# Tuesday Morning, October 29, 2013

## Energy Frontiers Focus Topic
## Room: 101 A - Session EN-TuM

## Energy Past, Present, and Future
**Moderator:** M.A. Filler, Georgia Institute of Technology

8:00am **EN-TuM1 Chasing the Photovoltaic Race with Quantum Dot Solar Cells**, ***P. Kamat***, University of Notre Dame **INVITED**

Assembling semiconductor nanostructures on electrode surfaces in a controlled fashion is an attractive approach for designing next generation solar cells. Quantum dot solar cells (QDSC) have emerged as the potential contender for making transformative changes. The size dependent electronic structure of quantum dots enables the design of photovoltaic devices with tailored electronic properties. We have now exploited this aspect in solar cells by assembling different size CdSe quantum dots on mesoscopic $TiO_2$ films either by direct adsorption or with the aid of molecular linkers. Upon bandgap excitation, CdSe quantum dots inject electrons into $TiO_2$ thus enabling the generation of photocurrent in a photoelectrochemical solar cell. Crystalline ternary metal chalcogenides ($CuInS_2$ and CdSeS) have been deposited within the mesoscopic $TiO_2$ film by electrophoretic deposition with a sequentially layered architecture. This approach has enabled us to design tandem layers of CdSeS QDs of varying bandgap within the photoactive anode of Quantum Dot Solar Cell (QDSC). Recent advances in the development of high efficiency QDSC will be described.

8:40am **EN-TuM3 Extremes of Heat Conduction in Molecular Materials**, ***D.G. Cahill***, University of Illinois at Urbana Champaign **INVITED**

Thermal conductivity is a basic and familiar property of materials that plays a pivotal role in a broad range of topics in energy science and engineering systems. In this talk I will emphasize recent examples of extreme behavior—and behavior under extreme conditions—in polymers and molecular solids. Our measurements of heat conduction in novel materials are enabled by variety of ultrafast optical pump-probe metrology tools developed over the past decade. At the low end of the thermal conductivity spectrum, fullerene derivatives display the lowest thermal conductivity ever observed in a fully dense solid, comparable to the conductivity of disordered layered $WSe_2$ and only twice that of air. Extremes of high pressures (up to 60 GPa) allow us to continuous change the strength of molecular interactions in glassy polymers and test theoretical descriptions of the mechanisms for heat conduction. The thermal conductivity of aligned, crystalline and liquid crystalline polymer fibers can be surprisingly high, comparable to that of stainless-steel. The dominate carriers of heat appear to be longitudinal acoustic modes with lifetimes dictated by anharmonic processes.

9:20am **EN-TuM5 The Role of Catalysis in Developing Energy Resources for the Future**, ***A. Bell***, University of California, Berkeley **INVITED**

The continuing economic success of developed nations and the growth in the economies of developing nations is intimately connected to the availability inexpensive sources of energy. For the past century, the primary energy resources have been coal, petroleum, and natural gas. Coal and natural gas have been used primarily for the generation of electricity, and petroleum as the primary source of transportation fuels. While these traditional resources are projected to last to the end of this century, it is recognized that they are finite and that their consumption contributes to the growing levels of atmospheric carbon dioxide and consequently to detrimental changes in the global climate. For these reasons, there has been a growing interest in finding more efficient means for utilizing traditional energy resources and developing sustainable energy resources such as biomass and solar radiation as alternatives. This talk will focus on the role of catalysis in enabling the efficient conversion of biomass and solar radiation to transportation fuels. It will be shown that the conversion of biomass to diesel and gasoline can be accomplished in a sequence of steps that involve dehydration, aldol condensation, hydrodeoxygenation, and hydrogenation, each of which requires a catalyst in order to achieve reaction rates that are commercially viable. The photoelectrochemical splitting of water and the photoelectrochemical reduction of carbon dioxide offer longer range means for producing fuels from sustainable resources. Here too, catalysts are required to achieve the formation of products at acceptable rates. This presentation will end with a set of illustrations showing how advances in methods of catalyst synthesis, screening, and characterization can be used to accelerate the discovery and evaluation of catalysts for the conversion of sustainable energy resources to fuels.

10:40am **EN-TuM9 A Direct Thin-Film Path towards Low-Cost Large-Area III-V Photovoltaics**, ***R. Kapadia***, *Z. Yu*, *A. Javey*, University of California, Berkeley

III-V photovoltaics (PVs) have demonstrated the highest power conversion efficiencies for both single-and multi-junction cells. However, expensive epitaxial growth substrates, low precursor utilization rates, long growth times, and large equipment investments restrict applications to concentrated and space photovoltaics (PVs). Here, we demonstrate the first vapor-liquid-solid (VLS) growth of *high-quality* III-V *thin-films* on metal foils as a promising platform for large-area terrestrial PVs overcoming the above obstacles. We demonstrate 1-3 mm thick InP thin-films on Mo foils with *ultra-large* grain size up to 100 mm, which is ~100 times larger than those obtained by conventional growth processes. The films exhibit electron mobilities as high as 500 $cm^2$/V-s and minority carrier lifetimes as long as 2.5 ns. Furthermore, under 1-sun equivalent illumination, photoluminescence efficiency measurements indicate that an open circuit voltage of up to 930 mV can be achieved with our films, only 40 mV lower than what we measure on a single crystal reference wafer.

11:20am **EN-TuM11 III-nitride Nanowires: Novel Materials for Light Emission**, ***G.T. Wang***, Sandia National Laboratories **INVITED**

Nanowires based on the III nitride (AlGaInN) materials system have attracted attention as potential nanoscale building blocks in LEDs, lasers, sensors, photovoltaics, and high speed electronics. Compared to conventional LEDs based on planar architectures, future LEDs based on III-nitride nanowires have several potential advantages which could enable cheaper and more efficient lighting. Nanolasers based on III-nitride nanowires also offer the potential for ultracompact, low-power, and coherent light sources in the UV-visible wavelengths for a number of applications. However, before the promise of nanowire-based optoelectronics can be fully realized, a greater understanding of and control over their synthesis, properties, and device integration needs to be achieved. I will discuss research involving the aligned, bottom-up growth of Ni-catalyzed GaN and III-nitride core-shell nanowires, along with results providing insights into the nanowire properties obtained using cutting-edge structural, electrical, and optical nanocharacterization techniques. I will also describe a more recent "top-down" approach for fabricating ordered arrays of high quality GaN-based nanowires with controllable height, pitch and diameter. Using this top-down approach, both axial and radial nanowire device heterostructures can be realized. The fabrication, structure, optical properties, lasing characteristics, and performance of top-down-fabricated nanowires and nanowire LEDs and lasers will be discussed. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# Authors Index

## Bold page numbers indicate the presenter