PAPER ABSTRACTS AND
LIST OF POSTERS

INDUSTRY AND RESEARCH

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CENTER FOR NANOSCALE SCIENCE AND TECHNOLOGY

Nanotechnology Workshop 2007
Venue: National Center for Supercomputing Applications
University of Illinois at Urbana-Champaign

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PREMISE

Nanotechnology research and development will lead to fundamental changes in how we live and interact with our environment. To harness the full potential of nanotechnology, fundamental research is needed to understand self-organizing molecular phenomenon and subcellular interactions among complex biological systems. Development efforts are needed to commercialize patentable ideas, processes, and products. This can be done through collaborative efforts among academia, industry, and policy makers. To advance these objectives, the Center for Nanoscale Science and Technology (CNST) was created as a campus-wide initiative of the College of Engineering, University of Illinois.

CNST campus-wide multidisciplinary initiatives span the Colleges of Engineering; Agricultural Consumer and Environmental Sciences; Applied Health Sciences; Liberal Arts and Sciences; Medicine, and Veterinary Medicine; with 150 faculty working on joint initiatives in the area of nanotechnology. The devised research strategy for the CNST includes identification of five research focus areas for nanotechnology applications: Agriculture and Food; Atmospheric and Environmental, Communications and Electronics, Computational, and Medical and Pharmaceutical.

CNST Nanotechnology Workshop is envisioned to foster a multidisciplinary collaboratory environment that will support the development and application of new nanoscale technologies in the formation, fabrication, and characterization of nanoscale materials for applications in agricultural and medical biotechnology, electronics, and optics.

OBJECTIVES

The overall objective of the workshop is to:

- provide an introduction to CNST and its multidisciplinary approach to nanotechnology research- from materials to devices to systems to applications, such as nanomedicine;

- provide a forum for interaction and collaboration among academic institutions, industry and policy makers.
INDUSTRY PARTNERS

At CNST we firmly believe in the value of partnerships, which it brings to advance the mission of the University of Illinois. By establishing linkages with industrial partners we commit ourselves to deliver quality education, bleeding-edge research synergistically with the industry in creating intellectual property resulting in technologies and products, which positively affect the lives of our fellow citizens.

Avenues for Industry to Partner with CNST

- **Affiliate programs.** Industry Partners participating in CNST’s affiliate program interact closely with university faculty in specific research areas. The nature and mode of participation can be informal visits to research laboratories, or formally at annual workshops or campus symposia.

- **Consulting.** CNST faculty members consult on a private basis with Industry Partners. These contacts occur through the individual faculty, not CNST directly.

- **Leveraging existing research.** Industry Partners may leverage ongoing research at CNST.

- **Licensing.** Industry Partners can license intellectual property, such as hardware, technology process, or software from CNST. Industry Partners that support the research have the opportunity to negotiate beneficial licensing terms through the Office of Technology Management.

- **Long-term research gifts.** Industry Partners also make long-term gifts dedicated to an area of research.

- **Personnel placement.** Industry Partners sometimes place their own personnel at CNST for a limited time.

- **Research center funding.** Some Industry Partners fund a research center, which can provide significant impetus to the Industry Partner's research direction. Funding a center entails developing a pool of talented students whose expertise can be leveraged by the Industry Partner through direct hire.

- **Research contracts.** Some Industry Partners contract for goal-oriented research, which targets a specific research area.

- **Research visitor program.** Provides a chance for researchers from academia and industry to interact with CNST faculty and students on novel, innovative, interdisciplinary research topics for an extended period.

- **Student interns and fellowships.** Industry Partners hire student interns as a way to meet short-term needs and recruit future employees. They also offer fellowships to support students' research.

Contact us to establish a partnership.
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PLENARY SESSION

Applied Nanotechnology for Human Space Exploration

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The Applied Nanotechnology Project at NASA Johnson Space Center (JSC) is engaged in solving some of the toughest problems facing the space program. Over the next 15 years, NASA will retire the Space Shuttle, finish assembly of the International Space Station (ISS), design, build, and fly the Orion spacecraft, and return humans to the Moon as a stepping stone to exploring Mars. Nanotechnology offers the potential to create new materials and systems that will enable NASA and its international partners to successfully send humans on missions to explore the solar system. Numerous technical challenges face NASA as it plans for long-term habitats on the Moon and long-duration missions beyond earth’s orbit. Structural materials need to be made lighter and more multi-functional for spacecraft, habitats, and for space suits. Power and energy must be generated and stored reliably and efficiently, and humans and equipment must be protected from harmful radiation. Key life support needs also face NASA as it extends human presence beyond low earth orbit, including the efficient recovery of water and the revitalization of breathing air. Other nanomaterial applications being investigated at JSC are supercapacitors, quantum conductors, electromagnetic interference shielding, radiation dosimetry, and thermal protection system materials. Fundamental research activities in nanomaterial growth, characterization, and processing are conducted at JSC in support of the above human spaceflight applications.

Dr. Leonard Yowell is the lead for the Applied Nanotechnology Project at NASA Johnson Space Center in Houston, Texas. He directs a multi-disciplinary research team in the field of nanotechnology, responsible for developing innovative, sustainable, and affordable technologies for the advancement of human and robotic space exploration missions. His group conducts substantial liaison with researchers throughout the agency and maintains significant technical collaborations with nanotechnology researchers in academia, industry, and other government agencies. He holds a Ph.D. in Materials Science from Rice University, as well as M.S. and B.S. degrees in Aeronautical Engineering from Stanford University and Rensselaer Polytechnic Institute, respectively.

Down-sizing Matter: The Impact on Ion Conductivity and Mass Storage

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Recent investigations have shown that size effects on ionic charge carriers and hence on transport and reactivity of the solid state can be severe. It is to be anticipated that the field of nano-ionics will play a similarly crucial role for solid-state electrochemistry as nano-electronics does for semiconductor physics [1]. After a general introduction into defect chemistry and ion conduction, effects of down-sizing ionic materials on defect concentrations, ionic conductivities and reactivities are discussed in the framework of thermodynamics, kinetics and defect chemistry. It is shown that not only quantitative variations but also qualitative ones such as changes in the type of conductivity occur. Besides conductivity anomalies also storage anomalies are addressed [2]. As nanocomposites can show conductivities very different from the constituent phases and – in the limit of strong space charge overlap – even behave as novel artificial phases, nanocomposites can show storage properties that are very different from those of the constituents. If space charges overlap, the bridge between an electrostatic...
A capacitor and a battery electrode is achieved. The contribution also stresses the consequences for application. Especially examples from the field of Li-batteries highlight the potential of these issues.

