nanoUtah2010
6th ANNUAL UTAH STATEWIDE NANOTECHNOLOGY CONFERENCE
THE CROSSROADS OF SCIENCE, ENGINEERING & INDUSTRY
Sensors • Electronics • Materials • Medicine
SALT LAKE CITY • MARRIOTT CITY CENTER • OCT 14-15
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Since the emergence of nanotechnology, the Intellectual Property Practice of Fulbright & Jaworski has worked with innovative nanotech entrepreneurs to help them protect and commercialize their groundbreaking ideas. Fulbright's IP practice is widely respected for its work in patent prosecution and litigation, licensing and trademark issues. We are proud to sponsor the 2010 nanoUtah Conference as it explores this exciting road to the future.

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Welcome from the Conference Organizers

Welcome to the Utah’s sixth nanotechnology conference, the first of which was held in 2003 to enable conference attendees to share in the latest research and development in nanotechnology among academic, industrial, and government sectors in the state of Utah. This year’s conference highlights key advances in nanobusiness, nanobiotechnology, nanofluidics, nanoparticles, nanomaterials and characterization, devices and sensors, nanomedicine, and energy. Keynote and other invited speakers are distinguished colleagues from industry, academia, and government agencies who will present overviews of advances in all fields of nanotechnology. Over sixty oral and poster presentations from across the state will provide an opportunity to foster pivotal interactions in these highly interdisciplinary and dynamic emerging fields of science.

We are pleased to highlight two special workshops this year: The first focuses on nano entrepreneurship and company building, and should give scientists, academics, students, and business people a starting framework to build a nano-based business. The second workshop will discuss nano-focused education and workforce development and how nanoscience will drive new workplace needs. These workshops are open to everyone who attends the conference.

We are again proud to partner with the Nano Institute of Utah for this year’s nanoUtah Conference. The Nano Institute of Utah, supported in part by the Utah Science Technology and Research (USTAR) initiative, was established to enable Utah researchers from disciplines such as chemistry, physics, biology, engineering, medicine, and pharmacy to create synergistic alliances driving higher levels of collaborative research, education and commercialization. The Nano Institute of Utah strives to position Utah as a global leader in nanoscience and technology distinguished by interdisciplinary collaboration and entrepreneurial excellence.

We are especially pleased that nanoUtah 2010 is being held at the beautiful Salt Lake City Marriott City Center, which will provide easy access to the conference venue while allowing conference attendees to freely interact with other nanoscience, nanoengineering and biomedical researchers and clinicians, and will permit folks to continue their discussions in a relaxed setting after the formal portions of the program conclude.

We are particularly grateful for the generous support of the sponsors and for the hard work of our dedicated staff, without whom this conference would not have been possible. We hope you enjoy the conference.

With best wishes,

The nanoUtah 2010 Organizing Committee
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Ilya Zharov
Associate Professor
Chemistry
University of Utah

NANOMEDICINE

Bruce Gale
Associate Professor
Mechanical Engineering
University of Utah

Ryan Marshall
Patent Attorney
Brinks Hofer Gilson & Lione
THURSDAY – OCTOBER 14, 2010

The Marriott City Center – Olympus Ballroom

1:00 p.m. **Workshops:**

*Practical Advice for Starting a Nano Business:* Panelists from local nanotechnology business will discuss such topics as protecting your intellectual property; do’s and don’ts of working with a university technology commercialization office; considerations when choosing a form of business entity and seeking startup capital; and, practical lessons learned when starting a nano business.

*Big Things from the Tiny World:* Specifically aimed at high-school students, high-school educators, and undergraduate students, this workshop will address education options and career opportunities in nanotechnology. Presenters will discuss education programs for nanotechnology in energy and medicine.

The Marriott City Center – Capitol Ballroom

3:00 p.m. **Open Registration**

4:00 p.m. **Welcome:**

David Pershing
Office of Academic Affairs, University of Utah

Greg Bell
Utah Lieutenant Governor

4:30 p.m. **Keynote Speakers:**

Mark Banash
Vice President, Nanocomp Technologies, Inc.

Viktoria Greanya
Program Manager, DARPA / DSO

6:00 p.m. **Dinner Reception**

Student Poster & Exhibition
FRIDAY - OCTOBER 15, 2010

The Marriott City Center – Capitol Ballroom

8:00 a.m.  Open Registration

8:45 a.m.  **Opening Remarks:**
Ted McAleer
Executive Director, USTAR

9:00 a.m.  **Invited Speakers:**
Nongjian Tao
Professor, Electrical Engineering
Director, Center for Biosensors and Bioelectronics,
Biodesign Institute
Arizona State University

9:40 a.m.  Neil Gordon
CEO and Founder
Early Warning, Inc., a NASA Spinoff

10:20 a.m.  Coffee Break

10:30 a.m.  **Parallel Sessions:**
15 minute Research Introductions

- Devices & Sensors - Capitol Ballroom
- Energy, Catalysis, & Environment - Olympus Ballroom

12:30 p.m.  Lunch
Poster Session & Exhibition

1:30 p.m.  **Invited Speakers:**
Juan Santiago
Professor and Chair of Thermosciences Group
Mechanical Engineering Department
Stanford University

2:10 p.m.  Jordan Gerton
Assistant Professor
Physics Department
University of Utah
2:50 p.m.  Coffee Break

3:00 p.m.  **Parallel Sessions:**
            15 minute Research Introductions
            Materials & Characterization - Capitol Ballroom
            nanoMedicine - Olympus Ballroom

5:00 p.m.  Student Poster Awards & Closing Remarks
Session Presentations - At a Glance

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<th>Time</th>
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<tbody>
<tr>
<td>10:35 AM</td>
<td>DS-T1-P1</td>
<td>Faisal Khair Chowdhury, U of U</td>
<td>“Surface enhanced Raman spectroscopy on dielectrophoresis induced diffusion limited aggregation of gold nano particles”</td>
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<tr>
<td>10:50 AM</td>
<td>DS-T2-P2</td>
<td>Steve McDaniel, U of U</td>
<td>“Increased OLED radiative efficiency using a nano-scale directive antenna”</td>
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<td>11:05 AM</td>
<td>DS-T3-P34</td>
<td>Mano Misra, U of U</td>
<td>“Self-ordered arrays of TiO$_2$ nanotubes for energy conversion, energy storage, and sensor applications”</td>
</tr>
<tr>
<td>11:20 AM</td>
<td>DS-T4-P3</td>
<td>Massood Tabib-Azar, U of U</td>
<td>“Novel single device XOR and AND gates fabricated using MEMS technology”</td>
</tr>
<tr>
<td>11:35 AM</td>
<td>DS-T5-P4</td>
<td>Landon A. Wiest, BYU</td>
<td>“Pellicular stationary phases created using graphite cores with porous nanodiamond shells for use in high pH reversed-phase HPLC”</td>
</tr>
<tr>
<td>11:50 AM</td>
<td>DS-T6-P5</td>
<td>Wen Yuan, U of U</td>
<td>“Nanofabrication of SERS and SET devices using atomic force microscope and field-assisted CVD”</td>
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<tr>
<td>12:05 PM</td>
<td>DS-T7</td>
<td>Yu Zhang, U of U</td>
<td>“Effect of surface bonding on semiconductor nanoribbon wiggling structure”</td>
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Devices & Sensors - Capitol Ballroom

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<td>Helin Huang, U of U</td>
<td>“A nanofiber-based heterojunction approach for high photoconductivity in organic nanofibers”</td>
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<td>Matthew D. Kane &amp; F. Sloan Roberts, U of U</td>
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<td>Brandon McMahon, U of U</td>
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Energy, Catalysis, & Environment - Olympus Ballroom

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12:05 PM (ECE-T14-P33) **Prashant K Sarswat**, U of U, “Surface characterization of CZTS absorber layers synthesized by solution-based methods”

**Materials & Characterization - Capitol Ballroom**

3:05 PM (MC-T15) **Nicole Brimhall**, U of U, “Sub-wavelength optical patterning via optical-saturable transformations”


3:35 PM (MC-T17-P36) **David S. Jensen**, BYU, “Microfabrication of porous chromatography media with an application in thin-layer chromatography”

3:50 PM (MC-T18-P37) **Brian D. Jensen**, BYU, “Carbon-infiltrated carbon nanotube MEMS fabrication”

4:05 PM (MC-T19) **Xiaobin Niu**, U of U, “Controlled composition profiles of semiconductor alloy quantum dots and nanowires by selecting the growth mode”

**nanoMedicine - Olympus Ballroom**

3:05 PM (NM-T22-P57) **Michael R. Franklin**, U of U, “Nano-silver particle effects on drug metabolism”

3:20 PM (NM-T23-P58) **Adam Gormley**, U of U, “Cellular uptake and biodistribution of targeted and non-targeted gold nanorods for photothermal therapy”


3:50 PM (NM-T25-P60) **Alexander Malugin**, U of U, “Mechanism of cell death induced by amorphous silica nanoparticles”

4:05 PM (NM-T26-P61) **Philip Moos**, U of U, “Contact-dependent gene transcription responses of skin and colon cells to nanosized ZnO”

4:20 PM (NM-T27-P62) **Gregory H. Teichert**, BYU, “An innovative mechanism for cell constraint”

4:35 PM (NM-T28-P63) **G. Thiagarajan**, U of U, “Charge-based in-vivo targeting and toxicity of dendritic constructs”
Welcome / Opening Remarks

GREG BELL

Greg Bell has served as the Lieutenant Governor of Utah since September 1, 2009. Previously he served in the Leadership of the Utah State Senate having been a state senator representing the 22nd District of Davis County from January, 2003 until his appointment.

Lieutenant Governor Bell was born and raised in Ogden, Utah. He graduated from Ogden High School, Weber State University and the S.J. Quinney College of Law at the University of Utah. He practiced law at the firms of Kirton & McConkie and later at Fabian & Clendenin specializing in real estate law and has had extensive experience with real estate development, land use and finance.

Lieutenant Governor Bell is a past mayor and city councilman of Farmington. He has been the Chair of Envision Utah, an internationally acclaimed collaborative land use and transportation planning organization.

TED MCALEER

Prior to USTAR, McAleer was the Director of Business Development for The University of Utah’s Technology Venture Development organization. Ted has 20 years of experience in technology innovation; business development; and product, services and operations management in both start-up and mature corporations. He has been Chief Operating Officer for Teleoptic Digital Imaging, LLC and the Sr. Director of Implementation services at Campus Pipeline, Inc. He has also worked for SunGard SCT, Procter and Gamble, PepsiCo. and the US Army. He holds a MBA from Harvard Business School, a Master of Engineering from the University of Virginia and a BS in Engineering Management from the United States Military Academy at West Point.
DAVID W. PERSHING

Distinguished Professor David W. Pershing, Senior Vice President for Academic Affairs since 1997, earned his B.S. degree in Chemical Engineering from Purdue University in 1970 and his Ph.D. in the same field from the University of Arizona in 1976.

Dr. Pershing joined the University of Utah as an Assistant Professor in Chemical Engineering in 1977. He was named a Presidential Young Investigator by the National Science Foundation in 1984 and became Dean of the College of Engineering in 1987. He has had a brilliant career in academia, government, industry and consulting. He has more than 80 peer-reviewed publications, more than 20 research grants, and five patents to his credit.

Dr. Pershing has won both the Distinguished Teaching and Distinguished Research Awards and is the 1997 recipient of the Rosenblatt Prize for Excellence. He is the director of the University of Utah Center for Simulation of Accidental Fires and Explosions, fueled by a $40 million grant from the U.S. Department of Energy of Utah.
Keynote Speakers

Mark A. Banash

Mark is responsible for addressing one of Nanocomp Technologies, Inc. (NCTI) greatest challenges with its carbon nanomaterials: Proving the links between their unique nanoscale features and how those features affect our manufacturing processes, the performance of end products, and the health of both our employees and the environment. Mark directs our quality program, establishing the techniques needed to test our materials from the bulk to the molecular levels. He runs our safety program, which is recognized by regulatory agencies as the standard for the nanomaterials industry. He also directs NCTI’s active collaborations with the National Institute for Occupational Safety and Health (NIOSH), the U.S. EPA, and the National Science Foundation’s Center for High-rate Nanomanufacturing.

Prior to Nanocomp, Mark was the director for production and quality for the company’s nanomaterial products for Zyvex Corporation, where he managed manufacturing operations and initiated the industry’s first supply chain certification process to qualify carbon nanotubes. Mark also led the firm to ISO:9001 registration and created its quality management system. Mark was also an R&D scientist at Millennium Chemicals and EniChem Americas, developing products that ranged from new types of optical glass to protective ceramic films.

Mark holds a Ph.D. in physical chemistry from Princeton University, an M.B.A. from the University of Maryland University College, and a B.A. with honors in chemistry from the University of Pennsylvania. He is an adjunct faculty member in operations and technology management at the University of Maryland, University College. Mark is a frequent speaker on the safe and ethical uses of nanotechnology and actively participates with the National Nanotechnology Initiative’s environmental, health, and safety programs. He is a member of the International Standards Organization (ISO) Technical Advisory Group on the measurement of nanomaterials. He is also a member of the American Society for Quality and is a Six Sigma Black Belt.
Dr. Viktoria Greanya is a Program Manager in the Defense Sciences Office (DSO). Prior to joining DSO in 2009, Dr. Greanya was a consultant at Booz Allen Hamilton providing technical support to the DARPA Microsystems Technology Office. In 2004, she completed a National Research Council Post-doctoral Associateship at the U.S. Naval Research Laboratory's Center for Bio/Molecular Science and Engineering conducting research into the acoustic response seen in nematic liquid crystals for use as novel acoustic imagers. She received her doctorate in physics from Michigan State University studying the band structures of thermoelectric materials and her bachelor's degree in physics from Guilford College. Dr. Greanya's background includes surface science, thermoelectric materials, liquid crystals, nanostructured materials, heterogeneous integration, vacuum electronics, and flexible electronics. As a program manager, her interests are focused on how micro- and nano-structures can enhance material and device functionality in the areas of materials physics, biologically inspired materials, and structures operating at the interface of biology and physics.
Invited Speakers

Jordan Gerton

Jordan Gerton is an Assistant Professor of Physics and Astronomy at the University of Utah. His Ph.D. work was on the growth and collapse dynamics of lithium Bose-Einstein condensates, and was carried out at Rice University in the group of Randy Hulet. He then moved on to Caltech as a Beckman Senior Research Fellow in the applied physics group of Stephen Quake. There he developed tip-enhanced fluorescence microscopy techniques for biological applications. This work has continued at Utah, where he has also become interested in fundamental processes such as energy transfer in nanostructured material systems. Professor Gerton received the Cottrell Scholar Award from the Research Corporation for Science Advancement in 2007, the NSF CAREER Award in 2009, and the Early Career Teaching Award from the University of Utah in 2009.

