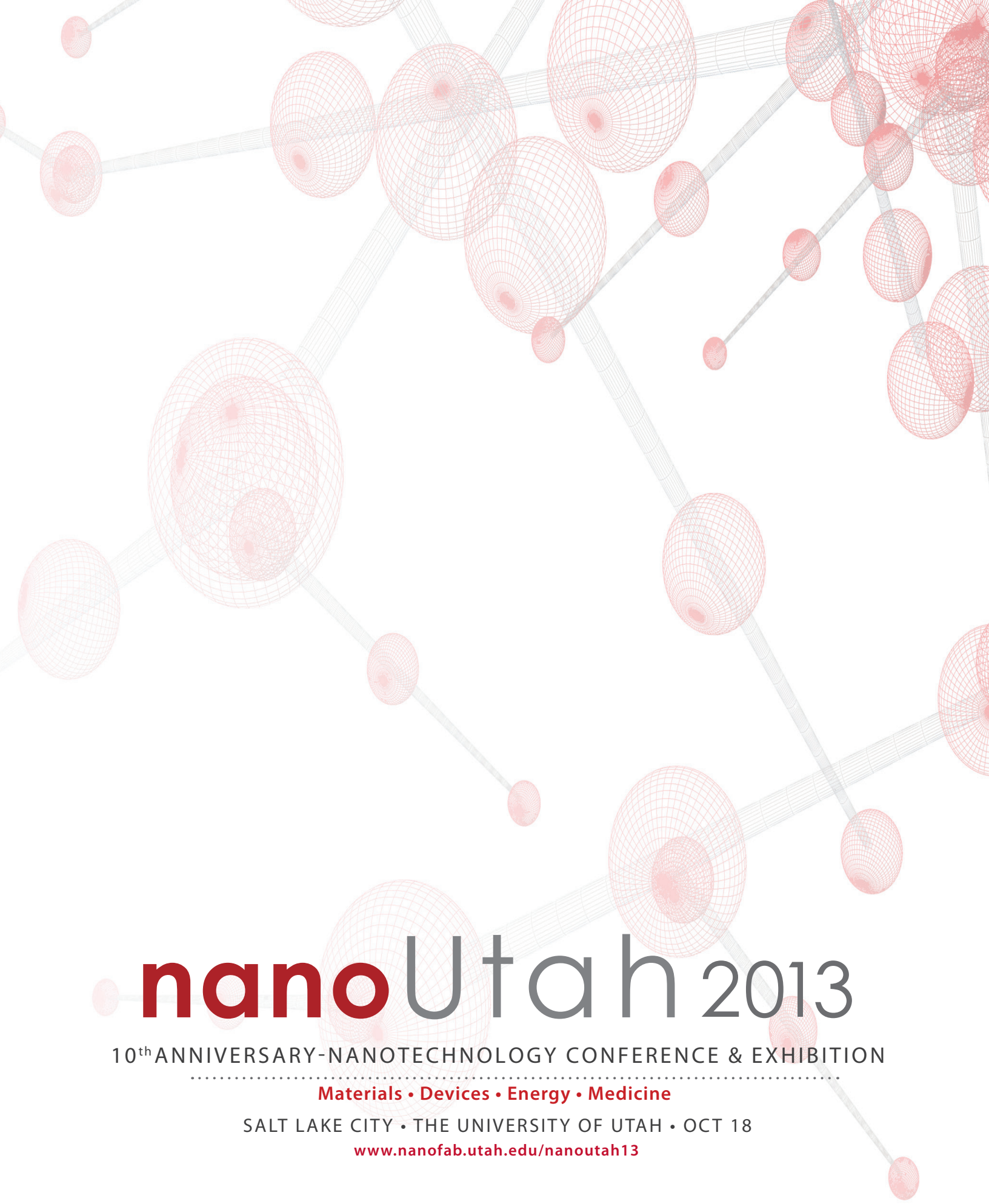

nanoUtah 2013

10th ANNIVERSARY-NANOTECHNOLOGY CONFERENCE & EXHIBITION

Materials • Devices • Energy • Medicine

SALT LAKE CITY • THE UNIVERSITY OF UTAH • OCT 18

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Welcoming Remarks

Dear Colleagues,

On behalf of the organizing committee I would like to welcome you to nanoUtah 2013. This state-wide conference is a collaborative effort between academic institutions, local industry and government agencies interested in the discovery, development and commercialization of nanotechnologies in Utah and beyond. By a grassroots initiative of faculties of the University of Utah, Utah State University, Salt Lake Community College and Brigham Young University, from 2003-2005, “mini conference” and “meet and greet” style gatherings focused on micro- and nano- science and engineering were organized. These forums were subsequently formalized into nanoUtah in 2006 under the leadership of colleagues in the Utah Nanofabrication Facility. Since that time the conference is held annually with participation and support of faculty and students from institutions of higher education in Utah; scientists from industry, local community leaders, and businesses; and leading national and international experts.

Fueled in part by support from the Utah Science Technology and Research (USTAR) initiative, in 2008 the Nano Institute of Utah was established to create synergistic interdisciplinary alliances and drive higher levels of collaborative research, education and commercialization in Utah. Key research areas in nanotechnology in the state include, but are not limited to, materials for plasmonics and organic spintronics, nanobiosensors, interfacial sciences, system integration, drug delivery, and nanotoxicology. Our colleagues in these disciplines have partnered with USTAR and the College of Engineering to create the new Utah Nanofab located in the state-of-the-art Sorenson Molecular Biotechnology Building, with its brand-new Microfluidics Prototyping Lab and the Center for Engineering Innovation. We encourage you to tour these fine facilities.

The establishment of the Nanotechnology Training Program as well as the National Science Foundation-funded Integrative Graduate Education and Research Traineeship Program on Nanobiosensors, Nanomaterials, and Microfluidics represented milestones in training the next generation of scientists in the state. Training in nanotechnology in Utah has not been limited to undergraduate and graduate settings at universities. Each year on “Nano Days”, in partnership with the Natural History Museum of Utah, educational programs about nanoscale science and engineering and its potential impact on the future are held for students from 1st thru 12th grade. In addition, the Science Olympiad (grade 7-12) program launched in 2012 at the U sponsors an annual materials science/nanotech event with scholarships and opportunities for high school students and freshmen to work in the Nanofab.

This year’s nanoUtah program encompasses topics in materials and characterization, devices, sensors, energy, catalysis, environment, and medicine. A panel of distinguished experts will address challenges in commercialization of nanotechnologies. I would like to take this opportunity to thank the keynote and invited speakers for sharing their latest results. This conference would not have been possible without the generous support of sponsors. Finally my sincere thanks go to the organizing committee for their hard work in putting this program together. I hope you enjoy it.

Hamid Ghandehari
University of Utah
October 2013

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Director, Utah Center for Nanomedicine
Director, Nanotechnology Training Program
USTAR Professor
Pharmaceutics and Bioengineering
University of Utah

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NANOMEDICINE

Margit M. Janat-Amsbury
Assistant Professor, Division of Gynecologic Oncology
Department of Obstetrics and Gynecology
University of Utah

MATERIALS & CHARACTERIZATION

David Britt
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Department of Biological Engineering
Utah State University

DEVICES & SENSORS

Swomitra K. Mohanty
Research Assistant Professor
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University of Utah

ENERGY & ENVIRONMENT

Michael H. Bartl
Associate Professor
Department of Chemistry
University of Utah

FRIDAY – OCTOBER 18, 2013

UNIVERSITY OF UTAH

Warnock Engineering Building (WEB)
Sorenson Molecular Biotechnology Building (SMBB)

7:30 a.m. **Warnock Engineering Building (WEB) – Catmull Gallery**
Open Registration and Breakfast

8:45 a.m. **Auditorium WEB L104**
Opening Remarks:
Thomas Parks
Vice President for Research
University of Utah

Richard B. Brown
Dean, College of Engineering
University of Utah

9:00 a.m.-
9:45 a.m. **Keynote Speaker:**
Dennis E. Discher
Robert D. Bent Chaired Professor
Biophysical Engineering and NanoBio-Polymers Lab
University of Pennsylvania

9:45 a.m. Coffee Break – WEB and SMBB

10:15 a.m.
12:15 p.m.- **Parallel Sessions:**

Auditorium WEB L104
Topic 1: Materials and Characterization
Matt Linford (10:15 a.m.)
Department of Chemistry and Biochemistry
Brigham Young University

Ling Zang (10:45 a.m.)
Department of Materials Science and Engineering
University of Utah

Auditorium SMBB 2650
Topic 2: Devices and Sensors
Eric Gardner (10:15 a.m.)
Moxtek, Inc.

Henry White (10:45 a.m.)
Department of Chemistry
University of Utah

12:15 p.m. **Sorensen Molecular Biotechnology Building (SMBB) – Atrium**

2:15 p.m. Lunch
Poster Session
Exhibitor Viewing

2:15 p.m.- **Auditorium WEB L104**
2:50 p.m. **Commercialization Panel:**
Moderator
Kevin Jessing
Life Science Cluster Director
Governor's Office of Economic Development (GOED)

Panelists
Aaron Osmond
State Senator for District 10

Glenn Prestwich
Presidential Professor
Department of Medical Chemistry
University of Utah

Dave Robinson
President
EZ Lift Rescue Systems

2:50 p.m.- Ryan Marshall
3:00 p.m. Brinks Hofer Gilson & Lione
Topic: How to Race through the U.S. Patent Office on the Fast Track

3:00 p.m. Coffee Break – WEB and SMBB

3:30 p.m.- **Parallel Sessions:**
5:30 p.m.

Auditorium WEB L104
Topic 3: Energy and Environment
Shelley Minteer (3:30 p.m.)
Department of Chemistry
University of Utah

Scott Anderson (4:00 p.m.)
Department of Chemistry
University of Utah

Auditorium SMBB 2650
Topic 4: Nanomedicine
You Han Bae (3:30 p.m.)
Department of Pharmaceutical Chemistry
University of Utah

Sunil Sharma (4:00 p.m.)
Division of Oncology, School of Medicine
Huntsman Cancer Institute

5:30 p.m. **Auditorium SMBB 2650**
Student Poster Awards & Closing Remarks

Session Presentations- At a Glance

T=Talk	Check schedule for location of each session

Materials & Characterization – WEB

11:15 AM (MC-T1) **Danielle E. Montanari,** U of U*, "From magnetic metamaterials to magnonic crystals"*

11:30 AM (MC-T2) **Bhupinder Singh,** BYU, *"Improving the performance of nanodiamond-containing core-shell particles via extensive characterization of the nanodiamonds"*

11:45 AM (MC-T3) **Brian Wood,** USU, *"Reflectance and absorptance of multi-walled carbon nanotube forests"*

12:00 PM (MC-T4 **Gaosong Yi,** U of U, *"Characterization and numerical simulation of precipitates formed in long-term aging Al 5083 alloy"*

Devices & Sensors – SMBB

11:15 AM (DS-T5) **Jason Beck,** U of U, *"Multiplexed immunoassay of potential pancreatic cancer markers using internal calibration"*

11:30 AM (DS-T6) **Ashrafuzzaman Bulbul,** U of U, *"Microfluidic bubble-based gas sensor"*

11:45 AM (DS-T7) **Benjamin R. Bunes,** U of U, *"A dual-gate field effect transistor for chemical vapor detection"*

12:00 PM (DS-T8) **Rebecca Goldstein,** U of U, *"Asymmetrically functionalized cubes for nanoparticle assemblies"*

Energy & Environment – WEB

4:30 PM (ECE-T9) **Nick Corbett,** U of U, *"Electronic response of platinum nanoparticles"*

4:45 PM (ECE-T10) **Sid Das**, U of U, *"Making catalysts fast, extremely robust, inexpensive, and well-defined at Å-scale, all at the same time: Beginning of a molecular-material journey*"

5:00 PM (ECE-T11) **Daniel Jacobs,** U of U, "*Enhanced performance of organic photovoltaics using plasmonic nanocrescent structures"*

5:15 PM (ECE-T12) **Oscar David Petrucci**, BYU, *"A green facile photochemical method for decontaminating water from ionic mercury"*

Nanomedicine – SMBB

4:30 PM (NM-T13) **Te-Wei Chu,** U of U, *"Oligonucleotide hybridization-mediated drug-free macromolecular therapeutics"*

4:45 PM (NM-T14) **Marjan Javadi**, BYU, *"Effect of folate on release of paclitaxel from eLiposomes*"

5:00 PM (NM-T15) **Richard J. McMurtrey,** U of Oxford, "*Novel 3-dimensional hydrogel constructs with patterned and functionalized nanofiber scaffolding for enhanced neurite outgrowth and directional control"*

5:15 PM (NM-T16) **Elizabeth Vargis**, USU, *"Development of tissue models and spectroscopic detection platforms for biomedical applications"*

Opening Remarks

THOMAS N. PARKS

Thomas N. Parks is the Vice President for Research at the University of Utah, where he has been a faculty member in the School of Medicine since 1978. Prior to assuming his current position in 2008, Dr. Parks was a neuroscience researcher and teacher, founding director of the interdepartmental graduate program in Neuroscience, chairman of the Department of Neurobiology & Anatomy, and the founding executive director of the university's Brain Institute. He was a co-founder of NPS Pharmaceuticals Inc. (NASDAQ: NPSP) and a board member from 1986-2006, and he has also served as a board member or scientific advisor for several private technology companies and as a trustee or director for several non-profit organizations.

RICHARD B. BROWN

Richard B. Brown received his bachelors and masters degrees in electrical engineering from Brigham Young University. Following graduation, he designed computers and instrumentation in California and Missouri. He returned to school at the University of Utah in 1981 and received an electrical engineering Ph.D. in 1985, at which time he joined the faculty of the University of Michigan Department of Electrical Engineering and Computer Science (EECS) where he developed their highly respected integrated circuit design (VLSI) program.

Prof. Brown has conducted major research projects in the development of sensors (for ions, heavy metals and neurochemicals) and microprocessors (high-performance, low-power, and mixed-signal). He holds 17 patents and has authored more than 200 peer-reviewed publications. He was the Micropower Electronics task leader in the University of Michigan's NSF Wireless Integrated Microsystems Engineering Research Center. He has won a variety of teaching and research awards.

