Physics Seminar

Michigan Technological University

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Room G05 Rekhi

Multi-dimensional Imaging of Energy-Materials

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Abstract: Efficient, environmentally-friendly, harvesting, storage, transport and conversion of energy is one of the foremost challenges now facing mankind. An important facet of this challenge is the development of new materials with improved electronic and photonic properties, which may, for instance, improve the efficiency of solar energy conversion, or increase the yield of bio-processing for bio-fuels. The unique properties of nano-materials hold promise in contributing towards these goals. An enabling step in making such discoveries is the advent of nano-scale microscopy, *i.e.* the ability to visualize and characterize the properties of matter on the nanometer length scale. My work focuses on the development and application of advanced optical imaging methods for characterizing "energy materials" on the nano-scale. Optical methods provide the advantage of direct excitation of relevant electronic transitions in materials (*e.g.* in solar cells) without the problems due to excess energy (*e.g.* ionizing radiation), they offer the advantage of highly tunable excitation (*i.e.* ability to come into resonance), and, by their vector nature, have inherent sensitivity to anisotropy and selection rules in nanostructures and bulk materials. Introducing pulsed laser sources, the added dimension of time and the ability to study transient phenomena and dynamics at femtosecond timescales is yet another advantage. To surpass the classical diffraction limit, the concept of imaging in a multi-dimensional space is employed, where, in addition to spatial dimensions, the added dimensions of energy and time allow to distinguish objects which are closely spaced, and in effect increase the achievable resolution of optical microscopy towards the molecular level. I will discuss these concepts, and their application towards the study of materials relevant to renewable energy processes. In particular, I will discuss (i) imaging the position and orientation of single carbohydrate binding modules and their interaction with cellulose with ~ 10nm resolution, an important step in identifying the molecular underpinnings of bio-processing, and (ii) characterizing the ultrafast carrier dynamics (~ 100fs) in a new class of nano-structured solar cells, predicted to have theoretical efficiencies exceeding 60%, using near-field microscopy and femtosecond laser spectroscopy.

Biography: Steve Smith received the BS in Mechanical Engineering from Michigan Tech in 1989 (double major in Physics), and the MS and PhD in Applied Physics from the University of Michigan in 1992, and 1996. He was a postdoctoral fellow (1996-1999) and Senior Scientist (2000-2005) at the National Renewable Energy Laboratory in Golden, Colorado. Since 2005, he has been an Associate Professor and Program Director of the Nanoscience and Nanoengineering PhD Program at the South Dakota School of Mines and Technology. His research interests center on nano-scale investigations of the optical and electronic properties of energy-materials, utilizing spectroscopic imaging, near-field optics, single molecule methods, and ultrafast laser spectroscopy.

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