APS ENERGY RESEARCH WORKSHOP PROGRAM
Westin Convention Hotel
1000 Penn Avenue
Pittsburgh, Pennsylvania 15222

Allegheny Ballroom I
Sunday, March 15, 2009

Workshop made possible in part by a grant provided by the US Department of Energy

8:30 WELCOME
JUDY FRANZ, APS EXECUTIVE OFFICER

8:35 WORKSHOP OVERVIEW
George Crabtree ***Argonne National Lab***
The expected doubling of global energy demand by 2050 challenges our traditional patterns of energy production, distribution and use. The continued use of fossil fuels raises concerns about supply, security, environment and climate. New routes are needed for the efficient conversion of energy from chemical fuel, sunlight, and heat to electricity or hydrogen as an energy carrier and finally to end uses like transportation, lighting, and heating. Opportunities for efficient new energy conversion routes based on nanoscale materials will be presented, with emphasis on the sustainable energy technologies they enable.

9:20 SESSION 1
Compound Semiconductor and Multijunction Solar Cells
Speaker: Harry Atwater – Cal Tech
The highest efficiency solar cells developed to date by solar researchers are III-V compound semiconductor single junction and multijunction solar cells. In this tutorial talk, I will describe the features that make compound semiconductors attractive for photovoltaic device researchers, including direct gap absorption, high quantum efficiency, energy gap tuning and heterojunction formation. Compound semiconductors also enable fabrication of high quantum efficiency quantum well solar cells, as well as quantum dot solar cells, and advantages and drawbacks of these designs will be discussed. I will also discuss terrestrial and space power module applications for compound semiconductor solar cells in flat-plate and concentrator photovoltaic systems. Finally, a key aspect that has historically limited photovoltaic applications for III-V compound semiconductors has been relatively high cost of cell and module fabrication, and prospects for cost reduction will be discussed.

10:05 COFFEE BREAK

10:20 SESSION 2

Recent advances in organic photovoltaics

Speaker: Gary Rumbles – NREL

Photovoltaic solar cells based on organic systems are considered an emerging and viable technology, with respectable device performance characteristics and lifetimes. Common to almost all of these new devices is a nanostructured interface that comprises a donor, often a conjugated polymer such as poly (3-hexylthiophene), and more often than not, C60 as an acceptor. A unique and essential feature of these interfaces is the ability to efficiently dissociate the photo-enerated excitons into free carriers and, more importantly, to very effectively inhibit the reverse, recombination process. A uniform consensus on why this happens has yet to emerge and it is therefore a topic of great interest. Although they are considered to be a viable technology, solar cell performances are struggling to exceed 6% power conversion efficiencies, and there is a need to increase this value significantly. To do so, requires more fundamental, basic research to be focused on the problem and this approach is what motivates this presentation. The seminar will discuss these low device performance efficiencies, their importance, how they might be increased, and how they compare with more conventional photovoltaic devices.

11:15 SESSION 3

Batteries for transportation

Speaker: Mark Verbrugge – General Motors

Past work and significant progress that have prompted the current focus on electrochemical energy storage devices for traction applications are reviewed in the context of large-format lithium ion batteries. We highlight the importance of thermodynamics, interfacial kinetics, transport phenomena, and solid mechanics on the system behavior. What limits the life of insertion-based batteries (including those based on lithium ion and metal hydride chemistry) today? This is a pressing problem and constitutes the central theme of the talk.

12:10 LUNCH

Box lunches will be provided for all registered participants. This is an opportunity to sit at a table with session speakers for informal discussion and networking.

1:15 SESSION 4

Vehicular Hydrogen Storage with Sorbent Materials

Speaker: Anne Dillon – NREL

The deployment of hydrogen to fuel the transportation sector offers the pollution-free promise of using entirely renewable resources. Currently, approximately 95% of hydrogen is produced by reforming natural gas through a catalytic thermochemical conversion process. However, hydrogen can be generated through the electrolysis of water using electricity derived from nuclear or wind power, photovoltaics, or thermo-chemical processing of biomass. Once produced, hydrogen can then be used in fuel cells that convert hydrogen and oxygen back into water and produce electricity in the process. Hydrogen can also be combusted in an engine to generate mechanical energy or even burned to produce heat. Regardless of the scenario, water is produced in a virtually pollution-free cycle that ultimately could rely on renewable resources. On-board storage has been deemed the cornerstone technology for implementing hydrogen for transportation as none of the many methods satisfy all of the volumetric, weight, safety and cost requirements necessary for hydrogen to perform competitively with fossil fuels.