At the University of Michigan, Prof. Brown served as Associate Chair for the Electrical Engineering Division of EECS for four years and then as Interim Chair of EECS. He has served on NSF, ASME and DARPA advisory committees for emerging technologies and VLSI education, and on three national advisory committees at other universities. He has been supportive of entrepreneurial activities and personally involved in technology transfer as a founder of Sensicore, i-sens, Mobius Microsystems, and e-SENS.

In July 2004, Prof. Brown was appointed the eleventh Dean of the College of Engineering at the University of Utah. He holds appointments in the School of Computing, the Department of Electrical & Computer Engineering and the Department of Bioengineering as well as an appointment at the University of Michigan Electrical Engineering and Computer Science Department.

Keynote Speakers

DENNIS E. DISCHER

Dennis E. Discher is the Robert D. Bent Professor at the University of Pennsylvania, with appointments in Engineering and Applied Science and in the Graduate Groups of Physics, Pharmacology, and Cell & Molecular Biology. He received a Ph.D. jointly from the University of California, Berkeley and San Francisco in 1993 and has been at Penn since 1996. He has coauthored nearly 200 publications with over 16,000 citations that range in topic from polymersomes and filomicelles to 'Self' recognition peptides and matrix mechanobiology of stem cells, with papers appearing in Science, Cell, PNAS, and various Nature journals. Additional Honors and Service include a Presidential Early Career Award, election to the US National Academy of Engineering – Bioengineering Section, and membership on the Editorial Board for Science.

Invited Speakers

SCOTT ANDERSON

Scott L. Anderson received a B.A. from Rice University in 1977 working with Phil Brooks on molecular beam reactions, and a Ph.D. from UC Berkeley in 1981, working on state-selected ion chemistry with Y. T. Lee. After a postdoctoral stint with Dick Zare at Stanford, focusing on REMPI and photoelectron spectroscopy, he took a position at SUNY Stony Brook in 1983. In 1995, he moved to the University of Utah, where he is currently a Distinguished Professor of Chemistry. His early research work focused on gas-phase reaction dynamics, cluster chemistry, soft X-ray photochemistry, and combustion chemistry. Currently his work is broadly in the area of nanoscale surface chemistry, including particle size effects in supported catalysts and electrocatalysts, nanoparticle mass spectrometry for single nanoparticle studies, and production, characterization, and combustion of high energy density aluminum and boron particles with controlled surface chemistry.

YOU HAN BAE

Dr. You Han Bae has a background of chemical engineering (BS, Seoul National University, Korea), polymer science/engineering (industry and research institute), and pharmaceutical chemistry (PhD, University of Utah, USA).

He served University of Utah as a post doctoral fellow and research assistant/associate professor until 1994. He joined the Department of Materials Science and Engineering at Gwangju Institute of Science and Technology (GIST) (Korea) – a graduate school – in 1994 as an associate professor with the first departmental chair and was promoted to full Professor in 1998. After serving 7.5 years at GIST, he re-joined the University of Utah as a full professor in 2002.

He researched stimuli-sensitive polymers and drug delivery, protein-drug stabilization and controlled release, and functionalized polymers for glucose sensor and biohybrid artificial pancreas. His current research interests include self-assembled super pH-sensitive nanoparticulates for multidrug resistance in cancer and tumor heterogeneity, novel polymeric vector design for the delivery of genetic materials, and preclinical cancer models. He has published over 250 peer-reviewed scientific papers, book chapters and U.S. Patents, which have been cited over 15,000 times.

He has been elected to the fellows of the American Institute of Medical and Biological Engineering and the American Association of Pharmaceutical Scientists. He served Controlled Release Society (CRS) as a member of the Board of Scientific Advisory (Aug. 2000-July 2003), as a member, co-chair and chair of CRS Young Investigator Award committee (1999-2007), and as a program co-chair for the 34th annual meeting of Controlled Release Society at Long Beach, CA (2007). He has been a co-chair of International Symposium on Recent Advances in Drug Delivery System (Salt Lake City, Utah) since 2006. He is an editorial board member of Pharmaceutical Research and Bioconjugate, and is also currently serving the Journal of Controlled Release (JCR) as an America Associate Editor as well as the Editor of The Concept Paper in JCR.

ERIC GARDNER

Dr. Gardner has nearly 30 years of experience in semiconductor and nanostructure design and processing, primarily focused on sub-wavelength optical elements which have greatly extended the life of LCD projection displays. Eric received his Ph.D. in physics and statistics from Brigham Young University and has a broad experience base, including software, medical devices, quality engineering, semiconductor processing, optics, and nanotechnology.

KEVIN JESSING

Kevin Jessing brings over 20 years' experience in the pharmaceutical industry to his position as Life Science Cluster Director. Kevin's most recent post was Executive Director of BioInnovations Gateway (BiG), a non-profit life science incubator located within Granite Technical Institute. Previous to BiG, Kevin founded Resonance Laboratories in 2007 to address the bio-analytical and ADME needs of small pharma. Kevin has led a diverse career across pharmaceutical, contract research and pharmaceutical technology industries with an emphasis in mass spectrometry and business development. He has also held recent positions as Interim Director of Bioanalytical Services for ABC Laboratories in Columbia,

MO and Associate Director of Discovery ADME at Myriad Pharmaceuticals in Salt Lake City, as well as positions at Tandem Laboratories, Cedra Corporation and Camitro. Kevin received his Bachelor's and Master's of Arts degrees in Biochemistry at the University of Texas at Austin.

MATT LINFORD

Matthew Linford graduated with a B.S. in chemistry from Brigham Young University in 1990 and received M.S. and Ph.D. degrees from Stanford in 1996 in materials science and chemistry, respectively. While at Stanford he published the first two papers on monolayers on hydrogen-terminated silicon with his adviser, Chris Chidsey. These two papers have been cited ca. 400 and 800 times. After a post-doc at the Max Planck Institute in Golm, Germany with Helmut Moehwald studying polyelectrolyte multilayers, Linford worked in industry for three years – one year with Rohm and Haas (now Dow) and two years with two start up companies. In 2000, he took a position as a faculty member at Brigham Young University and is now a full professor there. While at BYU, Linford has studied the chemomechanical functionalization of silicon, new materials for separations science, and new materials for data storage. His work in separations science has led to the launch of the Flare chromatography column by Diamond Analytics. His work in data storage led him to co-found Millenniata, which sells a DVD, and now a Blu-ray disc, that last 1000 years. Linford has more than 170 publications, including more than 90 peer-reviewed papers, 20 U.S. patents, and various conference proceedings, book chapters, peer-reviewed contributions to Surface Science Spectra, and commercial application notes.

RYAN MARSHALL

Ryan Marshall is a Shareholder at Brinks Gilson & Lione. He has extensive prosecution experience with patent and trademark matters as well as litigation experience with patent, trade secret, trade dress and unfair trade practice claims. He has substantial experience in the chemical, nanotech, pharmaceutical, biochemical and medical device arts industries. Ryan also advises clients on strategic patent portfolio development, landscape analysis, and legal opinions, and he drafts U.S. and foreign patent applications.

Ryan has a master's degree in chemistry and eight years of laboratory research experience. As a graduate student, he investigated nucleoside and peptide chemistry including the synthesis of novel compounds and characterization of protein interactions with lipopolysaccharides using spectroscopy and calorimetry. He has worked with a broad range of chemical technologies, particularly in the fields of polymers, cosmetics, chemical instruments, fuel processing, animal health, and pharmaceuticals including synthesis, peptides, protein complexes and chelates, nucleosides, DNA sequence tags, point-of-care DNA diagnostics, and DNA amplification.

SHELLEY MINTEER

Shelley Minteer is a USTAR Professor in both the Departments of Chemistry and Materials Science and Engineering at the University of Utah. She received her PhD in Analytical Chemistry at the University of Iowa in 2000 under the direction of Professor Johna Leddy. After receiving her PhD, she spent 11 years as a faculty member in the Department of Chemistry at Saint Louis University before moving to the University of Utah in 2011. She is also Technical Editor for the Journal of the Electrochemical Society. She has published more than 150 publications and has given more than 250 presentations at national and international conferences and universities. She has won several awards including the Missouri Inventor of the Year, International Society of Electrochemistry Tajima Prize, and the Society of Electroanalytical Chemists' Young Investigator Award. In 2003, she co-founded Akermin, Inc. with her previous graduate student, which has focused on the commercialization of her biobattery technology and has moved on to carbon capture technology. Her research interests are focused on electrocatalysis and bioanalytical electrochemistry. She has expertise in bioelectrochemistry and bioelectrocatalysis for biosensors and biofuel cells.

AARON OSMOND

Aaron Osmond has been serving as State Senator for District 10 since April 2011 (replacing Senator Chris Buttars upon his retirement). Aaron, his wife Nancy, and their 5 children have lived in South Jordan since Feb 2006. In his professional life, Aaron is working as the VP of North American Sales for Certiport (based in American Fork), a high stakes test development and delivery company serving the academic market. Aaron has demonstrated a willingness to be engaged and accountable to the people

of District 10, through regular quarterly meetings, monthly newsletters, and proactive communication about his views on policy issues and upcoming legislation. He is seeking a full term to continue as Senator for District 10.

GLENN D. PRESTWICH

Glenn D. Prestwich created and directs the Entrepreneurial Faculty Scholars program which co-hosts this annual symposium. He is Presidential Professor of Medicinal Chemistry and Presidential Special Assistant for Faculty Entrepreneurism at the University of Utah. His research encompasses drug discovery in cell signaling, synthetic matrices for regenerative medicine, and glycosaminoglycan derivatives as anti-inflammatory agents. He co-founded 8 companies including Echelon Biosciences, Glycosan BioSystems, Sentrx Animal Care, GlycoMira Therapeutics, and Metallosensors. He received the Governor's Medal for Science and Technology for 2006, the 1998 Paul Dawson Biotechnology Award & the 2008 Volwiler Research Award of the American Association of Colleges of Pharmacy, and the 2010 University of Utah Distinguished Scholarly and Creative Research Award. During 37 years as a faculty member, he has published over 640 technical papers, patents, and book chapters, and has trained over 125 postgraduate scientists. He is also a pilot and sings first tenor in the Utah Symphony Chorus.

DAVID ROBINSON

Serving as the chief executive and/or operational officer of four companies over the last 30 years has helped David become a visionary, executive level manager with extensive real-world experience and successes in managing the day-to-day operations and finances of business including public relations, marketing communications, project planning, financing, budget process, sales, and project management.

Currently David is the President of EZ LIFT Rescue Systems, Inc., a Park Citybased company that designs, manufactures, sells, and services patient lifting and immobilization systems that incorporate a patented extendable handle that is designed to minimize lift impacts to the back. The EZ Lift Rescue System will minimize or even eliminate many of the serious back injuries being experienced by trauma personnel who are constantly struggling to lift and move patients at trauma scenes. EZ LIFT launched their first product in November 2012, and it is now in use in more than 140 Fire and EMS Departments throughout the United States including several Utah EMS services (www.ezliftrescue.com)

David is also one of the Managing Partners of SimplicityMD, a Salt Lake City-based company that invests in and develops medical devices for the critical care market. SimplicityMD's first product, a safety scalpel called PenBlade, is now being introduced into the market. SimplicityMD already has developed a portfolio of more than a dozen devices now in development including Simplicity Solutions which was just awarded a $10,000 Engine Grant from the University of Utah Technology Commercialization Program.

David has lived full time in Park City since 2005 and has been an active participant in the community spending his time, energy and money to help found – and fund – the One Revolution Foundation with Paralympian Chris Waddell, and he is working with the Big Brothers and Big Sisters of Summit County.

SUNIL SHARMA

Sunil Sharma, MD, is Chief of Medical Oncology for the Department of Internal Medicine and Senior Director of Clinical Research at Huntsman Cancer Institute (HCI). Dr. Sharma is also the Director of the Center for Investigational Therapeutics at HCI and a Professor in the School of Medicine at the University of Utah. He is a member of the Research Leadership Council and Co-Leader of the Experimental Therapeutics Program. He holds a Jon and Karen Huntsman Presidential Professorship in Cancer Research.

Dr. Sharma is an expert in the development and testing of new cancer therapies. At HCI, he is working to increase the portfolio of high-quality clinical trials, including Phase I trials. He has established a translational oncology lab to support related studies. In addition, his clinical interests are focused on treatment of patients with gastrointestinal cancers (colon, pancreatic, esophageal, rectal, liver), mesothelioma, and rare tumors (carcinoid, neuroendocrine tumors, and carcinomas of unknown primarys).

Before joining HCI, Sharma built a Phase I clinical trials program at the Nevada Cancer Institute where he oversaw more than 25 clinical trials. He led a global oncology drug development program at the drug manufacturing company Novartis Pharmaceuticals. He also worked as a physician in the Division of Gastrointestinal Oncology at Memorial Sloan-Kettering Cancer Center, New York City. He earned a medical degree at the University of Delhi, New Delhi, India.

HENRY WHITE

Henry S. White received the B.S. degree in chemistry from the University of North Carolina (1978) and the Ph.D. degree in chemistry from the University of Texas (1983). Following a postdoctoral appointment at the Massachusetts Institute of Technology, he joined the faculty of the Department of Chemical Engineering and Materials Science at the University of Minnesota, where he was the McKnight and Shell Professor of Chemical Engineering. In 1993, he moved to Chemistry at the University of Utah. Prof. White is an electrochemist, with interests in biological, physical, and materials chemistry. Current research interests include DNA structural analyses using ion channel recordings, electrochemistry in nanometer-wide cells, the formation and stability of nanobubbles, and ion transport in nanopores. He is a Fellow of the American Academy of Arts and Sciences and is the recipient of the Faraday Medal of the Royal Society of Chemistry, the Reilley Award of the Society of Electroanalytical Chemistry, the Grahame Award of the Electrochemical Society, and the ACS Analytical Division Award in Electrochemistry.