Neil Gordon

Neil Gordon is Chief Executive Officer and Founder of Early Warning, a nanotechnology spin-off company from NASA’s Ames Research Center. He is responsible for the business and technical direction of the world’s first pathogen sensor that automatically samples fluids and measures the concentration of a suite of pathogenic bacteria, viruses and parasites in the same test. Prior to Early Warning, Neil participated on 20 diverse nanotechnology projects. As Partner-Nanotechnology at Sygertech Consulting Group he led a nanotechnology business consulting practice for early-stage nanotechnology companies, multinationals, venture capitalists and government labs including the Taiwan Government’s Industrial Technology Research Institute (ITRI). In parallel, he co-founded the Canadian NanoBusiness Alliance, an industry association to advocate for a Canadian National Nanotechnology Initiative and to develop nanotechnology business activities in Canada and internationally. He led the establishment of the world’s first high throughput NanoImprint Lithography Prototyping Center in collaboration with the National Research Council of Canada and EV Group. Neil is an technology executive with a 25-year track record in starting up new entities, managing a $100 million high growth operation, commercializing first-of-a-kind technologies, raising equity and government funds, managing interdisciplinary teams, and negotiating IP agreements. Neil has a Bachelor of Engineering degree from McGill University and a Masters in Business Administration from the University of Western Ontario.
Juan G. Santiago

Juan G. Santiago is Professor and Chair of the Thermosciences Group of Mechanical Engineering at Stanford University. He received his MS and PhD in Mechanical Engineering from the University of Illinois at Urbana-Champaign in 1995. His research includes the development of microsystems for on-chip chemical and biochemical analysis, drug delivery, sample preparation methods, and miniature fuel cells. Applications of this work include genetic analysis, drug discovery, chemical weapon detection, and power generation. Among other recognition, he was awarded a National Science Foundation Presidential Early Career Award for Scientists and Engineers (PECASE) (‘03-'08) and the Outstanding Achievement in Academia Award by the GEM Foundation (‘06). He is Associate Editor of the journal Lab on a Chip, co-founder of Cooligy Inc., co-inventor of micron-resolution particle image velocimetry (Micro-PIV), and director of the Stanford Microfluidics Laboratory. Santiago has given 13 keynote lectures and more than 100 additional invited lectures. He and his students have been awarded 10 best paper and best poster awards. He has graduated 18 PhD students and advised nine postdoctoral researchers (12 of his advisees are professors at major universities). He has authored and co-authored over 110 archival publications and 200 conference papers, and holds 25 patents.

Nongjian Tao

NJ Tao joined the Arizona State University faculty as a Professor of Electrical Engineering and an Affiliated Professor of Chemistry and Biochemistry in August 2001. Before that, he worked as an Assistant and Associate Professor at Florida International University. Since 2008, he has been serving as Director of the Center for Bioelectronics and Biosensors, Biodesign Institute, leading an effort to develop sensors for health and environmental applications. He has published over 190 refereed journal articles and book chapters, and given over 180 invited and keynote talks worldwide. His current research interests include chemical and biological sensors, molecular and nanoelectronics, nanostructured materials and devices, and electrochemical nanofabrications.
Keynote Speaker Abstracts

OCTOBER 14, 2010

4:30 PM

“NanoEHS and its reduction to practice at Nanocomp Technologies”

Speaker: Mark A. Banash
Nanocomp Technologies, Inc.

As the nanomaterials industry moves out of the laboratory and into the production plant, companies must protect their workers, their customers, the public, and the environment from any hazards associated with those materials. However, there are no established frameworks, equipment, or other processes and tools available; instead, the industry faces a dynamic regulatory environment where information about the nature of hazards or the efficacy of engineering controls is limited. In this talk we will present a detailed overview of NanoComp’s program and how it manages the legal, scientific, technical, and ethical challenges of EHS on a practical level.

5:15 PM

“Functional nanostructured materials for next generation defense applications”

Speaker: Viktoria Greanya
DARPA Defense Sciences Office

Nanoscale fabrication of materials offers a pathway to control structure at the scale of the relevant physical phenomena. DARPA research efforts in functional materials, biomaterials and bio-inspired materials leverage nanoscience for defense-relevant applications. Dr. Greanya will highlight the improved functionality possible through nanomaterials and the context and contribution of DARPA research efforts to the nanotechnology and defense community.
Invited Speaker Abstracts

OCTOBER 15, 2010

9:00 AM

“Molecular electronics and sensors”

Speaker: Nongjian Tao
Arizona State University: Center for Biosensors and Bioelectronics, Biodesign Institute, and Electrical Engineering

Although molecular electronics has been proposed as an alternative to Si in post CMOS devices, molecules with properties and functions that are fundamentally different from Si-based microelectronics are only beginning to be discovered. These properties and functions include thermoelectric, electromechanical and molecular recognition, which promise new devices with functions that are not possible for conventional materials and devices. To study and develop device functions of molecules, a basic task is to wire a molecule to two or more electrodes to form a molecular junction, which has proven to be a difficult challenge. We have developed methods to create molecular junctions, and studied electron transport in various molecules. Unlike conventional electronic materials, the removal or addition of even a single electron from or to a molecule is often accompanied by a large structural change in the molecule, which leads to interesting electromechanical and thermoelectric effects. The specific interactions between molecules often significantly change the electrical and mechanical properties of the molecules, which is the basis of chemical sensors. In addition to studying the basic properties of molecular junctions, we have explored and developed chemical sensors for environmental health studies.

9:40 AM

“Challenges in bringing nanotechnology to market”

Speaker: Neil Gordon
Early Warning Inc.

Bringing nanotechnology projects to market is challenging for business people and scientists alike. Neil will share his experience from 20 nanotechnology commercialization projects undertaken as a nanotechnology business consultant, the head of a national nanotechnology advocacy group, and, most recently, as CEO of a nanotechnology spin-off company from NASA.

1:30 PM

“On-chip isotachophoresis for toxin detection and nucleic acid extraction”

Speaker: Juan G. Santiago
Stanford University: Thermosciences Group and Department of Mechanical Engineering
Microfluidics lies at the interface between engineering, chemistry, and biology, and aims to develop laboratory functions on a chip. One important class is on-chip capillary electrophoresis devices which have been applied to a wide range of chemical and biochemical assay applications for just over a decade.

At Stanford, we are working on on-chip isotachophoresis (ITP) and related electrophoretic displacement techniques. These methods date back 60 years, and yet there remain significant opportunities in the innovation of novel, widely applicable ITP assays. In ITP, analyte ions focus and self-segregate into distinct zones between leading and trailing electrolytes (LE and TE). The zone order is determined by analyte effective mobilities, and high (over one million fold) sample preconcentration is possible. We use ITP to create highly concentrated sample ion zones in microchannels (effectively ion concentration shock waves). The talk will summarize novel on-chip ITP techniques and devices. We first present assays and devices which use ITP as a precisely selective method to extract biological macromolecules from complex mixtures. We will show extraction of various nucleic acids from cell lysate and whole blood lysate. We will also demonstrate the application of ITP-based devices to the detection and quantitation of unlabeled species. As examples, we will show multiplexed detection of toxic industrial chemicals in tap water and river water. Our goal is the development of widely-applicable on-chip ITP assays with unprecedented sensitivity and new functionality.

2:10 PM

“Single-molecule measurements of energy transfer in nanocomposite materials”

Speaker: Jordan Gerton
University of Utah: Department of Physics and Astronomy

To precisely control energy flow in complex, integrated materials requires a deep understanding of energy transduction pathways in nanoscale systems. Indeed, without insight into the basic physical processes that couple the components within a nanostructured material, optimizing functionality is inefficient at best, and quite likely impossible. Of particular interest is the potential to improve the efficiency of solar energy conversion devices by optimizing the energy transfer efficiency between different functional elements within a nanocomposite light-harvesting material, for example, between a component with strong light absorption, such as semiconductor nanocrystal quantum dots (QDs), and another component with efficient charge transport, such as carbon nanotubes (CNTs). The interfacial area between components in such composite materials is extremely large, so nanoscale energy transfer is very important but difficult to measure precisely due to the minute quantities of energy exchanged. We have succeeded in making such measurements by manipulating individual CNTs into the nanoscale vicinity of isolated QDs using an atomic force microscope. Energy transfer is reported macroscopically via a reduction in the QD-fluorescence, which affords extremely high sensitivity. Our technique produces sub-nanometer precision spatial maps of the energy transfer efficiency as a function of the QD-CNT separation, and reveals novel behavior which informs the development of nanocomposite light harvesting materials and is also of fundamental interest.
10:35 AM (DS-T1-P1)

“Surface enhanced Raman spectroscopy on dielectrophoresis induced diffusion limited aggregation of gold nano particles”

Speaker: Faisal Khair Chowdhury

Massood Tabib-Azar
University of Utah: Departments of Electrical and Computing Engineering; and Bioengineering

Wires formed by diffusion-limited aggregation (DLA) and dielectrophoresis (DEP) of gold nanoparticles were investigated as an effective sample preparation method for surface enhanced Raman spectroscopy (SERS). Thymine was used as a test molecule and its SERS response was measured to investigate the effectiveness of this technique that reproducibly resulted in $10^9$ enhancement. We attribute this enhancement to the localized surface plasmons of the gold nanoparticles and the formation of “hotspots” in DEP wires. There are other methods that reproducibly yield in excess of $10^8$ enhancement in SERS using tunable lasers and very elaborate Raman spectroscopy. Our results were obtained using fixed laser excitation source at 785 nm and a simple spectrometer (5 cm$^{-1}$ resolution). An attractive aspect of DEP is that it can be used while monitoring SERS to track and halt or modify the Raman spectra in real time by changing the DEP conditions such as voltage (or current), frequency and DC bias. In addition, the effect of E-field variation on SERS was also examined using interdigitated structures based on fine single strand fiber optic cables. SERS was interrogated on this substrate while applying varying E-fields. Furthermore, experiments using nano-scale “optical antenna” constructed using AFM probes on a quartz surface coated with silver and the Raman signal for thymine was investigated and will be reported.

This project was supported by the USTAR program.

10:50 AM (DS-T2-P2)

“Increased OLED radiative efficiency using a nano-scale directive antenna”

Speaker: Steve McDaniel

Steve Blair, Seung Ko
University of Utah: Department of Electrical and Computer Engineering

We investigate the improvement in efficiency of organic light emitting diodes/displays (OLEDs) by embedding a typical OLED structure within a metallic patch grating resonator. A patch grating resonator is similar to the more familiar Fabry-Perot resonator, except that one mirror of the resonator is a metallic patch grating with a pitch $\lambda/2$ that reduces lateral propagation of radiative emission. FDTD simulations of the proposed structure indicate a potential 71% increase in emitted power over that of a reference
OLED structure, and an additional 5% gain from adding an ITO spacer adjacent to the metallic electrode layer (for a total 76% increase). Implementation of this structure requires little to no modification of the OLED manufacturing process.

11:05 AM (DS-T3-P34)

“Self-ordered arrays of TiO₂ nanotubes for energy conversion, energy storage, and sensor applications”

Speaker: Mano Misra*

Poster Presenters: K.S. Raja and S.K. Mohanty

University of Utah: Departments of Chemical Engineering; and Metallurgical Engineering

*Present Affiliation: University of Nevada, Reno

Vertically oriented, self-ordered arrays of TiO₂ nanotubes are synthesized by a facile, ultrasonic assisted-anodization process. This process is less expensive, easily scalable and highly controllable. Diameter, wall thickness and length of the nanotubes can be easily and accurately modulated by varying anodization potential, time and composition of the anodization electrolyte. The resulting nanotubes have superior electronic and catalytic properties compared to the conventional TiO₂ nano-particles. Inherent oxygen vacancies present in the nanotubes make the material easily amenable to band-gap engineering. The high surface area of nanotubes and one dimensional electronic conduction path render the material's electronic properties highly sensitive to complexation with environmental molecules. This presentation will discuss the application of TiO₂ nanotubular structures for solar energy conversion, energy storage, and utilization in design for improvised explosive sensors and radiation detectors.

11:20 AM (DS-T4-P3)

“Novel single device XOR and AND gates fabricated using MEMS technology”

Speaker: Massood Tabib-Azar

Faisal Khair Chowdhury, Karumbaiah C. Nanaiah
University of Utah: Departments of Electrical and Computing Engineering; and Bioengineering

Daniel Saab
Case Western Reserve University: Department of EECS

MEMS integrated circuits and processors are being developed for different applications in harsh and radiation-rich environment. Two different strategies are being pursued. In the first one, MEMS and NEMS switches similar to CMOS are connected to form universal gates such as XOR and NAND gates. In the second approach, a single MEMS device is envisioned to operate as a universal gate. Our group is pursuing both of these strategies and here we discuss single functional MEMS devices that are designed, fabricated and tested to demonstrate the feasibility of performing a universal gate function in
a single device. We discuss novel functional MEMS XOR and AND gates that use doubly clamped silicon nitride beams and tungsten interconnect. A ground electrode is used for field-effect transistor action or for separating the two bridges in case they adhered to each other due to stiction. In these devices, the gap was defined using sacrificial Al₂O₃ deposited using atomic layer deposition (ALD) technique. We discuss the operation characteristics of XOR and AND gates, 1 bit full adder and a 2 bit multiplexer.

This project was supported by DARPA NEMS program under Dr. A. Lal and Dr. Tayo Akinwande.

11:35 AM (DS-T5-P4)

“Pellicular stationary phases created using graphite cores with porous nanodiamond shells for use in high pH reversed-phase HPLC”

Speaker: Landon A. Wiest

David S. Jensen, Chuan-Hsi Hung, Rebecca E. Olsen, Matthew R. Linford
Brigham Young University: Department of Chemistry and Biochemistry

Michael A. Vail, Andrew Dadson
US Synthetic Corporation, Orem UT

A pellicular diamond-based reversed-phase (C₁₈) was developed for HPLC using 3 µm graphite cores with 0.5 µm porous nanodiamond shells. The resulting 3 cm × 4.6 mm ID slurry packed column was used to separate a test mixture containing four aromatic analytes: benzene, ethylbenzene, n-butylbenzene and n-hexylbenzene, using a 40:60 water/acetonitrile mobile phase set at pH 11.3 with triethylamine. All compounds were baseline separated, where the n-butylbenzene peak had an efficiency of 56,000 N/m with a symmetry factor of 1.03. A flow rate of 0.5 mL/min gave a back pressure of ca. 950 psi. At higher temperatures (80°C) efficiencies of 70,000 N/m were attained with the analytes phenyloctane and phenyldecane. The purpose in preparing this new stationary phase was to create a material with high stability at both high and low pH and elevated temperatures. A stability test was performed at pH 13.0 and the phase showed a reduction in retention factor of ca. 1% over 1000 column volumes. The material had a surface area of ~45 m²/g, which equates to about 90 m²/g equivalent silica, with pore diameters of ~200-300 Å. This phase shows the best efficiencies yet attained with diamond-based stationary phases and has the greatest pH stability of any LC reversed-phase material we are aware of. We will also demonstrate that greater plate counts can be achieved with further refinement of this type of diamond-based phase and that multiple types of analytes (parabins, basic drugs, pesticides, etc.) can be separated effectively.

11:50 AM (DS-T6-P5)

“Nanofabrication of SERS and SET devices using atomic force microscope and field-assisted CVD”

Speaker: Wen Yuan

Yan Xie, Carlos H. Mastrangelo and Massood Tabib-Azar
University of Utah: Departments of Electrical and Computer Engineering
Our group has been involved in developing different nanofabrication techniques based on local probes and the associated microscopy techniques. These so called “tip-based” nanofabrication (TBN) techniques have attracted great interest due to their versatile control of nanofabrication over position, shape and size. One promising approach of TBN is AFM-based CVD. In this technique, a gas channel in the AFM probe is used to deliver gases to the AFM tip. The AFM tip is then used to apply an electric field to dissociate the nearby gases and deposit/etch nanometer-scale regions under the tip. In addition, with an atomic layer deposition gas controller system connected to the AFM probes, nanostructures of different materials can be fabricated on one sample. This is of great advantage compared to the conventional micro-fabrication process, where different masks need to be applied to achieve the desired features with different materials. Our functionalized AFM probe with integrated gas channels were fabricated by surface and bulk micromachining techniques. Si$_3$N$_4$ was used to form the cantilever beam and the integrated gas channel while the probe tip was formed using polycrystalline Si. We discuss the applications of the so called “nanotorch” probe in patterning Ti, Si, and W. Local oxidation of Ti thin film by the nanotorch tip resulted in features with a width of 130 nm. Silicon quantum dots as small as 10 nm in diameter were deposited using a simple conducting AFM probe. We will discuss design, fabrication, and applications of AFM-based CVD to realize room-temperature single-electron transistors and surface-enhanced Raman spectroscopy devices.

