Newsletter

AIChE NSEF
NANOSCALE SCIENCE & ENGINEERING FORUM

Nanoscale Science & Engineering Forum
Advancing nanoscale science & engineering

American Institute of Chemical Engineers **4th Quarter 2007**

Message from the Former Chair

I am delighted to report that the NSEF technical sessions held at the 2007 AIChE Annual Meeting in Salt Lake City represent some of the highest quality and best attended programming coordinated to date by NSEF. Many thanks are due to Bill Grieco and his programming chairs for their generous investment of time and effort that led to the success in Salt Lake City. As you will read below, the quality of the plenary sessions sponsored by NSEF was outstanding. NSEF Award lectures delivered by Peter Cummings of Vanderbilt University and Joerg Lahann of University of Michigan nicely illustrated the broad and varied contributions that the discipline of chemical engineering is making to nanoscience and technology. The standing-room-only attendance at the plenary session on Chemical Engineering Principles for Nanotechnology confirmed that an important mission of NSEF is to provide non-experts within chemical engineering with high level perspectives on nanoscience and nanotechnology. The attendance also reflects on the quality of the presentations delivered by lecturers Sharon Glotzer (University of Michigan), Paula Hammond (MIT), Stefan Zaucher (Duke University) and Nick Kotov (University of Michigan). I thank them for their contributions, and hope you will read on below to learn more about the outstanding NSEF plenary sessions held in Salt Lake City.

Nanotech News

- Silicon nanowire arrays yield high-performance lithium battery anodes. Silicon has been known to have higher capacity than carbon, however, the expansion/shrinking process fractures the anodes and degrades the performance. The researchers found that nanostructures did not fracture.
  http://www.nature.com/nnano/journal/v3/n1/full/nnano.2007.411.html
- InAs nanoflakes may lead to large increases in efficiency for photovoltaic devices. The nanoflakes have been observed to have very high light absorption.
  http://www.nature.com/nnano/journal/v2/n12/full/nnano.2007.378.html
- Researchers demonstrate how to selectively place graphene sheets onto substrates for high-performance transistors. They use a printing style approach where the graphene is first stuck to pillars and then stamped onto the substrate. The stamps are coated with a temperature sensitive material allowing the graphene to be picked up and released.
  http://pubs.acs.org/cgi-bin/abstract.cgi/nalefd/2007/7/i12/abs/nl072566s.html
- Single-wall carbon nanotubes are visualized inside living animals. Researches utilize the near infrared fluorescence of well-dispersed SWNTs to visualize them inside fruit flies. The highest concentration of nanotubes were found in the blood vessels.
  http://pubs.acs.org/cgi-bin/abstract.cgi/nalefd/2007/7/i09/abs/nl0710452.html
- Wireless, nanoscale voltmeters were developed to measure the electric field deep within cells. These photonic devices are about 30 nanometers in diameter and contain voltage-sensitive dyes.
  http://www.biophysj.org/cgi/content/full/93/4/1163
- Fibers spun from double-walled carbon nanotubes have strengths, stiffness, and toughness twice that of Kevlar. The fibers are spun by mechanically drawing them from an aerogel and measure approximately 1 mm in length.
  http://www.sciencemag.org/cgi/content/full/318/5858/1892

New NSEF Leadership

Please welcome the new NSEF leadership that you elected in October. These volunteers provide events throughout the year and make the society run smoothly.

New Past Chair: Nick Abbott, *University of Wisconsin*

New Chair: Bill Grieco, *Alkermes*

New 1st Vice Chair: Michael Wong, *Rice University*

New 2nd Vice Chair: Mary Ellen Ternes, *McAfee & Taft*

New Sec/Treasurer: Joerg Lahann, *University of Michigan*

Dir Membership: Bert Diemer, *DuPont*

Dir Communications: Kirk Ziegler, *University of Florida*

NSEF Events — ICBN in Ireland

NSEF is co-sponsoring the Society for Biological Engineering's **4th International Conference on Bioengineering and Nanotechnology (ICBN)**. ICBN will be held at the University College, Dublin, Ireland on July 22-24, 2008. This conference provides a unique forum to discuss interdisciplinary research at the intersection of bioengineering and nanotechnology.

Our keynote speakers will highlight opportunities and challenges at this intersection:

- Ruth Duncan, Professor of Biology and Drug Delivery at the Welsh School of Pharmacy, Cardiff University, UK and Director of the Centre for Polymer Therapeutics
- Jérôme Bibette, Colloids and Divided Materials Laboratory, ESPCI, Paris, France
- Jeffrey Hubbell, Laboratory for Regenerative Medicine and Pharmacobiology, Integrative Biosciences Institute, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland.