Professor Maier is currently director at the Max-Planck-Institute for Solid State Research in Stuttgart (Germany) and heads the department of Physical Chemistry. J. Maier studied chemistry in Saarbrücken, made his Masters and PhD in Physical Chemistry there. He received his habilitation degree at the University of Tübingen. From 1988 to 1991 he was responsible for the activities on functional ceramics at the MPI for Metals Research in Stuttgart and (as a Foreign Faculty Member) was teaching defect chemistry at the Massachusetts Institute of Technology. In 1991, after having declined other prestigious offers (Materials Science M.I.T., Institute of New Materials Saarbrücken, Physical Chemistry Marburg), he was appointed director at the MPI for Solid State Research and honorary professor at the University of Stuttgart. J. Maier has authored more than 500 scientific papers in refereed journals, 10 patents in the field of physical chemistry and solid state electrochemistry. His major research field is ion transport in solids. He is also author or editor of several books and has organized various international conferences on these subjects. He received the Carl-Duisberg-Award, the E.-Martin-Prize and the Norman Hackerman Award. He is co-recipient of the 2002, 2004 and 2005 Edward C. Henry Award and of the 2005 Ross Coffin Purdy Award of The American Ceramics Society. He was Visiting Professor at the M.I.T. and TU Graz and Herbert-Johnson-Award lecturer at Cornell University. He is member of the German Academy of Sciences and Literature (Mainz), member of the Academia Europaea, Fellow of the Royal Society of Chemistry and honorary member of the National Institute of Chemistry in Ljubljana. Joachim Maier is Editor-in-Chief of Solid State Ionics and on the Board of various scientific journals. He served as officer in councils of various societies (ISE, ISSI, DBG, GDCh, MPG, BDI, and IAEA among others); he was chairman of the Solid State Chemistry Division of GDCh, chairman of the New Topics Committee (ISE) and Titular Member of the IUPAC Physical and Biophysical Chemistry Division Committee.

Characterization of Adsorption Properties of Single-Walled Carbon Nanotubes for Gas Storage and Purification

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Carbon nanotubes are being considered as new materials for hydrogen-storage for fuel-cell electric vehicles and methane-storage for adsorbed natural gas vehicles since they are chemically stable and have low mass density. Identifying the concepts of adsorption on carbon nanotubes would be the first step to determine their relevance as effective gas-phase adsorbents. In this study the results from N2 adsorption at 77 K and grand canonical Monte Carlo simulations of N2 adsorption were used to identify various adsorption sites of SWNT bundles in two SWNT samples and their contributions to the overall adsorption capacity. The following conclusions were made. First, adsorption on the peripheral surfaces of the bundles was at least as significant as that inside of the nanotubes. Second, the groves on the periphery of a bundle were an important contribution to the overall adsorption capacity of a SWNT. Third, the amount of N2 adsorbed on the external surface of the boundless was insensitive to the diameter of nanotubes comprising the bundle. Fourth, adsorption in the interstitial channels between nanotubes did not occur in the homogeneous arrays unless the nanotubes were wider than 1.4 nm. Fifth, only 45% to 60% of the nanotubes in the samples were open. And lastly, adsorptive capacities of the impurities were 5% and 25% of the total adsorptive in the samples which were close to the impurity mass concentrations present in the two samples. This indicated that common impurities in nanotube samples were at least as adsorptive as the nanotubes themselves. The results from this study would be beneficial to any adsorption related application of SWNTs, such as hydrogen and methane storage.
Massoud Rostam-Abadi is Principal Chemical Engineer and Head of Energy and Environmental Engineering Section at the Illinois State Geological Survey. He also is an Adjunct Professor of Environmental Engineering at the University of Illinois at Urbana-Champaign. He has been involved in development and application of carbon-based materials for gas clean up, purification, and storage for more than 25 years. He received his PhD in Chemical Engineering from Wayne State University in 1980.

Nanoparticle Coating in Low-pressure Plasma Reactor for Energy-related Applications

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Nanoparticles of various materials are building blocks and important constituents of ceramics and metal composites, pharmaceutical and food products, energy related products such as solid fuels and batteries, and electronics related products. The ability to manipulate the surface properties of these particles through deposition of one or more materials can greatly enhance their applicability. In this talk, we discuss simulation of a low-pressure, non-equilibrium plasma process for deposition on surfaces of nanoparticles. The plasma modeling is conducted via both particle-in-cell (PIC) method and ‘fluid’ transport equations for ions and electrons. Whereas the PIC approach is mainly limited to a single nanoparticle, due to excessive computational cost, it is capable of providing a detail fundamental understanding of charging and coating process. For practical purposes, the method of choice is via the solution of the ‘fluid’ transport equations augmented by an ionization model. The nanoparticle dynamics is modeled by considering a variety of forces acting on the particle. These include gravitational, electric, ion drag, and neutral drag forces. Finally, the chemical reaction modeling is discussed by considering a CH4/H2 plasma. The reaction model considers neutral species (CH4 and H2) introduced in the reactor, along with positive ions, radicals (which are the species that contribute to the growth of the nanoparticle surface) and other neutral molecules produced by reaction of the above.

Farzad Mashayek received a Ph.D. degree in Mechanical Engineering from the State University of New York at Buffalo in 1994. He is currently Associate Head and Director of Graduate Studies in the Department of Mechanical and Industrial Engineering at the University of Illinois at Chicago. Mashayek’s research interests are in the areas of turbulence, two-phase flow, combustion, nanoparticle coating in dusty plasma, electrostatic atomization, and interface modeling. He is a Fellow of ASME and an Associate Fellow of AIAA. Mashayek received the CAREER award form the National Science Foundation and the Young Investigator award from the U.S. Office of Naval Research in 1999.