LING ZANG

Dr. Zang is a USTAR faculty at University of Utah affiliated with the Departments of Materials science and Engineering, Chemistry and Nano Institute of Utah. He was previously an Alexander von Humboldt Fellow at Erlangen-Nuremberg University in Germany, NSF CAREER Award winner, and K. C. Wong Foundation Research Fellow. Dr. Zang's current research focuses on nanoscale imaging and molecular probing, organic semiconductors and nanostructures, optoelectronic sensors and nanodevices, with the long-term goal to achieve real applications in the areas of national security, renewable energy, and clean environment. Dr. Zang has been awarded various federal grants to support his broad range of research in nanoscience and nanotechnology. Beyond the regular faculty duty on campus, Dr. Zang also remains active in organizing and chairing the nanotechnology sessions of various national and international conferences, and reaching out to K-12 students and publics for education of nanotechnology and the impacts to society and industry. Dr. Zang also strives to foster the technology transfer and commercialization along the strategy of USTAR. In the past five years, more than fifteen patents have been filed from Dr. Zang's lab, and two University spinoff companies have been founded based on the patented technologies, Vaporsens Inc., Metallosensors Inc.

Keynote Speaker Abstracts

OCTOBER 18, 2013

9:00 AM

Minimal "Self" peptides that inhibit phagocytic clearance and enhance delivery of nanoparticles

Speaker: Dennis E. Discher
University of Pennsylvania: Biophysical Engineering & NanoBio-Polymers Lab
Robert D. Bent Chaired Professor

Foreign particles and cells are cleared from the body by phagocytes that must also recognize and avoid clearance of "self" cells. The membrane protein CD47 is reportedly a "marker of self" in mice that impedes phagocytosis of self by signaling through the phagocyte receptor CD172a.
Minimal "Self" peptides were computationally designed from human CD47 and then synthesized and attached to virus-size particles for intravenous injection into mice that express a CD172a variant compatible with hCD47. Self peptides delay macrophage-mediated clearance of nanoparticles, which promotes persistent circulation that enhances dye and drug delivery to tumors. Self-peptide affinity for CD172a is near the optimum measured for human CD172a variants, and Self peptide also potently inhibits nanoparticle uptake mediated by the contractile cytoskeleton. The reductionist approach reveals the importance of human Self peptides and their utility in enhancing drug delivery and imaging.

Invited Speaker Abstracts

OCTOBER 18, 2013

10:15 AM

The blind men and the elephant as a metaphor for surface and materials characterization

Speaker: Matt Linford
Brigham Young University: Associate Professor, Department of Chemistry and Biochemistry

In the story of the blind men and the elephant, a group of blind men encounter an elephant and each man touches a different part of it. One man touches the animal's ear; another, its leg; another, its tusk; etc. After their experiences the men argue about what they have found because each had a different experience. Just like the combined stories of the blind men were necessary to fully understand the animal, surface and materials analysis relies on information from multiple characterization techniques because, in general, the information provided by each technique is somewhat limited and specific. In this talk we show how combining the results from time-of-flight secondary ion mass spectrometry (ToF-SIMS), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), scanning electron microscopy (SEM), X-ray diffraction (XRD), and spectroscopic ellipsometry (SE) leads to a much higher understanding of materials than would be possible with a single technique. We consider the case of a sputtered ternary alloy that has been developed as a possible optical data storage layer. The result of applying multiple characterization techniques to this film is that: (i) we can determine the optical constants of the film, which will be important in its future device design, and (ii) we understand the film morphology (porous columnar), which could be improved by other deposition methods.

10:45 AM
Optoelectronic Gas Sensors Based on Organic Nanofibers

Speaker: Ling Zang
University of Utah: Associate Professor, Department of Materials Science and Engineering, and Nano Institute of Utah

Organic nanofibers have gained increasing interests in the past few years, largely due to the potential applications in various nanodevices in competition with the inorganic counterparts. Nanofibers fabricated from rigid, planar aromatic molecules possess one-dimensional (1D) optical and electronic

properties along the long-axis of nanofiber. Such 1D dominant property is coincident with the long-range charge transport and exciton migration, making the nanofibers unique building blocks for optoelectronic sensor devices. In this talk, we will discuss our recent progress in the fabrication of high quality nanofibers from various building block molecules and the applications in vapor detection of nitro-based explosives, drugs and other chemicals, which are of great interest to security, environment and health concerns.

10:15 AM

Shape parameters and other considerations for wire-grid polarizers

Speaker: Eric Gardner
Brigham Young University: VP-CTO Optics, Moxtek Inc.

Wire-grid polarizers for visible light applications have been commercially available for over ten years. This presentation will discuss important factors that affect polarization performance, such as grid pitch, wire shape, and addition of thin films to the structure. Understanding reliability or the polarizer in application is also of interest. Some data will be presented on accelerated testing to determine long term reliability.

10:45 AM

Monitoring the base-excision pepair activity of uracil-DNA glycosylase using an α-hemolysin nanopore

Speaker: Henry White
University of Utah: Distinguished Professor, Department of Chemistry

Nanopores have been investigated as a simple and label-free tool to characterize DNA nucleotides when a single-stranded DNA (ssDNA) strand translocates through the constriction of the pore. Here, a wild-type α-hemolysin protein nanopore was used to monitor DNA repair enzyme activity based on base-specific interactions of double-stranded DNA (dsDNA) with the vestibule constriction "latch", a previously unrecognized sensing zone in α-hemolysin specific for dsDNA structure. The presence of a single abasic site within dsDNA that is in proximity of the latch zone results in a large increase in ion channel current, allowing accurate quantitation of the kinetics of base repair reactions involving an abasic site product. Taking advantage of the high resolution for abasic site recognition, the rate of uracil-DNA glycosylase hydrolysis of the N-glycosidic bond, converting 2'-deoxyuridine in DNA to an abasic site, was continuously monitored by electrophoretically capturing reaction substrate or product dsDNA in the ion channel vestibule. Our results can be adapted to monitor the activity of other enzymes that introduce a change in the oligonucleotide structure, and thus provide a new approach for monitoring enzymatic activity on DNA. The discovery of a very sensitive sensing zone at the latch suggests the potential development of new methods to detect site-specific changes in dsDNA structure relevant to epigenetic, forensic and medical diagnostic applications.

3:30 PM

Functionalization of multi walled carbon nanotubes with pyrene-based groups for enhanced oxygen reduction by laccase

Speaker: Shelley D. Minteer
University of Utah: Professor, Department of Chemistry

Blue copper oxidases are enzymes that catalyse the oxygen reduction reaction (ORR). This property makes them a suitable biocatalyst at cathodes in biofuel cells. Among them, fungal laccase is an attractive enzyme due to its ability to reduce O_2 directly to water. Laccases are known to be able to undergo direct electron transfer (DET) from the current collector material to the active center of the enzyme where oxygen is reduced in a four electrons process. To achieve DET at the electrode, the enzyme has to be orientated specifically in close proximity of the electrode.

One elegant approach is to use phenyl structures that can fit in the hydrophobic pocket of laccase where the natural substrate is oxidized and acts as an electron relay to shuttle electrons directly from the electrode to the active site. Different modifications showed that anthracene groups can be

covalently immobilized on carbon nanotubes to help orientate the enzyme and increase catalytic current ORR.

More recently, we reported a new strategy to functionalize carbon nanotube (CNT) walls using pyrene groups modified by anthracene groups. Pyrene groups themselves have been reported to improve DET of laccase (thus orientation). A further modification of the pyrene with an anthracene group shows an increase in catalytic current compared to the regular pyrene-based CNTs, providing more hydrophobic site for the laccase to bind near the electrode. Different pyrene moieties with different functional groups are being examined to graft to the anthracene.

4:00 PM

Novel approaches to production and characterization of nanoscale surface and optical properties

Speaker: Scott L. Anderson
University of Utah: Distinguished Professor, Department of Chemistry

The study of nanoscale materials is impeded by the fact that real materials have a wide distribution of particle sizes, shapes, active site geometries, etc., so that typical analytical methods average over distributions, and may miss the importance of particular sizes, or geometries. Scanning probe and single molecule approaches allow individual features or particles to be studied, one by one. This talk will present two approaches to unraveling the averaging problem. One set of experiments is based on preparing materials by depositing mass-selected, (*i.e.*, size- and composition-selected clusters) on well characterized surfaces. The focus of our work has been on catalysis, but the method is general. We recently have been developing a new "single molecule" method – nanoparticle mass spectrometry – based on studying single, trapped nanoparticles, isolated in vacuum. The principle measurement is the particle mass, but we are able to obtain high enough precision (~2 ppm) to be able to see mass changes (*e.g.*, reactions) occurring in a small fraction of the surface layer. We have also applied the method to examining the optical properties of semiconductor quantum dots, blinking and bleaching behavior for different charge states of the quantum dots, and the effects of the ligand layer removal.

3:30 PM

Tissue penetrating self-assembled nanoparticles activated by tumor microenvironment

Speaker: You Han Bae
University of Utah: Professor, Department of Pharmaceutics and Pharmaceutical Chemistry

Unlike small molecule drugs, systemic pharmacokinetics of intravenously introduced therapeutic cancer nanomedicines poorly represent the tissue distribution and concentration profiles of cancer drugs in solid tumors, which often leads to clinical outcomes that are not better than control small molecules. This contrasts to impressive preclinical results. One of reasons for such discrepancy would be poor penetration and distribution of the nanoparticles in tumor tissues, which are dense in cell population and extracellular matrix components, after extravasation. We have discovered that cationic self-assembled nanoparticles derived from a short-branched polyethyleneimine (1.8K) penetrate into solid tumor tissues with unknown mechanisms at the moment. On one hand, we explore the underlying mechanisms with a 3-dimensional *in vitro* tumor model that mimics tumor microenvironment. On the other hand, nanoparticles, of which cationic charge is shielded, have been investigated for *in vitro* and *in vivo* models. Deshielding occurred by digestive enzymes in tumor microenvironment or by slightly acidic tumor extracellular pH. This approach has developed nanoparticle systems that may in part overcome tumor heterogeneity, multidrug resistance and problems relevant to the transport of the nanoparticles to individual cancer cells.

4:00 PM

Histone demethylase inhibitors for treatment of cancer

Speaker: Sunil Sharma
University of Utah: Professor, School of Medicine, Division of Oncology

Epigenetic modifications are important for gene transcription and cancer cell initiation and maintenance. There are several types of epigenetic modifications including DNA methylation, histone modifications and RNA subtypes (*e.g.* microRNAs), that are emerging as interesting drug targets. Histone modifications are important epigenetic regulatory mechanisms that influence cancer cell growth. There is evolving data that suggests that histone methylation and demethylation can be oncogenic in various tumor backgrounds. In this talk, I will provide an introduction to epigenetics and its relevance in tumor biology. I will mainly focus on the basic biology that governs histone modifications in cancer. I will also describe the drug discovery efforts around the world that are targeting histone modifications. Most specifically, I will describe our efforts to target a novel histone demethylase pathway called lysine specific demethylase 1 (LSD1). LSD1 is an important regulator of cancer stem cells and cancer cell migration, and it plays an important role in gene transcription. Our efforts span computational chemistry, medicinal chemistry and biology. Our collaborations with Stephen Lessnick's laboratory that explain the seminal role of our LSD1 inhibition in Ewing's sarcoma will be highlighted. In addition I will also describe our collaboration with Kapil Bhalla's laboratory in the area of Acute Myelogenous Leukemia (AML). Finally, I will describe our efforts to credential our clinical candidate SP-2577 and our future plans to move this inhibitor to the clinic.

Session Speaker Abstracts

Materials & Characterization – WEB

11:15 AM (MC-T1)

From magnetic metamaterials to magnonic crystals

Speaker: Danielle E. Montanari

Michael H. Bartl
University of Utah: Department of Chemistry

This presentation explores the bottom-up colloidal self-assembly of magnetic metamaterials for the future fabrication of 3-D magnonic crystals – the magnetic counterparts of photonic crystals. Magnonic crystals have the potential to control the propagation and dynamics of spin waves at the nanometer scale, and are thus considered key components in next-generation spintronics and magnetic data storage technologies. We will present a method to organize magnetic nanoparticles into ordered 3-D superlattices with lattice diameters of a few hundred nanometers. The known method for the fabrication of opal films via evaporative deposition was used to build a sacrificial template of silica spheres. This film was thoroughly infiltrated with magnetic nanoparticles via a dip-coating process, followed by calcination of the film. This process was repeated to maximize the fill fraction of nanoparticles into the opal void volume. The silica template was then removed using hydrofluoric acid, leaving behind a stable, magnetic inverse. Using SEM, reflectance spectroscopy, and computational simulations, the structural integrity of the sample was determined and optical bandgaps were explored. These intermediate structures provide a sturdy foundation for the fabrication of a 3-D magnonic crystal.

11:30 AM (MC-T2)

Improving the performance of nanodiamond-containing core-shell particles via extensive characterization of the nanodiamonds

Speaker: Bhupinder Singh

Matthew R. Linford
Brigham Young University: Department of Chemistry and Biochemistry

David S. Jensen, Andrew J. Miles, Michael A. Vail, Andrew E. Dadson
Diamond Analytics, Orem, Utah

We have been developing ca. 4.0 μm nanodiamond-based core-shell particles by alternatively depositing nanodiamonds and an amine-containing polymer (polyallylamine) onto carbon cores. These

nanodiamond-based particles have shown promise in separating a number of critical pairs of acidic herbicides and in high pH separations of pharmaceuticals. However, until now, relatively little has been known about the materials used to make these particles. Therefore, a comprehensive study of the nanodiamonds used to make the shells of our particles has been undertaken. These nanodiamonds have been characterized by X-ray photoelectron spectroscopy (XPS), time-of-flight secondary ion mass spectrometry (ToF-SIMS), Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), X-ray diffraction (XRD), electron energy loss spectroscopy (EELS), inductively coupled plasma mass spectroscopy (ICP-MS), Brunauer-Emmett-Teller (BET) isotherm measurement, and elemental analysis. For comparison, other nanodiamond samples from other sources have also been characterized by the same methods. These techniques have revealed the elemental compositions of the nanodiamonds, the key functional groups present in them, and their surface areas and particle size distributions. Efforts are being made to apply this understanding to enhance the performance of our core-shell particles**.**

11:45 AM (MC-T3)

Reflectance and absorptance of multi-walled carbon nanotube forests

Speaker: Brian Wood

Elizabeth Geyerman, T.-C. Shen
Utah State University: Department of Physics

J.S. Dyer, V.A. Thurgood
Space Dynamics Laboratory, North Logan, Utah

N.A. Tomlin, J.H. Lehman
National Institute of Standards and Technology, Boulder, Colorado

Black surfaces are useful as black-body sources for optical calibration, as detectors for radiometry, and as absorbers for thermal energy conversion. It has been reported that single-walled carbon nanotube (CNT) forests provide a nearly constant absorptivity of 0.98-0.99 across a wide spectral range from UV (200 nm) to far IR (200 μm) on silicon oxide. However, the correlation between optical properties with CNT forest morphologies remains unclear. In their 2009 paper, Mizuno *et al.* claim that the emissivity is nearly wavelength independent and independent of the CNT forest heights from 2 to 460 μm in the wavelength range from 5 to 12 μm. However, we observe a wavelength and high CNT forest morphology dependent reflectance and transmittance in the mid-IR (2-16 μm) regime. In this presentation, I will discuss our integrating-sphere study of total reflectance and transmittance of CNT forests of different heights and densities on different substrates (quartz, Al/Si, Nb/Si). We find that the surface chemistry plays an important role in CNT forest morphology and greater forest height may not reduce reflectance if the density is not properly adjusted. The shorter forest height enhances robustness against cleaning and vibration, which is important for various applications. Using the interference effect when the CNT density is low, we can deduce the index of refraction and absorption coefficient of the CNT films.

