

SYMPOSIUM X

X: Frontier of Materials Research

December 1 - 4, 2003

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Symposium Support

National Renewable Energy Laboratory

* Invited paper

This symposium is the Society's principal vehicle to maintain the interdisciplinary and integrative nature of its mission within the materials community with invited reviews presented over the lunch hour. Leaders in various specialties represented by the topical symposia present reviews designed for materials researchers who are **NOT** specialists in the reviewed field.

SESSION X1:

Chairs: Rommel Noufi and Fred Roozeboom
Monday Afternoon, December 1, 2003
Grand Ballroom (Sheraton)

12:05 PM *X1.1

Interfacing Silicon Technology With the Human Body: Bionics In the New Millennium. Leigh T. Canham, pSiMedica Ltd., Malvern, Worcs, United Kingdom.

Microelectronics within the human body have a history almost as long as that of microelectronics itself. The most well known, the cardiac "pacemaker", was first implanted in 1960 but even prior to this "radio pills" were being swallowed and tested in-vivo. Today's commercial products include a range of electrical stimulation devices for both cardiovascular and neurological conditions. There are programmable pumps for terminal cancer patients, cochlear implants for profoundly deaf toddlers, and microsensor systems for "smarter" surgical tools. The emergence of bioMEMS and some synergistic major trends in medicine promises a very broad range of minimally-invasive products that utilize silicon technology. However, to date it has been necessary in all FDA-approved devices to completely isolate the chip from the body by packaging with established biomaterials. At pSiMedica Ltd we have been accumulating evidence that silicon can be much more biocompatible than previously imagined. BioMEMS chips will be developed to directly integrate with living tissue and forms of poly-Si and porous Si are even biodegradable at a range of body sites. An overview will be given of how such biocompatible forms of silicon will facilitate many more clinical applications in the future.

12:45 PM *X1.2

The Novel Materials Science of Normal and Glassy Water. H. Eugene Stanley, Department of Physics and Physiology, Boston University, Boston, Massachusetts.

Recent experimental and theoretical investigations highlight the central importance of supercooled and glassy states for understanding liquid water, and are providing a body of knowledge from which a coherent interpretation of its properties is beginning to emerge [1]. We will review some of the highlights of this recent work in a style suitable for all audiences. [1] See, e.g., P. G. Debenedetti and H. E. Stanley, "The Physics of Supercooled and Glassy Water", *Physics Today* **56** (6), (2003) pp.40-46 and references cited therein.

SESSION X2:

Chairs: Paula Hammond and Susan Trolier-McKinstry
Tuesday Afternoon, December 2, 2003
Grand Ballroom (Sheraton)

12:05 PM *X2.1

Thin Film Electronics - Electronics Anywhere. Thomas N. Jackson, Center for Thin Film Devices, Pennsylvania State University, University Park, Pennsylvania.

Microelectronics has been spectacularly successful at providing increasingly complex digital processing and large-capacity digital memory. It has been less successful at providing simple function at very low cost and in providing electronic function over large areas or on arbitrary surfaces. There is increasing interest in active thin film electronics, based on both inorganic and organic semiconductors, as alternatives to conventional semiconductor devices and integrated circuits. Inorganic amorphous silicon thin film transistors are widely used as pixel access devices in displays and large area sensors on glass substrates. It is also possible to fabricate these devices on polymeric or other unconventional substrates. Organic semiconductors are also of interest because they can be deposited and processed at low temperature (often less than 100°C). Organic thin film transistor (OTFT) device performance now rivals or exceeds that of amorphous silicon devices, and low OTFT process temperatures allow fabrication on a range of surfaces including cloth, paper, or polymeric substrates. Device of either type (organic or inorganic) are of particular interest

for applications where their switch characteristics can be used for selection or isolation of arrays of devices. This approach, widely used for display addressing, allows many thousands or even millions of sensor, actuator, or other elements to be controlled with simple, low-cost electronics and the flexible processing used for thin film active devices allows direct integration with a wide range of materials and devices.

12:45 PM *X2.2

Micro Fuel Cells as a Supplement or a Substitute to Batteries. Christopher Hebling, Department Energy Technology, Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany.

Small fuel cells can play an important role in the power supply of portable and remotely located off-grid electronic appliances such as medical appliances, sensors, global area network components or consumer electronics like the various classes of mobile computing devices, usually categorized as 4C-products (camcorders, cell phones, computers, cordless tools). The major driver for fuel cell systems is the fact that the improvements in the energy density of batteries have not kept pace with the growing power demand of such units which again is a result of an increase in intelligence (computation), connectivity (band width) and the promotion of 'always on'. This development can be slowed down a little bit by low power micro controller or new kinds of low power displays (e.g. OLEDs) but the general trend will remain like this. There are plenty of intrinsic properties of fuel cell systems which make them attractive candidates as a new generation of power sources for mass market products next to batteries. Fuel cells can be laid out exactly according to the power demand of the device and the fuel storage can be dimensioned due to the service time which should be achieved. This is different with batteries where the capacity is an integral part of the power source. Compared to batteries, fuel cells do show their greatest benefits whenever small power requirements are combined with a long operation time. Depending on the application and the boundary conditions, small fuel cells can be used both as a supplement or as a substitute to batteries. The major issues to be addressed in terms of micro fuel cells are in the field of materials improvements. One of the key components, the membrane electrode assembly (MEA) for example is a highly complex unit consisting of an ion-conducting membrane and a three-dimensional electrode with the catalyst. Additionally, for the operation of micro fuel cells, hydrophilic and hydrophobic properties of the electrode and the adjacent gas diffusion carbon cloth have to be designed appropriately in order to remove the emerging water of the overall chemical reaction.