Integration of Biology and Silicon Devices; Opportunities and Prospects

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Integration of biology with silicon devices and silicon-inspired fabrication promises to enable a wide range of applications in diagnostics, therapeutics, and tissue engineering. In this talk, we will present an overview of a range of projects in our group in microfluidics, nanotechnology, and nanomedicine focused towards detection and characterization of biological entities using electrical or mechanical phenomenon at the micro and nano scale. Towards this end, we will present our work on developing silicon-based petri dishes-on-a-chip.
Rashid Bashir completed his Ph.D. from Purdue University in 1992. From Oct 1992 to Oct 1998, he worked at National Semiconductor in the Process Technology Development Group as Sr. Engineering Manager. He is currently Professor of Electrical and Computer Engineering and Courtesy Professor of Biomedical Engineering at Purdue University. He has authored or coauthored over 100 journal and conference papers and has over 25 patents. His research interests include biomedical microelectromechanical systems, applications of semiconductor fabrication to biomedical engineering, advanced semiconductor fabrication techniques, and nanobiotechnology. In 2000, he received the NSF Career Award for his work in Biosensors and BioMEMS. He received the Joel and Spira Outstanding Teaching award from School of ECE at Purdue University, and the Technology Translation Award from the 2001 BioMEMS and Nanobiotechnology World Congress Meeting in Columbus, OH. He was selected by National Academy of Engineering to attend the Frontiers in Engineering Workshop in Fall 2003. He was also a finalist in the Small Times Magazine 2005 Innovator of the Year Award.

Materials for the 21st Century: Biological Inspiration for Complex Synthetic Nanoscale Materials Systems

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A grand Challenge facing the materials community is moving beyond just the synthesis of individual or homogeneous arrays to complex arrangements of nanoscale materials that lead to new classes of functionality. Responding to this grand challenge presents insurmountable obstacles for the classical approach of reductionism that works to understand phenomena in segments rather than as a system, when confronting the twin difficulties of scale and complexity. Instead, what is required is the rethinking of the usual paradigm of materials research flowing from synergies between theory, synthesis, and characterization, as there is no general theory to guide the synthesis and organization of nanoscale materials into highly interactive collectives. I will discuss a research paradigm that includes a fourth component – the top-down observation of the organization and associated function of natural complex systems, and the transfer of these principles into the bottom-up synthesis of complex synthetic nanoscale materials systems. The best examples of high levels of functionality emerging from ensembles of nanoscale elements are found in biological cells that perform extremely complex functions that include sensing, communication, navigation, cooperation, and even fabrication and organization of synthetic nanoscale materials. There are striking differences when synthetic and natural nanoscale systems are compared, and these difference are found both in scale (density of functional elements) and complexity (density of interactions between the elements), and it follows that nanoscience efforts should focus both on the synthesis of nanomaterials (scale) and their organization into ensembles (complexity). This talk will focus on the use of bio-inspired strategies in the construction of synthetic complex nanoscale systems.

Michael L. Simpson received the Ph. D. in Electrical Engineering from the University of Tennessee. Before this he was employed by EG&G Nuclear Instruments where he published the first theoretical analysis of charge trapping correction in germanium radiation detectors. Simpson designed the first commercial instrument based on this concept and later received a U. S. patent for this innovation. Also at EG&G, he published the first analysis of the effective deadtime of de-randomized nuclear ADCs and developed the first commercial instrument based on this concept. Simpson’s recent research interests have been in the emerging field of monolithic sensors. He was the principle investigator for a two-year research project to create an optical application specific integrated circuit (OASIC) capability at ORNL. This work has resulted in the first photodetector realized in a standard integrated circuit process. Simpson and his team received a Lockheed-Martin
Energy Research award for Technical Innovation for this development, and a patent application based on this device has been submitted. Also, Simpson is a member of the team that developed a new direct-write electron beam lithography concept that is one of a very few methods under consideration for the fabrication of deep sub-micron feature-size integrated circuits. Simpson is leading the DARPA-funded research effort for the precise electronic control of these massively parallel electron-beam emitters. A patent application for the lithography concept has recently been filed. Simpson is an Adjunct Faculty Member of the University of Tennessee (UT) Electrical Engineering Department and the ORNL coordinator of the UT/ORNL Joint Program in Mixed-Signal VLSI and Monolithic Sensors. He is a Senior Member of the IEEE and an active member of the IEEE Nuclear Science and Solid-State Circuit Societies. He has published more than 40 technical papers, holds three patents, and has three patents pending.

Identification of Transcription Networks in Embryonic Stem Cells

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Embryonic stem cells (ESCs) have remarkable potential to develop into many different cell types in the body and therefore represent a theoretically inexhaustible source of precursor cells to treat degenerative, malignant, or genetic diseases, or injury due to inflammation, infection, and trauma. These pluripotent cells have been hailed as a possible means for treating diabetes, Parkinson's disease, Alzheimer's, spinal cord injury, heart failure, bone marrow failure, and can serve as a platform to develop and test new drugs. Transcriptional control, the control mechanism for making mRNA out of a gene, is thought to be a key control mechanism for ESCs to maintain their undifferentiated state. We are in the process of studying the engineering principles built within the transcriptional networks of human and mouse ESCs, and using reverse-engineering approaches to reconstruct these transcriptional networks. We show how blueprints of the transcription networks of ESCs might be revealed through biophysical modeling, computational inference and biological validation.

Dr. Zhong obtained a B.S. from School of Mathematics and a B.A. in Economics from Beijing University, China. From 2001 to 2004 he did his Ph.D. research with Professor Wing Wong in Department of Biostatistics at Harvard University, with a Ph.D. minor in Molecular Biology. From 2004 to 2005 he was an exchange student scholar at Department of Statistics and BioX Center at Stanford University. He joined University of Illinois as an assistant professor in 2005.

Informatics Resource for Nanotechnology Research in Cancer Diagnostics and Therapeutics

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We report on the development of an informatics resource comprised of ontology and comprehensive database containing data related to nanotechnology applications in cancer diagnostics and therapeutics, as well as a comprehensive set of pharmacokinetics modeling tools for nanoparticle based therapeutics. The technologically attractive properties of materials at the nanoscale have sparked worldwide research in the application of nanoparticles in cancer treatment, and this has led to the generation of copious amounts of data. We will discuss our logical model, which possesses the flexibility to represent the different types of observations and studies that
are associated with the diverse nature of nanoparticle and physiological tumor data. The functionality of the underlying model will be illustrated using selected data examples. We will also present the elements of our pharmacokinetic modeling and illustrate why nanoparticles pose a particular challenge in this regard. Our informatics resource will serve as a common platform where the global research community can access and analyze existing data ensuing from nanoparticle-based cancer research. Broad accessibility to the database will be achieved via integration with the cancer Bioinformatics Grid (caBIG).