12:00 PM (MC-T4)

Characterization and numerical simulation of precipitates formed in long-term aging Al 5083 alloy

Speaker*:* Gaosong Yi

Yakun Zhu, Alexander T. Derrick, Michael L. Free
University of Utah: Department of Metallurgical Engineering

Al 5083 alloy sensitized at 343 K(70 ℃) for 1, 3, 12 and 30 months has been investigated using transmission electron microscopy (TEM) and energy dispersive X-ray spectroscopy (EDS). Magnesium-rich β phase, Al_3Mg_2, precipitated along grain boundaries as well as around and between preexisting Mn-Fe-Cr-rich particles. β' phase was found to form at the grain boundary of Al 5083 alloy aged for 30 months. EDS mapping results showed that Mg-Si-rich particles also formed at the grain boundary after 1 and 3 months of aging. A large Mg_2Si particle was observed to form within the grain matrix of Al 5083 alloy aging for 30 months, and EDS line scan results revealed Si-rich phase formed along the Mg_2Si

particle. A numerical model was built to predict the growth behavior of *β* phase at the grain boundary based on a solute mass balance, different Mg concentration profiles, and collector plate mechanism. Experimental results of *β* phase length and thickness were obtained using TEM images of Al 5083 alloys aged at 343 K for different times. Modeling results of *β* phase thickness and continuity agree well with experimental observations.

Devices & Sensors – SMBB

11:15 AM (DS-T5)

Multiplexed immunoassay of potential pancreatic cancer markers using internal calibration

Speaker: Jason G. Beck

China Lim, Aleksander Skuratovsky, Jennifer H. Granger, Michael C. Granger, Gayatri Khandeharo, Matthew A. Firpo, Sean J. Mulvihill, Marc D. Porter

University of Utah: Nano Institute of Utah and Departments of Chemical Engineering; Chemistry; Bioengineering; Surgery; and Pathology

The Huntsman Cancer Institute, Salt Lake City, Utah

Most immunoassays are designed to detect the presence of, and/or to quantify the amount of, a single disease marker in a patient specimen like serum or urine. However, mounting evidence suggests that for many diseases (*e.g.,* pancreatic cancer), accurate diagnosis and therapeutic monitoring necessitates the simultaneous measurement of a suite of biomolecules. Multiplexed assays are nonetheless hindered by the need to establish calibration curves from standardized solutions of each analyte. Here we present a novel method for calibrant-free calibration that takes advantage of the radially dependent flux that results when a substrate is rotated in solution. Each microfabricated sample coupon consists of an 11 × 11 array of 200 μm gold squares patterned on a silicon chip. Each set of radially offset addresses are modified with antibodies to capture a specific antigen that is subsequently tagged with Raman-active gold nanoparticles. The coupons are then interrogated by surface-enhanced Raman scattering. Results from our preliminary efforts to validate this calibration approach will be described in studies using human IgG and osteopontin (a probable pancreatic cancer marker) as model antigens. Challenges in moving this approach forward will also be discussed.

11:30 AM (DS-T6)

Microfluidic bubble-based gas sensor

Speaker: Ashrafuzzaman Bulbul

Hao-Chieh Hsieh, Hanseup Kim
University of Utah: Department of Electrical and Computer Engineering

This presentation reports a new class of gas sensor that utilizes the variations in bubble sizes when different gases are introduced into a liquid flow to identify gas types and even quantify the amounts. To our knowledge, this is the first attempt to use changes in bubble size of individual gases introduced into liquid as a gas sensor. As the first report on a gas sensor, the feasibility of detecting pentane (C_5) in nitrogen (N_2) flows has been demonstrated along with the quantification possibility. Previous gas sensors have relied on surface chemistry and have suffered from the performance degradation overtime. While FID- and TCD-based sensors avoided such overtime drift issues, they required complex supporting equipment such as vacuum or were difficult to integrate with chip-scale devices. The presented work avoids all such issues by simply utilizing a micro channel without dependence on surface chemistry. When a gas (*e.g.*, nitrogen) is introduced into a micro channel where there is a liquid flow, it forms a train of bubbles with a specific size depending on the flow rates, surface tension, dissolvability and viscosity. When a different type of gas (*e.g.,* pentane) is mixed into the nitrogen flow under the same flow rate, the produced bubbles reduce the size compared to the N_2 bubbles. The measurement also showed a correlation between the injection volume and the size: an increase in the injection volume of pentane decreases the bubble size even more and also elongates the size variation period.

11:45 AM (DS-T7)

A dual-gate field effect transistor for chemical vapor detection

Speaker: Benjamin R. Bunes

Daniel L. Jacobs, Paul Slattum, Trevor Knowlton, Ling Zang
University of Utah: Department of Materials Science & Engineering

Chemical sensors that provide electronic signaling can be classified in two categories: chemiresistors and chemical-sensing field effect transistors (chemFETs). The primary advantage of chemFETs is fewer materials requirements; the sensory material need not be conductive, as in chemiresistors. Although chemFETs have been studied since the 1970s, low sensitivity continues to limit their potential. Such devices are typically fabricated using organic semiconductors, which include trap states that arise from the environment (e.g., water, air). These trap states induce a large threshold voltage, which is the cause of the low sensitivity. Essentially, the trap states must be filled before an appreciable change in conductivity is measured. The implication for sensors is that low concentrations of analyte only fill trap states; high concentrations are required before a response is observed.

To combat this issue, a second gate electrode is added. In previous works, this second gate, opposite the sensing gate, is used to read the signal from the sensing gate as a shift in threshold voltage. While this is acceptable in a laboratory environment, it is impractical for use in real applications. In our configuration, the second gate is used to set the threshold voltage of the sensing gate, enabling simpler current-based signaling. With the ability to set the threshold voltage, we can also set the sensitivity. We use this strategy to demonstrate a signal enhancement of over four orders of magnitude compared to traditional chemFETs. Emphasis will be placed on device design and the enabling materials used to produce the improved signal.

12:00 PM (DS-T8)

Asymmetrically functionalized cubes for nanoparticle assemblies

Speaker: Rebecca Goldstein

Aixiang Liu, Jennifer Shumaker-Parry
University of Utah: Department of Chemistry

Silver nanocubes exhibit unique localized surface plasmon resonance properties. Because the faces of the cubes have a high surface area for forming junctions, nanocubes are an ideal system for probing formation of nanoparticle assemblies. We demonstrate the first steps of developing a method to produce nanocube dimers with controllable inter-particle spacing. Our approach, based on asymmetric functionalization, should lead to spatially-localized ligands on the nanocube surface. Silver nanocubes with an edge length of ~50 nm were synthesized using the polyol method. The cubes were then immobilized on a glass coverslip functionalized with 3-aminopropyldiisopropylethoxysilane. We found dispersed cubes were immobilized face down on the glass substrate, rather than interacting with the surface at an edge or corner site. As a first step, cubes were functionalized using poly(acrylic)acid on the exposed surfaces of the cube. The face in contact with the silane-functionalized substrate should be protected. The stability of the PAA-coated cubes was determined in Tris buffer solution with varying pH and ionic strength conditions. When removed from coverslips, the PAA-functionalized cubes were stable in high salt concentrations (100 mM) and a physiologic pH of 7.4. The stability of the cubes in solution after asymmetric functionalization shows the potential to use the particles to form dimers using DNA hybridization through spatially localized DNA oligomers.

4:30 PM (ECE-T9)

Electronic response of platinum nanoparticles

Speaker: Nick Corbett

Ryan P. Steele
University of Utah: Department of Chemistry; and Henry Eyring Center for Theoretical Chemistry

We present a theoretical study of the global and site-specific electronic structure of a platinum nanoparticle using density functional theory computer simulations. For Pt_{38}, eight nonequivalent surface sites were identified. Using simple charges to scan the surface at varying distances, changes in electron density were calculated for each site, and a global minimization of the perturbed particle was performed. Importantly, non-uniform response of the electronic density is observed; the response of Pt nanoparticles to external charges is decidedly chemical in nature and site-specific, rather than simple electrostatic polarization. Graphical depictions of this process are presented in this work. Understanding the ground state electronic structure of nonequivalent sites will facilitate further studies into ion and ligand site-specific interactions, as well as the chemical and electrochemical activity of Pt nanoclusters.

4:45 PM (ECE-T10)

Making catalysts fast, extremely robust, inexpensive, and well-defined at Å-scale, all at the same time: Beginning of a molecular-material journey

Speaker: Sid Das

Utah State University: Department of Chemistry and Biochemistry

Catalysts are either very fast (*i.e.*, highly reactive and thus unstable) or very long-lasting (*i.e.*, less reactive). Having both criteria at the same time is the most fundamental quest in catalyst-design. It is especially true if the catalyst is made of earth-abundant 1^{st} row transition metals. Material-based catalysts tend to be robust, but lack the predictable molecular scale fine-tuning. In this century when we are targeting multi-dimensional challenges in catalysis such as solar water splitting and CO_2 sequestration, the molecular fine-tuning is critical. Over the last two years, we have taken a molecular-material strategy in catalyst design: material-based catalysts with molecular scale tunability and freedom to incorporate versatility at the molecular scale. The ease of synthesis, characterization and tunability inherent in our design-strategy allow us to (a) develop water-oxidation catalyst that is >4 times faster than the previously known fastest material (a cobalt-based catalyst), (b) improve it by further ~8 times, and (c) synchronize light-absorption, electron transfer and $H_2O \rightarrow H_2$ in one material. We would like to present a synopsis of this recent ongoing effort with the goal of developing catalysts that conjoin molecular chemistry, materials, and nanostructure.

5:00 PM (ECE-T11)

Enhanced performance of organic photovoltaics using plasmonic nanocrescent structures

Speaker: Daniel Jacobs

Jennifer Shumaker-Parry, Ling Zang
University of Utah: Departments of Chemistry; and Materials Science and Engineering

Using organic semiconductor materials in photovoltaic devices (OPV) is the focus of a fast growing and promising research field owing to their cheap materials, moderate processing conditions and ability to be fabricated on lightweight flexible substrates. However, optically thin active layers (~100 nm) limit the performance through incomplete absorption. Incorporation of plasmonic nanostructures into OPV devices has been shown to effectively enhance the device performance by creating a localized near field at the nanostructure's plasmon resonance wavelength. This high intensity near field can extend

into the active layer of the device, allowing for an increase in absorption. Ideally, the plasmonic materials should have tunable and broadband resonances for efficient light harvesting, as well as inexpensive fabrication to maintain the cost effectiveness of OPVs. However, such structures typically require complicated fabrication, making them too costly for real devices. Novel nanocrescent (NC) structures can be fabricated in a cheap large-area technique and have shown broad multipeak resonances that can be easily tuned from the visible to the infrared wavelengths.

Here, the effect of gold NCs on the performance of a low band gap bulk heterojunction active layer (PCPDTBT:PC71BM) was investigated. Fabricated structures showed multipeakpolarization-dependent resonances straddling the active layer's absorption band edge, and resulted in broadband absorption enhancement. Preliminary device performances showed an increase in efficiency via short circuit current increase by more than a factor of two. Studies to optimize the device and determine the enhancement mechanism are underway.

5:15 PM (ECE-T12)

A green facile photochemical method for decontaminating water from ionic mercury

Speaker: Oscar David Petrucci

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

The contamination of large bodies of water by mercury constitutes a serious threat to human health. Mercury accumulates inside the cells of planktonic species and seaweeds and concentrates in the flesh and organs of animals at each step of the food chain up to humans. In our bodies mercury accumulates in the kidneys, liver, brain, reproductive system, and fetus leading to severe organ damage, neurological diseases (*e.g.*, Minamata disease), birth defects, and death.

The state-of-the-art methods for decontaminating water from mercury are capping, immobilization, or precipitation of the metal *in situ*. All of these methods have major flaws: capping and immobilizing reduce the problem only temporarily, until the immobilizing/capping agents are degraded and mercury is again released in the environment. Current precipitation protocols are complex, costly and require the use of harsh chemicals.

Our laboratory has previously employed ferritin-based photochemistry to reduce a number of metal ions. Ferritin is a protein with photo-catalytic properties found in the liver of all animals. We ventured to apply and optimize a ferritin-citrate-based method to reduce Hg(II) to Hg(0) and precipitate it. Hg(II) was efficiently precipitated and cleared from solution by simple centrifugation or settling. Our results are comparable with those obtained by the best methods available, but without their drawbacks.