This project is supported by DARPA TBN program under Dr. T. Kenny and Dr. Tayo Akinwande.

12:05 PM (DS-T7)

“Effect of surface bonding on semiconductor nanoribbon wiggling structure”

Speaker: Yu Zhang

Feng Liu
University of Utah: Department of Materials Science and Engineering

Minrui Yu, Donald E. Savage, Max G. Lagally, and Robert H. Blick
University of Wisconsin–Madison: Materials Research Science and Engineering Center

This presentation describes a very interesting phenomenon of SiGe nanoribbons bonded to Si substrate as experimentally observed in a Hall-bar structure. As one important class of stretchable electronics, SiGe nanomembranes and nanowires can be self assembled and directly integrated in electronic circuits. Therefore, understanding the interaction between SiGe nanostructures and substrate is very important. Based on continuum linear stability analysis, we establish a scaling rule between the wiggling period and surface bonding area in relation to the ratio of strain energy over the interfacial bonding energy. In experiment, SiGe nanoribbon was fabricated as Hall bars by growing SiGe multilayer structure on insulator (SiO$_2$). The mesa is then defined by optical lithography and dry etching. We found that unlike previous approaches of making wavy structures which used predefined bonding sites, the SiGe wiggled Hall-bar structure is completely self-assembled with no predefined bonding sites. The undulation width $l$ can be varied from 10 to 30 $\mu$m, the wavelength $L$ covers a range from 20 to 200 $\mu$m, and the amplitude $A$ can be as high as 8.7 $\mu$m. We believe such wiggling is related to the strain energy and the interfacial bonding energy. Through continuum linear stability analysis, a scaling rule is established between the wiggling period and surface bonding area. This provides guidance for future fabrication of
controllable wiggling structures using semiconductor nanomembranes. Such structures can be used as optical phase gratings or integrated into circuits for high performance stretchable electronics.

Energy, Catalysis, & Environment - Olympus Ballroom

10:35 AM (ECE-T8-P27)

“Impact of metallic nanoparticles on growth and secondary metabolism of a plant-beneficial Pseudomonad (Pseudomonas chlororaphis O6)”

Speaker: Christian Dimkpa

David Britt and Anne Anderson
Utah State University: Biological Engineering Program and Biology Department

Nanoparticles (NPs) of Ag, CuO and ZnO are antimicrobial for pathogenic bacteria such as Escherichia coli and Staphylococcus aureus. We are testing the effects of these “as-manufactured” NPs on an environmental bacterium that plays a role in plant growth promotion, Pseudomonas chlororaphis O6 (PcO6). Treatment with water-based suspensions of Ag NP and CuO NP affected cell growth in a dose-dependent manner. Cell inactivation of Ag NP was linked to the production of extra cellular reactive oxygen species; however, bacterial cellular polymeric substances could circumvent NP-induced cell death at a certain NP threshold. In contrast to Ag and CuO NPs, ZnO NP was less toxic to the cells. Using a Cu ion-specific chelator, we demonstrate that release of metal ions contributes to the activity of the NPs. As bacterial secondary metabolites are important in bacteria-bacteria (e.g., siderophores), bacteria-plant (e.g., siderophores, auxins) and bacteria-human (e.g., antibiotics) interactions, we investigated the effect of NPs on their production. Under conditions that promote the concomitant production of these plant-useful metabolites, sub-lethal doses of the NPs presented a flip story: Ag and CuO NPs stimulated the production of plant growth promoting microbial auxins, while ZnO NPs did not. ZnO NP promoted the production of iron-chelating siderophores while Ag NP, and especially CuO NP, suppressed siderophore production.

We conclude that the impact of NPs on bacteria varies, depending on the specific NP involved and that while NPs can completely inactivate environmental bacteria when present at high amounts, they can enhance or diminish the plant growth promoting potentials of plant-associated microbes when present in the environment at sub-lethal amounts.

10:50 AM (ECE-T9-P28)

“A nanofiber-based heterojunction approach for high photoconductivity in organic nanofibers”

Speaker: Helin Huang

Miao Xu, Chengyi Zhang, Benjamin R. Bunes, Yanke Che and Ling Zang
University of Utah: Department of Material Science and Engineering
This presentation describes a novel way to fabricate nanofiber-based heterojunctions to achieve high photoconductivity in organic nanofibers. We use carbazole derivatives as donor and perylene diimide nanofibers as acceptor materials. The donor molecules are adsorbed onto perylene diimide nanofibers by dropcasting. The adsorption is mainly due to donor-acceptor interactions and intermolecular alkyl chain interactions. By comparing the photocurrents, we find that the nanofiber structure is critical to facilitate efficient long-range electron migration, which cannot be achieved by controlled thin-film devices. Also, the alkyl chains play an important role in spatially separating the photogenerated charge carriers and hindering the charge carrier recombination. By adding different amounts of carbazole donors to the nanofibers, the photocurrent increases proportionally to the amount of donor molecules until saturation. The photocurrent can be reduced to a small value and recovered by washing or recasting, which confirms the physical adsorption on the surfaces of the nanofibers. It is also an interesting phenomenon that carbazole oligomers have a much stronger adsorption ability than the carbazole monomers by comparison of the saturation concentrations. Overall, this is a simple method to construct photoconductive organic materials for large-area photoelectronic devices with good electron transport channels.

11:05 AM (ECE-T10-P29)

“Size-dependent oxygen activation efficiency over Pd\textsubscript{n}/TiO\textsubscript{2}(110) and catalyst deactivation for the CO oxidation reaction”

Speakers: Matthew D. Kane, F. Sloan Roberts
William E. Kaden, William A. Kunkel, Scott L. Anderson
University of Utah: Department of Chemistry

The efficiency of oxygen activation and the subsequent deactivation of the CO oxidation reaction over Pd\textsubscript{n}/TiO\textsubscript{2}(110) (n = 4, 7, 10, 20) were examined using temperature programmed reaction (TPR) mass spectrometry and X-ray photoemission spectroscopy (XPS). The TPR was conducted over Pd/TiO\textsubscript{2} while varying exposure to O\textsubscript{2} and CO at selected temperatures. There are two distinct CO binding sites on Pd at 200 and 430 K and the CO\textsubscript{2} product desorbs between 170 and 450 K. The data show CO\textsubscript{2} production is correlated to the CO binding at 430 K, which is believed to be a high coordination binding site on the topside of the Pd cluster. For the sizes studied, larger shifts in the Pd\textsubscript{20} XPS correlate to the highest efficiency for oxygen activation. This suggests that at small oxygen exposures, CO\textsubscript{2} production is limited by competitive CO and O\textsubscript{2} binding, while the other clusters are limited by lack of activated oxygen.

Deactivation of the CO oxidation reaction under net reducing conditions is caused by strong metal support interaction (SMSI) which inhibits reactive CO binding to the catalyst. Loss of these active sites can be induced solely by 500 K thermal excitation with no changes to morphology, but a shift in Pd 3d binding energy indicates a change in electronic structure. After sequential TPRs, a drop in Pd ISS signal indicates either cluster encapsulation or a Ti species overlayer. The SMSI deactivation is partially reversible after oxygen exposure, but after three experimental cycles the catalyst is inactive.
“Design and fabrication of high-efficiency ultra-broadband diffractive optics”

Speaker: Ganghun Kim

Jason E. Kleinschmidt and Rajesh Menon  
University of Utah: Department of Electrical and Computer Engineering

Diffractive optics, or diffractive phase elements (DPE), have been widely used because they have significant advantages in size and cost over refractive optics. But they are limited to specific wavelengths, and their efficiencies drop dramatically as illumination wavelength varies.

We recently proposed a new design approach that we call Iterative Pixelated Perturbation Algorithm (IPPA) to design a DPE that can operate over a broad spectrum. Here, we demonstrate the efficacy of this approach by designing a broadband solar concentrator. Furthermore, we exploit the wavelength sensitivity of such elements to separate spectral bands for efficient photovoltaic power generation.

Since such optics require multiple levels, their fabrication tends to be more complex. We are developing a grayscale patterning process that enables fabrication of multi-level diffractive optics over cm-square areas. Here, we will discuss the challenges and innovative solutions associated with this fabrication process.

“Capped boron nanoparticle synthesis for suspension in both polar and nonpolar fuels”

Speaker: Brandon McMahon

Poster Presented by: Brandon McMahon & Paulo Perez  
Scott Anderson  
University of Utah: Department of Chemistry

This presentation will discuss the synthesis of capped boron nanoparticles, which can be selectively added to both polar and nonpolar fuels. Boron is a known highly energetic fuel that can be used to increase the energy density of common fuels. A simultaneous top-down size reduction and capping process allows for crude yet effective development of polarity-specific oxygen-protected boron nanoparticles for colloidal suspensions. This process has proven to be easily modified for specific applications as well as scalable. This approach allows for synthesis of nanoparticles within a fuel of interest, as well as evaporation of solvent with addition into other fuels of interest. An in-lab engineered Turbulent Flame Coil Calorimeter has been developed to measure the energetics of both polar and nonpolar boron modified fuels. Reflectance infrared Fourier-transform spectroscopy has been implemented to assist in determining the nature of attachment of specific capping agents. Size distribution was measured using dynamic light scattering (DLS) and scanning electron microscopy (SEM). Surface analysis of the particles was characterized using X-ray photoelectron spectroscopy (XPS) and zeta potential measurements. Capped boron nanoparticles have been shown to combust in a turbulent flame and produce an overall increase in the energy density of ethanol. This technology could have near future applications in the jet and rocket fuel industries.
11:50 AM (ECE-T13-P32)

“Enhanced light-trapping in thin-film silicon solar cells via embedded dielectric nanoparticles”

Speaker: James R. Nagel
Michael A. Scarpulla
University of Utah: Department of Electrical and Computer Engineering

This presentation summarizes our recent progress in the enhancement of light trapping in thin-film silicon solar cells. Through the use of finite-difference time-domain (FDTD) simulations, we have shown that dielectric nanoparticles embedded directly within the active layer of a 1.0 um silicon solar cell can increase the total absorption of sunlight by 20% relative to the same design without any particles. More complex particles utilizing metallic cores with dielectric coatings can increase absorption to as high as 40%. We also performed parametric sweeps on the particle’s depth and diameter to determine the optimal conditions for light-trapping. Embedded particles are more effective near the top of the cell than towards the back contact, and particle diameter should generally be minimized in order to avoid displacing the active semiconductor material. The benefit to the embedded nanoparticle concept is its compatibility anti-reflective coatings, which can readily improve light absorption by 40% on their own without any light-trapping schemes. This allows light-injection and light-trapping to be independently optimized, thereby maximizing the total light absorption within thin-film silicon solar cells.

12:05 PM (ECE-T14-P33)

“Surface characterization of CZTS absorber layers synthesized by solution-based methods”

Presenter: Prashant K Sarswat
Michael L. Free, Ashutosh Tiwari
University of Utah: Departments of Metallurgical Engineering; and Materials Science and Engineering

The efficiency of polycrystalline solar cells increases with increasing grain size of absorber material. Smaller nano-crystalline grains result in a large grain boundary per unit volume, which produces more recombination centers and hence reduced device performance. It is very desirable to produce a grain size that is on the order of film thickness to minimize recombination effects. Copper zinc tin sulfide (CZTS), an emerging wide band gap p-type absorber material, is synthesized by solution-based techniques (electrochemical and spin coating) followed by sulfurization at elevated temperature. In this study the grain size is modified and evaluated using a variety of analytical techniques. The deposition is carried out using different complexing agents and different solvents (for spin coating). The surface morphology and grain size from various synthesis conditions are reported and compared.
“Sub-wavelength optical patterning via optical-saturable transformations”

Speaker: Nicole Brimhall

Rajesh Menon
University of Utah: Department of Electrical and Computer Engineering

Trisha Andrew
Massachusetts Institute of Technology: Department of Chemistry

Optical lithography has many advantages; however, conventional optical lithography is limited by diffraction to feature sizes greater than about half the wavelength. Here, we report on an approach to optical patterning that exploits a sequence of spectrally-selective photochemical transitions to achieve deep subwavelength resolution. This approach, which we refer to as Patterning via Optical-Saturable Transformations (POST), involves only single-photon transitions and hence has the potential for massive parallelism and high speeds.

POST relies upon photochromic molecules, or molecules that undergo a reversible chemical transition from state A to state B when exposed to a specific wavelength of light, $\lambda_1$, and from state B to state A when exposed to a second wavelength of light, $\lambda_2$. In addition, POST requires a third ‘fixed’ state, accessible from only one of the two reversible photochromic states; for example, state C can be reached from state B but not from state A. Patterning is accomplished when a film of molecules in state B is exposed to a focused ring at $\lambda_2$. All regions in the film that receive a non-zero intensity will convert to form A. In the vicinity of the node, a small population of molecules will remain in form B. A subsequent transformation can convert this population to the fixed form C. Next, uniform illumination at $\lambda_1$ brings all the molecules in form A back to form B while the molecules in form C retain their state. After translating the sample, the process is repeated to create complex geometries in a “dot-matrix” fashion.

“A negative role for the ferritin nano-cage: Anion transport”

Speaker: Robert J. Hilton

Richard K. Watt and William M. Anderson
Brigham Young University: Department of Chemistry and Biochemistry

Ferritins are abundant iron storage proteins found in nearly all organisms. Ferritin has the unique ability to act as a nano-cage for the novel synthesis of a variety of materials, including metal nanoparticles. We describe another interesting aspect of ferritin to form novel iron-anion materials within the nano-cage. To form these materials, we reduce the Fe(O)OH core of ferritin with formamidine sulfonic acid. The Fe$^{3+}$ within ferritin is reduced to Fe$^{2+}$ and two hydroxide ions are released. The net result is one negative charge in (e$^-$) and two negative charges out (OH$^-$). To compensate for the charge imbalance on the
interior of ferritin, anions present in solution enter ferritin. These anions create a new mineral inside ferritin in the form of iron-anion hydroxide, Fe(X)OH. We demonstrate that a variety of anions are able to be pumped inside of ferritin, including F\(^{-}\), Cl\(^{-}\), Br\(^{-}\), I\(^{-}\), and ClO\(_4\)\(^{-}\). These novel nano materials may have applications in materials chemistry, redox reactions, and medicine.

3:35 PM (MC-T17-P36)

“Microfabrication of porous chromatography media with an application in thin-layer chromatography”

Speaker: David S. Jensen

Supriya Kanyal, Ricky Wyman, Robert Davis, Richard Vanfleet, Matthew R. Linford
Brigham Young University: Departments of Chemistry and Physics

Andrew Dadson, Michael A. Vail
US Synthetic, Orem, UT

Carbon nanotubes (CNTs) were used as a template material to produce novel silica-based thin-layer chromatography plates (TLC). The use of CNTs as the framework provides the precise collocation of the chromatographic absorbent by means of photolithography. The resulting CNTs are infiltrated with elemental silicon by chemical vapor deposition. These silicon-coated CNTs are annealed in air which removes the CNTs and converts the material to silica. The resulting material is extremely white, indicative of silica. This process produces silica-based TLC plates that are very porous and robust. Since this is a microfabrication process it excludes the need for a binder to adhere the TLC adsorbent to the backing. These robust microfabricated TLC plates circumvent the possible secondary interactions with the binder. The resulting normal phase microfabricated TLC plates are shown to give at least baseline separation of a CAMAG (Muttenz, Switzerland) dye test mixture (five components) using toluene as the mobile phase. The chromatographic efficiencies of these microfabricated TLC plates are approximately 70% higher than commercially available high-performance TLC plates and show a 150% reduction in development time. These microfabricated TLC plates provide both efficiency and speed of analysis.