In addition, invited talks will be presented by the following speakers:

- Frank Caruso, *University of Melbourne*
- Adam Cohen, *Harvard University*
- Kenneth Dawson, *University College Dublin*
- Dennis Discher, *University of Pennsylvania*
- Yves Dufrene, *Université Catholique de Louvain, Belgium*
- Nikolaj Gadegaard, *University of Glasgow*
- David Gracias, *Johns Hopkins University*
- Kevin Healy, *University of California, Berkeley*
- Darrell Irvine, *Massachusetts Institute of Technology*
- Igor Medintz, *Naval Research Laboratory*
- David Mooney, *Harvard University*
- Paul Nealey, *University of Wisconsin at Madison*
- Tae Gwan Park, *Korea Advanced Institute of Science and Technology*
- Robert Prud'homme, *Princeton University*
- Samuel Stupp, *Northwestern University*
- Matthew Tirrell, *University of California at Santa Barbara.*

For more information, please visit our web site at http://www.aiche.org/icbn. The deadline for abstract submittal is April 15, 2008.

NSEF at the AIChE Annual Meeting in Salt Lake City

Award Lectures

Forum Award – Peter T. Cummings, Vanderbilt University, Nashville, TN and Oak Ridge National Laboratory, TN, presented his award lecture on *"Computational and Theoretical Nanoscience – Emerging Tools for Nanoscience and Nanotechnology."*

Professor Peter Cummings, recipient of the 2007 NSEF Forum Award, gave a superb lecture on the role of computational methods and theory in nanoscience and nanotechnology. The lecture began with an overview of the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory, which Peter helps lead in the capacity of Principal Scientist. The Center, which is one of several nanoscience centers established by the Department of Energy, is a facility that integrates synthesis of nanomaterials with state-of-art capabilities for characterization, theory, modeling and simulation. Following this overview, Peter presented a number of examples spanning nanotribology, nanocomposites and molecular electronics to illustrate how theory, modeling and simulation tools are enabling research in nanoscience and nanotechnology. An important theme addressed in his talk was the need for multiscale modeling approaches that can connect chemical detail to mesoscopic phenomena in complex molecular systems. Peter also highlighted some of the fundamental differences between the behavior of macroscopic and nanoscopic systems by describing experimental observations dealing with nanoscopic systems that do not conform (over short times) to the Second Law of Thermodynamics (see Physical Review Letters, vol 89, 050601 (2002)).


Peter T. Cummings (left) receiving the NSEF Forum Award and Joerg Lahan (right) receiving the NSEF Young Investigator Forum Award from Nicholas Abbott.

Young Investigator Forum Award – Joerg Lahann, University of Michigan, Ann Arbor, MI presented his award lecture on *"Enabling Novel Technologies through Nano- and Meso-Scale Designed Materials."*

A presentation by Joerg Lahann, NSEF's recipient of the 2007 Young Investigator Award, touched on a number of emerging themes related to the design of multi-functional and nanostructured materials for engineering interfaces between synthetic and biological systems. The first theme revolved around a general and versatile process developed in Joerg's laboratory for the synthesis of particles with patterned bulk and surface properties. A clever approach based on electro-jetting of multiphase liquids was shown to lead to patterned, multi-functional particles comprised of a broad range of materials, including biodegradable, semi-conductive, and magnetic materials. A second theme in the talk addressed the design of switchable surfaces - here careful engineering of surface chemical functionality based on molecular self-assembly was combined with the use of external electric fields to realize surfaces that change, for example, their wettability in response to the magnitude of the applied fields. Potential applications of such tunable surfaces to the analysis of metabolites were discussed. The final theme of the talk addressed the design of reactive coatings based on chemical vapor deposition, with the focus directed to recent progress from the Lahann laboratory in which coatings presenting a broad range of chemical functionality have been demonstrated. Joerg pointed out that these advances enable approaches for solvent-free and conformal coating of materials for a range of biological applications, including the preparation of materials for the culture of stem cells.

NSEF Poster Awards

From left, Nicholas Abbott, Santosh Rupa Dumpala, Monica Sanders, Kedarnath Kolluri , and William Grieco.

There were many great posters at the NSEF Poster Session this year. The posters spanned diverse topics from materials properties, self-assembly, education, devices, sensors, and biomaterials. This year's award winners were:

1st Place – Kedarnath Kolluri with co-authors M. Rauf Gungor and Dimitrios Maroudas, from the University of Massachusetts, Amherst for their poster entitled *"Relaxation of Biaxial Strain in Ultra-Thin Films of Face-Centered-Cubic Metals through Ductile Void Growth and Structural Phase Transitions."*

2nd Place – Santosh Rupa Dumpala with co-authors Boris D. Chernomordik and Mahendra K. Sunkara, from the University of Louisville for their poster entitled *"Nucleation and Growth of Diamond on Carbon Nanopipettes."*

3rd Place – Monica Sanders with co-author Sergey Vasenkov from the University of Florida and co-authors Konstantin Ulrich and Farida Grinberg from Universität Leipzig for their poster entitled *"Nanoscale Studies of Protein-Lipid Model Membranes Using PFG NMR."*

Session on Chemical Engineering Principles for Nanotechnology

This year the forum programming included a session that covered chemical engineering principles applied to nanotechnology from several experts in the field.