Nanomedicine – SMBB

4:30 PM (NM-T13)

Oligonucleotide hybridization-mediated drug-free macromolecular therapeutics

Speaker: Te-Wei Chu

Jiyuan Yang, Rui Zhang, Monika Sima, Jindřich Kopeček
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry; Bioengineering; and Center for Controlled Chemical Delivery

An emerging trend in nanomedicine is the use of biomaterials not only as drug delivery vehicles but also as "bio-mimics" to trigger cellular events and define new therapeutic effects. Motivated by this rationale, we designed a novel biomimetic system that crosslinks cell surface antigens and induces apoptotic cell death. This design was inspired by the mechanism of receptor clustering-mediated apoptosis. In particular, when CD20-bound antibodies are hyper-crosslinked by immune effector cells, CD20 clustering occurs within lipid rafts and triggers apoptosis. We synthesized a hybrid system comprised of two nanoconjugates: (1) an anti-CD20 Fab' fragment covalently linked to a single-stranded morpholino oligonucleotide 1 (Fab'-MORF1), and (2) a linear polymer (P) of *N*-(2-

hydroxypropyl)methacrylamide (HPMA) grafted with multiple copies of the complementary morpholino oligonucleotide 2 (P-MORF2). We show that the exposure of malignant B-cells (CD20+) to Fab'-MORF1 first decorates the cell surfaces with MORF1; the further treatment of decorated cells with P-MORF2 then results in MORF1-MORF2 hybridization at the cell surface with concomitant CD20 crosslinking, which triggers apoptosis. When tested in a murine model of human B-cell lymphoma, the two conjugates, either administered consecutively or as a premixture, eradicated cancer cells and produced long-term survivors. We named the proposed strategy of apoptosis induction "drug-free macromolecular therapeutics" because the therapeutic system contains no small molecule cytotoxic compounds. The therapeutic activity is direct (independent of immune effector mechanisms) and specific (targeted to CD20+ B-cells), aiming to improve over immunotherapy, chemotherapy and radiotherapy.

4:45 PM (NM-T14)

Effect of folate on release of paclitaxel from eLiposomes

Speaker: Marjan Javadi

William G. Pitt
Brigham Young University: Chemical Engineering Department

A nano-sized drug carrier was made that can be burst by applying ultrasound (US). Whereas most ultrasonic drug delivery requires gas bubbles, this technique does not. The carrier, called an eLiposome, is a liposome containing therapeutics and a liquid nanodroplet of perfluorocarbon (PFC) that can vaporize to gas upon application of US. While applying ultrasound, the local pressure drops below the high vapor pressure that induces the formation and expansion of a vapor phase. The expansion ruptures the liposome, which releases the drug or genes locally.

We loaded nanoparticles of paclitaxel into the interior of the eLiposome. This study revealed an essential component of the eLiposome delivery vehicle. Folate attached to the eLiposomes was found to be necessary to deliver paclitaxel to the cytosol of cells. Without folate, intracellular delivery was very low. Cell viability was measured to determine the effect of folate on release of paclitaxel from eLiposomes.

5:00 PM (NM-T15)

Novel 3-dimensional hydrogel constructs with patterned and functionalized nanofiber scaffolding for enhanced neurite outgrowth and directional control

Speaker: Richard J. McMurtrey

University of Oxford: Department of Engineering; and Institute of Biomedical Engineering

Institute of Neural Regeneration and Tissue Engineering

Neural tissue engineering holds incredible potential to restore functional capabilities to damaged neural tissue. 3-Dimensional hydrogels were constructed with a layer of patterned nanofibers to support neuronal cell cultures. Nanofibers were composed of polycaprolactone (PCL) polymer, PCL mixed with denatured collagen, or PCL with a biofunctional coating, and a method of creating aligned nanofibers was developed. Fiber characteristics were analyzed using environmental scanning electron microscopy. A diffusion model was created to evaluate viable diffusion of oxygen and nutrients into the 3-dimensional hydrogel construct, and a method of analyzing neurite morphology with reference to aligned fibers was developed. Microscopic images were captured at high-resolution in single and multi-focal planes with green fluorescent protein (GFP)-expressing neuronal cells in a fluorescent channel and nanofiber scaffolding in another channel, and neuronal morphology and neurite tracking of nanofibers were then analyzed in detail. It was found that the biofunctionalized nanofibers in 3-dimensional hydrogels exhibited significant alignment of neurites with fibers, significantly increased the distance over which neurites could extend, and resulted in significant neurite tracking of nanofibers. This work demonstrates the ability to create unique 3-dimensional neural tissue constructs using a combined system of hydrogel and nanofiber scaffolding. Furthermore, it is shown that patterned and biofunctionalized nanofiber scaffolds can control direction and enhance length of neurite outgrowth. This approach offers several potential advancements in the development of implantable neural tissue

constructs that enable control of neural development and reproduction of neuroanatomical pathways, thereby making a significant step towards achieving functional neural regeneration.

5:15 PM (NM-T16)

Development of tissue models and spectroscopic detection platforms for biomedical applications

Speaker: Elizabeth Vargis

Utah State University: Department of Biological Engineering

The goals of the newly formed Tissue Engineering and Biophotonics (TEB) lab at Utah State University (USU) are: to develop (1) models of normal and diseased tissues and (2) nanoscale disease detection platforms. *In vitro* models of disease are developed using nanopatterned surfaces, biomaterials, and microfluidic channels to mimic tissues and the *in vivo* microenvironment. The development of these biocompatible materials will be performed at USU, in conjunction with the Oak Ridge National Lab and CFD Research Center. Initially, two tissues will be modeled: the retina and pediatric vascular system. Within the retina, the effect of oxidative species will be ascertained to determine how age-related macular degeneration occurs and how it can be prevented and treated. The vascular system will be used to understand and test treatments of childhood acute myeloid leukemia, a major pediatric cancer.

The second research area of the TEB lab is targeted, surface-enhanced Raman spectroscopy (SERS). Raman spectroscopy is a spectroscopic measure resulting from changes in the vibrational modes of samples of interest. It can be used to non-invasively detect biochemical changes, but suffers from a relatively weak signal. The Raman signal can be enhanced by adding metal surfaces or nanostructures to the sample. For these studies, targeted SERS particles will be fabricated using gold nanoparticles and antibodies of interest, initially for markers of cardiovascular disease and lymphoma, to enhance their detection by up to 10^{10}. Research goals, methods and initial results from the TEB lab will be presented in this presentation.

Poster Session Abstracts

Materials & Characterization

MC-P1

Plasma cleaning changes HDPE bulk crystal properties

Presenter: Shawn Averett, Martin Morales

James Patterson
Brigham Young University: Department of Chemistry and Biochemistry

Plasma is often used to change surface properties such as adhesion, friction, or wetting. Plasma is especially useful because it was thought to change the surface without affecting the bulk of the material. In 2012 our group published the discovery that plasma treatment of polystyrene thin films causes the phenyl groups in the bulk of the material to align. Recently we have discovered that plasma treatment affects more than just the phenyl groups of a polystyrene thin film.

Plasma treatment of injection molded, high density polyethylene (HDPE), was found to cause a change in the crystallization of the material. Our samples are injection molded, and roughly 3 mm thick. Powder X-ray diffraction (XRD) with a probe depth of approximately 1.5 mm was used to investigate the crystallization. Plasma treatment caused the main peaks to shift indicating that distance between crystal planes was changed by plasma treatment. Perhaps even more intriguing is the fact that different samples have been found to shift in different ways. After treatment some samples decreased and other samples increased the distance between planes. We are currently in the process of investigating the cause of these variations.

MC-P2

Vapor-phase deposition and silane functionality to address issues in silane capping of ZnO nanoparticles

Presenter: Sean K. Bedingfield

Kyle J. Isaacson, Rachael Johnson, David W. Britt
Utah State University: Department of Biological Engineering

The delivery of zinc ions using ZnO nanoparticles within the body has been shown to cause the destruction of tumor cells and may also treat neurodegenerative disorders. The silane capping of ZnO nanoparticles is widely employed as a post-synthesis method to protect them from dissolution in polar solvents. Preliminary research demonstrates standard methods of silane capping result in aggregation of silanes around the ZnO, producing particles significantly larger than 20 nm in diameter, which are too large for some medical applications.

Two methods, vapor-phase deposition of silanes and varying the number of functional groups, were investigated to address silane aggregation and create smaller nanoparticles. Three vapor-phase deposition methods were tested with a variety of commercially available silanes and solvents. These solvents included ethanol, toluene, and hexane. The use of silanes with a varied number of functional groups in liquid-phase deposition was also compared with standard methods. Performance of methods was evaluated using dynamic contact angle analysis, nanoparticle partition and emissability in different solvents, dynamic light scattering, and fluorometric analysis.

Vapor-phase deposition was shown to be a feasible means of silane capping. Efficiency and generated particle size of methods tested are discussed.

MC-P3

High resolution nanoparticle mass spectrometry

Presenter: David Bell

Collin R. Howder, Scott L. Anderson
University of Utah: Department of Chemistry

Several methods for non-destructive mass measurements on a single, trapped nanoparticle are demonstrated. Charge particles are introduced by electrospray ionization and are trapped in a quadrupole ion trap. The particles for a coulomb lattice in the ion trap and are detected by light scattering. Once an ensemble is trapped, particles are systematically ejected so that only a single particle remains. When a particle is in the trap, the particle has a very well-defined secular motion, which relates to the particles mass-to-charge-ratio. Three methods are used to detect the secular frequency of the particle. The first involves utilizing a Fourier transform of the fluctuations in light scattering; these fluctuations are a result of the particle's secular motion in the trap. Another method involves varying the frequency modulation of the laser thus modulating the light pressure on the particle. When the modulation of the laser is in resonance with the particle's motion, the particle's motion is excited and a decrease in scattered light intensity is observed. The final method involves sweeping the frequency of a weak AC potential near the trap and, similar to the previous method mentioned, when the frequency of the AC potential is in resonance with the particle's secular motion the particle is excited and a decrease in scattered light intensity is observed. These methods have a resolution between 100 ppm – 10 ppm. Comparing the peak position over several measurements approaches 1 ppm resolution.

MC-P4

Diffraction-unlimited nanopatterning with optical saturable transformations

Presenter: Precious Cantu

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

Trisha Andrew
University of Wisconsin at Madison: Department of Chemistry

We report that the diffraction limit of conventional optical lithography can be overcome by exploiting the transitions of organic photochromic derivatives induced by their photoisomerization at low light intensities. This limit has been of central importance as patterning of truly nanoscale devices has in the past been limited by diffraction effects which prevented conventional optical lithography from providing spatial lateral resolution better than λ/2 (where λ is the wavelength of the radiation used). We define this novel method as Patterning via Optical Saturable Transformations (POST).

A photochromic BTE derivative, namely, 1,2-bis(5,5′-dimethyl-2,2'-bithiophenyl) perfluoro-cyclopent-1-ene, is used to demonstrate POST. Upon irradiation with short-wavelength UV, the open-ring isomer converts to the closed-ring form. A subsequent illumination with a node at 633 nm converts the molecules back to the open-ring form, except in the near vicinity of the node. By optically saturating this transition, the molecules in the closed form remain in a region that is far smaller than the far-field diffraction limit. Then, selective-oxidation of the closed-ring form into a stable radical cation completes the patterning. Finally, the cations are dissolved in a polar solvent, leaving behind a nanoscale topography.

MC-P5

Reversible assembly of novel ultrafiltration membranes made of polymer-modified silica nanoparticles

Presenter: Emily Fulwood, Patrick Kolbay

Amir Khabibullin, Ilya Zharov
University of Utah: Department of Chemistry

Nanoporous membranes are attracting increased attention of researchers due to their possible application in separations and sensing. Nanoporous membranes should possess controllable thickness and area, as well as narrow pore size distribution, simplicity of preparation and good mechanical and chemical stability. The possibility of controlled disassembly and further re-assembly of the membrane creates advantages in recycling, cleaning and reusing the material. The membrane stands repeated cycles of controlled disassembly and re-assembly, which has significant advantage in processes where parameters are tuned during experiment.

Here we report two types of non-covalent nanoporous membranes made of silica colloidal spheres with polymer brushes grafted on silica surface. The silica spheres in the membrane are held together via non-covalent interactions between polymer brushes carrying either acidic (sulfonic) and basic (amino) or neutral (hydroxyl) groups. Due to the non-covalent nature, the reversible assembly (*i.e.*, the capability of dispersion and re-assembly of the membrane in various solvents) is possible. Good control over membrane thickness, area and pore-size is achieved by variation of membrane parameters, such as silica sphere size, silica concentration in colloidal solution and polymer brush length. Pressure-driven filtration experiments were carried out to test the membranes for ultrafiltration application. We showed that our membranes are capable of ultrafiltration.

MC-P6

Characterization of thermal properties of fine fibers by 3-omega technique

Presenter: Levi Gardner

Changhu Xing, Colby Jensen, Benjamin White, Troy Munro, Heng Ban
Utah State University: Department of Mechanical & Aerospace Engineering

The 3ω method has long proven to be a reliable measurement technique for thermal characterization of micro to nanoscale suspended wires. In this case, the technique was successfully applied for measurements of carbon nanotubes and silicon nanowire. In this research, a new, simple, explicit model combining the merits of past researchers was proposed to describe the heat transfer process through the suspended wire. Generic plots of the 3rd harmonic voltage amplitude and phase responses clearly indicate the frequency limits for thermal conductivity, heat capacity determination, and the condition for thermal diffusivity estimation. Two main issues needing further exploration are the experimental effects of radiation heat loss and the comparison of measurements between current and voltage sources. Radiation influence on measurement results can be foundationally defined by a linear relationship to a dimensionless radiation parameter modeled in the heat equation. A comparison of measurements with a current source to those with a voltage source and a Wheatstone bridge indicates that the latter configuration renders more reliable results. By carefully selecting parameters, the configuration of voltage source together with a Wheatstone bridge is an accurate means of determining a sample's thermal properties.

MC-P7

Threading the pore: Non-covalent display of multiple proteins on the exterior surface of a bacterial protein capsid via charge complementarity

Presenter: Larry Grant
Erik Hasenoehrl, Ken Woycechowsky
University of Utah: Department of Chemistry

A major challenge in the development of nanoscale structures is achieving reliable, monodisperse assembly. Many proteins form symmetric assemblies, which offer a natural solution to this problem. Icosahedral protein capsids form multi-subunit shells via hierarchical association of lower-order oligomers and also possess an inherent potential for even higher levels of supramolecular assembly. Such structures are readily modified by genetic or chemical methods, which further increase their versatility. *Aquifex aeolicus* lumazine synthase (AaLS) is an attractive scaffold for engineering novel nanostructures. The AaLS capsid self-assembles from 60 identical subunits to form a dodecahedron with 12 pores at its five-fold symmetry axes. We hypothesized that these pores may be engineered to serve as docking sites for the multivalent display of tagged proteins on the capsid exterior. To generate such a supramolecular assembly, we installed negatively charged aspartates in the AaLS pores and appended a positively charged deca-arginine tag to green fluorescent protein. Upon mixing, these proteins spontaneously form a non-covalent complex, presumably via threading of the cationic tag through the anionic pores. The K_D of this association is 41 nM at a buffer ionic strength of 275 mM, significantly above that of typical human blood plasma, suggesting that non-covalent molecular display via engineered charge complementarity presents a potentially viable strategy for the targeted delivery of protein capsids to cells. Additionally, this approach may provide a means for generating a reversible cap capable of controlling access to the capsid interior, which would be an attractive feature for drug delivery or nanoreactor applications.