3:50 PM (MC-T18-P37)

“Carbon-infiltrated carbon nanotube MEMS fabrication”

Speaker: Brian D. Jensen

Poster Presenter: Walter C. Fazio

Jason Lund, Walter Fazio, Taylor Wood, Robert C. Davis, Richard Vanfleet, David D. Allred
Brigham Young University: Departments of Physics and Mechanical Engineering

The purpose of this presentation is to describe a new material created using carbon nanotube microfarication (CNT-M) and its mechanical properties. This material has consistently demonstrated high maximum strain, which is a material property key to creating compliant mechanisms. We have
previously demonstrated carbon nanotubes as a framework for high aspect-ratio MEMS devices. To create the new material, we have used CNTs as a framework and infiltrated the CNT forest with carbon to create a cohesive structure. Our CNT forests were grown to between 100 and 300 microns high but reaching heights of 500 microns or more is very realistic. This high aspect ratio material can be attained without needing to implement etching processes. We have also investigated how several parameters in the carbon-infiltrated carbon nanotube microfabrication (C-I CNT-M) process affect the resulting material properties. We present the results of these tests to allow a greater understanding of how to handle the material to produce the desired properties for a given application.

4:05 PM (MC-T19)

“Controlled composition profiles of semiconductor alloy quantum dots and nanowires by selecting the growth mode”

Speaker: Xiaobin Niu

Gerald B. Stringfellow, Feng Liu
University of Utah: Departments of Materials Sciences and Engineering; and Electrical and Computer Engineering

Semiconductor alloy quantum dots (QDs) and nanowires (NWs) are promising building blocks for modern nanophotonic and nanoelectronic devices. The overall composition profiles of low-dimensional nanostructures are usually far from equilibrium due to limited bulk diffusion, but local equilibrium may be established in the surface regions via surface-enhanced diffusion. Consequently, the kinetic growth mode, which dictates surface mass transport and alloy mixing at the growth front, becomes a key factor in determining the kinetically limited composition profile. Here we report the discovery of a striking correlation between the composition profiles of epitaxial strained semiconductor alloy QDs and NWs with the growth mode, based on kinetic simulations of InGaN (GeSi) QDs and NWs. The layer-by-layer growth mode results in spontaneously-formed, core-shell structures with the core rich in the unstrained component (relative to the substrate), while the faceted growth mode leads to the strained core component. Our findings suggest a promising method for the control of the composition profile of semiconductor alloy QDs and NWs by selecting the growth mode.

4:20 PM (MC-T20-P38)

“Thin smooth carbon nanotube/polymer composite membranes”

Speaker: Lei Pei

Matthew R. Linford, Richard Vanfleet, Robert C. Davis
Brigham Young University: Departments of Chemistry and Biochemistry; and Physics and Astronomy

A straightforward method for fabricating freely suspended thin carbon nanotube (CNT) membranes infiltrated with polymers will be presented. CNT sheets are made by multiple methods including vacuum filtration of liquids containing suspended CNTs. The CNT films are transferred to solid substrates.
Nanotube – polymer composite film was then fabricated by spin casting a polymer layer on top of the transferred CNT sheet. If the solid substrate was coated with a polymer film prior to CNT transfer, a polymer/CNT/polymer sandwich was created. The composite membranes were subsequently released from the substrate. Strength tests were performed and microcharacterization of the films and membranes was done using scanning electron microscopy and atomic force microscopy.

4:35 PM (MC-T21)

“Chemical vapor deposition (CVD) of three aminosilanes on silicon dioxide: Surface characterization, stability, effects of silane concentration, and cyanine dye adsorption”

Speaker: Feng Zhang

Adam M. Larsen, Daniel A. Findley, Matthew R. Linford, Robert C. Davis
Brigham Young University: Departments of Chemistry and Biochemistry; and Physics and Astronomy

Ken Sautter
Yield Engineering Systems

Hussein Samha
Southern Utah University: Department of Physical Science

This presentation showed the deposition of covalently bonded monolayers of two monofunctional aminosilanes (3-aminopropyl(dimethylethoxysilane, APDMES, and 3-aminopropyl(diisopropylethoxysilane, APDIPES) and one trifunctional aminosilane (3-aminopropyltriethoxysilane, APTES) on dehydrated silicon substrates by chemical vapor deposition (CVD) at 150°C and low pressure (a few Torr) using reproducible equipment. Standard surface analytical techniques such as XPS, contact angle goniometry, spectroscopic ellipsometry, AFM, and ToF-SIMS have been employed to characterize the resulting films. These methods indicate that essentially constant surface coverages are obtained over a wide range of gas phase concentrations of the aminosilanes. XPS data further indicate that the N1s/Si2p ratio is higher after CVD with the trifunctional silane (APTES) compared to the monofunctional ones, with higher N1s/Si2p ratio for APDMES compared to APDIPES. AFM images show an average surface roughness of 0.12 - 0.15 nm among all three aminosilane films. Stability tests indicate that APDIPES films retain most of their integrity at pH 10 for several hours, and are more stable than APTES or APDMES layers. The films also showed good stability against storage in the laboratory. ToF-SIMS of these samples showed expected peaks, such as CN⁻, as well as CNO⁻, which may arise from an interaction between monolayer amine groups and silanols. Optical absorption measurements on adsorbed cyanine dye at the surface of the aminosilane films show the formation of dimer aggregates on the surface. This is further supported by ellipsometry measurements. The concentration of dye on each surface appears to be consistent with the density of the amines.
nanoMedicine - Olympus Ballroom

3:05 PM (NM-T22-P57)

“Nano-silver particle effects on drug metabolism”

Speaker: Michael R. Franklin

John G Lamb, Laura B Hathaway, Mark A Munger.
University of Utah: Departments of Pharmacology and Toxicology, and Pharmacotherapy

Nano-silver particles are present in many consumer and health care products. Solutions containing nano-silver particles comprising an elemental silver interior and an ionic silver oxide exterior (mean size, 10 nm) are available as ingestable preparations. From literature sources, mice fed 13 nm silver nanoparticles show signs of liver inflammation indicating access; and for in vitro cultures, 10 nm silver nanoparticles gained access to all subcellular compartments of liver cells. Since contact with drug metabolizing enzymes concentrated in hepatocyte endoplasmic reticulum is therefore to be expected with oral administration, the present study sought to evaluate whether nano-silver particles could affect the important liver cell function of detoxification and elimination of drugs, and be a potential source of unanticipated drug-drug interactions in the human population. The direct effects of nano-silver particles on the major drug metabolizing enzymes, the cytochrome P450s, was investigated for in vitro systems. The eight major P450s showed differences in sensitivity to inhibition by nano-silver with IC50 values ranging from < 10 uM silver (CYP2C19, CYP3A4, CYP2C9) to ~40 uM (CYP2A6, CYP2B6). P450s are notoriously subject to transcriptional up-regulation (induction) through drug-occupied receptors interacting with enhancer sequences in the gene. At 10 uM silver, nano-silver particles attenuated the rifampicin induction response via the pregnane X receptor mechanism by 50% and the omeprazole induction response via the Ah receptor by 30%. Extrapolating from in vitro observations, nano-silver particles reaching the liver can be anticipated to be a potential source of both inhibition- and induction-related drug-drug interactions.

3:20 PM (NM-T23-P58)

“Cellular uptake and biodistribution of targeted and non-targeted gold nanorods for photothermal therapy”

Speaker: Adam Gormley

Alexander Malugin, Abhijit Ray, Khaled Greish, Ryan Robinson, Joe Hui, and Hamid Ghandehari
University of Utah: Departments of Bioengineering; Pharmaceutics and Pharmaceutical Chemistry; Utah Center for Nanomedicine; Nano Institute of Utah; and School of Medicine

With a highly tunable surface plasmon resonance in the near-infrared (NIR) region depending on their size, gold nanorods (GNRs) have recently been investigated as antennas for the generation of tumor hyperthermia. As the surface functionality greatly dictates the extent of tumor delivery, GNRs were surface functionalized with poly (ethylene glycol) (PEG) terminating in either a methoxy group (non-targeted) or the RGDfK angiogenic targeting peptide (targeted) to increase the therapeutic ratio of photothermal therapy. Targeting was visualized in prostate cancer (DU145) and endothelial cells
(HUVEC) by dark field microscopy and quantified using inductively coupled plasmon mass spectrometry (ICP-MS). The biodistribution of the non-targeted GNRs was evaluated in non-tumor bearing mice by ICP-MS. Finally, the efficacy of the non-targeted GNRs to induce tumor hyperthermia was evaluated in DU145 tumor bearing nu/nu mice. Microscopy and ICP-MS results indicate a significant increase in GNR binding and uptake with targeted versus non-targeted GNRs in both cell types. This effect was most apparent with HUVEC cells which are known to significantly over-express the targeted receptor. In mice the non-targeted GNRs were primarily found in the liver and spleen after 24 hrs with a long blood circulation half-life. Finally, 2 minutes of laser radiation at 0.75 W/cm² resulted in significant tumor necrosis and tumor size reduction.

Financial support was provided by a pre-doctoral fellowship by the Department of Defense Prostate Cancer Research Program (PC094496), NIH grant R01DE019050, and the Utah Science Technology and Research (USTAR) initiative.

3:35 PM (NM-T24-P59)

“Anticancer and antiangiogenic activity of HPMA copolymer-aminohexylgeldanamycin-RGDfK conjugates for prostate cancer therapy”

Speaker: Abhijit Ray

Khaled Greish, Hillevi Bauer, Nate Larson, Alexander Malugin, Daniel Pike, Hamid Ghandehari
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry; Bioengineering; Utah Center for Nanomedicine; and Nano Institute of Utah

Tumors are dependent on neoangiogenesis for survival. Neoangiogenic vessels are made by dividing endothelial cells that over-express focal adhesion molecules recognizing specific peptide sequences in basement membrane proteins. The tripeptide sequence, Arg-Gly-Asp (RGD), binds to αvβ3 focal adhesion molecules on endothelial cells with high affinity. N-(2-hydroxypropyl)- methacrylamide (HPMA) copolymers containing side chains terminated in cyclic RGD show increased accumulation in prostate tumors. Coupling this targeting system to antiangiogenic agents can be a plausible strategy for tumor antiangiogenic therapy.

The geldanamycins (GDM) are benzoquinone ansamycins that have both antiangiogenic and antitumor activity. GDM binds with high affinity to the chaperone protein heat-shock protein 90 (HSP90). HSP90 is a major regulator of hypoxia inducible factor and vascular endothelial growth factor in the endothelial cells, and has nitric oxide-mediated proangiogenic effects. In this work the antiangiogenic and antitumor activities of targetable HPMA copolymer-RGDfK conjugates containing side chains terminated in aminohexylgeldanamycin (AH-GDM) were compared with non-targetable systems in vitro and in vivo. Copolymer-drug conjugates containing RGDFK showed superior activity against endothelial and prostate cancer cell lines in vitro as well as inhibition of angiogenesis in nude mice bearing prostate xenografts in vivo. At equimolar doses of the drug, the RGDFK-containing conjugates showed superior antitumor activity in the same xenografts models. These findings suggest the utility of HPMA copolymer-RGDFK conjugates for targeted delivery of AH-GDM with a dual mode of action.

Financial support was provided by the National Institutes of Health grant (R01-EB007171) and the Utah Science Technology and Research (USTAR) Initiative.
"Mechanism of cell death induced by amorphous silica nanoparticles"

Speaker: Alexander Malugin

Hamid Ghandehari
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry; Bioengineering; Utah Center for Nanomedicine; and Nano Institute of Utah

With an increasing use of nanomaterials in biomedical applications grows an apprehension about the possible toxic effects of nanomaterials and a demand to understand the mechanisms of their toxicity and interaction with biological systems. The purpose of this study was to assess the influence of size and surface functionalization of amorphous silica nanoparticles (SNPs) of 50 and 200 nm in diameter on their interaction with cultured murine macrophages. Confocal microscopy revealed fast kinetics of accumulation and differential intracellular localization of plain, amine- or carboxyl-terminated SNPs in RAW264.7 macrophages. Toxicological effects of SNPs depended both on the particle size and the presence of surface functional groups. Incubation of macrophages with plain and amine- but not carboxyl-terminated SNPs led to increased level of intracellular reactive oxygen species. Plain 50 nm SNPs caused mitochondrial membrane depolarization. All tested SNPs induced phosphatidyl serine transposition in plasma membrane but did not induce caspases-3 activation or Poly(ADP-ribose) polymerase-1 cleavage. Longer incubation times were required for surface functionalized particles to initiate cell death when compared to plain particles. The prevalence of necrotic mode of cell death was observed after treatment with plain SNPs. Plain SNPs induced more severe damage to plasma membrane compared to functionalized counterparts. It is concluded that plasma membrane damage and mitochondrial dysfunction should be considered as prime mechanisms of cell death induced by tested amorphous SNPs.

Financial support was provided by the NIH Grant R01DE19050, and the Utah Science Technology and Research (USTAR) Initiative.

“Contact-dependent gene transcription responses of skin and colon cells to nanosized ZnO”

Speaker: Philip Moos

John M. Veranth, Garold S. Yost
University of Utah: Department of Pharmacology and Toxicology

Metal oxides that have long been used as food and cosmetic ingredients are now being manufactured as nano-sized powders, and the unique physical properties of these nanomaterials have motivated speculation regarding toxicity. Our study used whole genome arrays to study in vitro responses of human-derived cell lines to nano-sized particles of four common chemicals that are used in topical products such as sunscreens and cosmetics: SiO₂, TiO₂, ZnO, and Fe₂O₃.
ZnO was the most cytotoxic of the tested materials and induced the greatest gene transcription responses in both colon- and skin-derived cells. Previously we showed contact was required for ZnO cytotoxicity. Genes related to metal metabolism were affected by soluble Zn, but two gene ontology pathways: GO:0051789 response to protein stimulus and GO:0006986 response to unfolded protein, were affected only when there was particle-cell contact.

Both nominally nanosized and conventional ZnO induced responses that differed from the response to soluble Zn and were cell-to-particle contact dependent. This work suggests that particles of commonly used metal oxides smaller than 100 nm have size-dependent differences in potency, but do not induce unique or unusual biological effects in human-derived cells compared to conventional powders of the same nominal substance.