"Simulation-Based Design of Nanoscale Building Blocks for Self- Assembly: The Shapes of Things to Come" by Sharon C. Glotzer, University of Michigan, Ann Arbor, MI

In recent years, a whole variety of nanoscale building blocks have been synthesized experimentally, ranging from branched tetrapods to colloidal molecules, faceted polyhedra, rods, ellipsoids and patterned, patchy particles. There are huge possibilities for assembling these building blocks into relevant structures. Theory has a significant role to play in this enterprise at all levels, ranging from detailed studies based on first-principles calculations to traditional methods in atomic-scale simulation to coarse-grained models to macroscopic theories and simulations. Pairing her computational research with that of experimental collaborators, Professor Glotzer demonstrated how surfactant "tethers" can organize themselves on nanoparticle surfaces to create "patchy", functionalized nanoparticles. In multi-scale simulations, she illustrated how the dipole moment on polyhedral CdTe nanoparticles can lead to unique assemblies seen experimentally. The predictive power of simulations was illustrated in her simulations of tethered spheres, where Glotzer and her students have demonstrated a variety of interesting assemblies. These studies demonstrate the exciting possibilities for new structures and applications that can result from nanoscale building blocks and the important role of simulation in the discovery of these structures.

"Single Molecule Force Spectroscopy for Nanoscience and Technology: What Can We Learn from Pulling on Single Macromolecules?" by Stefan Zauscher, Duke University, Durham, NC

Professor Zauscher highlighted the abilities of single molecule force spectroscopy to measure inter- and intramolecular interactions within an atomic force microscope. He first discussed the work his group has done on studying the unbinding behavior of proteins. The single molecule force spectroscopy was able to provide a better understanding of the energy landscape. This information allowed them to discover reagents that can inhibit specific interactions. Next, he described the force-induced isomerization in polypeptides. This work focused on polypeptides that cannot be catalyzed by enzymes. Finally, the hydrophobic hydration of proteins was studied, allowing them to study single molecule interactions of peptides with water.

"Nanoparticles and Proteins: How Similar Are They?" by Nicholas A. Kotov, University of Michigan, Ann Arbor, MI

Professor Kotov presented an interesting comparison between proteins and nanoparticles. He noted that these structures have similar shape, charge, surface chemistry, and intermolecular interactions. He proceeded to show that similarities of intermolecular interactions leads to similar processing (e.g. gel electrophoresis and size-selective precipitation) and self-assembly behavior (e.g. 1D, 2D, 3D assemblies and helical nanowires) while similarities in structure leads to similar functional replication (e.g. inhibition, enzymatic activity, gene therapy and signal function). He concluded that the chemistry of nanoparticles can be as rich as the chemistry of proteins possibly allowing some proteins to be replaced with nanoparticles.

"Nanolayer Assembly Routes to Functional Thin Films, Hybrid Nanomaterials and Devices" by Paula T. Hammond, Massachusetts Institute of Technology, Cambridge, MA

Professor Paula Hammond (MIT) presented research progress on layer-by-layer thin-film assemblies as possible components for electrochromic displays, fuel cell devices, and drug delivery systems. This layer-by-layer assembly approach involves the formation of thin films by the alternate adsorption of polyelectrolytes from aqueous solutions. She discussed several interesting findings, such as the dynamic mobility of polyelectrolytes within layer-by-layer thin films and the forced expulsion and accumulation of virus particles at the thin-film surface. Finally, she presented work on Prussian blue/Poly(ethyleneimine) nanocomposites for novel

electrochemical-based drug delivery system. These films exhibited linear degradation profiles and could be engineered to release multiple drugs in series or in parallel.

Visit the NSEF Website

The NSEF website contains online Web/Forum Community at http://forum.aiche.org/Forum23-1.aspx. Visit the forum and exchange ideas, post suggestions, questions, or news to the NSEF community.

Comments and Feedback

Please let us know what you think of NSEF, its newsletter, or provide us with your suggestions by emailing: nano@aiche.org.

Gold Level Sponsors

Hielscher USA, Inc.: Ultrasonic Dispersing, Deagglomeration and Milling Equipment Nanomaterials are currently on the way from lab to production. Very small powders and particles are available for materials, such as metal oxides, nanotubes or nanoclays. Often these materials need to be mixed into liquid formulations. This is where agglomeration and aggregation blocks surface area from contact with other matter. In particular very fine powders and carbon nanotubes are very cohesive and hard to disperse. As surface activity is a key aspect of nanomaterials, only well dispersed or single-dispersed particles allow utilization of the full potential of the nanomaterials. In result good dispersing reduces the quantity of nanomaterials needed to achieve the same effects. Conventional processing devices, e.g. high-shear or rotor-stator mixers, high-pressure homogenizers or colloid and disk mills fall short in separating the nanoparticles into discrete particles.

Ultrasonic cavitation is very effective in breaking agglomerates, aggregates and even primaries. When ultrasound is being used for the milling of high concentration batches, the liquid jets streams resulting from ultrasonic cavitation make the particles collide with each other at velocities of up to 1000km/h. This breaks van der Waals forces in agglomerates and even primary particles (milling).

Hielscher manufactures ultrasonic devices for the efficient dispersing, deagglomeration and milling of nanomaterials in lab, bench-top and production level. With devices from 50 to 16,000 watts you can select the appropriate device for quantities from 1mL to several tons/hour. There is more information available at: http://hielscher.com/ultrasonics/nano.htm

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