MC-P8

Finite element analysis of transient ballistic-diffusive heat transport in two-dimensional plates

Presenter: Sina Hamian

Keunhan Park
University of Utah: Department of Mechanical Engineering

Mohammad Faghri
University of Rhode Island: Department of Mechanical, Industrial and Systems Engineering

As microelectronic devices keep shrinking below the mean free path of thermal energy carriers, fundamental understanding of sub-continuum heat conduction becomes critically important for effective power management and reliable operations. However, due to the finite speed of thermal energy carriers, the conventional Fourier law is incapable of predicting the thermal diffusion in such devices. The Boltzmann transport equation (BTE) has shown promising results in predicting the ballistic-diffusive nature of heat transfer and temperature distribution in the sub-continuum domain. In this study, we report the numerical simulation of the transient 2-D BTE under the gray relaxation-time approximation by combining the finite element analysis with the discrete ordinate method (DOM) for discretizing the angular domain. This method is validated by comparing the calculation with the 1-D analytical solution of the equation of the phonon radiative transport (EPRT) for a high-aspect-ratio rectangular geometry. For an illustrative boundary condition (T_H at the top wall and T_C at the other walls), the obtained results clearly show a ballistic feature of heat transport and resultant temperature jump at the wall. The transient analysis shows the propagation of thermal energy as time approaches the relaxation time constant. The ray effect is discussed as the primary error source, which can be suppressed by increasing the number of the discretization in the angular domain. The success of this study will provide a reliable engineering tool in computing ballistic-diffusive heat conduction in micro/nanostructures.

MC-P9

Diffusion of proteins through nanoporous silica colloidal crystals

Presenter: Robert Haynes

Ilya Zharov
University of Utah: Department of Chemistry

Diffusion of three proteins, bovine serum albumin (BSA), lysozyme (Lz), and bovine hemoglobin (BHb), across silica colloidal crystals were studied as a function of pore size, pH, ionic strength, and surface properties of the nanopores. We found that the flux of Lz was ca. 2.5 times higher compared to that of BHb due to the protein size difference for nanopores with 25 nm radius. Comparing BHb and BSA provided information of how protein shape affected flux, and it was shown that BSA diffused 2.7 times faster than BHb, even though they possess similar molecular weights. At pH 6 Lz and BHb are cationic and BSA is anionic, and at pH 4 all three proteins are cationic. We found that changing the pH from 4 to 6 did not affect the diffusion rates of the proteins. We also found that increasing the ionic strength of the solution from 10 mM to 250 mM did not significantly affect the diffusion rates. Therefore, the diffusion of proteins through colloidal nanopores is predominantly controlled by their size. Finally, we modified the nanopore surfaces with polyethylene glycol (PEG) chains of varying length to minimize nonspecific adsorption and to manipulate the pore size.

MC-P10

Fluorescence of charged quantum dots in the gas phase

Presenter: Collin R. Howder

David M. Bell, Scott L. Anderson
University of Utah: Department of Chemistry

Charged quantum dots (CdSe/ZnS core shell nanocrystals) are generated by electrospray ionization and trapped in a split ring quadrupole ion trap. A 532 nm laser is used to observe fluorescence of the particles. It has been previously shown that in solution and in solid media, the fluorescence of a quantum dot is strongly attenuated when the dot is charged. It is shown that gas phase quantum dots are fluorescent despite being highly charged. In addition to blinking and photo bleaching behavior, significant activation of fluorescence is observed upon heating dots with a 532 nm laser or a CO_2 laser.

MC-P11

Reversible pH-sensitive micelle as drug carrier increases the efficacy of cancer chemotherapy

Presenter: Jun Hu

You Han Bae
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry

Intravenously introduced nanoparticles for solid tumors translocate from blood vessels to tumor compartments by extravasation via open gap junctions and fenestraes on the tumor blood vessels. However, due to high interstitial fluid pressure, there is a high probability of migration of the extravasated nanoparticles back to the blood stream before deep penetration into the tumor tissue. So, back-diffusion can be one of the major causes for the disappearance of accumulated inert nanoparticles in solid tumors over time, as observed from various *in vivo* investigations. To recycle the drug-loaded nanoparticles back to the blood, polysulfonamide-based copolymer is employed as a model for proof-of-concept for a unique pH-sensitive micelle system, which is a reversible activation for binding between blood pH and tumor pH.

A new polymer, PLGA-Polysulfadimethoxine-mPEG, was synthesized and self-assembled into spherical micelles. Before loading drugs, the micelle reversibly changed its size between 90 nm at pH 7.4 and 99 nm at pH 6.3, and its surface changed between negative charge at pH 7.4 and neutral at pH 6.3. After loading Doxorubicin, the size of the micelle decreased to 28 nm at pH 7.4 with 80% loading efficiency. Also, the drug release and the cell uptake of the micelles showed pH dependency and reversibility.

MC-P12

Characterization of the carbonized poly(divinylbenzene) microspheres in the diamond analytics "flare" core-shell C18/amino polymer/nanodiamond mixed-mode column

Presenter: Chuan-Hsi Hung

Bhupinder Singh, Anubhav Diwan, Matthew R. Linford
Brigham Young University: Department of Chemistry and Biochemistry

Andrew J. Miles, David S. Jensen, Michael A. Vail, Andrew E. Dadson
Diamond Analytics, Orem, Utah

The synthesis of various carbon-based materials has been widely studied, and these materials have drawn attention in high performance liquid chromatography (HPLC) because of their inertness at extremes of pH and temperature. In our research group, we have prepared core-shell particles for HPLC from core particles made from carbonized poly(divinylbenzene) (CPDVB), with poly(allyamine) (PAAm) and nanodiamond porous shells. Functionalization of these particles by epoxides creates a mixed-mode C18/weak anion exchange material, which is now commercially available from Diamond Analytics as the Flare core-shell column. This column shows high efficiency (> 110,000 N/m) with very good stability at extremes of pH and temperature. It also shows weak anion exchange in various separations, *e.g.*, acidic herbicide analytes. In this presentation, we focus on the characterization of the carbonization process of poly(divinylbenzene) using X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Brunauer-Emmett-Teller (BET) isotherm measurements, and time-of-flight secondary ion mass spectrometry (ToF-SIMS).

MC-P13

Examination of the synthesis and purity of zinc oxide nanoparticles

Presenter: Rachael A. Johnson

Kyle J. Isaacson, David W. Britt, Joan E. McLean, Anne J. Anderson
Utah State University: Department of Biological Engineering

Zinc Oxide Nanoparticles (ZnO NPs) are readily synthesized via sol-gel protocols leading to unique synthesis-dependent properties, such as size, geometry, and fluorescence, that enable them to be used in a wide variety of applications and products. Many journal articles have been published on the synthesis of ZnO NPs; however, upon reviewing the current literature, it is evident that the purity of the final product is often poorly characterized. The aim of this study was to optimize wet synthesis methods of ZnO NPs and analyze the purity of ZnO NPs in order to reduce carryover of excess reactants into the final NP product. ZnO NPs were synthesized by zinc acetate reduction in a lithium-hydroxide (LiOH) in ethanol solution following standard published protocols, andresulted in a highly alkaline final product. Several post-processing methods of removing the remaining LiOH were examined and are presented. Dynamic light scattering, atomic force microscopy, X-ray diffraction, fluorimetry and absorbance spectrophotometry are used to characterize the properties and purity of the synthesized ZnO NPs.

MC-P14

Characterization of thin films for fabrication of carbon-nanotubes templated thin-layer chromatography plates

Presenter: Supriya S. Kanyal

David S. Jensen, Andrew Dadson, Matthew R. Linford
Brigham Young University: Department of Chemistry and Biochemistry
Michael A. Vail
Diamond Analytics, Orem, Utah

Here we characterize the films used for fabricating binder-free, carbon nanotube (CNT)-templated, thin layer chromatography (TLC) plates via ellipsometry, Diffuse Reflectance Infra-red Spectroscopy (DRIFT) and Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS). The films studied here were $Si/SiO_2/Al_2O_3$, $Si/SiO_2/Al_2O_3/Fe$ and $Si/SiO_2/Al_2O_3/Fe_{(annealed)}$ which is used for fabricating TLC plates described earlier.[1-3] Thicker Fe films (~20 nm) were found to be more metallic than thinner Fe films (~6 nm). Alumina films could be well parameterized by Cauchy model. Fe film (6 nm) was used to grow CNTs via chemical vapor deposition. Infiltration of silicon with low-pressure chemical vapor deposition followed by oxidation at 1000 °C was done to get silica nanowire backbone. The high temperature oxidation process renders the silica nanowire surface hydrophobic (with less silanol groups). ToF-SIMS showed that, as the hydration became more effective, $SiOH^+/Si^+$ ratio increases. DRIFT spectra showed that the $SiOH^+/Si^+$ ratio could be directly correlated to the isolated silanol peak position (characteristic of degree of hydration). Extensive study was done on ammonium hydroxide and hydrofluoric acid using these techniques to find the optimum hydration conditions.

MC-P15

Diffraction unlimited maskless optical lithography using absorbance modulation

Presenter: Apratim Majumder

Farhana Masid, Rajesh Menon
University of Utah: Department of Electrical and Computer Engineering

Trisha Andrew
University of Wisconsin at Madison: Department of Chemistry

Diffraction limits the size of the smallest features that can be fabricated using conventional optical lithography. Absorbance Modulation Optical Lithography (AMOL) is one of the emerging methods by which this barrier can be circumvented. AMOL employs a thin layer of two-state-photo-switchable photochromic material as an absorbance modulation layer, which is exposed simultaneously to a standing wave at a wavelength λ_2, and another one λ_1, such that the peaks of λ_1 are spatially collocated with the troughs of λ_2. Absorption at the first wavelength λ_1 (ultraviolet) converts the photochromic layer into a transparent form, while absorption at the 2nd wavelength, λ_2 (visible) renders the photochromic layer opaque. The competing action of the two states of the photochromic material under the influence of the two wavelengths squeezes the transmission of λ_1 through the layer, such that a nanoscale optical probe emerges on the other side. An underlying photoresist layer can capture the λ_1 light that transmits through the aperture and thereby record a sub diffraction pattern in the photoresist. Further, the size of the pattern in the resist can be scaled according to the ratio of the intensities of λ_2 and λ_1. In this presentation, we will describe the principle and process characterization of AMOL as a lithographic process, the elimination of a barrier layer that was previously used in between the photoresist and the photochromic layer, as well as extension of the method to printing two-dimensional patterns.

MC-P16

Bile acid transporter mediated oral drug delivery: Therapy and diagnosis

Presenter: Md Nurunnabi

You Han Bae
University of Utah: Department of Pharmaceutics and Pharmaceutical Chemistry

Yong-Kyu Lee
Korea National University of Transportation: Department of Chemical and Biological Engineering

Oral drug delivery is one of the emerging fields of drug delivery research. Due to patient convenience and ease-of-administration, the oral route is considered as most convenient route for drug administration. However, many drugs and large molecules, such as anticancer drugs (Docetaxel, doxorubicin), heparin, proteins, and insulin, are not usually administered orally due to any absorption thus not bioavailability observed. Therefore several strategies have been considered for investigation to deliver those drugs through oral administration. Our group usually focuses on bile acid transporter mediated oral drug delivery system using commercially available bile acids such as deoxycholic acid (DOCA) and taurocholic acid (TCA). Heparin and insulin are not orally absorbed though they are known as very essential drugs and are widely used. However, our group has observed that through DOCA conjugation, both the heparin and insulin were observed to be absorbed through small intestine and bioavailability. Our group also observed oral delivery of optical imaging agent (quantum dots) through bile acid transporter for GI tract imaging of mice. Recently we have investigated TCA instead of bile acid and thought it would be a better candidate for oral drug delivery due to hydrophilic properties. The hydrophilic TCA would express on the outer surface of the formulation (micro/nanoparticles) and would have direct interaction between the particles and bile acid transporter of small intestine in GI tract. Recently, we have observed pharmacokinetics profile of orally administered docetaxel through TCA. We have also observed absorption mechanism through bile acid transporter. The TCA conjugated particle/vehicle/carrier could be used for drug delivery as well as gene (DNA, RNA, and plasmid) delivery through oral administration.

MC-P17

Mechanism and growth of aggregated zinc ferrite nanocubes and their characterization

Presenter: Jooneon Park

Michael C. Granger, Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Chemical Engineering; Chemistry; Bioengineering; Pathology; and Surgery

Magnetic nanoparticles (MNPs) are becoming important to many applications of science and medicine (*e.g.*, magnetic resonance imaging, drug delivery, and chemical and biological sensing). In each of these applications, the utility of these materials is intimately linked to the ability to synthesize MNPs with specific magnetic moments and predetermined sizes and shapes. Among the many MNP synthetic

routes, methods based on thermal decomposition not only allow for control of particle shape and size, but also provide the ability to incorporate different metals, resulting in zinc-, manganese-, and cobalt-ferrites with rationally designed magnetic moments and specific effective anisotropy constants. This presentation describes the results of our studies aimed at synthesizing aggregated zinc ferrite nanocubes (AZnNCs), their characterization, and the mechanistic synthetic details. Though others have reported on zinc ferrite nanocubes (ZnNCs) composed of smooth {100} facets, we believe that this work represents the first description of AZnNCs. Scanning electron microscopy shows that AZnNCs are comprised of nodular sides rather than the smooth surfaces observed for traditional ZnNCs. AZnNCs exhibit tight size dispersion, much like their smooth-sided counterparts. X-ray diffraction of both AZnNCs and ZnNCs match zinc ferrite reference data. The saturation magnetization of AZnNCs was measured at ~135 emu/g, which is much higher than that of ZnNCs at ~77 emu/g. We suspect that the different magnetic moments are due to different shape and crystalline anisotropies, which could be used as a design parameter. We will describe our initial results of surface functionalization of AZnNCs for subsequent biological derivatization.

