MECHANICAL ENGINEERING **SEMINAR**

"Life Beyond Diffranction: Sensing, Imaging, and Controlling Local Environments and Material Properties with Nano-light"

Dr. P. James Schuck
Director of Imaging and Manipulation of Nanostructures Facility,
Lawrence Berkeley National Lab

Abstract: My group focuses on investigating and controlling light-matter interactions at the nanoscale, and using light to probe local environments. We are particularly interested in understanding the nano- and meso-scale interactions between localized states in materials, and relating these properties with system and device functionality. We do this by correlating spatially-dependent physical properties (e.g. electronic structure) with chemical and/or biological information (e.g. molecular composition, reaction rates and dynamics) and morphological structure. We use two main approaches for optically sensing and probing properties at the nanoscale: One is hyperspectral near-field microscopy, and I will spend a majority of this talk describing the first nano-optical investigation of 2D transition metal dichalcogenides (TMDCs). By using plasmonics to establish a solution to the "nanospectroscopy imaging" problem for these materials, we cross the boundary from insufficient to sufficient resolution, mapping critical optoelectronic properties in these exciting materials at their native length scales. In doing so, we uncover new optoelectronic regions and spatially-varying features in MoS_2 that were hidden in prior optical studies. These findings have broad implications for the development of atomically thin transistors, quantum optical components, photodetectors and light-emitting devices based on high-quality ML-TMDCs.

Our second approach is based on single-molecule-level imaging. Here, I will describe our development of a novel type of luminescent nanocrystal, upconverting nanoparticles (UCNPs). While there has been significant progress in building microscopes able to image single molecules with increasing sensitivity and resolution, an ongoing critical challenge is the development of luminescent probes with the photostability, brightness, and continuous emission necessary for single-molecule sensing and imaging applications. Lanthanide-doped upconverting nanoparticles (UCNPs) overcome problems of photostability and continuous emission, but their brightness has been limited by a poor understanding of energy transfer within the nanocrystal and an unavoidable trade-off between brightness and size. I will discuss our novel design paradigm that has resulted in UCNPs that are an order of magnitude brighter under single-particle imaging conditions than the brightest existing compositions, allowing us to visualize single UCNPs as small as fluorescent proteins. Finally, I will finish by with our initial attempts at applying these nano-probes to deep-tissue biological sensing and brain imaging.

Bio: Jim Schuck is currently the Director of the Imaging and Manipulation of Nanostructures Facility at the Molecular Foundry, located at Lawrence Berkeley National Lab. He earned his B.A. in Physics at UC Berkeley, and his Ph.D. in Applied Physics with Prof. Robert Grober at Yale University. Jim then did his postdoctoral studies at Stanford University with Prof. W. E. Moerner, studying optical nanoantennas and single-molecule spectroscopy. He has recently been awarded the LBNL Director's Award for Exceptional achievement, as well as a 2013 R&D 100 Award. His research currently focuses on nanoscale spectroscopic investigations of optoelectronic, bio, and hybrid materials.

Date: Thursday, February 4th, 2016
Time: 11:30am – 12:30pm
Location: 233 Mudd