Knowledge Foundation's International Symposium

Portable Energy 2009

Innovations in Alternative Energy Sources for Portable Devices

May 6, 2009 • Orlando, FL USA

KNOWLEDGE FOUNDATION
TECHNOLOGY COMMERCIALIZATION ALLIANCE

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TECHNOLOGY COMMERCIALIZATION ALLIANCE

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Symposium Agenda

Wednesday, May 6, 2009

9:00 *Registration, Exhibit Viewing/Poster Setup, Coffee and Pastries*

9:50 **Organizer's Welcome and Opening Remarks**

10:00 **The Paradigm of Alternative Energy**

Kartijn Coninx, PhD, Assistant Professor, Personal Energy Systems (PES), Delft University of Technology, The Netherlands

When designing a 1kW power generator, standard practice research would not produce more than the standard alternatives like fuel cells, solar panels or wind turbines. 'Exotic' conversion technologies are often left out as an option. To search for such 'non-conventional' conversion technologies we need a shift in thinking. The paradigm that alternative energy sources consist of energy forms such as biomass, wind or solar energy, is one of the obstacles to find possible other sources of energy. By getting round this paradigm alternative energy can be drawn from other sources. In this paper the Dimensional Analysis is used as a method to get passed this paradigm. The methodology to derive analytical models is used as a creativity tool generating new ideas. This paper discusses the methodology being used in the search for new exotic energy sources and a preliminary test gives more insight in the usefulness of the Dimensional Analysis.

10:30 **New Breakthrough in Photovoltaic Module with Transparent Polymers to Replace Glass**

Elena Shembel, DSc, President and CEO, Enerize Corporation*

Enerize Corporation has developed new design for photovoltaic (PV) modules using proprietary transparent polymer material that substantially outperforms the glass conventionally used as a protective coating. Solar cell module entire surface is covered with the optically transparent polymer layer having a flat surface morphology or the crinkle coat surface morphology. Enerize's polymer coating materials and methods of hermetic sealing have important advantages in that it increases the PV efficiency and improves the following aspects of PV module characteristics and performance: (a) Effective utilization of shorter wavelength range of the spectrum, including UV, due to the high transparency of the polymeric coating; (b) More resistant to degradation by UV and ionizing radiation (so-called photon degradation); (c) Increased value of the index of refraction as compared to glass provides a reduction in reflection (clarifying effect; (d) Capability to form surface relief of various types, including a surface consisting of sets of micro lenses (concentrating properties); (e) Capability to be formed with a relief/ crinkle coat surface morphology and to thus change the trajectory of incident photons; (f) High mechanical strength and capability to adhere to various other materials; (g) Stability while exposed to high and low temperatures and thermal-cycling, mechanical impact, and high relative humidity; (h) Reduction in weight and cost. Current estimation indicates that the cost of the polymer encapsulation for PV modules will be on 20-30 % less than the cost of laminating the PV modules using glass. *In collaboration with: A. Shmyreyva, V. Redko, T.T. Todosiychuk, L.F. Kocynchuk

11:00 *Networking Refreshment Break, Exhibit/Poster Viewing*

11:30 **Photosynthetic Based Photovoltaic Devices**

Chanoch Carmeli, PhD, Professor, Center for Nanoscience and Nanotechnology, Tel Aviv University; and Larry Loev, Ramot at Tel Aviv University, Ltd., Israel

A novel device for photovoltaic conversion which consists of an oriented photoactive monolayer bound to a bottom metal electrode and a top transparent electrode. The photoactive components are oriented dry layers of a photosynthetic reaction center protein which were isolated from photosynthetic cyanobacteria and encapsulated in solid state substrate. The generated photocurrent at an absorbed light energy conversion efficiency of 34% (out of the theoretical 47%) and was found to be stable for at least one year.

12:00 **Light Energy Conversion by Photosynthetic Reaction Center Proteins at Inorganic Electrodes**

Nikolai Lebedev, PhD, Research Physicist, Center for Bio/Molecular Sciences & Engineering, U.S. Naval Research Laboratory*

Most of the current photovoltaic devices are based on crystallized silicon. They have energy conversion efficiency of about 12% (19-25% in the lab) and cost $(1-3.5)/W. An alternative approach is organic photovoltaic devices, having small size and weight, however less efficient in energy conversion compared to Si. An innovative approach to the construction of photovoltaic devices is in the utilization of biological systems and principles designed for similar purposes by nature. Biological electronic devices, proteins, have extremely high efficiency, precise spatial organization, light weight, and are inexpensive in fabrication. Recently, we have successfully fabricated photosynthetic protein based light energy converting surfaces. For this purpose we use bacterial photosynthetic reaction center protein (RC) that has nearly 100% quantum yield of primary charge separation, fast operation time (about 10^{-9} s, or operation frequency of ~109 Hz), and is very efficient in stabilization of separated charges (electron transfer aspect ratio is about 104). Using genetically engineered RC proteins and specifically synthesized organic linkers, we were able to construct self-assembled and aligned protein monolayers on various metals and semiconductors, including gold, indium tin oxide (ITO), highly ordered pyrolytic graphite (HOPG) and carbon nanotube (CNT) arrays. In the constructed layers, the charge separation and stabilization take place in the protein of 7 nm size and lead to the formation of a local electric field of about 106V/cm Our data shows that photosynthetic protein-inorganic complexes can operate as highly efficient photosensors, optical switches, photorectifieres, and photovoltaic devices. *In collaboration with: S.A. Trammell, S. Tsoi, J. Schnur, NRL; I. Griva, George Mason University; A. Spano, University of Virginia