MC-P18

Controlled ZnO hexagonal prism formation with ethanol amines and water

Presenter: William Rankin

Jared Hancock, William Rankin, Brielle Woolsey, Roger Harrison
Brigham Young University: Department of Chemistry and Biochemistry

Formation of ZnO single crystal hexagonal prisms from a sol-gel method is presented. The method requires water, zinc acetate, and ethanol amine to create a gel of zinc hydroxide and zinc hydroxide acetate. Upon heating, the gel forms single crystal hexagonal prisms. Characterization of the gel was done by X-ray diffraction (XRD) as well as XRD high temperature chamber (HTK) to determine the role of temperature in prism formation. Scanning electron microscopy (SEM) images showed hexagonal prisms were of uniform size (approximately 0.5 × 2 μm). Transmission electron microscopy (TEM) and electron diffraction images showed a change from randomly oriented particles to an ordered single crystal after heating. Water and the acetate salt of zinc proved to be critical to prism formation.

MC-P19

Phonon engineering via nanoscale material synthesis

Presenter: Nick Roberts

Utah State University: Department of Mechanical and Aerospace Engineering

The study of phonons, the dominant heat carriers in semiconductors and insulators, is an important area of research. As the density of transistors on integrated circuits continues to increase, thermal management of microelectronic devices is limited by phonon transport in materials. Of particular interest is phonon transmission at interfaces, which is a current bottleneck. In addition to the need for better understanding of phonon transport for thermal management of electronics, there is alsoa need to study engineering materials for thermoelectric energy conversion, solar energy absorption and thermal energy storage. The newly formed nanoscale Thermal Energy Laboratory (nTEL) at Utah State University (USU) is working to improve the knowledge base of phonon transport in solid and multi-phase nanocomposite systems through a combination of computational, theoretical and experimental approaches and applying this to energy conversion and storage systems using scalable nanomanufacturing techniques. Current areas of interest include nanostructured thermoelectrics for thermal energy conversion, nano-enhanced phase change materials for thermal energy storage, hybrid solar conversion systems, nanofluids, thermal interface materials and thermal rectification in solid materials. Current capabilities include direct thermal and thermoelectric property measurement of one- and two-dimensional nanomaterials, thermal and electrical property measurement of bulk materials, characterization of nanofluids and phase change materials for thermal transport and energy storage, characterization of thermal transport properties of thermal interface materials and characterization of photovoltaics. This poster will present the research focus, methods and results of some recent work produced by nTEL at USU.

MC-P20

Plasmonic near-field mapping using positive and negative photoresists

Presenter: Mark Swartz

Cara Barnes, Xiaojin Jiao, Steve Blair, Jennifer Shumaker-Parry
University of Utah: Departments of Chemistry; and Electrical and Computer Engineering

Plasmonic nanocrescents are interesting substrates for refractive index sensing spectroscopies because of their highly tunable, polarization-dependent resonances and enhanced electric near field. Computational models show the near-field enhancement is localized to the tips or backbone of the structure, depending on the incident light polarization. In this study, the two-photon absorption of two different photopolymers is used to map and image the optical near-field enhancement. Two-photon absorption is an inherently weak process requiring high light intensities. By using a low intensity incident laser and plasmonic nanostructures with different shapes, selective polymerization occurs where there is a significant enhancement of the optical near field. The resulting polymerization patterns were imaged using atomic force microscopy (AFM) to examine the depth of field enhancement and scanning electron microscopy (SEM) to examine lateral and longitudinal enhancement. The negative photoresist SU-8 and the positive PMMA resist were both used to image the near-field enhancement. Polymerization patterns are in good agreement with computational models, showing polymerization spanning the tips when light is polarized with the long axis of nanocrescents. When light is polarized along the short axis of nanocrescents, polymerization patterns are localized to the backbone and outside the tips. Symmetric disk and ring structures were also examined and, as expected, the symmetric structures did not result in polarization-dependent polymerization patterns. The SU-8 and PMMA systems provide a chemical scaffold to selectively functionalize nanoparticles where there is increased field enhancement and increased sensitivity.

MC-P21

Biomimetic approaches to novel photonic materials

Presenter: Bryce A. Turner

Michael H. Bartl
University of Utah: Department of Chemistry

This presentation will illustrate how biological and biomimetic systems can be used to develop novel optical materials with a special focus on 3-D photonic crystals. Many current synthetic approaches to optical materials rely on a top-down approach, which proves complex and costly, requiring specialized equipment such as interference lithography. Biology has already created a variety of optically interesting structures that are often superior to current synthetic materials and produced at ambient temperature, pressure and pH. These structures range from Bragg stacks in silverfish, reflective surfaces in fly eyes, waveguides in tree shrew retinas, and perhaps most striking, 3-D photonic crystals in various butterfly and weevil species. Although methods have been developed to use biological photonic crystals as templates, they are destructive and have little to offer for tunability of the structural features. As an alternative, current work is being done using biomimetic systems to develop a cell-free, bottom-up fabrication method of the complex photonic crystals. This involves investigating self-assembly of lipids into cubic lipid structures, cubic membranes found in biological systems, and possible ways to manipulate existing lamellar structures into a cubic symmetry. A cell-free, bottom-up fabrication method would allow for high-efficiency, low-cost photonic crystals, increasing the utility of photonics in industrial and academic research.

MC-P22

Thermal properties of synthetic and natural spider silks at cryogenic temperatures

Presenter: Ben White

Troy Munro, Heng Ban, Randy Lewis
Utah State University: Departments of Mechanical and Aerospace Engineering; and Biological Engineering

Spider silk is known for its impressive strength, elasticity, and flexibility; however, it was recently reported that stretched dragline silk from the *Nephila* Clavipes spider has a thermal conductivity similar to copper. The objective of this project is to determine if synthetic spider silk is a suitable replacement for current thermal management materials (*i.e.*, copper) in space system devices, such as thermal links. The benefit of spider silk, as opposed to other high conductivity materials, is that its density is significantly lower, making it an ideal candidate for space applications.

Selected silk samples from Utah State University's USTAR bio-fabrication lab were used to measure thermal properties (*i.e.*, conductivity and diffusivity) in a cryogenic vacuum chamber. A cryogenic measurement system was developed, which consisted of a constant current supply to induce Joule heating in the gold-coated sample, a digital multimeter to record the temperature rise of the sample, a vacuum chamber to reduce convective heat losses, and a cryocooler capable of reaching 80K.

To validate this system's measurements, the thermal properties of 25.4 μm diameter platinum wires were measured and compared to literature values. The effect of sample mounting material was investigated as well. Results show a decrease in thermal diffusivity of both the natural and synthetic spider silks as temperature decreases, which is different from most polymers. The data developed from the project can be used to evaluate the use of spider silks as an effective thermal management material and to develop a basic understanding of spider silk thermal properties.

MC-P23

Mems technology in thermal conductivity detection systems for gas chromatography

Presenter: Pascal Wüst

Hanseup Kim
University of Utah: Department of Electrical and Computer Engineering

This presentation describes the evolution of Thermal Conductivity Detector (TCD) systems for GC applications during the last few years. Much lower power and gas consumption and shorter analysis times are the main advantages of novel micro TCD's.

A TCD system compares the thermal conductivity of inhomogeneous gaseous mixtures with a reference gas flow. Because TCD is a concentration-sensitive measurement setup, the TCD is predestinated for a geometrical scaling. Micro Electro Mechanical Systems (MEMS) is the technology of choice to machine microstructures. Smaller device structure stands for shorter diffusion lengths, higher surface interaction, less gas consumption and, ultimately, shorter analysis times and smaller analyte volumes.

We organized several groups' reports in enhanced performance of gas chromatography by MEMS technique. Most of the papers are related to the column and detector performance. Critical points are the column surface deposition layer, the thermal insulation of the sensor element, and the integration of all the described subsystems in one monolithic device. The monolithic integration reduces the number of prone connections and the dead volume. Up to date MEMS TCD/GC systems are able to characterize small volumes (1 μL) of several volatile organic compounds (VOC) in less than 2 minutes compared to 10-60 minutes in conventional systems.

Devices & Sensors

DS-P24

A high-throughput permeability assay platform for shear stress characterization of endothelial cells

Presenter: Ross Booth

University of Utah: Department of Electrical and Computer Engineering

We present the first high-throughput permeability assay platform that enables the characterization of shear stress effects covering the full physiologically relevant spectrum (1-60 dyn/cm^2) for endothelial cells *in vitro*. Despite abundant previous studies on shear stress effects on endothelial cells and permeability assays through cell-laden membranes, none of these studies have managed to simultaneously induce full-spectrum shear stress range and investigate effects on permeability. We have introduced a parallel-array structure allowing trans-endothelial electrical resistance monitoring of microfluidic blood-brain barrier cultures at various shear stress; but, permeability assays were unfeasible due to its single I/O design. The presented structure adds four separate outlets branching from a common inlet (1) to enable permeability assays and (2) to cover the full-spectrum shear stress in only 2 stages due to the ~15x shear stress range indicated from Comsol simulations. A micro-flow sensor was developed in an array to measure flow velocity in each channel to experimentally verify simulated flow distributions. The fabricated assay platform demonstrated the first full-spectrum permeability assays under full-spectrum shear stress (1-60 dyn/cm^2) on brain endothelial cells, indicating decreased permeability with increasing shear stress at a rate of 4.06e^{-8} and 6.04e^{-8} cm/s per dyn/cm^2 for fluorescein isothiocyanate-conjugated Dextran and propidium iodide, respectively. Hematoxylin/eosin staining showed increased elongation and cell alignment under shear stress at rates of 9.15e^{-4} and 0.12° per dyn/cm^2, respectively, ranging from static (0.28 and 47.9°) to 86 dyn/cm^2 (0.18 and 39.9°). These results demonstrated the utility of the presented system for rapidly quantifying effects of shear stress across the full physiological spectrum.

DS-P25

Super-enhanced optical energy concentration through a subwavelength aperture using a photonic nanojet

Presenter: Mehdi Hasan

Jamesina J. Simpson
University of Utah: Department of Electrical and Computer Engineering

A photonic nanojet is a sub-wavelength (as small as λ/3) electromagnetic beam that can propagate multiple wavelengths from the shadow-side surface of a dielectric sphere. We present here a means to further compress the transverse width of a photonic nanojet by placing a plasmonic nano-aperture in its path. Three-dimensional finite-difference time-domain (FDTD) modeling results demonstrate that a gold nano-aperture illuminated by a nanojet compresses the nanojet to λ/6. Further, we achieve an absorption enhancement factor of nearly 350 in a subwavelength volume of 0.004 μm^3 on the shadow side of the gold nano-aperture for an incident wavelength, λ of 633 nm. This phenomenon may find utility in a wide range of applications such as high-speed photodetectors, optical data storage, optical lithography, biosensors, etc.

DS-P26

Miniature circulatory column system for gas chromatography

Presenter: Hao-Chieh Hsieh

Hanseup Kim
University of Utah: Department of Electrical and Computer Engineering

This paper presents the first micro-scale circulatory column system for functioning gas chromatography and the resultant highest separation capacity demonstrated by any commercial and non-commercial GC column systems beyond the current state-of-art, by enabling the extension of the effective column length through the circulatory loop without increasing the device volume. Compared to the state-of-art conventional linear micro GC systems, this fabricated circulatory GC system has (1) demonstrated the enhancement of the detection capacity by 66%, represented by the highest theoretical plate number per length-pressure of 206 plates/m-kPa ever reported; and (2) accomplished the longest effective column length of 5 meters ever reported among micro columns.

The circulatory loop is constructed with 4 components: (1) a set of two micro columns, (2) six control valves, (3) a target-gas-injector utilizing the commercial Thermal FOCUS GC system, and (4) a flame ionization detector (FID). To enable the circulatory gas flows in the clockwise direction, the six solenoid valves were accurately timed to turn on and off in two phases through a programmable microcontroller.

The results show that the circulatory cycles reached up to 10 cycles, which is equal to 5-meter effective column length, and demonstrate the successful separation of the pentane and decane mixture during the circulation through the micro columns.

DS-P27

Platinum functionalized titania nanotube array sensor for detection of trichloroethylene in water

Presenter: Harikrishnan Jayamohan

York R. Smith, Bruce K. Gale, Manoranjan Misra, Swomitra K. Mohanty
University of Utah: Departments of Mechanical Engineering; Chemical Engineering; and Metallurgical Engineering

A sensor using platinum functionalized titania nanotubes for the detection of trichloroethylene (TCE) in water samples has been developed. The titania nanotubes were synthesized using an electrochemical anodization technique and platinum was photocatalytically deposited on the nanotubes. The sensor exhibits a good response to TCE concentrations in the range of 10 to 1000 ppm.

DS-P28

Diagnosis of oxidative stress using a titanium dioxide nanotube sensor for glutathione measurement

Presenter: Younghwan Kim

Seung Hei Cho, Jules Magda, Swomitra K. Mohanty
University of Utah: Departments of Metallurgical Engineering; and Chemical Engineering

High concentration of reactive oxygen species (ROS) in the body is a factor of oxidative stress that causes chemical damages on nucleotide level molecules following several diseases. The state of overproduction of ROS in the body is known as oxidative stress. Various factors trigger the oxidative stress, and oxidative stress also causes diseases, *vice versa*. Overexpressed ROS is removed and regulated by the redox process of the reduced form of glutathione (GSH) to the oxidized glutathione (GSSG), which are types of antioxidants. Therefore, a decreased amount of GSH represents an increased amount of GSSG, and the ratio of GSH and GSSG in the body can indicate the level of oxidative stress. In this work we present a low-cost glutathione sensing platform using copper functionalized titanium dioxide nanotubes (Cu-TiO_2-NTs). The presence of copper on the titanium oxide nanotubes shows an enhanced sensitivity for GSH and GSSG using cyclic voltammetry. The results show that the current change of Cu-TiO_2-NTs at -0.3 volts is larger than bare TiO_2-NTs: 3.2 times larger for GSH, and 1.7 times larger for GSSG. These results suggest that this sensing platform has the potential to be used as a low-cost rapid test for assessing oxidative stress based on concentrations of GSH and GSSG.