Fluorescence Lifetime Imaging of Microarrays

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The fluorescence properties of molecules located close to metallic surfaces change because of the interactions of the local field generated in the metallic surface with the molecules. It is found that the characteristic decay times of fluorescence change dramatically; this effect is utilized for the detection of molecules at low concentrations and for studying their binding properties. We present the use of fluorescence lifetime imaging (FLIM) for the discrimination of fluorophores on microarrays, which can open new applications in high throughput screening and for the development of sensors conducive to the detection of specific metabolites in the medical field. The instrument is based on frequency-domain spectroscopy where the laser light beam is modulated at a set frequency; the phase shift and the demodulation of the fluorescence are measured for the determination of the changes in the decay times.

Beniamino Barbieri is President of ISS, an instrumentation company dedicated to the design and manufacturing of fluorescence and near infrared instrumentation used in chemistry, the life sciences, and in medical research. He holds degrees in Physics from the University of Pisa, Italy. ISS instruments are installed in universities and corporations (chemical; biochemical; pharmaceutical) in the United States, South America, Europe, Asia and Australia. Corporations include Amoco Research, Marion Merrell Dow, Merck & Co., Pfizer, Eli Lilly, Novartis, Unilever); hospitals (The Mayo Foundation); federal research institutions (National Institute of Standards and Technology, The National Institutes of Health; Oak Ridge National Laboratories).

Nanotechnology: Innovation through Collaboration with FDA

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As part of its mission, FDA is responsible for helping speed innovations to make medical products* more effective, safe, and affordable, which leads to better public health.

Nanotechnology holds huge promise for the design and manufacture of many types of novel medical products---from devices to therapeutics to combination products. There remain, however, a number of questions about the behavior of nanoparticles and the potential effects of products containing nanoparticles once they are introduced into complex human and animal physiology, and even into the environment. We need to better understand the physical and physiological characteristics of different nano-engineered materials. We also need to work with stakeholders to develop new test methods, characterization protocols, nomenclature and standards to efficiently translate potentially meaningful products from proof of concept studies to preclinical and clinical development, manufacture, FDA submission and commercialization. Post-market issues are also under FDA’s jurisdiction and will be part of the agency’s on-going activities in this area.
Dr. Sanhai will outline some of the ways FDA is working internally and with stakeholders, and link these efforts to the agency’s public health mission.

*Includes Drug and Biological Products and Medical Devices

As Senior Scientific Advisor, Office of the Commissioner, FDA, Dr. Sanhai is responsible for developing and implementing scientific initiatives and strategic alliances under the agency’s Critical Path Initiative. Dr. Sanhai also serves as FDA’s chair for the Nanotechnology Sub-Committee of the Interagency Oncology Task Force and as FDA’s Federal Liaison on numerous consortia and committees. Prior to her current appointment, Dr. Sanhai was the Director of Public-Private Partnerships at the Foundation for the National Institutes of Health (FNIH) and was the senior Foundation officer responsible for creating, implementing, managing and evaluating all new and existing programs in clinical research, education and training. Dr. Sanhai has a Ph.D. in biochemistry and structural biology from the School of Medicine, State University of New York at Buffalo and a baccalaureate degree in chemistry from the University of Florida, Gainesville.

**Nanoparticles with Predefined Drug Loading and Controlled Drug Release for Cancer Therapy**

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Abstract: Polymeric nanoparticles are attractive vehicles for delivery of anticancer drugs to solid cancer tumors because they are able to mediate concentrated delivery of therapeutics to tumor cells by selective extravasation through leaky tumor vessels. Of the various forms of nanoparticulate carriers being investigated, nanoencapsulates of chemotherapeutics show particular promise because of their ease of formulation through co-precipitation of polymer and drug molecules, and the capability of modulating drug release by controlling polymer biodegradation. However, current nanoencapsulates also exhibit low drug loading and encapsulation efficiency, bimodal particle distributions, and undesirable drug burst release kinetics that limit their clinical translation. We developed an improved material and formulation method for producing unimodal nanoparticles with high drug loading and no burst release. We demonstrated the ability to prepare unimodal nanoparticles with high drug loading (up to 40%), 100% encapsulation efficiency, and controlled drug release without burst effect. Various chemotherapy drugs, such as docetaxel, paclitaxel, doxorubicin, and camptothecin, have been successfully encapsulated into 50-150 nm sized, salt-stable particles. The delivery vehicle may be applied in vivo to deliver chemotherapeutic agents to solid cancer tumors with high efficiency and reduced toxicity.

Dr. Jianjun Cheng received his Ph.D. from University of California, Santa Barbara in 2001. From 2001-2004, he was a senior scientist of Insert Therapeutics, Inc. After being as a postdoctoral associate at MIT from 2004-2005, he joined the Department of Materials Science and Engineering of UIUC as an assistant professor in 2005.
Improving Host Immune Response to Cancer using Targeted Anti-Angiogenic Nanoparticles

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Expansion of the neovasculature has long been recognized as a feature of solid tumor development, particularly associated with rapidly developing or metastatic cancers 1-3. Recent data in immune competent animal models, as well as results derived by others from human cancer specimens4-6, collectively suggest that angiogenesis provides not only vital sustenance to support rapid cancer growth, but also creates a barrier of protection for the tumor from the host immune defense by down regulating critical endothelial markers, such as intercellular adhesion molecule-1 (ICAM-1), needed to mount a maximal immune and inflammatory response to the abnormal cancer cells. These data suggest that early detection and quantification of angiogenesis will help recognize the most aggressiveness tumor, which are being shielded from the host immune response. Moreover, others 7, 8 and we have found that suppression of angiogenesis with targeted anti-neovascular therapy may reduce this protective barrier, leading to smaller tumors and greater immune cell infiltration of the cancer. In the VX-2 adenocarcinoma model that targeted anti-angiogenic therapy reduced the neovasculature (~80%), reduce tumor volume (~60%), and increased CD8+ lymphocyte infiltration. Emerging opportunities in nanomedicine techniques may allow specific detection, characterization and local deliver anti-neovascular drugs to nascent neovasculature which may offer new ways to lessen the neovasculature barrier to immune recognition and improve the early treatment of nascent tumors in otherwise healthy patients.