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4:20 PM (NM-T27-P62)

“An innovative mechanism for cell constraint”

Speaker: Gregory H. Teichert

Brian D. Jensen, Larry L. Howell, Sandra Burnett, Quentin T. Aten
Brigham Young University: Departments of Mechanical Engineering; and Microbiology & Molecular Biology

The ability to introduce DNA into cells is a powerful tool in genetic research. Several methods of DNA injection have been developed, each of which require restraint of the cell during injection. MEMS devices provide a solution to the necessity of cell constraint. This presentation describes an innovative mechanism for cell constraint. The cell constraint mechanism employs two symmetric copies of a unique mechanism, which is termed a cylindrical mechanism due to its motion. The entire system is fabricated in a surface micromachining process. Input motion causes the cylindrical mechanisms to rise out of the plane of fabrication. As the input motion continues, two links move inward, toward each other, to capture and constrain the cell that is between them. The links include specially designed arcs which contact the cell along several nonparallel planes to better hold the cell in place. The benefits associated with this cell constraint mechanism include, among others, the ability to self-center the cell and high level of support to the cell during the injection process, including insertion and retraction. The constraint system has been tested to capture and constrain mouse egg cells during DNA injection. Constraint was found to be very strong, improving the ease of injection without causing damage or death to the cells. The presentation will include videos of the operation of the system during cell injections.
Dendrimers are branched polymers with controlled molecular sizes and multiple surface functional groups that are increasingly being employed in various biomedical applications. Extensive investigation of the effect of surface charge of dendrimers on biodistribution and their in vivo toxicity is necessary for potential clinical translation. In this study dendrimers were characterized by dynamic light scattering, zeta potential, titration and chromatography. Immune-competent CD-1 mice (6-8 weeks) were used to study the effects of toxicity. Dendrimers were also applied to human blood to visualize effects on clotting and were radiolabeled with $^{125}$I for biodistribution studies. Results show that amine-terminated dendrimers (G4-NH$_2$, G7-NH$_2$) were at least 30-fold more toxic compared to hydroxyl- (G4-OH, G7-OH) or carboxyl-terminated (G3.5-COOH, G6.5-COOH) dendrimers. Treatment with G4-NH$_2$ and G7-NH$_2$ also showed severe signs of hematological complications such as hemolysis, bleeding, and disseminated intra-vascular coagulopathy, and showed decreased fibrinogen levels and high levels of fibrin degradation products. Biodistribution profile of differentially surface functionalized dendrimers administered at sub-toxic doses showed that amine-terminated dendrimers (G7-NH$_2$) partitioned out of blood circulation as early as 2h and accumulated almost entirely in the liver whereas the carboxyl- (G6.5-COOH) and hydroxyl-terminated (G7-OH) dendrimers of comparable size were retained longer in blood and slowly excreted via the urine. Positively charged dendrimers could potentially opsonize proteins making them more susceptible to clearance by reticulo endothelial system. An observation was that dendrimers started appearing in the stool and gastrointestinal tract over time. Hepatocytes, rather than macrophages in the liver, could potentially take up these polymers to clear them through bile secretions.
“High-density ultra-efficient electrostatically driven low-pressure pneumatic valve banks”

Presenter: Doug Anjewierden

Greg Liddiard, Bruce K. Gale
University of Utah: Departments of Electrical and Computer Engineering; and Mechanical Engineering

With the increasing popularity of LOC systems and exploration into point-of-care medical diagnostics, the need for small, reliable, and disposable pneumatic microvalves is quickly emerging. Microfluidic systems enjoy many advantages due to their small footprint; however, often an entire laboratory bench top of support equipment is necessary for their proper operation.

This support equipment often includes, but is not limited to, an array of pneumatic microvalves. These microvalves are required for the pneumatic pumping and valving of on-chip samples and reagents. This paper presents a novel 64-valve, electrostatically driven, ultra power-efficient valve bank with a footprint no larger than a standard glass microscope slide. The valve bank is constructed of a sandwich of PMMA, chromium, parylene type c, and copper foil. The valves are actuated using a high-voltage power supply providing up to 1 kV. The devices have been tested to valve pressures of up to 7 psig.

Another novel attribute of this device is its disposable nature. Due to its high density, high efficiency, simple fabrication and low-cost materials, the device is ideal for portable and disposable analysis systems. Also, due to its thin profile, the device could easily be adapted to act as a pneumatic switching and routing layer in a larger LOC device.

“An asymmetrical cross flow-based split flow thin fractionation (SPLITT) system”

Presenter: Venu M Arremsetty

Bruce Kent Gale
University of Utah: Department of Mechanical Engineering

A growing need for the separation of nano particles may be solved by split flow thin cell fractionation (SPLITT). This work introduces a novel cross flow-based SPLITT microsystem that is capable of high-speed continuous separations based on size and density of the sample. Flow-SPLITT is a new member of SPLITT/FFF family of techniques that uses cross flow as the driving field and has potential to be more efficient than diffusion SPLITT or T-sensor. An asymmetrical cross flow-based SPLITT system has been used to separate 470 nm polystyrene nanoparticles and albumin in less than 15 minutes. The paper describes design, fabrication and characterization of this new separation technique that is capable
of small molecular weight biological separations. Work is still under progress to model the system to identify an optimized set of inlet flowrates, total flowrates, cross flow and two other outlets for high-resolution separation.

**DS-P8**

“Design, fabrication and characterization of micro-gyroscope”

**Presenter:** Venu M Arremsetty

**Massood Tabib-Azar**  
**University of Utah: Departments of Mechanical Engineering; and Electrical and Computer Engineering**

Gyrosopes are an essential part of navigation systems. In most cases, the high-end gyroscopes are hand polished hemispherical quartz that are excited in the vine glass mode and provide integrated rate information over many cycles. Microfabrication techniques are best suited to fabrication of precise and inexpensive gyroscopes. Many groups already have reported microfabricated gyroscopes. Here we report a very innovative gyroscope design based on a large number (N) of coupled 2-D mechanical resonators that when disturbed by rotation of their reference frame, they couple energy into other nearby resonators that enable measuring the angular velocity very accurately. We describe design and microfabrication of these coupled gyroscopes and their fabrication using deep reactive ion etching (DRIE). The gyroscopes foot-mass were single-crystal rectangular silicon with sizes ranging from 500 microns to 2000 microns. Characterization of the devices involved finding the resonant frequency of electrostatic vibrations for both the longitudinal and the angular axis of the devices. We will discuss the fabrication process and noise performance of these gyroscopes.

This project was supported by the USTAR program.

**DS-P9**

“Novel non-volatile memory devices based on ferromagnetic material”

**Presenter:** Karumbaiah N. Chappanda

**Massood Tabib-Azar and Faisal Khair Chowdhury**  
**University of Utah: Department of Electrical and Computer Engineering**

We discuss a novel non-volatile memory device based on silicon nitride bridges separated by a 5 nm gap. Electrically conducting ferromagnetic strips enable the bridges to be actuated using electrostatic and magnetic forces. The magnetic force along with electrostatic force and the restoring force generated by the residual stress in the nitride bridge, determine the equilibrium position of the two suspended bridges with respect to each other. The restoring force is strong enough so that when only magnetic force is present, the bridges do not touch each other. But when sufficiently large electrostatic force is added, the bridges touch each other. Owing to the very strong magnetic forces at very small distances,
once the bridges contact each other, the restoring force is not sufficient to separate them even when the electrostatic force is removed. To separate these bridges, a third ground electrode is used to pull down the bottom bridge. The device is fabricated on a silicon wafer consisting of 50 nm of LPCVD nitride. Square pits of 50 nm were etched in the nitride to reach the bare silicon that was used as the pull-down electrode. The exposed silicon is then oxidized to fill the pits. Then, the two Fe/nitride bridges that are perpendicular to each other were fabricated. Aluminum oxide deposited using ALD was used as the sacrificial layer to form the gap between the bridges. Design, fabrication and testing of these devices will be discussed.

This project was supported by the DARPA NEMS program under Dr. A. Lal and Dr. Tayo Akinwande.

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**DS-P10**

“Novel graphene bridge for NEMS-based switches”

Presenter: Karumbaiah N. Chappanda
Abhishek Mathur, and Massood Tabib-Azar
University of Utah: Department of Electrical and Computer Engineering

Graphene has become an important electronic material with the potential to enable Terra Hertz electronics and impressive NEMS devices. This presentation describes graphene chemical vapor deposition technique and a very novel device structure and fabrication technique that enables formation of graphene bridges between self-aligned copper electrodes. The graphene growth was carried out at 900 °C in 10 sccm C_2H_2 and hydrogen carrier gas at 5 mTorr. A very thin layer of copper on silicon was used as the substrate and ~1 nm graphene layer was grown on copper. Subsequently, lithography was used along with copper etch to produce free-standing graphene bridges supported under a thin layer of photoresist. The free-standing graphene was produced by over-etching the underlying copper under the bridge. The graphene bridges were then characterized and their electrical properties were measured using Agilent 4156C parameter analyzer. Graphene has very high electron mobility and promises to revolutionize NEMS switches as well as other electronic devices. We will discuss electrical and mechanical properties of graphene bridges and their applications in NEMS and sensors.

This project is supported by DARPA NEMS program under Dr. A. Lal and Dr. Tayo Akinwande.

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**DS-P11**

“1 V, 1 GHz, Sub-femto amp leakage MEMS switches”

Presenter: Faisal Khair Chowdhury

Karumbaiah C. Nanaiah, Massood Tabib-Azar
University of Utah: Departments of Electrical and Computing Engineering; and Bioengineering
Mico- and nano-electromechanical switches are good candidates in very low power electronics, leakage power management in 20-30 nm VLSI, FPGAs, harsh environment processors and related applications. Here we present the design and fabrication of MEMS switch structures with sub-10 nm air gap defined by a sacrificial Al₂O₃ deposited using Atomic Layer Deposition (ALD) technique. The devices have sub femto-amp leakage current, and actuation voltages around 1V. Our tungsten MEMS devices have shown highly reliable and repeatable switching characteristics and have withstood high-temperature testing without appreciable increase in their characteristics. The study conducted with these switches has served as a pathway for novel applications of MEMS structures in fabricating prototype computational circuits involving logic gates formed using MEMS devices. In addition, it has also led to the design and fabrication of MEMS-based magnetic memory devices and those that can survive high radiation environments while still maintaining its near perfect switching characteristics.

This project is supported by DARPA NEMS program under Dr. A. Lal and Dr. Tayo Akinwande.

DS-P12

“Pulsed infrared (IR) radiation-evoked calcium events in neonatal cardiomyocytes”

Presenter: Gregory M. Dittami

Richard A. Lasher, Robert W. Hitchcock, Sameera S. Dharia, Richard D. Rabbitt
University of Utah: Department of Bioengineering

Suhrud M. Rajguru
Northwestern University: Department of Otolaryngology

Neonatal rat ventricular cardiomyocytes were used to investigate mechanisms underlying transient changes in intracellular free Ca²⁺ concentration ([Ca²⁺]ᵢ) evoked by pulsed infrared radiation (IR, 1862 nm). Fluorescence confocal microscopy revealed IR-evoked [Ca²⁺]ᵢ events with each IR pulse (3-4 ms/pulse, 9.1 – 11.6 J/cm²/pulse). IR-evoked [Ca²⁺]ᵢ events were distinct from the relatively larger spontaneous systolic [Ca²⁺]ᵢ transients, with IR-evoked events exhibiting smaller amplitudes and shorter time constant. Both IR-evoked [Ca²⁺]ᵢ events and spontaneous systolic [Ca²⁺]ᵢ transients could be entrained by the IR pulse (0.2 – 1 pulse/sec), providing the IR dose was sufficient and the radiation was applied directly to the cell. Examination of IR-evoked events during systolic elevated [Ca²⁺]ᵢ periods revealed a rapid drop in [Ca²⁺]ᵢ followed by a transient increase in [Ca²⁺]ᵢ. Cardiomyocytes were challenged with pharmacological agents to examine potential contributors to the IR-evoked [Ca²⁺]ᵢ events. Three compounds proved to be the most potent, reversible inhibitors: 1) CGP-37157 (20 mM, N=12 cells, K=12 blocked), an inhibitor of mitochondrial Na⁺/Ca²⁺ exchanger (mNCX), 2) Ruthenium Red (40 mM, N=13), an inhibitor of the mitochondrial Ca²⁺ uniporter (MCU), and 3) 2-APB (10 mM, N=6), an IP₃ channel antagonist. Ryanodine blocked spontaneous systolic [Ca²⁺]ᵢ transients but did not alter the IR-evoked events in the same cells. This pharmacological array implicates mitochondria as the major intracellular store of Ca²⁺ involved in IR-evoked responses reported here. The biophysical mechanism(s) responsible for mitochondrial sensitivity to pulsed IR remains unknown.

Supported by NIH R01DC006685 and NIDCD R01 DC04928
DS-P13

“Nano-textured multilayer photoelectrochemical device to produce hydrogen from water using sunlight”

Presenter: Faisal Faruque

Massood Tabib-Azar
University of Utah: Departments of Electrical and Computing Engineering; and Bioengineering

We are developing devices that can photosynthesize hydrogen from water under sunlight. In one approach, we used a silicon p-n junction solar cell with a coating of very thin platinum, titanium and other catalysts to enhance the photosynthesis process. To increase the photo-voltage of the device, we used multiple p-n junctions. Characteristics of the multi-junction cell were further improved by incorporating atomic-layer deposited Al₂O₃ tunnel junctions and tungsten carbon nanopores (CNP) with 2-5 nm pores. These devices were then tested using both acidic and basic electrolytes under illumination. The pH level of the electrolytes ranged from 1 to 13. Photo-voltaic, photocatalytic, cyclic voltametry, I-V and SEM studies were carried out to study the device characteristics. The CNP enhanced the surface area of the photo-electrochemical cell and increased the efficiency of injecting electrons to produce hydrogen. The 1-10 nm thin layer of Al₂O₃ ALD reduced the leakage current and made improved the cell efficiency. The several I-V characteristics of the device showed the effect of hydrogen production under illumination and dark environment.

This project is supported by the USTAR program.

DS-P14

“High temperature stability tests for HPLC separations using a diamond-based core-shell reversed-phase material”

Presenter: Chuan-Hsi Hung

Landon A. Wiest, Matthew R. Linford
Brigham Young University: Department of Chemistry and Biochemistry

Andrew Dadson, Michael A. Vail
US Synthetic

A core-shell reversed-phase material, made of spherical, non-porous graphite cores and nanodiamond has previously been developed for HPLC. The core-shell particles packed into a 30 mm × 4.6 mm ID column were made with 3 μm graphite cores and 0.5 μm thick porous nanodiamond shells. These particles were made into a reversed-phase (C₁₈) material and separations of alkylbenzenes (ethylbenzene, n-butylbenzene, n-hexylbenzene, n-octylbenzene, and n-decylbenzene) were performed on them under high pH conditions. The initial motivation for the creation of this phase was to perform separations under extreme pH conditions. This presentation will focus primarily on the stability test of the columns under high temperature conditions as well as applications that this phase is uniquely suited to perform. Separations were performed with a mobile phase composition set at water:acetonitrile (40:60, v/v) at
pH 11.3 with triethyl amine and a temperature test for 40, 60, and 80 °C. Under higher temperature conditions, 80 °C, the material showed little to no degradation, and also a 35% improvement in efficiency over similar separations performed at 35 °C. At these temperatures back pressures were greatly reduced and resistance to mass transfer was very low as shown by the van Deemter plots obtained under the high temperature conditions. Separations of pharmaceuticals and other basic analytes were also performed further demonstrating the stability of this phase at high pH and high temperature.