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12:30 *Lunch*

2:00 **3D On-Chip Micropower**

Chunlei Wang, PhD, Professor of Mechanical and Materials Engineering, Florida International University

Carbon microelectromechanical systems and carbon nanoelectro-mechanical systems (C-MEMS/NEMS) have received much attention because of their various potential applications, such as: Li-ion microbatteries, biofuel cells and supercapacitors. Electrostatic Spray Deposition (ESD) is another promising method to fabricate carbon based and metal oxide based porous/fibrous structures which can be used as electrodes for micropower devices. In this conference, our recent progress in developing micropower based on various 3D carbon and hierarchical porous metal oxide electrodes will be presented.

2:30 **3D Thin-Film Lithium Ion Microbattery**

Emanuel Peled, PhD, Dina Golodnitsky, PhD, Menahem Nathan, PhD, Tel Aviv University; and Larry Loev, Ramot at Tel Aviv University, Ltd., Israel

Our 3D NanoBatteries have a sandwich-like structure of conformal thin film electrodes, electrolyte and current collectors. The films are deposited sequentially on all available surfaces of a perforated substrate (e.g. silicon or a glass microchannel plate or "MCP") using wet chemistry. The substrate has tens of thousands of high aspect ratio holes per square cm, thereby providing more than an order of magnitude increase in surface area per given footprint.

3:00 **Thin Film Electrode and Solid Electrolyte for Li-Batteries, Materials, Technologies, and Apparatus**

Volodymyr Redko, PhD, Executive VP & CTO, Enerize Corporation*

In order to develop thin film solid state batteries the composition of the proprietary vitreous inorganic solid electrolyte with amorphous structure, similar to a glass structure for lithium batteries was developed. Vitreous electrolyte has high lithium ion conductivity (up to 10^{-5} Ohm/cm) at room temperature, chemical stability in contact with electrode materials, electrochemical stability in the wide range of working potentials (from 0.6 to 4.5 V). Proprietary method and equipment based on gas discharge electron gun with a cold cathode for production of thin layers of electrode materials and solid electrolytes with the predetermined structural, morphological and electrochemical properties was developed. Method and equipment developed for thin film deposition allow increasing the rate of process for deposition of thin film of vitreous solid electrolyte and LiPON solid electrolyte as compared with the magnetron sputtering process. We will also report on the development and use of special non-destructive electromagnetic, ultrasonic, holographic interferometry methods and devices for testing properties of the thin film electrode, electrolyte and batteries, as well as the results of these tests. *In collaboration with: E. Shembel, I. Maksuta, V.Tutyk, A.Nosenko, N. Klyui, A.Markevich, V.Khandetskyy, A.Tron.

3:30 *Networking Refreshment Break, Exhibit/Poster Viewing*

4:00 **Bioelectrocatalysis for Fuel Cells**

Shelley D. Minteer, PhD, Professor of Chemistry, Saint Louis University

Enzymes are highly efficient catalysts that have been shown to be useful as electrocatalysts for low temperature fuel cells. However, recently, enzyme cascades of naturally occurring metabolic pathways and of synthetic pathways have been shown to be capable of deep and complete oxidation of complex fuels. This is of particular interest in the development of high energy density fuel cells for complex fuels, such as: ethanol, glucose, glycerol, pyruvate, and other carbohydrates.

4:30 **MWCNT Based Metal Matrix Composite for Micro-Bio-Fuel Cells**

Norman Munroe, PhD, Professor, Applied Research Center, Florida International University*

Future demands of biomaterials will not only require good biocompatibility but also high performance particularly as the size of devices continue to shrink. The MWCNT based metal matrix composites appear to be promising in this regard, however, their biocompatibility poses a variety of questions. In this investigation, a Cu-Cr-MWCNT composite was prepared and found to possess superior electrical conductivity and mechanical properties, which are essential for its application as an electrode material for micro-bio-fuel cells. In an effort to assess its corrosion resistance, potentiodynamic polarization tests were conducted with various electrolytes. The surface morphology of the material was examined by SEM/EDS after each test. *In collaboration with: P.K. Singh Gill, S. Amruthaluri, C. Pulletikurti, W. Haider

5:00 **Fuel Cells Hybrids: Minimizing Failure at the Concept Design Stage**

Bas Flipsen, PhD, Assistant Professor, Personal Energy Systems (PES), Delft University of Technology, The Netherlands

New power sources emerge very quickly. Implementation of hybrid power sources for portable electronics depends on the knowledge of industrial designers. For now this group has little understanding of fuel cells and especially hybrids, which slows implementation and increases the chance of failure. In this paper a first order method is presented which gives concept designers a first guesstimate of the volumes they have to deal with when designing the power source. Second there will be a first approach to a second-order model and method which should produce an optimized volumetric design of the fuel-cell hybrid, being used in concept phase of design.

5:30 *Concluding Discussion, End of Symposium*

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