

Center for Integrated Bio and Nano Systems
Houston Chapter of IEEE Nanotechnology Council and Houston Chapter of IEEE Magnetics Society
Friday, November 6, 2015
12:30 p.m. (Refreshments served at 12:00 pm)
Room: W122 Eng. Bldg. 2

PLASMONIC NANOMATERIALS FOR OPTICAL-TO-ELECTRICAL ENERGY CONVERSION

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Abstract: High-quality semiconductor solids have been the dominant photovoltaic materials platform for decades. Although several alternative approaches have been proposed, e.g. dye-sensitized cells or polymeric solids, none compete in terms of cost and conversion efficiency, the crucial benchmarks for industrial scale implementation. However, semiconductors suffer from several fundamental limitations relating to the microscopic mechanism of power conversion that preclude them, even theoretically, from achieving conversion efficiency at the Carnot limit of 95%. Indeed, the fundamentally different tasks of semiconductors in photovoltaic devices, both as optical absorbers, and separately, for electron-hole pair separation and collection, often demand opposing trade-offs in materials optimization. Alternatively, recent advances in subwavelength metal optics, e.g. nanophotonics, metamaterials, and plasmonics, provide several new examples where nanostructured metals perform the separate tasks of absorption and charge separation necessary for photovoltaic power conversion. Nanostructured metals are extremely efficient broadband absorbers of radiation, with tailorable optical properties throughout the visible and infrared spectrum. It is traditionally assumed that the lack of a band gap and consequent fast electronic relaxation (\sim fs) and short mean free path (\sim 100 nm) hinders efficient carrier collection. However, new phenomena have been observed resulting from the remarkable energy concentration and nanoscale collection geometry afforded by plasmonic systems. In this talk, I will describe two ongoing studies in our laboratory that exemplify opportunities for metal-based optical energy conversion: (1) Excitation with circularly polarized illumination can induce strong, persistent electrical drift currents in resonant metal nanostructures via the inverse faraday effect. (2) Plasmonic absorption in metal nanostructures provides an entirely new mechanism for generating electrochemical potential from photons. I have termed this behavior 'the plasmoelectric effect' (Science, 2014).

Bio of Dr. Sheldon: Matthew Sheldon is an Assistant Professor in the Departments of Chemistry and Materials Science & Engineering at Texas A&M University. He received his BA in Chemistry from Carleton College in 2004 and a PhD in Chemistry in 2010 from the University of California, Berkeley, where his thesis work characterized the electrical properties of individual semiconductor nanocrystals. From 2010-2014 he was a postdoctoral fellow in the Materials Science and Applied Physics department at the California Institute of Technology. His research centers on the use of nanomaterials for solar energy, as well as related opportunities at the intersection of material science, chemistry and nanophotonics. His work has generated multiple patents relating to optical power conversion, and has been featured in Nature Magazine 'Research Highlights' and on the cover of the IEEE Journal of Selected Topics in Quantum Electronics.

Contact Prof. Jiming Bao (jbao@UH.EDU) if you would like to arrange for a time to meet with Dr. Sheldon.