**DS-P15**

“A programmable microfluidic system for selective RNA or DNA extraction from various raw biological samples”

Presenter: Michael Johnson

Jungkyu Kim, and Bruce Gale

University of Utah: Departments of Mechanical Engineering; and Bioengineering

A system is presented that promises to be a step towards universal sample preparation in its ability to take genetic material from various sample sources and selectively extract and purify nucleic acids (DNA or RNA). The entire extraction system provides a compact, portable control platform with minimal inputs (electrical power, a USB connector, and an optional pressure supply). The polydimethylsiloxane (PDMS) microfluidic that performs the main fluid handling tasks of the system is fabricated in three layers. The PDMS chip contains on-chip valves, channels, reservoirs, and pumps that are all pneumatically controlled via electrically actuated solenoid valves. A LabView computer program operates the solenoid valves in sequence to perform a variety of tasks such as sample input, lysis, incubation, mixing, extraction, cleaning, etc. The PDMS chip also has input ports for the reagents required to extract nucleic acid from a variety of samples. The extraction process operates by pumping the sample and various buffers and solutions through integrated pipetting/mixing reservoirs and past the extraction filter. Altering the amounts, types, and sequences of reagents used is easily accomplished by adjusting the control program, which allows selective adjustment of the protocol to handle different sample types and control the output as DNA, RNA or both. The ability of the system to handle different sample inputs is demonstrated by extracting DNA from both a stock DNA solution and whole blood, and by extracting RNA from both a stock RNA solution and living E. coli cells.

**DS-P16**

“Pneumatically driven 16-channel disposable nucleic acid filter device with integrated demultiplexing and multiplexing”

Presenter: Greg Liddiard

Erik Liddiard, Bruce K. Gale

University of Utah: Departments of Electrical and Computer Engineering; and Mechanical Engineering
Filter-based nucleic acid (NA) extraction systems are growing in popularity. A unique advantage of filter-based nucleic extraction systems is their relatively straightforward fabrication of major extraction system components. Unlike their centrifugation-centric counterparts, integrated soft lithography solutions don’t require complex, power-hungry, poorly scalable centrifuges to separate NAs from the sample material. Instead, the solution is passed through a filter which provides a binding surface whereby NAs can be temporarily attached. These NAs are later released in the presence of an elution buffer. This method, along with other solid state extraction schemes, has demonstrated extraction efficiencies comparable to those attained with a conventional centrifugation process.

A challenge presented by this type of system is the regeneration of the filter material. If proper elution and sterilization are not performed, cross-contamination is almost guaranteed; consequently, in most cases the filter is disposable. Extraction systems, though, can be complex and may not be disposable, so an interface between disposable and reusable components is necessary. This paper presents a novel solution that can act as a stand-alone device or can be integrated into a larger system. We propose a disposable or limited use filter ring containing 16 individual filters, each addressable by means of pneumatically driven microvalves.

The device offers a single input and single output. All demultiplexing and multiplexing of the solution is handled inside the device. By integrating demux/mux capabilities the device can be quickly integrated into any current single filter system.

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**DS-P17**

“Design and moving mechanism of SEM-actuated levitation trains”

Presenter: Keng-Min Lin

Ian Harvey, and Brian Baker

University of Utah: Department of Mechanical Engineering; and Utah Nanofabrication Laboratory

This presentation discusses design concept and actuation mechanism of several scanning electron microscopy (SEM)-actuated levitation trains. Electrostatic repulsive and attractive forces between train carriages and ties are used to suspend and guide the trains. Sandia National Laboratories equipment is used to design and build these five-layer polysilicon levitation trains. The maximum thickness of the trains is 13.6 microns with each layer no more than 2.25 microns, and the maximum theoretical movement of the train is 1 mm each way.

These levitation trains can be divided into two categories: I-beam tie systems and electrostatic micro-fan systems. The former consists of I-beam tie series with a floating omega-shape train. The latter consists of a series of ties with a floating “U” shape train constrained in walls based on the concept of a micro-fan actuated by electrostatic repulsive force between the fin and the rails. For both designs, when applying given range of SEM accelerating voltage to raster actuation area in the systems, incident electrons will stay in both the train carriage and the ties, leaving them negatively charged; thus, train carriages are suspended on the ties. In some systems, additional positive charging plates connecting to the ties give attraction force in desired direction. The actual trains will be tested in November 2010.
DS-P18

“Deep subwavelength patterning via absorbance modulation”

Presenter: Rajakumar V. Manthena

M. Diwekar, Rajesh Menon
University of Utah: Department of Electrical and Computer Engineering

T. L. Andrew
Massachusetts Institute of Technology: Department of Chemistry

This presentation will describe Absorbance Modulation, which is a novel optical patterning technique that has the ability to overcome the far-field diffraction barrier. In our implementation of absorbance modulation, a standing wave at $\lambda_2$ (633 nm) is overlaid with a uniform beam from a light-emitting diode with a center wavelength at $\lambda_1$ (310 nm). Both beams illuminate a photoresist film overcoated with a photochromic layer. This photochromic layer localizes the transmitted light at $\lambda_1$ to sub-wavelength spatial dimensions. The sub-wavelength lines are spaced by a diffraction-limited grating period. In order to generate dense lines, the sample is mounted on a single-axis high-precision scanning stage that will enable multiple exposures.

The photoresist layer is separated from the photochromic layer by a barrier layer composed of poly-vinyl alcohol (PVA). Moreover, the small photochromic molecules are typically doped into a support polymer matrix such as PMMA for easy spin-casting. After exposure, the photochromic layer and the barrier layer are removed prior to development. In this presentation, we will describe our experiments that study the efficacy of the barrier layer and also the effect of different photoresists. Finally, we will report on our process for transferring the pattern from the thin imaging layer into the underlying substrate.

DS-P19

“A modular controller for an atomic layer deposition system”

Presenter: Abhishek Mathur

Massood Tabib-Azar
University of Utah: Departments of Electrical and Computer Engineering; and Bioengineering

Our group is involved in developing an AFM-based nanometer scale chemical vapor deposition (CVD) technique. To enable good control over the flow rates of different gasses for the AFM probe to deposit silicon quantum dots, a computerized gas control unit was required. In this talk we discuss the flow rates and various gases that are needed in AFM-CVD. The gas controller unit enables the desired gases to be delivered directly to a functionalized AFM with integrated channels that take these gases to the region near the probe tip. The gas control system is modular and incorporates solenoids, relays, mass flow controllers and temperature controllers. Sublimation chambers are integrated into the system to sublimate solids in a stream of inert gas to deposit metals such as Ni and Fe using nickelocene and ferrocene. The flow of gas can be measured and controlled down to 0.01 sccm and with less than 0.1 °C/s variation in temperature. The maximum flow rate pulse delivers 4 ml/s. The LabView controller is
capable of detecting error in the system as well as errors in user input and takes appropriate action to
preserve the safety of the environment and the integrity of the system. The system is remotely controlled
and monitored using serial interfaces, data acquisition boards and an interactive display with a low
reaction time. We will discuss the issues involved with the design and interfacing of the controllers and
their applications in tip-based nano manufacturing and reactive deposition on a substrate.

This project is supported by DARPA TBN program under Dr. T. Kenny and Dr. Tayo Akinwande.

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**DS-P20**

“Using nanoreactors to develop biosensors”

Presenter: Spencer Plott

Yen-Chi, Chen, Dr. Agnes Ostafin
University of Utah: Department of Materials Science and Engineering

Nanoreactors can be used as active elements in a variety of sensor platforms including those for diabetes.
For such sensors, chemically responsive dyes are loaded inside phosphatidycholine-based liposomes
and covered with a thin mineral shell created from calcium and phosphate. These nanoreactors can
be attached to a glass slide using the Langmuir-Blodgett film technique to create a film of chemically
sensitive nanoreactors. If this layer is then in contact with a specific analyte, it can cause a change
in the optical property of the nanoreactor allowing read-out. In this work we investigate the process of
making nanoreactors and their use.

Currently I am working on the process of creating a viable nanoreactor using fluorescent and non-
fluorescent dye molecules. Spectroscopic and photostability behaviors of nanoreactors made using
fluorescein, eosin Y, and methylene blue are compared. The results show that inside the nanoreactors
dyes, which are normally damaged by excessive light exposure, are more resilient. Reasons for this, and
the relationship to encapsulated dye concentration, are discussed.

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**DS-P21**

“DNA origami template assembly and surface placement for nano-scale electronic circuits”

Presenter: Elisabeth Pound

Jeffrey R. Ashton, James A. Havican, Anthony C. Pearson, Robert C. Davis, John N. Harb, and Adam T.
Woolley
Brigham Young University: Departments of Chemistry and Biochemistry; Physics and Astronomy; and
Chemical Engineering

DNA's self-assembly and programmability through base pairing make it an excellent building block for
nanostructures. I am using the technique of DNA origami to assemble templates for the fabrication
of nano-scale electronic circuits. I have designed and assembled several narrow and branched DNA
origami structures as well as prototype circuit DNA origami templates. These structures are well suited as templates for making metallic nanowires. Surface placement is also a key issue in assembling circuit structures. We have attached DNA origami to two-dimensional gold nanoparticle arrays as a step towards selective surface attachment. Current work includes continued improvement in selective placement of DNA origami on patterned surfaces and controlled metallization of DNA templates. DNA origami templates, in combination with surface attachment and localization, metallization of the DNA template into conductive wires, and the placement of semiconducting elements, should enable the bottom-up fabrication of nano-scale circuits.

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**DS-P22**

“Fabrication of an MRI standardization device from stacking highly patterned thin PDMS layers”

Presenter: Raheel Samuel

Himanshu J. Sant, Bruce K. Gale
University of Utah: State of Utah Center of Excellence in Biomedical Microfluidics

Fangxiang Jiao, Christopher R. Johnson
University of Utah: Scientific Computing and Imaging Institute

Magnetic resonance imaging (MRI) is a widely used biomedical imaging technology. The magnetic resonance image is formed by detecting the nuclear magnetization (caused by powerful magnetic fields) of hydrogen atoms in water, which are prevalent in the human body. We present a unique fabrication method of a multilayered polydimethylsiloxane (PDMS) device that can be used as a physical model for the standardization of Diffusion Tensor MRI machines. The device consists of 30 stacked, 10 µm thick PDMS patterned layers. Each 10 µm layer is stacked by a unique air pressure technique which helps in laying the layers flat on top of each other without any trapped air bubbles or wrinkles, which are common problems associated with bonding of thin PDMS layers on flat substrate surfaces. Each layer includes 1000 microchannels that are filled with deionized (DI) water—leading to 30,000 parallel microchannels in a 1.5 cm × 1.5 cm (top surface area) micro-device. Furthermore, having the ability to make thin patterned PDMS layers (that can be stacked) can help in increasing the analytical ability and functionality of PDMS-based microfluidic devices and micro-electromechanical systems in general.

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**DS-P23**

“Evaluation of in-vitro functional stability and recording longevity in fully integrated wireless neural interfaces based on Utah Slant Electrode Array (USEA)”

Presenter: Prashant Tathireddy

A. Sharma, L. Rieth, R. Harrison, R. Normann, G. Clark and F. Solzbacher

University of Utah: Departments of Electrical and Computer Engineering; and Bioengineering
H. Oppermann, M. Klein, M. Töpper, E. Jung
Fraunhofer Institute for Reliability and Microintegration, Germany

There has been a growing interest to develop biomedical implants for use, e.g., in neuroprosthetics that can provide an electrical interface to the human nervous system and to allow treatment of patients with neurodegenerative diseases, sensory, or movement dysfunctions. One example is a 100 electrode neural interface based on the Utah Slant Electrode Array (USEA), which is designed to record and stimulate from peripheral nerves. One of the most significant challenges for implanted neural interfaces is the percutaneous connectors, which are likely to cause infections during chronic use. To eliminate the use of wired connections, we are developing fully integrated wireless neural interfaces. These implantable wireless neural interfaces must be designed to eventually function in-vivo for years. We evaluate the long term in-vitro functional stability and recording longevity of fully integrated and encapsulated USEA/integrated neural interface-recording version 5 (USEA/INI-R5) wireless systems. In vivo wireless recording of neuronal data using USEA/INI-R5 has been recently demonstrated in an acute experiment. The USEA/INI-R5 employed Parylene-C as an encapsulation layer and was immersed in phosphate buffered saline (PBS) for a period of over 200 days. The full functionality together with the ability to track artificial neural signals for >200 days of PBS soak provides a measure of the encapsulation reliability, and the functional stability in the integrated neural interface. These results potentially evaluate the usefulness of wireless neural interfaces for future chronic implants.

This work was supported by NIH/NINDS Contract No. HHSN265200423621C, and by DARPA under Contract No. N66001-06-C-8005.

DS-P24

“Detection of H₂ using NiO thin films at high temperatures in gas mixtures”

Presenter: Hannwelm Steinebach

L. Rieth and F. Solzbacher
University of Utah: Departments of Materials Science and Engineering; Electrical and Computer Engineering; and Bioengineering

Gas sensors operating at high temperatures (T>500 °C) that can operate near combustion engines are needed to improve combustion control and to monitor and control emission. We investigated the effects of film thickness and operating temperature on the gas sensitivity of NiO films for sensing H₂. 50 nm films had the best sensitivity and were further characterized for repeatability and selectivity. The gas sensing properties were correlated with the microstructure and surface morphology of the deposited films as measured by XRD and AFM, respectively. Gas sensor responses were tested at temperatures from 300 to 650 °C for H₂ test gas concentrations ranging from 500 to 10,000 ppm in a synthetic air carrier gas. After annealing, 50 nm thick films showed the highest surface roughness of 14.6 nm and the highest gas sensor response at all operating temperatures tested. An average gas sensor response of 55 was found at an operating temperature of 600 °C and an H₂ concentration of 5,000 ppm. Repeatability measurements were collected at 600 °C for 8 hours using H₂ 11 times at concentrations varying from 500 to 10,000 ppm. Selectivity was investigated for individual test gases and gas mixtures containing 1,100 ppm CO₂, 150 ppm NH₃ and 50 ppm NO₂. Selectivity and sensitivity decreases as the operating temperature increases.
**DS-P25**

"Microfluidic magnetic particle fractionation device"

Presenter: T. Onur Tasci

Bruce K. Gale  
University of Utah: Departments of Bioengineering; and Mechanical Engineering

In this study, modeling of a microfluidic magnetic particle fractionation system was implemented. Simulations showed that by using AC and DC magnetic field gradients, size fractionation of magnetic micro and nano particles can be achieved effectively.

Today, magnetic micro and nano particles have many applications in bio-medicine, such as magnetic separation of labeled cells; drug and gene delivery; RF hyperthermia; and contrast agents for MRI. In these applications, better results are achieved as the distribution of the particle sizes approaches monodisperse distribution. As a result, an effective method of particle separation should be implemented.

In this study, we showed a model which uses both AC and DC magnetic field gradients for effective separation of the particles. Equal but opposite DC magnetic fields are applied from the sides of the fluidic channel and they cancel each other along the channel axis. A region having approximately zero magnetic field (Hz) is produced in the middle of the channel, which can be named as Field Free Region (FFR). As a result of this magnetic field gradient, bigger particles are attracted to the side walls, and the smaller particles reside in the middle of the channel. The pumping of the nanoparticles is achieved by applying additional sinusoidal currents to the coils where $I_{coil} = I_{offset} + \cos(2\pi f t)$. In this way, particles residing in the FFR will be pushed from inlet to outlet.

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**DS-P26**

"Design of an independent blood-brain barrier module for micro cell culture analog studies"

Presenter: Ross Booth

Hanseup Kim  
University of Utah: Departments of Bioengineering; and Electrical and Computer Engineering

We present a design for a microfluidic module to emulate the presence of the blood-brain barrier (BBB) in a micro cell culture analog (µCCA) system integrating neuron culture. µCCAs provide a microfluidic platform which accounts for organ-organ interaction, and could have significant value for drug development studies.