Hydrogen storage via physisorption on lightweight porous materials is a promising approach as the sorbent can allow for increased hydrogen capacities at lower pressures than typically employed in compressed gas cylinders as well as higher temperatures than required for liquification. In physisorption, gas molecules are held to the surface of a solid by relatively weak van der Waals forces. The strength of the interaction is determined by the effective contact area of the H_2 with the sorbent. Therefore in order to develop sorbents that tether significant quantities of H_2 on a gravimetric (weight %) basis, it is necessary that lightweight materials with very high specific surface areas (SSA) be developed. Another important metric for hydrogen storage materials is the volumetric capacity, which dictates a high material density. Thus the optimized hydrogen sorbent is a high SSA material composed of small densely packed pores that are fashioned primarily from light elements in the first row of the periodic table. To that end, many promising sorbents for vehicular hydrogen applications are carbon-based materials. The binding energy of an H_2 molecule on a carbon surface is typically 4-6 kJ/mol. This binding energy will allow for the development of tanks with significant volumetric and gravimetric capacities at 77 K and with moderate overpressure of ~ 100 bar. In order for the tank to operate at near ambient temperatures, the binding energy of the H_2 must be increased to ~ 10-20 kJ/mol. An increase in the binding energy may occur at sites where metal atoms or other substitional atoms are introduced into the sorbent network. The development of highly porous materials as well as the possibility of enhancing the binding energy of H_2 on the sorbent materials will be discussed. An overview of the potential for utilizing hydrogen in the transportation sector will also be provided.

2:10 SESSION 5:

Solid State Lighting

Speaker: Jeff Tsao - Sandia National Lab

Throughout its history, lighting technology has made tremendous progress. Enabled by advances in physics and materials, the efficiency with which power is converted into usable light has increased 2.8 orders of magnitude over three centuries. This progress has, in turn, fueled large increases in the consumption of light and in the productivity of human society. At this point in time, the importance of lighting is such that it consumes 6.5% of the world’s energy and 0.72% of its gross domestic product. In this talk, we review an emerging new technology, solid-state lighting, and place it in the larger historical context of lighting: the underlying advances in physics and materials that have enabled its current performance; its frontier performance potential; the energy consumption and human productivity benefits associated with achieving this performance potential; and exciting scientific challenges that lie enroute.

3:05 BREAK

3:20 SESSION 6

Superconductivity: Challenges and Opportunities for Our Energy Future

Speaker: John Sarrao – Los Alamos

Demand for electricity, the fastest growing energy carrier, is expected to double worldwide by 2030. Incremental expansion of the electricity grid will not be able to meet this demand and deliver adequate capacity, reliability and efficiency for 21st century needs. Superconductors provide dramatically higher current carrying capacity, greater reliability through unique power control devices that are fast, smart and self-healing, and significant increases in efficiency in urban areas where most electricity is used.[i] Cable based on high temperature cuprate superconductors outperforms conventional copper cables by a wide margin and is being demonstrated successfully on the commercial grid in cities and suburbs. To carry renewable electricity long distance from remote sources to urban areas, new superconducting materials with higher transition temperature and higher current carrying ability are needed. Further research is needed on the present generation of materials to lower the cost of superconducting wire, simplify its layered architecture, and raise its current carrying ability. Finding the mechanism(s) of high temperature superconductivity is one of the premier scientific challenges of modern condensed matter physics. This knowledge would provide a powerful guide for predicting and discovering new superconductors and controlling their technological performance.

[i] Basic Research Needs for Superconductivity, Report of the Basic Energy Sciences Workshop, May 2006, <http://www.sc.doe.gov/bes/reports/abstracts.html#SC>http://www.sc.doe.gov/bes/reports/abstracts.html#SC, accessed July 2008.

4:15 PANEL DISCUSSION: Career Opportunities in Energy Research

Panel Members:

- Art Nozik – *National Renewable Energy Laboratory*
- Jerry Simmons – *Sandia National Laboratory*
- Jan Herbst – *General Motors*
- Vivek Mohta, *Massachusetts Department of Energy Resources*
- Others to be announced later

5:15 – 6:30 RECEPTION

For registered participants.

Open beer, wine, and soft drink bar with light appetizers.

Program Committee

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