Received the B.A. degree in Biology from Colby College, Waterville, ME in 1975. He received the M.S. and Ph.D. in Poultry Genetics from the University of Georgia, Athens, GA in 1978 and 1981. He served as Research Manager at Monsanto Company, St. Louis while directing development of bovine somatotropin (Posilac). In 1992, he received the M.D. degree from Northwestern University School of Medicine, Chicago, IL. He is currently Associate Professor of Medicine and Biomedical Engineering at the Washington University Medical Center, St. Louis, MO. Among various other honors, he has received the Barnes-Jewish Hospital Research Foundation Award and the NCI Unconventional Innovation Program Award. His research interests include site-targeted ultrasonic contrast agents.

Magnetomotive Nanoparticle Contrast for Optical Coherence Tomography and Multi-Modality Imaging

Presenter: Amy L. Oldenburg, Ph.D.1,2

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A new paradigm for contrast in optical coherence tomography (OCT) images has recently been developed called magnetomotive OCT (MM-OCT). In this technique, OCT measures nanoscale motion of magnetic nanoparticles induced via an externally applied magnetic field gradient. The ability to locate magnetic nanoparticles with microscale resolution is demonstrated in living animals (African frog tadpoles) and excised rat mammary tumors (carcinogen-induced). The magnetomechanical response is not only fortuitous for imaging, but may provide biomechanical information. Early results suggest that the mechanical response is modulated by the viscoelastic properties of the embedding medium, with potential application for in vivo elastography and tumor identification.

The requirements for contrast in MMOCT and MRI are similar, as nanoparticles with high magnetic susceptibility exhibit a large magnetomechanical response and also negative T2 contrast. We demonstrate this using ~25nm Fe3O4 nanoparticles for both MMOCT and MRI contrast in tissue phantoms. The ability to perform whole-body MRI and subsequently mesoscale OCT has great clinical potential for diagnosis and surgical resection. In collaboration, we have begun screening a variety of magnetic nanoparticles for this application. This includes a range of iron oxide particle sizes, polymer coatings to reduce opsonization and cytotoxicity, and labeling with antibodies to target early-stage breast cancer. It also includes novel constructs such as plasmon-resonant gold nanorods attached with magnetite nanoparticles, polymer-coated clusters of magnetite nanoparticles, and DNA-coated single-walled carbon nanotubes enriched with maghemite nanoparticles. We will present our latest results which emphasize the particular merits of these nanoparticles and outlook for clinical application.

Dr. Amy Oldenburg received her B.S. at the California Institute of Technology in Applied Physics in 1995. Her Ph.D. was awarded in 2001 in Physics at the University of Illinois at Urbana-Champaign, and currently she is a senior research scientist in the Beckman Institute in the Electrical and Computer Engineering Department working with Dr. Stephen Boppart on contrast methods for optical coherence tomography.

Advancing Cancer Research through Nanotechnology

Larry Nagahara, Ph.D.
Nanotechnology Projects Manager, National Cancer Institute

Novel and multi-functional nanodevices capable of detecting cancer at its earliest stages, pinpointing its location within the body, delivering anticancer drugs specifically to malignant cells, and determining if these drugs are effective is a vision shared by many scientists, engineers and clinical researchers. Functionalized nanoparticles would deliver multiple therapeutic agents to tumor sites in order to simultaneously attack multiple points in the pathways involved in cancer. Such nano-therapeutics are expected to increase the efficacy of drugs while dramatically reducing potential side effects. In vivo nanobiosensors would have the capability of detecting tumors and metastatic lesions that are far smaller than those detectable using current, conventional technologies.

The National Cancer Institute (NCI) is strongly engaged in efforts to harness the power of nanotechnology to radically change the way we diagnose, image, and treat cancer. The NCI established the Alliance for Nanotechnology in Cancer and allocated $144.3 millions in funding over a 5 year period (2005 – 2010) to ignite nanotechnology-enabled product development and advanced research. To make this vision a reality, the Alliance funds Centers of Cancer Nanotechnology Excellence, the development of nanotechnology platforms, and the Nanotechnology Characterization Laboratory. This presentation will describe in details some of the advances achieved by Alliance members and the challenges that nanotechnology faces for eliminating cancer.
Dr. Nagahara is a Nanotechnology Projects Manager for the National Cancer Institute (NCI) Alliance for Nanotechnology in Cancer, where he oversees and develops promising diagnostics and therapeutics projects and turns them into applications that will eventually benefit cancer patients. He has been actively involved in nanotechnology for over 15 years, most notably novel scanning probe microscopy development, carbon nanotube applications, molecular electronics, nanoenergy and nanosensors. Prior to joining NCI, he was a Distinguished Member of the Technical Staff at Motorola and led the nanosensor effort. Dr. Nagahara was a member of Motorola’s Scientific Advisory Board, an advisory member of U.S. Army Material Command Nanotechnology Executive Roundtable, and an industrial liaison for NSF-NIRT projects, and Semiconductor Research Corporation (SRC) projects. He is currently an adjunct professor in the Department of Physics and Astronomy at Arizona State University. Dr. Nagahara has published over 80 technical papers as well as over 15 patents issued/filed in the field of nanotechnology.

**Hybrid Viral/Synthetic Gene Delivery Nanovectors: Toward an “Artificial Virus”**

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Gene therapy could revolutionize treatment of diseases ranging from cystic fibrosis to cardiovascular disease to cancer. The success of the technology awaits development of safe and efficient methods for gene delivery, however. Efficient gene delivery demands a “device” that is capable of escorting genes through the body to the desired tissue or cell type, as well as directing genes through an intracellular obstacle course and into the nucleus. Viruses are obviously very efficient vectors, but have critical disadvantages including potential pathogenicity and immunogenicity. Synthetic vectors, including liposomes and cationic polymers, are generally much safer but are orders of magnitude less efficient. We are developing a new class of gene delivery vectors by combining viral and synthetic components to produce active nanostructures designed to exhibit advantages of both types of vectors. These nanodevices comprise electrostatic complexes of “bald” retrovirus-like particles (VLPs) and polycations. We will report investigation of the effects of vector composition, especially alternate polycations, and assembly on gene delivery function as well as the mechanisms of intracellular trafficking. The hybrid vectors represent an entirely new, “top-down” approach to design of gene delivery materials and may lead to the construction of “artificial viruses” that will help move human gene therapy from the bench to the clinic.