To accurately model systemic interactions with neural cells, a µCCA component must be developed which can mimic the presence of the BBB. A currently popular BBB model consists of a microporous membrane separating an endothelial cell layer from a layer of astrocytes. The primary physical barrier in the BBB is the presence of tight junctions (TJ) in the endothelial cell layer. We observed through immunofluorescence that the immortalized mouse brain endothelial cell line bEnd3 expresses ZO-1, a major tight junction component.
We designed an independent module to fit snapwell inserts (Corning) which have 10 μm thick polycarbonate membranes. Cell layers can be cultured to confluence in a traditional 6-well format prior to device assembly. The top and bottom pieces of the module were fabricated from poly-dimethylsiloxane (PDMS). PDMS was also used to make gaskets for an airtight seal around the culture chambers.

The surface area exposed to fluid flow in both chambers is approximately 6.15 mm². The channels are stepped from 740 μm exterior to 610 μm interior diameters. This provides a more physiologically relevant environment than in traditional static models. The device can be connected to one or more μCCAs via a shared reservoir, allowing for flexibility in experimental design.

**Materials & Characterization**

**MC-P39**

“Synthesis and characterization of responsive nanoporous materials”

Presenter: Alexis E. Abelow

Ilya Zharov

University of Utah: Department of Chemistry

Self-assembled nanoporous films and membranes (nanofrits) can be prepared by vertical deposition of silica spheres (ca. 250 nm diameter) from their colloidal solution. Molecular transport in these materials can be controlled at the nanoscale via attachment of responsive functional groups to the surface of the nanopores. Thus, the surface of these nanopores has been modified with polymers and oligonucleotide-based macromolecules.

The first of these polymers is a polypeptide (poly(L-alanine)) brush, grown on the surface of nanopores inside the colloidal films. Polymer length was controlled by polymerization time to produce temperature and pH responsive polypeptide brushes on the surface of the nanopores. The second polymer is an oligonucleotide-based binder, or aptamer, which acts as a small molecule receptor. A cocaine-sensing aptamer has been immobilized inside the nanopores and changed conformation in response to cocaine in solution, thereby altering the nanopore size.

The third type of system described includes two electrically active polymers, polypyrrole (PPy) and poly(3,4-ethylene-dioxythiophene) (PEDOT), which have been polymerized onto commercially available alumina Anodisc membranes to produce electrically active, free-standing, nanoporous membranes. These Anodiscs were used in a proof of principle experiment to show that surface modification is possible and produces a membrane which is responsive as either a zero, positive, or negative potential is applied.

Thus, we have developed three types of nanoporous membranes that respond to changes in pH, temperature, small molecule concentration, and electric potential.
MC-P40

“Nanoscale deposition, patterning, and measurement at the University of Utah Nanofab”

Presenters: Brian Baker and Brian Van Devener

Ian Harvey
University of Utah: Utah Nanofabrication Laboratory; and Department of Mechanical Engineering

Several new tools at the University of Utah Nanofab enable nanoscale fabrication and characterization. The results of process characterization for each tool are presented along with potential applications. The tools discussed include the Fiji Atomic Layer Deposition (ALD) system for aluminum oxide deposition, the Oxford 100 ICP Deep Reactive Ion Etcher (DRIE) for nanoscale silicon etching, the FEI Quanta 3D FEG Focused Ion Beam (FIB) system for direct-write patterning, the Xactix Xenon Diflouride silicon isotropic etcher, the EVG 520IS for Nano Imprint Lithography (NIL), the Veeco Dimension Icon PT atomic force microscope (AFM) and Kratos Axis Ultra DLD (XPS, AES, ISS) for surface characterization, and the FEI Quanta 600 FEG Scanning Electron Microscope (SEM) for imaging of delicate samples. These tools are valuable resources to the nano community in Utah because they can be accessed by academic and industrial researchers, helping them to build and analyze nanoscale devices and materials.

MC-P41

“New organically modified silica (ORMOSIL) materials with applications in complex particle design”

Presenter: Eric M. Brozek

Ilya Zharov
University of Utah: Department of Chemistry

Silica and modified silica particles/tubes have found a variety of applications in materials science, nano-fluidics and even drug delivery. Silica particles are typically synthesized using the well known “Stöber method” in high yields with size control between tens of nanometers to microns in diameter. The end particle is covered in silanol functionalities that can be post modified with a variety of materials, ranging from simple dyes to complex polymers. A new series of ORMOSIL particles has been designed and synthesized possessing a variety of organic handles throughout the particle. The organic moiety induces a natural porosity throughout the particle that allows for additional modification of the material both internally and externally.

The organically modified silane of choice (mercapto, cyano, alkenyl, etc.) was added via syringe pump to a round bottom flask charged with water and ethanol to act as the solvent system, and sodium hydroxide which catalyzed the condensation of the silica precursor. The solution was stirred overnight to yield a white precipitate easily collected via centrifugation. The precipitate was washed, dried, and collected as a uniform white powder. The powder was analyzed via scanning electron microscopy to observe shape and size distribution of the solid. Thermogravimetric analysis and IR data were collected to confirm the preservation of the organic handle. Additionally, the vinyl-enriched silica particles could be further optimized to induce large pores within the particle by the addition of a surfactant and simple modification of the general experimental method. Post modification has already shown great promise.
MC-P42

“A study of surface diffusion of metals in tungsten for NEMS applications”

Presenter: Karumbaiah N. Chappanda

Massood Tabib-Azar
University of Utah: Department of Electrical and Computer Engineering

Our group is developing strategies to form well-defined air gaps between structural materials for applications in nano-electromechanical switches, high-frequency acoustic delay lines and nanopores for bio sensing. Tungsten is a refractory metal with good conductivity and very high Young’s modulus that we use to fabricate high-speed and low-voltage NEMS switches for high-temperature applications. An interesting technique for creating nano-scale air gaps is to use diffusion of metals in other structural metals. In some cases, the diffusion process depletes a region near the surface and forms the desired gap. In this presentation the solid diffusion behavior of different metals on tungsten is discussed.

100 nm thick tungsten was sputtered on 100 nm LPCVD silicon nitride on silicon wafer. Various metals were then deposited on tungsten and patterned using lift–off technique. These metals on tungsten films were thermally annealed in steps of 10, 20 and 30 minutes at 500˚C in nitrogen. The changes in surface roughness and film thickness were studied extensively using AFM. We then measured the film conductivity using I-V technique to track the resistivity of the metal-W devices with thermal annealing. We will discuss the incorporation of this technique as sacrificial layer for gap generation without etching any materials. We also show that some metals on W reduce its surface roughness and some increase it. We will show how film thickness, roughness, and resistivity undergo upon annealing and unintentional heat treatment in device fabrication processes.

This project is supported by DARPA NEMS program under Dr. A. Lal and Dr. Tayo Akinwande.

MC-P43

“Metallization of DNA origami for nanocircuits”

Presenter: Yanli Geng

Jianfei Liu, Elisabeth Pound, Shailendra Gyawali, John N. Harb, Adam T. Woolley
Brigham Young University: Departments of Chemistry and Biochemistry; and Chemical Engineering

Metal nanostructures for reduced feature-sized circuits have been fabricated using “bottom up” technology. To satisfy the demands of future generations of devices, it’s essential to have more complex templates than linear features to fabricate nanocircuits. DNA origami has attracted more and more interest since its first demonstration by Rothemund, due to the arbitrary and complex 2D and 3D shapes that can be formed, and that show promise for templating nanocircuits. Here, we use DNA origami as a template to make metallic nanostructures, and demonstrate a relatively simple method to metallize those structures on surfaces. The process consists of two steps after putting DNA origami on a surface: palladium seeding and palladium/gold plating. The seeding process entails Pd activation followed by reduction to get Pd seeds on the DNA origami. It’s important to control the experimental conditions during the metallization process, as DNA origami is smaller and less stable than typical linear double-stranded
DNA. Several factors that influence the metallization results include standing time for DNA origami on a surface before seeding, activation time and magnesium ion concentration in the activation solution. We have now made metallic (Au and Pd) nanostructures using DNA origami templates that resemble circuit architectures. AFM results showed that the diameter of plated lines was around 40 nm. SEM data demonstrate that the structures are metallized continuously and selectively. Additionally, SEM-EDX confirmed the composition of the nanostructures. We are presently working on electrical conductivity measurements on these nanostructures.

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**MC-P44**

“Perfluorocarbon surfactant systems designed for nano emulsion-based oxygen carriers”

Presenter: Kyu-Bum Han

Curtis Takagi, Agnes Ostafin
University of Utah: Department of Materials Science and Engineering

A perfluorochemical emulsion is useful as a carrier for the transport of oxygen to body tissues. Manufacture of stable emulsions relies on the proper selection of surfactants and must be balanced with the cost of the manufacturing process. Three ternary phase diagrams were generated to discover the conditions for a stable homogeneous solvent/solute nanoemulsion: 1) perfluorooctylbromide/1,2-dioleoyl-sn-glycero-3-phosphatidic acid/water 2) perfluorooctylbromide/L-alpha-phosphatidylcholine (95%, soy)/water, 3) perfluorooctylbromide/L-alpha-phosphatidylcholine (95%, soy)/sodium phosphate buffer were determined to discover the conditions for stable homogeneous solvent/solute nanoemulsions. Particle size was refined by choice of stirring, extrusion, or sonication. Using density as a tool for separation, hematocrit centrifugation was used to compare the relative densities of the products relative to whole blood, in order to determine the efficiency of nanoemulsion formation. Further coating of the nanoemulsions with calcium hydrogen phosphate (CaHPO$_4$·2H$_2$O), maintained the sample density, size and morphology but also showed reduced hemolysis of red blood cells compared to nanoemulsion alone.

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**MC-P45**

“Dilute magnetic semiconductors: ZnO doped with transition metals”

Presenter: Jared Hancock

Roger G. Harrison
Brigham Young University: Department of Chemistry and Biochemistry

Zinc oxide is widely studied as a semiconductor. Semiconductors can be used to develop microprocessors capable of handling information at high speeds. This process could be enhanced in the semiconductor material by incorporating magnetic materials. Magnetization in a fixed direction without a power supply is used for storage of information. The combination of the two processes could lead to faster
and cheaper devices. Dilute magnetic semiconductors (DMS) are being created with small amounts of magnetic impurities. DMS can be made through a variety of syntheses.

Our synthesis of the ZnO nanoparticles (NPs) is realized at low temperatures, minimal equipment and reproducible integration of the transition metals manganese and cobalt, (Zn$_{1-x}$M$_x$O). The cobalt and manganese content is measured with various instruments, but can also be tracked by the significant color change in the white ZnO powder to blue and yellow powders respectively. Metal dopants in the ZnO nanoparticles have been shown to cause changes in the physical characteristics. The self-assembled microstructures of nanoparticles are spherical in shape with most containing hollow centers. The microstructures deform and diminish in size through the addition of Co and Mn. Lattice fringe alignment between the NPs is also disrupted at higher concentrations of each metal dopant.

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**MC-P46**

“pH-responsive transport through free-standing colloidal membranes”

Presenters: Patricia Ignacio-de Leon & Marcus Keyes

Ilya Zharov
University of Utah: Department of Chemistry

Free-standing nanoporous membranes (nanofrits) composed of gold-coated sintered 275 nm silica spheres have been surface-modified with the goal of achieving charge-selective transport within the nanopores. We modified the nanopore surface with polyelectrolyte poly(methacrylic acid) (PMAA), grown via ATRP from a surface-bound thiol initiator. The polymer chains were between 20 nm and 110 nm long, and the surface coverage was about 7 chains/nm$^2$. PMAA brushes are well known to exhibit swelling at higher pH values of the solution as a result of electrostatic repulsion between the carboxylate groups along the chain. Diffusion experiments of a neutral dye, ferrocene carboxaldehyde, through the PMAA-modified nanofrits showed ca. 13-fold increase in flux upon addition of an acid. Under the acidic conditions, higher diffusion rates are observed since the fully protonated polymer backbone could then collapse onto itself leading to larger pores within the membrane. These results illustrate that transport through these membranes can be controlled via electrostatic effects. We then studied the diffusion of a cationic dye, Rhodamine B, with the expectation of observing the same trend as above. Interestingly, a 16-fold decrease in flux is instead observed in the presence of the acid. We will present a rationalization for these results.

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**MC-P47**

“Novel silica-based microfabricated reversed-phase thin-layer chromatography plates manufactured using carbon nanotubes as the framework”

Presenter: Supriya S. Kanyal

David S. Jensen, Rob Davis, Richard Vanfleet, Matthew R. Linford
Brigham Young University: Departments of Chemistry and Biochemistry; and Physics and Astronomy
A novel method for manufacturing microfabricated reversed-phase TLC plates is accomplished. These TLC plates are manufactured by transferring a zig-zag pattern of ca. 5 μm features onto substrates using photolithography. Carbon nanotubes (CNTs) are grown on these patterned wafers with the help of a uniformly sputtered catalyst (Fe). Infiltration of the CNTs with polysilicon is done using low-pressure chemical vapor deposition (LPCVD) followed by oxidation at 1000°C to give silica (SiO₂)-based TLC plates, which are mechanically stable, robust and outperform commercially available TLC plates. These properties are attributed to a more homogeneous adsorbent material and better fluid flow. These plates were functionalized by introducing C8 and C18 silane ligands. A baseline separation of a Camag dye was achieved using these reversed-phase TLC plates, which shows their tremendous potential.

MC-P48

“Chemically stable functionalization of Au(111) with custom-synthesized polymers and thiolated DNA for self assembly of nanocircuits”

Presenter: Nitesh Madaan

Aaron Terry, Elizabeth Pound, Tony Pearson, Adam T. Woolley, Robert Davis, John Harb, Matthew R. Linford
Brigham Young University: Departments of Chemistry, Physics, and Chemical Engineering

Helmut Schlaad
Max Planck Institute of Colloids and Interfaces, Germany: Department of Colloid Chemistry

The goal of this work is to achieve efficient and stable self assembly of DNA origami structures on a patterned gold nano-dot surface. Commercially available, unmodified PBd has been successfully attached to a dithiol monolayer on Au(111) and further modified with a perfluorinated thiol and thiolated DNA. This assembly was found to be more stable than the corresponding perfluorinated thiol monolayer on Au(111). Commercially available 1,2-polybutadiene (PBd) has been chemically modified by sulphonated, phosphonated, and PEGylated thiols, and also a thiolated secondary amine using thiol-ene chemistry. These other modified PBds could also be attached to a dithiol monolayer on gold. These surfaces were further modified by thiolated DNA. We achieved only selective DNA hybridization on these surfaces as sulphonated and PEG species prevented nonspecific binding of DNA and proteins.

MC-P49

“Surface localization of DNA origami using a block copolymer patterned surface”

Presenter: Anthony C. Pearson

Elisabeth Pound, Adam T. Woolley, Matthew R. Linford, John N. Harb, and Robert C. Davis
Brigham Young University: Department of Physics and Astronomy; Chemistry and Biochemistry; and Chemical Engineering
An ongoing objective in surface patterning research is development of new materials and methods that allow smaller feature sizes than conventional techniques. Self-assembling materials are interesting because they can form controllable patterns with nanometer feature sizes. Here two self-assembling systems, block copolymers and DNA origami, are investigated. In DNA origami a long single-stranded DNA chain, known as the scaffold strand, bonds by complementary base-pairing to shorter DNA strands, known as helper strands. With the correct base sequence, the helper strands cause the scaffold strand to fold into a controllable shape. Block copolymers create surface patterns by phase separation of immiscible polymer blocks. The resulting pattern can be used as a template to control the location of metal nanoparticles on a surface. By using block copolymer templated metal nanoparticles as chemical binding sites for DNA origami, the combination of these two self-assembling systems gives the capability of creating controllable nanoscale patterns on a surface. Work has been done using gold nanoparticles positioned by block copolymer assembly to attach DNA origami to silicon dioxide surfaces. Here gold particles are functionalized with thiol modified single-stranded DNA, allowing complimentary base-pairing with single-stranded sticky ends on the origami. Results will be presented showing stable attachment of origami to gold nanoparticles where nonspecific adsorption of origami to silicon dioxide surfaces is minimal.

