a route for infrared photodetection, but the dominant route for hot-carrier generation from current noble metals (e.g., Au) is interband transitions from high-energy (≥2 eV below Fermi level) d-band states. There is a need for plasmonic materials which offer efficient hot-carrier generation from intraband transitions utilizing low energy (~1 eV from Fermi level) infrared excitations. I will present both calculated and experimental data showing how alloying a lossy metal such as Pd with Au can create a more favorable density of states for infrared hot carrier generation.

* Dr. Kevin McPeak is an assistant professor in the department of Chemical Engineering at Louisiana State University. Born in 1977, Prof. McPeak received a BS in environmental engineering from Northwestern University in 1999 and a PhD in chemical engineering from Drexel University in 2010. He did his postdoctoral work with David Norris in the Optical Material Engineering Laboratory at ETH Zurich. Prof. McPeak is the first resident researcher in the BASF Sustainable-Living Lab at LSU and a recent recipient of a National Science Foundation CAREER award. In his laboratory, Prof. McPeak investigates light-matter interactions on the nanoscale. Current efforts explore the structural properties of biomolecules, non-noble plasmonic materials, and photocatalysis. Applications are in the fields of biosensing, water treatment, and photodetection.