Tuesday, March 22, 2011 2:30PM - 5:30PM – Session L5 COM: Topics in Alternative Energy  Ballroom C1

2:30PM L5.00001 Efficient High Surface Area Vertically Aligned Metal Oxide Nanostructures for Dye-Sensitized Photoanodes by Pulsed Laser Deposition1 RENE LOPEZ, Department of Physics and Astronomy, University of North Carolina at Chapel Hill, NC, 27599 — Dye Sensitized Solar Cells (DSSCs) differ from conventional semiconductor devices in that they separate the function of light absorption from charge carrier transport. At the heart of a DSSC is a metal oxide nanoparticle film, which provides a large effective surface area for adsorption of light harvesting molecules. The films need to be thick enough to absorb a significant fraction of the incident light but increased thickness results in diminished efficiencies due to augmented recombination. Losses in efficiency are due to the slow trap-limited diffusion process responsible for electron transport. This process limits the effective electron diffusion length to about ~ 10 µm and results in an efficiency-limiting trade-off between light absorption and carrier extraction. Here we introduce a new structural motif for the photoanode in which the traditional random nanoparticle oxide network is replaced by vertically aligned bundles of oxide nanocrystals. This structure improves absorbed photon to current efficiencies (APCE) to values above 90% over most of the dye absorption range. The bundled anode is fabricated by a simple laser deposition process and features a surface area ~ 2 times larger than that of traditional anodes. The direct pathways provided by the vertical structures also appear to provide for an enhanced collection efficiency for carriers generated throughout the device.

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3:06PM L5.00002 Predictive Defect Science for Cost-Effective Photovoltaics, TONIO BUONASSISI, Massachusetts Institute of Technology — Low-cost photovoltaic materials are typically defect-rich, and defects impede electronic transport and photovoltaic conversion efficiency. Since efficiency and cost are inversely related, defect-rich materials have until recently resulted in poor-quality, economically uncompetitive solar cells. In this presentation, we review defect physics in low-cost photovoltaic absorbers. Accurate identification of performance-limiting defects requires multiscale characterization, evaluating cm-size devices while probing down to the nanometer scale for defect recognition. We will review recent advances in macroscopic CCD-based PV characterization tools, and elucidate how these can be coupled to synchrotron nanoprobe techniques. Once the nature and underlying physical behavior of these defects are known, we demonstrate how manipulation of defect distribution and state, aided by predictive modeling, can enhance solar cell performance.

3:42PM L5.00003 Nanoscale heat transfer and thermoelectrics for alternative energy1, RICHARD ROBINSON, Cornell University — In the area of alternative energy, thermoelectrics have experienced an unprecedented growth in popularity because of their ability to convert waste heat into electricity. Wired in reverse, thermoelectrics can act as refrigeration devices, where they are promising because they are small in size and lightweight, have no moving parts, and have rapid on/off cycles. However, due to their low efficiencies bulk thermoelectrics have historically been a niche market. Only in the last decade has thermoelectric efficiency exceeded ~20% due to fabrication of nanostructured materials. Nanoscale materials have this advantage because electronic and acoustic confinement effects can greatly increase thermoelectric efficiency beyond bulk values. In this talk, I will introduce our work in the area of nanoscale heat transfer with the goal of more efficient thermoelectrics. I will discuss our experiments and methods to study acoustic confinement in nanostructures and present some of our new nanostructured thermoelectric materials. To study acoustic confinement we are building a nanoscale phonon spectrometer. The instrument can excite phonon modes in nanostructures in the 100s of GHz. Ballistic phonons from the generator are used to probe acoustic confinement and surface scattering effects. Transmission studies using this device will help optimize materials and morphologies for more efficient nanomaterial-based thermoelectrics. For materials, our group has synthesized nano-layer superlattices of Na₇CoO₂. Sodium cobaltate was recently discovered to have a high Seebeck coefficient and is being studied as an oxide thermoelectric material. The thickness of our nano-layers ranges from 5 nm to 300 nm while the lengths can be varied between 10 µm and 4 mm. Typical aspect ratios are 40 nm: 4 mm, or 1:100,000. Thermoelectric characterization of samples with tilted multiple-grains along the measurement axis indicate a thermoelectric efficiency on par with current polycrystalline samples. Due to phonon confinement in nano-structures, it is expected that the thermoelectric efficiency of these sheets will be much higher than that of single crystalline Na₀.₇CoO₂, when the nanosheets have single grains along the heat transport path.

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4:18PM L5.00004 Alternative Energy: A New Frontier for Microfluidics, CULLEN BUIE, Massachusetts Institute of Technology — Microfluidics is classified as the physics of fluid manipulation at sub-mm length scales. Typically, microfluidic techniques benefit from small sample volumes, low power consumption, and increased surface-to-volume ratio. Because of their high surface to volume ratio, microfluidic systems often utilize surface phenomena such as wettability (i.e. droplet microfluidics) and surface charge (i.e. electrokinetics) for actuation. To date, most applications of microfluidics are in medicine or biology with the purpose of creating "lab on a chip" devices. However, the scale of microfluidics is favorable for other engineering problems as well. In this talk we will discuss how phenomena typically applied to lab on a chip devices can be used to enhance energy systems. Specifically, we explore electric field driven fluid and particle flows such as electrophoresis, electroosmosis, and dielectrophoresis. We will show how these phenomena can solve a diverse array of problems, from water management in fuel cells to the selection of microorganisms for bio-energy applications.

4:54PM L5.00005 Fusion related physics: Understanding the basic physics of High Energy Density Plasmas (HEDP) using ultra-short pulse laser-matter interactions1, RONNIE SHEPHERD, Lawrence Livermore National Lab — Nuclear fusion is one nature’s most fundamental methods of generating energy. In stars, the fusion reactions that occur deep within stellar interiors generate radiation and particles that fill the Universe. For many years, a goal of scientists has been to utilize these processes on earth to generate energy. However, understanding the basic physics of the interacting particles is required to exploit this energy source. We present data and analysis from one technique (ultra-short pulse laser matter interactions) currently being used to understand this physics. High power, short pulse lasers offer the ability of studying matter heated to extremely high temperatures (as high as 700 eV) and near solid density (10²⁷ part/cm³). Two aspects of the basic physics will be presented, namely radiation absorption and particle energy exchange currently under investigation using these lasers.

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