**MC-P50**

“Tuning the surface chemistry of quantum dots for use in aqueous media”

Presenter: Nhi Ma

David Riassetto, Michael H. Bartl
University of Utah: Department of Chemistry

Mike Mella, Peter Rose
University of Utah: Energy and Geoscience Institute (EGI)

Colloidal semiconductor nanoparticles are also called quantum dots (QDs) due to quantum confinement effects which strongly influence their physical properties. In particular, they exhibit interesting photoluminescence properties. Best optical quality QDs are synthesized by organometallic/solvothermal methods using hydrophobic organic surfactants for controlling the size and shape of QDs. Unfortunately, the presence of these surfactants, which are attached to the QDs surface, makes as-synthesized QDs insoluble in aqueous media and prevents many attractive applications.

In order to transfer these hydrophobic QDs into water, they are coated with an inorganic shell, such as silica or titania, by a new simple one-pot method. Optical and morphological properties of these core/shell QDs have been investigated by DLS, TEM and optical spectroscopy (UV-visible, photoluminescence and FTIR). It is shown that, after transfer in water, photoluminescence efficiency of QDs can be improved by a factor of more than 10 by UV-light treatment. Furthermore, the inorganic layer improves QDs robustness, and luminescence is also increased after hydrothermal treatment during five days at 250°C under a pressure of 4 MPa.

The thickness of shell is easily tuned from one to tens of nanometers simply by adjusting the inorganic precursor’s injection conditions (i.e. volume injected and/or multi-injection protocol) or on the precursor solution parameters. Shells are microporous and it could be possible to fill these microporosities
with specific functional groups. Moreover, the inorganic surface can be functionalized with different molecules. All these attractive properties open the way to application in drug delivery, in vivo imaging or geothermal well tracing.

MC-P51

“Low temperature methods for synthesis, size and shape control of CdSe nanocrystal quantum dots”

Presenter: Jacqueline T. Siy

Eric H. Brauser, Taylor K. B. Thompson, Michael H. Bartl
University of Utah: Department of Chemistry

Semiconductor nanocrystals have emerged as promising building blocks in an extensive range of applications. This can be attributed to their unique size-dependent optical and electronic properties, as well as their chemical flexibility. Despite numerous studies on these materials, their enormous potential impact on industrial output faces several challenges. High-quality CdSe semiconductor nanocrystals for instance, which are the most sought after and well-studied nanocrystal system by far, require high-temperature synthesis methods (200-360 ºC). This makes large-scale production of these materials extremely difficult and expensive. To overcome these challenges, we developed a low-temperature (between 50 -130 ºC) organometallic method to synthesize CdSe nanocrystal quantum dots with narrow size distribution, tunable optical properties and efficient luminescence. Furthermore, we also developed a post-synthesis size and shape control method for CdSe nanocrystal quantum dots. These methods provide greater flexibility both in nanocrystal fabrication and their incorporation into applications, which can be highly advantageous to industry-based production.

MC-P52

“Luminescent Au nanoparticles with a pH-responsive nanoparticle-supported molecular brush”

Presenter: Curtis A. Takagi

Chang-won Lee, Thanh Truong, Yen-Chi Chen, and Agnes Ostafin
University of Utah: Departments of Material Science and Engineering; Bioengineering; and Chemistry

The pH-dependent properties of Au nanoparticles ~2.2 nm in diameter decorated with bifunctional ligands possessing thiol and carboxylic acid functional groups are described. The Au-S linkage creates a polarity-sensitive photoluminescent charge transfer (CT) complex at the particle periphery, which acts as a built-in sensor for ligand configuration at the nanoparticle interface. When a pH change eliminates the charge on the exposed carboxylic acid group, van der Waals interactions between the carbon chain of the ligand and the Au nanoparticle lead to collapse of the ligands, and the photoluminescent Au-S CT species responds to the change in local polarity accordingly. Electron microscopy, electrophoresis, dynamic light scattering, and mass spectrometry were used to characterize the physical nature of the nanoparticles. Absorption, fluorescence emission and excitation, and zeta potential measurements were
used to understand the reversible pH-dependent spectral response. The number of charged ligands on each particle and pKa for the brush collapse were estimated. The Lippert-Mataga equation was used to provide evidence of the change in local polarity of the CT complex coincident with observed spectral changes.

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**MC-P53**

"Custom-synthesized polymeric reagents at surfaces"

Presenter: Aaron Terry

Nitesh Madaan, Joshua Robinson, Robert C. Davis, Adam T. Woolley, John N. Harb, Matthew R. Linford
Brigham Young University: Departments of Chemistry; Physics; and Chemical Engineering

Helmut Schlaad
Max Planck Institute of Colloids and Interfaces, Germany: Department of Colloid Chemistry

We demonstrate the functionalization of Si(100) and H-terminated Si(100) with custom-synthesized polymers. Commercially available 1,2-polybutadiene (PBd) was chemically modified by sulphonated, phosphonated, and PEGylated thiols, and also a thiolated amine using thiol-ene chemistry. The modified polymers were attached to Si(100) using layer-by-layer polyelectrolyte deposition. Poly(diallyldimethylammonium)chloride and/or cysteine-modified PBd were used as the first counterion layer. These layers can be functionalized at each deposition step through residual carbon-carbon double bonds in the PBd using a variety of thiols, and finally cross linked by ethanedithiol to create robust multilayer assemblies by thiol-ene chemistry. These custom-made polymers can also be directly attached to H-terminated silicon.

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**MC-P54**

"Biocompatible boron nanoparticles"

Presenter: Zhe Gao & Nathan Walton

Ilya Zharov
University of Utah: Department of Chemistry

The relatively large amount of boron needed for Boron Neutron Capture Therapy (BNCT) of cancer can be met by using boron nanoparticles. Boron nanoparticles can be prepared by a ball milling of boron powder with undecenoic acid to protect the resulting boron nanoparticles from atmospheric oxygen. The resultant particles cannot be used in biomedical applications because they are hydrophobic and do not disperse in aqueous solutions. We overcome this problem using two methods: (i) by performing a ligand exchange, replacing the undecenoic acid with dopamine; and (ii) by coating the boron nanoparticles with silica. Both types of boron nanoparticles become water dispersible, and can react with potential targeting molecules and fluorophores.
MC-P55

“Characterization of LPCVD Parylene C thin films as encapsulation material for integrated neural interface”

Presenter: Xianzong Xie

Xianzong Xie, Asha Sharma, Loren Rieth, and Florian Solzbacher
University of Utah: Departments of Electrical and Computer Engineering; and Bioengineering

Silicon-based integrated neural interfaces are implantable biomedical devices that are being developed for neural prostheses to stimulate or record neuronal activities by interacting with neurons in the context of serum. One of the most challenging aspects is the hermitic encapsulation of these devices. A long-term testing verification of Parylene C’s encapsulation and insulation properties on large number of samples is essential in order to compare the performance with the conventional materials. In this regard, we are developing a soaking test station capable of testing a large number of samples, which will allow us to simultaneously measure the leakage current, electrochemical impedance, etc. In this poster we present our preliminary measurements using the newly developed soaking test station. Silicon-based interdigitated electrodes test structures were patterned, and LPCVD Parylene C thin film was deposited as the encapsulation layer. Leakage current was measured, and Electrochemical Impedance Spectroscopy was performed from 0.1 Hz to 100 KHz at 37 °C in PBS on multiple samples. Our preliminary results show that Parylene C is a promising encapsulation material for biomedical implantable devices. Future work will focus the suitability of the Parylene C on wireless neural interface devices that have additional topology of various wireless components.

MC-P56

“Study of biotemplated photonic crystals using sol-gel chemistry”

Presenter: Benjamin P. Yonkee

Matthew R. Jorgensen, Michael H. Bartl
University of Utah: Department of Chemistry

Photonic crystals are materials that can manipulate light in non-classical ways similar to how atomic lattices manipulate the flow of electrons; this is why they are sometimes called the semiconductors of light. These materials have potential applications in technologies such as solar cells and optical computing. Unfortunately, current fabrication methods for photonic crystals that operate in the visible range are severely limited. However, the Bartl group has discovered several insects that are able to create highly complex three-dimensional photonic crystal structures in their scales. We present a novel method to use biological structures as a template to produce photonic crystals made from technologically relevant semiconducting compounds.

The weevils Lamprocyphus augustus, Pachyrhynchus moniliferus, and Eupholus schoenherri, which are known to contain a favorable three-dimensional morphology, were used as templates. It was found that utilizing simple and inexpensive sol-gel chemistry techniques, several different semiconductor structures could be made using a single type of biological template. True replicas, inverse structures,
and hollow shell architectures made out of silica and titania were fabricated by altering the sol-gel recipe and sample preparation. These new materials are not only optically superior to the original biopolymer structures but are much more diverse. The final structures are characterized through optical reflectance and scanning electron microscopy and the results are compared to theoretical calculations. Through analysis of the data we are not only able to monitor and optimize the transformation process, but also gain new insights into the structure-function relationship of photonic crystals.

**nanoMedicine**

**NM-P64**

“Geometry and surface characteristics of gold nanoparticles influence their biodistribution and uptake by macrophages”

Presenter: Arnida M.M. Janáť-Amsbury, A. Ray, C. M. Peterson and H. Ghandehari
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry; Bioengineering; Obstetrics and Gynecology; Center for Nanomedicine; and Nano Institute of Utah

One class of inorganic particles that shows promise in targeted cancer therapy including ovarian cancer is gold nanoconstructs. Physical and chemical properties of gold nanoparticles, in addition to their unique optical properties, make them particularly attractive for disease detection and therapy. Data are emerging about the influence of geometry as well as surface charge on toxicity and cellular uptake of nanoparticles including gold. In this work we examined the influence of geometry and surface characteristics of gold nanoparticles on their biodistribution in mice bearing orthotopic ovarian tumors as an in vivo model. In addition, the uptake of PEGylated gold nanoparticles by macrophages was evaluated. Upon intravenous injection through the tail vein, gold nanorods with near neutral charge were taken up to a lesser extent by the liver, had longer circulation time in the blood, and higher accumulation in the tumors, compared with their spherical counterparts with negative surface charge. The cellular uptake of PEGylated gold nanoparticles by a murine macrophage-like cell line was examined. Compared to nanospheres, PEGylated gold nanorods were taken up to a lesser extent by macrophages. This observation in part explains the lower accumulation of rods in the liver compared to spheres and the subsequent longer circulation time in the blood. These results have implications in the in vitro and in vivo biomedical applications of gold nanoparticles.

**NM-P65**

“Effects of carbon nanotube-collagen scaffolds on cell proliferation, differentiation, mineralization, and inflammatory response in mesenchymal stem cells”

Presenter: Rena Baktur
Soonjo Kwon
Utah State University: Department of Biological Engineering
Studies of the application of carbon nanomaterials have been carried out for the substrate of cell culture, drug delivery systems, and medical implant materials. Carbon nanotubes (CNTs) will provide an exciting opportunity for novel therapeutic modalities. However, little is known about the impact of CNTs on cellular processes such as adhesion, proliferation, and differentiation, especially Mesenchymal Stem Cells (MSCs) differentiation. We hypothesized that augmenting the properties of naturally derived polymers (collagen, in this study) through incorporation of CNTs might enhance in vitro osteogenic and osteoblastic differentiation of MSCs. In this study, we evaluated the cell proliferation, differentiation, mineralization and inflammatory response of MSCs in the presence of collagen-CNT matrix with several different types of CNTs (MWCNT-COOH, MWCNT-OH, MWCNT-long and MWCNT-short). Alkaline phosphatase (AP) and mineralization of extracellular matrix (ECM) were monitored as osteoblastic and osteogenic differentiation markers. AP activity was significantly increased 12 days after replacement with differentiating media in the presence of CNT-Collagen scaffolds. An increasing percentage of ECM mineralization was seen at day 16 after replacement with differentiating media in the presence of CNT-Collagen scaffolds. This study showed the possibility of enhancement in MSC differentiation in the presence of CNT-Collagen scaffolds. More characterized data on new materials and differential analysis on biological activity at different stages of differentiation are required.

**NM-P66**

“An exclusive way to measure cellular response to diesel particulate matter exposure using in vitro dynamic cell culture model”

Presenter: Hemang Patel

Soonjo Kwon
Utah State University: Department of Biological Engineering

Soomi Eo

Diesel particulate matter (DPM), an ingredient of urban pollution matter, possesses the potential to induce acute and chronic health issues upon occupational and daily exposure. Due to the complex nature of its composition and variability in shape and size, adverse effects of DPM has not been completely characterized. Many studies have focused on understanding molecular mechanisms to depict DPM’s side effects inside the lung using static cell culture models. These studies have provided abundant fundamental information on DPM’s adverse effects on cellular responses, but these systems were limited by the absence of dynamic nature to access relevant cellular responses and functionality. We hypothesized that the level of cellular response may differ between static and dynamic environments. In this study, we used dynamic cell growth conditions to mimic a mechanically dynamic environment similar to the normal breathing in vivo. We also used high (20, 10, and 5 ppm) and low (3, 1, 0.1, and 0.01 ppm) ranges of DPM exposure to mimic both accidental and occupational exposure, respectively. A549 cells were exposed to all concentrations of DPM and then grown under either static or dynamic cell growth conditions for 24, 48, and 72 hours. Following each exposure duration, media supernatant and cell lysate samples were analyzed for Interleukin-8 (IL-8), C-reactive protein (CRP), reactive oxygen species (ROS), and total amount of protein.
“Influence of polymer architecture on biodistribution of PAMAM dendrimers and HPMA copolymers in ovarian tumor-bearing mice”

Presenter: S. Sadekar

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The purpose of this study was to compare the biodistribution of linear HPMA copolymers containing glycylglycine ethanolamine and tyrosinamide in their side chains and hyperbranched poly amido amine (PAMAM) dendrimers of similar molecular weights in orthotopic, ovarian tumor-bearing mice. Polymer architecture affected the increment in hydrodynamic radii of the polymers with increase in molecular weight. Along with molecular weight, polymer architecture and hydrodynamic volume were critical to the in vivo fate of the macromolecules. Specifically, polymer architecture influenced renal and hepatic uptake of the constructs under study, with the hyperbranched PAMAM dendrimers showing more persistent accumulation in these organs than their linear HPMA copolymer counterparts. The difference in hepatic and renal accumulation between PAMAM dendrimers and HPMA copolymers is indicative of a difference in the extravasation of polymers of varying architecture through fenestrations of vasculature within healthy tissue. Tumor accumulation and plasma exposure were correlated with the hydrodynamic size of the polymers. The tumor accumulation data indicated the value of hydrodynamic radius cutoff to be around 4.0 nm, below which prolonged tumor retention was not observed for orthotopic ovarian carcinoma tumors under study. Comparative biodistribution studies for PAMAM and HPMA copolymers can aid in the selection of appropriate carriers for specific drug delivery needs to solid tumors.

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