Professor Daniel W. Pack is an Associate Professor of Chemical and Biomolecular Engineering at the University of Illinois, Urbana-Champaign. He is also an affiliate faculty of the Department of Bioengineering and is associated with the Beckman Institute and Center for Nanoscale Science and Technology at UIUC. Dan graduated from the University of Illinois with a B.S. degree in Chemical Engineering in 1990 and earned his Ph.D., also in Chemical Engineering, with Prof. Frances H. Arnold at the California Institute of Technology in 1997. Dan was a NIH post-doctoral fellow with Robert Langer at the Massachusetts Institute of Technology during 1997-1998 before starting his independent career at UIUC in 1999. He was promoted to Associate Professor with tenure in 2005. Dan was twice awarded the Excellence in Teaching Award from the School of Chemical Sciences at UIUC, he won a Faculty Early Career Development (CAREER) award from the NSF in 2002, and he was a Beckman Fellow in the Center for Advanced Studies at UIUC in 2004-2005.
Novel Techniques for Fabricating Uniform Micro and Nanospheres, Thin Films, Nanofibers, and Nanowires and Their Applications

Kevin Kim, Ph.D.
Professor of ECE; Affiliated Professor of BioE, MatS&E, NPRE, MNTL, Beckman and IGB
University of Illinois at Urbana-Champaign, IL
kevinkim@uiuc.edu

This presentation will describe three novel techniques that are particularly suited to processing nanophase materials with unique properties and architectures: 1) the precision particle fabrication (PPF) technique that can fabricate uniform micro- and nanospheres and micro- and nanocapsules of precisely controlled size and size distribution for controlled release, cell encapsulation, targeted imaging and treatment of cancers and other diseases, and other applications including laser fusion targets and fusion plasma refueling. The two most versatile aspects of this technique are: a) it is insensitive to the choice of materials and b) it is naturally suited to volume production; 2) the flow-limited field-injection electrostatic spraying (FFESS) that is particularly suited to producing thin films, micro- and nano-particles, nanowires, nanofibers, and pattern generation. Applications of this technique involve nanotechnology, biotechnology, and flat panel displays; and 3) the chemical vapor deposition (CVD) with specially designed precursors promoting seedless growth of nanowires (e.g., copper nanowires) with variable sizes. Also included in the presentation are a new method that can accurately measure the resistivity of a single nanowire and a novel method that can produce uniform coatings of variety materials on a single microscopic object.

Fibrous Scaffolds for Cartilage Engineering

G Ragetly, G Slavik, B Cunningham, DJ Griffon
University of Illinois

According to the Center for Disease Control, one of every three adults in the United States suffers from arthritis or chronic joint pain. Articular cartilage has an extremely poor intrinsic healing capacity and none of the actual treatment can completely restore the normal structure and composition of hyaline articular cartilage. Although tissue engineering offers new hope for the treatment of damaged cartilage, the ideal matrix for in vitro chondrogenesis remains undetermined. We have previously found that chondrocytes attach preferably to a fibrous mesh rather than a sponge but that isolated cells lost their desired chondrocytic phenotype in contact with large fibers. We also reported that chitosan, a natural polysaccharide sharing structural similarities with glycosaminoglycans naturally present in the extracellular matrix of cartilage appeared to improve the biosynthetic activity of chondrocytes. The effect of fiber diameter on chondrocyte function remains unclear. Based on the structural characteristics of the extracellular matrix of cartilage, we hypothesize that decreasing the diameter of fibers in the nano-range will promote chondrocyte attachment, proliferation and matrix production. We have already produced silicon “master” wafers for three diameters of chitosan fibers, and developed techniques for molding, mold filling, curing, and harvesting fibers. We are currently evaluating the influence of chitosan fibers on chondrocytes’ attachment, proliferation and matrix production, comparing chitosan fibers of different diameters to a reference group consisting of a polyglycolic acid mesh. Cell attachment is tested at 2 days, while the relationship between fiber diameter and cartilage production is evaluated after 3 weeks of dynamic culture.

Dominique J. Griffon DMV, PhD, Diplomate ECVS, Diplomate ACVS
Dominique Griffon is the Director of the Laboratory for Orthopedic Research on Biomaterials (LORB) and Head of Small Animal Surgery, College of Veterinary Medicine, at the University of Illinois. She is a clinician
scientist, dividing her time between a clinical service in orthopedics, training of students and residents and research. Her laboratory evaluates biomaterials that may be applicable to orthopedic surgery, especially for the in vitro production of cartilage and bone.

**Public Perceptions and Understanding of Nanotechnology**

**Dietram A. Scheufele, Ph.D.**

Life Sciences Communication and Journalism & Mass Communication

University of Wisconsin, WI

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This talk focuses on the dynamics surrounding media coverage and public opinion on nanotechnology. Comparing public opinion polls since 2004, it explores the factors shaping public awareness of nanotech and attitudes toward future funding and research. These factors include the increasing focus on the potential dangers and unknown risks of nanotechnology in mass media; catalytic events, such as the Magic Nano debacle in Germany and recent FDA regulations in the U.S.; and the natural progression of issue cycles, similar to what we saw for GMOs or stem cell research. This talk will also explore these dynamics in greater detail. Most public opinion data on attitudes toward nanotech show that successful communication about nanotechnology depends on a careful segmentation of audiences, depending on their interest levels, risk and benefit perceptions, media use patterns, ideology, and other predispositions. Previous research in the area of science and risk communication also suggests that people form opinions and attitudes even in the absence of relevant scientific or policy-related information, relying on factors, such as media coverage or ideology, when forming attitudes. Based on research conducted by the Public Opinion and Values Research Team at the Center for Nanotechnology in Society at ASU, this talk will explore the idea of cognitive shortcuts or heuristics – often provided by mass media – as currently a key factor in influencing how the public thinks about nanotechnology and about its risks and benefits, and in developing strategies for communicating with various publics and engaging them in successful outreach efforts.