SESSION X3:

Chairs: Paula Hammond and Rommel Noufi
Wednesday Afternoon, December 3, 2003
Grand Ballroom (Sheraton)

12:05 PM *X3.1

LEDs for Solid State Lighting: Status, Trends, and the Remaining Challenges. M. George Craford, Lumileds Lighting, LLC, San Jose, California.

LED technology developments over the past decade have enabled the use of LEDs in a variety of colored and white lighting applications. Colored LEDs have already become the technology of choice for traffic signals, much of interior and exterior vehicle lighting, signage of various types often as a replacement for neon, and other areas. LEDs are expected to become the dominant technology for most colored lighting applications. LEDs are beginning to penetrate white lighting markets such as flashlights and localized task lighting. With further improvement LEDs have the potential to become an important technology for large area general illumination. White LEDs with outputs of more than 100 lumens are already available commercially. LEDs are expected to save energy, be environmentally friendly, and provide a variety of other features, including long lifetime, compact size, and programmable color control, which enable design options for new approaches to lighting. In this presentation the LED technology status and trends will be described and LEDs will be compared to conventional lighting technologies. Developments that will need to occur for LEDs to be viable for large area general illumination will be discussed

12:45 PM *X3.2

Envisioning Materials Research - Finding a New Visual Voice. Felice Frankel, MIT, Cambridge, Massachusetts.

Human beings assimilate the world chiefly through their sense of sight. It is not surprising, therefore, that scientists continually seek new and better ways to see in order to become better observers. With only the occasional exception, science forgets that the phenomena whose characteristics it seeks to understand may be stunningly

beautiful when skillfully visualized. Unfortunately, however, generating images in the laboratory is usually carried out with only minimal expertise with virtually no consideration for their aesthetic or communicative qualities. This talk will encourage materials researchers to consider a new approach for making images and presentations for the following reasons: - As research becomes more interdisciplinary, illuminating and intelligent images and various forms of data will become more useful in communicating to various fields of expertise. - When investigators spend more time making these new images of research to communicate to a larger community, they will see their work differently, expand the way they think about their work and therefore the way they envision it. - Compelling and accessible pictures and data representations will draw the public's interest to the world of research.

SESSION X4:

Chairs: Fred Roozeboom and Susan Trolier-McKinstry
Thursday Afternoon, December 4, 2003
Grand Ballroom (Sheraton)

12:05 PM *X4.1

Nanostructures for Mechanical and Biological Applications.

H. G. Craighead, Dept of Applied & Engineering Physics, Cornell Univ, Ithaca, New York.

Nanofabrication technology is advancing and creating new ultra-small structures and devices in an increasingly broad class of material systems. The integration of nanoscale mechanical systems with optics and electronics is enabling new experiments on small amounts of material down to the single molecule level. The ability to fabricate these new types of ultra-small structures and devices will yield new tools for biological research. It should also provide new approaches to chemical analysis, biological sensing, and medical diagnostics. This talk will describe some new methods for creating nanostructures and patterning of biochemicals. It will also address the application of nanostructures and new physical principles to the detection and analysis of individual cells and molecules.

12:45 PM *X4.2

Bioprocessing of Silk Proteins - Design Rules from Nature.

Hyoung-Joon Jin, Jaehyung Park, Regina Valluzzi, Ung-Jin Kim, Peggy Cebe and David L. Kaplan; Depts of Biomedical Engineering, Chemical & Biological Engineering & Physics, Tufts University, Medford, Massachusetts.

A model for silk processing in silkworms and spiders is proposed and is based on the unique domain structure in the sequences of silk proteins. A hypothesis for the silk spinning process begins with chain folding at lower concentrations of protein, proceeds through formation of micelles and then micellar aggregates (globules) through water loss and increasing protein concentration, and finally leads to fiber formation due to the physical shear process during fiber spinning. Many aspects of this process can be mimicked *in vitro* and the all-aqueous environment used is instructive as a model for polymer processing in general. The overall process is controlled by the content and location of water in the system (protein polymers and gland) and the intra- and inter-chain interactions among the silk proteins. This system represents an important intersection between an evolutionarily optimized complex hydrophobic polymer design/sequence chemistry to deal with an all-aqueous processing environment. The result of this process is a product (silk fiber) that is water insoluble - required for environmental stability. The engineering designs also must accommodate high-end mechanical performance for the required functions of these fibers. Together, these factors provide a complex intersection among polymer chemistry, constraints in processing environment and evolutionary pressure to achieve a remarkable outcome of engineering suitable as a model for green chemistry, polymer processing and polymer designs in general.