Dietram A. Scheufele is Professor and Director of Graduate Studies in the Department of Life Sciences Communication and Professor in the School of Journalism & Mass Communication at the University of Wisconsin. He is also co-leader of the Public Opinion and Values Research Team and Wisconsin PI of the Center for Nanotechnology in Society at Arizona State University (CNS-ASU). His work for CNS-ASU is part of his larger research agenda on public attitudes toward science and technology, which has been supported by grants from the National Science Foundation, the U.S. Department of Agriculture, the Worldwide Universities Network, and other funding agencies. Scheufele is a member of the Nanotechnology Technical Advisory Group to the U.S. President's Council of Advisors on Science and Technology (PCAST). He also serves on the National Conference of Lawyers and Scientists, a joint committee of the American Association for the Advancement of Science and the American Bar Association, and the National Academy of Engineering's committee on Developing Effective Messages for Improving Public Understanding of Engineering. Prior to joining UW, Scheufele was a tenured faculty member and Director of Graduate Studies in the Department of Communication at Cornell University.
Three-Dimensional Fountain Pen Nanofabrication

Min-Feng Yu, Ph.D.
Department of Mechanical Science and Engineering,
University of Illinois at Urbana-Champaign, IL
mfyu@uiuc.edu

Nanofabrication based on direct-writing technique has many unique advantages in meeting many demanding nanomanufacturing needs. However, the existing direct-writing techniques are either limited to patterning in-surface nanostructures or incapable of producing 3-D structures with characteristic dimension much smaller than 1 μm. In this talk, we present a new direct-writing nanofabrication technique, electrochemical fountain pen nanofabrication (ec-FPN), which overcomes this technology gap. The technique exploits the meniscus formed between an electrolyte-filled nanopipet (“the fountain pen”) and a conductive substrate to serve as a confined electrochemical cell for reducing and depositing metal ions. We demonstrate the local electrochemical deposition of freestanding metallic nanowires by moving the nanopipet away from the substrate while maintaining a stable meniscus formation between the nanopipet and the nanowire growth front. High quality and high aspect-ratio nanowires, such as Pt nanowires with diameter of ~ 150 nm and length over 30 μm and Cu nanowire array, were locally grown. The ec-FPN technique is shown to be an efficient and clean technique for localized fabrication of a variety of vertically grown metal nanowires and can be used for fabricating nanoscale scaffold or freeform 3-D nanostructures.

Solid-State Superionic Stamping: A Direct Approach to Nanopatterning of Metallic Structures

Placid Ferreira, Ph.D.
pferreir@uiuc.edu

Creating high-resolution metallic interconnects is an essential part of the fabrication of microchips and other nanoscale devices. We have developed a simple and robust electrochemical process for the direct patterning of metallic interconnects and other nanostructures. Solid-state superionic stamping offers a new approach, both as a stand-alone process and as a complement to other nanofabrication techniques, for creating chemical sensors, photonic structures and electrical interconnects. The S4 process uses a patterned superionic material as a stamp, and etches a metallic film by an electrochemical reaction. In superionic materials, metal ions can move almost freely around the crystal lattice. These mobile materials can also be used in batteries and fuel cells.

Unlike conventional processing – in which patterns are first placed on photoresist, followed by metal deposition and subsequent etching – the S4 process creates high-resolution metallic nanopatterns in a single step, potentially reducing manufacturing costs and increasing yields.

Placid Ferriera is Grayce Wicall Gauthier Professor of Mechanical Science and Engineering, and Director of NSF-funded Center for Nano-Chemical-Electrical-Mechanical-Manufacturing Systems at the University of Illinois.
Carbon Nanotube FETs for High Frequency Electronics

Hong Zhang, Aaron A. Pesetski, James E. Baumgardner, James M. Murduck, John X. Przybysz, and John D. Adam
Northrop Grumman Corporation, Baltimore, MD

It is known that carbon nanotube field effect transistors (CNT FETs) are potential candidates for high frequency electronics applications. CNT FETs have demonstrated the highest carrier mobility at room temperature of any known material and high electrical and thermal conductivity, along with their small size and low parasitic resistances, making them ideal candidate for mm-wave and terahertz active devices for many emerging systems applications including radars, mobile communications, and man-portable THz imagers.

A top-gated carbon nanotube (CNT) field-effect transistor (FET) was fabricated on a quartz substrate using a single nanotube grown by CVD and a sputtered SixNy gate dielectric. Measurements of the mixing products produced by two closely spaced microwave input signals applied to the gate of the FET circumvented the problems associated with measuring high impedance RF devices in 50 systems. The frequency-independent performance of a CNT FET, at frequencies as high as 23 GHz, was demonstrated for the first time. This observed operating frequency represents a significant breakthrough in the realization of carbon nanotube-based electronics for high frequency applications.

Dr. Hong Zhang, Fellow Engineer at Northrop Grumman, has 22 years extensive R&D experience in the areas of material synthesis, growth, and characterization. Dr. Zhang is the NGC ES Nanotechnology IPT lead and principal investigator and program manager of contract and IR&D programs on Carbon Nanotube Electronics. Recently in a world first, the CNT RF Electronics team led by Dr. Zhang, collaborating with Prof. John Rogers group, has measured RF power gain from a CNT into a 50 ohm system.

Electro-Thermal Interaction in Nanoscale Devices: Carbon Nanotubes and Phase-Change Memory

Eric Pop, Ph.D.
ECE Department, University of Illinois at Urbana-Champaign, IL
http://poplab.ece.uiuc.edu

Rising power densities are often considered the ultimate roadblock in the evolution of nanoelectronics. From a device perspective, high power densities in small volumes are complicated by reduced thermal conductance, and the thermal impedance of material interfaces. This talk will focus on two relatively novel devices, carbon nanotubes and phase-change memory, where the electro-thermal interaction is particularly strong. Single-wall carbon nanotubes exhibit significant self-heating, showing negative differential conductance, light emission and ultimately burning in air at high bias. Phase-change memory must, by design, have high and localized power density during operation, since the state of the bit is altered thermally. Simple experiments are used to gain new insight into the fundamental behavior of both device types. This work suggests much room for the optimization of nanoscale devices through geometry, interface and materials design.

Eric Pop joined the Electrical and Computer Engineering faculty at UIUC in March 2007. Prior to that, he was an Intel Researcher in Residence at Stanford working on phase-change memory and high-k dielectrics for Flash memory. He did post-doctoral work at Stanford on the electrical and thermal properties of carbon nanotubes (2005). He received his PhD in EE from Stanford (2005) and holds MS/BS degrees from MIT in EE and Physics (1999).
‘Wavy’ Semiconductor Nanomaterials for Stretchable Electronics

John Rogers
Materials Science and Engineering/Nano-CEMMS, University of Illinois Urbana-Champaign, IL  
jrogers@uiuc.edu

This talk will describe the synthesis and physics of semiconductor nanomaterials -- inorganic ribbons/membranes and single walled carbon nanotubes – that are structured into ‘wavy’ geometries through engineering control over nonlinear buckling instabilities. Experimental measurements on various systems of this general type, together with analytical and finite element modeling of their responses, reveal the essential physics. Use of these ‘wavy’ semiconductors in high performance field effect transistors and pn junction and Schottky diodes on elastomeric supports illustrates pathways to electronic systems that offer full stretchability, with purely elastic responses to applied strains of up to ~100%. Hemispherical electronic eye imagers, conformable sensor skins and other devices that rely on this type of approach will be discussed.

Research in Beyond CMOS Materials, Devices and Architectures

George Bourianoff, Ph.D.
Intel Corporation

Organized research directed at developing the next information processing technology beyond CMOS based nanoelectronics has surged well past the $100M/year level in the US alone. It has been led by the semiconductor industry itself, embraced by many federal and state government institutions and carried out in a distributed manner at the leading research campuses across the country. This research effort has generated a significant results in materials, alternative state variables, novel information transport processes, memory devices, logic devices, and characterization capabilities. A parallel effort has surveyed future computational tasks and applications and analyzed the work loads involved. Similarly, high level architectural paradigms required to accomplish the future tasks have begun to emerge and generate consensus.

This presentation will highlight a very limited sample of the recent research results from the Nanoelectronics Research Initiative and the Focus Center Research Program. It will include highlights of novel materials, devices, and interconnects. It will also survey recent trends in multi-core architectures as a way to incorporate novel nanoelectronic elements. It will point to a lack of circuit level concepts that can integrate the novel components as a key research element that is lacking in the current research environment.

George Bourianoff is a senior program manager in the Strategic Research Group at Intel Corporation, and is responsible for managing Intel's external semiconductor research program in universities and other research organizations. He is directly responsible for the external research programs in optoelectronics and advanced devices. He has research interests in spin devices, energy of computation and ferromagnetic semiconductors. Dr. Bourianoff serves as co-chair of Intel's Semiconductor Technology Committee (STC), chairs the Emerging Logic technology working group associated with the ITRS, chairs the International Planning Working Group on Nanoelectronics, and serves on the executive committee of with the Western Institute of Nanoelectronics the Focused Center Research Program and the Global Research Corporation.
Mechanical Behavior of Polymeric Nanofibers Subject to Cold Drawing

Ioannis Chasiotis, Ph.D.
Aerospace Engineering, University of Illinois at Urbana-Champaign, IL
chasioti@uiuc.edu

The mechanical behavior of submicron and nanoscale soft organic structures in response to quasi-static and intermediate loading rates is largely unexplored. A novel method that utilizes a MEMS-based mechanical property-testing platform was implemented to investigate the effect of strain rate during cold drawing of electrospun polyacrylonitrile (PAN) nanofibers with 200-500 nm diameters and 10-60 microns lengths. The fiber strength and elastic modulus were found to be comparable to bulk measurements, 90±30 MPa and 7.6±1.5 GPa, respectively. However, the ultimate strain of PAN nanofibers was larger than bulk varying between 100-200% at the fastest and the slowest strain rates respectively. Smaller fiber diameters resulted in stronger fibers, while the ultimate strain was insensitive to changes in fiber diameter. The effect of strain rate on fiber properties was not as uniform: At fast strain rates, increasing strain rate reduced ductility and increased fiber strength. These trends were reversed at quasistatic strain rates (10-4 s⁻¹): The yield and ultimate strength were higher by a factor of two compared to faster drawing rates. Similarly, at the slowest strain rate the enhanced fiber strength was accompanied by significantly increased ductility. This seemingly conflicting behavior was the result of formation of a cascade of necks along the fiber that allowed for exceptionally large stretch ratios while maintaining a high value of failure strength.

Novel Techniques in Fine-Particle Manufacturing for Liquid Crystal Displays and Inkjet Printing

Anne Shim, Ph.D.
Cabot Corporation
anne_shim@cabot-corp.com

Cabot Corporation is the world leader in fine-particle manufacturing. Cabot has developed both novel particles and novel surface modifications. These new materials are enabling new applications such as black matrix for liquid crystalline displays, novel inks for inkjet printing, silver based ink for printed electronics and other applications, and silica for toners yielding prints with improved resolution.

This presentation will discuss how the morphology of the black, as measured by the primary particle size and the aggregate size, can affect the properties of carbon black such as color development and ability to reinforce a network. In addition, surface modification of the carbon black particle will be discussed. The novel technology developed at Cabot enables the coupling of many different molecules to the particle thus allowing the particle to be engineered for specific applications where controlled resistivity, dispersivity, etc. may be required.

Anne Shim received her PhD from University of Akron, Ohio in Polymer Science in 1998. She held a postdoctoral position at Carnegie Mellon University under Prof. Matyjaszewski. She went on to work for Dow Corning Corporation from 1999 to 2005 where the last position she held was as chief technologist for Advanced Lithography. During the fall of 2005, she joined Cabot Corporation as Research and Development Project Leader. Anne has 10 papers and 12 patents.
LIST
OF
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May 3: 12:35PM – 2:00PM and 5:15-6:30PM POSTER SESSION- NCSA ATRIUM
POSTERS BY UIUC FACULTY, GRADUATE STUDENTS, CAMPUS UNITS, INDUSTRY, AND LOCAL TECHCOMMUNITY-EDC *

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For More Information or Technical Collaboration Contact:

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