DS-P29

Atomic layer deposition of Al_2O_3 on plasmonic nanostructures for surface chemistry and multiplex analysis

Presenter: Cady Lancaster

Aixiang Liu, Curtis Sudbury, Bruce K. Gale, Jennifer Shumaker-Parry
University of Utah: Departments of Chemistry; and Mechanical Engineering

Nien-Hui Ge
University of California, Irvine: Department of Chemistry

Plasmonic nanomaterials have tunable optical properties that can serve as chemical and biological sensors and substrates for surface-enhanced spectroscopies. Previous research in our lab investigated a model reaction of the reduction of 4-nitrophenol (4-NP) by sodium borohydride catalyzed by triphenylphosphine-protected gold nanoclusters (TPP-AuNCs). We plan to investigate this model reaction at the cluster surface using enhanced vibrational spectroscopy by tethering the TPP-AuNCs to tunable plasmonic nanocrescents. By introducing a precisely deposited oxide layer via atomic layer deposition onto the nanocrescents, we can create a surface which can aid in the investigation of the catalytically-active TPP-AuNCs without interfering with the cluster-mediated chemistry. Additionally, we are investigating how ALD of alumina affects nanocrescents due to the multiple plasmon resonance modes that can enhance signals in the vis-NIR for surface-enhanced Raman spectroscopy (SERS) and in the IR for surface-enhanced infrared absorption (SEIRA) spectroscopy. This will lead to another avenue of research for the integration of the substrate into a multiplex, microfluidic device for pesticide detection.

DS-P30

A novel arterial coupler for microvascular surgery

Presenter: Huizhong Li

Cody Gehrke, Himanshu Sant, Bruce K. Gale, Jay Agarwal
University of Utah: Departments of Mechanical Engineering; and Surgery

This paper describes a new vascular coupling device (VCD) for end-to-end anastomosis. Compared with traditional hand suturing and other prior attempts made at improving the anastomotic technique such as various mechanical devices, adhesives and laser welding, this vascular coupling device is quicker, easier and safer.

The VCD has a ring-shaped base with four hinged wings. Four pinholes are evenly placed on the ring base. The four wings are attached to the ring base by plastic hinges, which allow rotation of the wings from 0-90°, opening or closing the coupler. There are four pins inserted into wings that can move back and forth. The VCDs were made from both polytetrafluoroethylene (PTFE) and high-density polyethylene (HDPE).

The four steps needed to complete the process of anastomosis using VCDs will be demonstrated. Four pull tests showed an average pull strength of 4.3±0.7 pounds for the PTFE VCDs, which is sufficient to ensure the couplers won't fall apart *in vivo*. The leakage test showed that there is no leakage under fluid pressures as high as 7 psi. The flow test, conducted multiple times and at various pressures, showed that the coupler did not restrict the flow significantly when compared to intact tubing. The coupling process was timed and the connections were all completed in less than five minutes.

DS-P31

Competing reactions of succinimidyl monolayers and applications in biosensor development

Presenter: China Lim

Nicholas A. Owens, Ronald D. Wampler, and Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Chemistry; Chemical Engineering; Bioengineering; and Pathology

Makoto Takahashi, Katsuaki Shimazu
Hokkaido University: Section of Materials Science; and Environmental Earth Science

Monolayers formed on gold surfaces with N-hydroxysuccinimide ester terminal groups are often used to immobilize molecular recognition elements in the fabrication of bioanalytical platforms. This chemistry, often performed in buffer solutions at near neutral pH (pH 6-9) to maintain biomolecule function, couples the amino acids of proteins through formation of an amide linkage. However, under these reaction conditions, the hydrolysis of the succinimidyl group competes with the amidization process, and this competing process may have an effect on immobilization efficiency. This presentation examines this competition by using a thiolate monolayer formed by the chemisorption of dithiobis (succinimidyl propionate) on gold. The structure, reactivity, and thermodynamics of these adlayers were analyzed via infrared external reflection spectroscopy (IR-ERS), X-ray photoelectron spectroscopy (XPS), electrochemical reductive desorption, and contact angle measurements. Results show rapid hydrolysis kinetics, both in solution and on the interface, after immersion in borate buffers of different ionic strength and pH. Further, rather than following a simple pseudo first-order rate law, the monolayer kinetics suggest a more complex mechanism in which the reaction begins at defect sites and progresses across the surface. The implications of these results will also be discussed.

DS-P32

A sequential cancer suppression in vitro *model by vitamin D_3 metalbolism*

Presenter: Seungbeom Noh

Hanseup Kim
University of Utah: Department of Electrical and Computer Engineering

Poki Yuen, Vasiliy N. Goral
Corning Incorporated, Corning, New York

This paper reports the first sequential cancer suppression *in vitro* system modeling vitamin D biological fate by sequence, starting with transforming vitamin D3 into 25-hydroxyvitamin D3 in liver cell, then 25-hydroxyvitamin D3 into 1,25-dihydroxyvitamin D3 in kidney cell, and finally suppression of cancer cell proliferation by 1,25-dihydroxyvitamin D3. This sequential *in vitro* model can isolate each of three processes into individual wells, allowing more focused experimentation as with previous compartmentalized models. Significant antiproliferation effect on breast cancer MCF7 cell was measured, showing the validity of both the cancer suppression and metabolism of vitamin D3 into 1,25-dihydroxyvitaminn D3 *in vitro*.

To date, any *in vitro* platform for cancer cell suppression modeling a combination of liver, kidney and cancer cell have not reported. Many other papers shows the metabolism of vitamin D3 in liver into 25-hydroxyvitamin D3 and the metabolism of 25-hydroxyvitamin D3 into 1,25-dihydroxyvitamin D3 and the effectiveness of the vitamin D3 for cancer suppression. The validity of a sequential cancer suppression *in vitro* model depends on whether the *in vivo* conditions are properly represented in the model, including drug efficacy as well as metabolism prior to reaching its target; thus, we have developed a model mimicking the key metabolic steps vitamin D3 takes before reaching its target.

The sequential *in vitro* model is composed of wells for liver, kidney and cancer cell and changing media sequentially. Media having 25-hydroxyvitamin D3 and other media having 1,25-dihydroxyvitamin D3 are moved to next well. To fully measure the transformation of 25-hydroxyvitamin D3 in kidney HEK293T

cell, at first, the concentrations of 25-hydroxyvitamin D3 and 1,25-dihydroxyvitamin D3 were measured with high-performance liquid chromatography (HPLC) (HP Agilent 1100). These chromatograms will be used to analyze the composition of media from kidney HEK293T cell before and after applying the 25-hydroxyvitamin D3.

DS-P33

3-D hemispherical micro glass-shell resonator with integrated electrostatic excitation and capacitive detection transducers

Presenter: Md Mahbubur Rahman

Yan Xie, Carlos Mastrangelo, and Hanseup Kim
University of Utah: Department of Electrical and Computer Engineering

This paper reports the development and performance of a 3D hemispherical micro glass-shell resonator with integrated electrostatic excitation and capacitive detection transducers. This paper presents the complete functioning 3D shell resonator integrated with micro fabricated excitation and sensing units and its first performance results.

Despite the inherent advantages of a macro-scale Hemispherical Resonator Gyroscopes (HRG), its miniaturization has been challenged due to the difficulty in fabricating ultra-symmetric and wineglass-like structures utilizing microfabrication techniques. Compared to other techniques, a glass bead-based molding could provide higher dimensional flexibility and easy scale-up to cm ranges.

This paper describes the complete fabrication process flow of the 3D wineglass resonator with integrating Electrostatic transducers. Integrated electrostatic electrodes were first fabricated into a tall structure by fusion-bonding a thin and a regular silicon wafer. Then the bonded wafer was anodically bonded to a Pyrex wafer and subsequently patterned utilizing DRIE to form electrodes as well as the center stem. The top half of the ULE coating of the ball bearing was removed by anisotropic Ar plasma etching. Subsequently the polysilicon inner layer was etched by XeF_2 etching. When the released glass bearing was carefully lifted, the lower part of the hemispheric ULE shells formed the wineglass resonator structure.

FEM analysis of the hemispherical shell was performed to predict the natural frequency of the two vibration modes. The fabricated device, placed into a ceramic DIP package, showed that for m=2 & m=3 wineglass modes, the resonance frequencies were measured respectively at 5.843 kHz and 17.532 kHz.

DS-P34

Computational simulation of internal calibrating immunoassay

Presenter: Aleksander Skuratovsky

China Lim, Jason G. Beck, Jennifer H. Granger, Michael C. Granger, Gayatri Khanderao, Matthew A. Firpo, Sean J. Mulvihill, Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Chemical Engineering; Chemistry; Bioengineering; Pathology; and Surgery

Huntsman Cancer Institute, Salt Lake City, Utah

The accurate quantification of health-related markers in patient samples requires careful calibration of the platform parameters. While mathematical approaches to fit calibration curves and establish statistical perspectives on the reliability of the results have clearly matured, the basic foundation for calibrating diagnostic tests – comparing the response of a sample to those of standards – has yet to undergo any significant change. We firmly believe that breakthroughs in methodologies for calibration will prove pivotal as health care management begins to more strongly rely on multiplexed tests, placing a premium on sample consumption and throughput, labor, and material and reagent costs. In this presentation, we focus on an innovation that has the potential to change the calibration paradigm with

several (*e.g.,* fluorescence, surface plasmon resonance, and surface-enhanced Raman scattering), but not all (*e.g.,* ELISA), platforms common to immunosorbent and other heterogeneous assays. This innovation draws on the use of hydrodynamically enhanced flux of antigen/label (*i.e.,* reactant) that is realized by rotating the capture substrate. Rotation is a well-established method for accurately controlling flux to a surface, and has long been used in investigations of electrode reaction mechanisms by manipulating the rate of mass transport at a rotated disk electrode. We exploit the fact that surface accumulation varies as a function of radius to develop the theoretical underpinnings for a calibrant-free multiplexed analyte calibration scheme. The discussion will focus on results from computational simulations used to guide experimental design and on the potential to reduce the platform to practice.

DS-P35

General approach for engineering small-molecule-binding DNA split aptamers

Speaker: Nicholas G. Spiropulos

Alexandra D. Kent, Jennifer M. Heemstra
University of Utah: Department of Chemistry; and Center for Cell and Genome Science

Here we report a general method for engineering three-way junction DNA aptamers into split aptamers. Split aptamers show significant potential for use as recognition elements in biosensing applications, but reliable methods for generating these sequences are currently lacking. We hypothesize that the three-way junction is a “privileged architecture” for the elaboration of aptamers into split aptamers, as it provides two potential splitting sites that are distal from the target binding pocket. We propose a general method to split aptamer engineering that involves removing one loop region, then systematically modifying the number of base pairs in the remaining stem regions in order to achieve selective assembly only in the presence of the target small molecule. We screen putative split aptamer sequence pairs using split aptamer proximity ligation (StAPL) technology developed by our laboratory, but we validate that the results obtained using StAPL translate directly to systems in which the aptamer fragments are assembling noncovalently. We introduce four new split aptamer sequences, which triples the number of small-molecule-binding DNA split aptamers reported to date. The methods described herein provide a reliable route for the engineering of additional split aptamers, dramatically advancing the potential substrate scope of DNA assembly- based biosensors.

DS-P36

A carbon/ternary alloy/carbon optical stack on Mylar as an optical data storage medium to potentially replace magnetic tape

Presenter: Hao Wang

Richard J. Gates, Bart M. Lunt, Matthew C. Asplund, Robert C. Davis, Matthew R. Linford
Brigham Young University: Departments of Chemistry and Biochemistry; Information Technology; and Physics and Astronomy

V. Shutthanandan
Pacific Northwest National Laboratory, Richland, Washington

Recently we made a novel write–once–read–many (WORM) optical stack on Mylar tape for archival data storage. A nano-scale co-sputtered bismuth–tellurium–selenium (BTS) alloy was employed as the write layer with carbon protective layers on both the top and bottom of the BTS film. We have successfully written information (matrix of marks) on the C/BTS/C optical stack using a 532 nm laser. Both optical stack structure (film thicknesses) and writing conditions (laser power and laser spot size) have been optimized.

In order to explore the optical properties of the C/BTS/C stack, we performed ellipsometry as well as other surface analysis on this tape. The optical constants were obtained by ellipsometry; the elemental composition of BTS write layer was then confirmed by X-ray photoelection spectroscopy (XPS) and Rutherford Backscattering (RBS); its film configuration was characterized by atomic force microscopy (AFM) and scanning electron microscopy (SEM); the crystallinity of the BTS film was tested by X-ray Diffraction (XRD); and the BTS material longevity in normal condition (room temperature and atmosphere) was explored by time of flight secondary ion mass spectrometry (ToF-SIMS) and XPS.

By summarizing all these characterization results, the BTS write layer turned out to be a stable film which can be stored in room temperature and atmosphere for months without obvious composition change, consisting of nano-scale particles which contained Bi, Te, Se and their oxides.

DS-P37

Electrical current signatures of DNA chemical modifications in the α-hemolysin ion channel

Presenter: Anna H. Wolna

Aaron M. Fleming, Na An, Henry S. White, Cynthia J. Burrows
University of Utah: Department of Chemistry

Emerging as a rapid and inexpensive single-molecule DNA sequencing platform, nanopore ion channel technology has been under intensive investigation. This method functions through monitoring the current deflections that occur as single-stranded DNA passes through a nanoscale ion channel pore: α-hemolysin. Individual current levels for the four-standard DNA nucleotides, and variety of structurally modified nucleotides, have been established by immobilization of a 3'-end biotinylated strand in the pore, in which the nucleotide of interest is suspended at the most sensitive region of the ion channel. While the use of immobilization experiments demonstrates that native DNA bases can be distinguished, the current level difference between them is too small to be observed during a translocation experiment because the rapid transit of the bases through the sensing zone does not permit enough signal averaging. As a consequence, we turned to the formation of DNA adducts via chemical modification that capitalizes on the unique chemistry of the various heterocycles or abasic sites. Among the adducts studied, only the 2-aminomethyl-18-crown-6 adduct was able to give a large current shift in the immobilization experiment, as well as to be observed in a translocation experiment. This methodology permits the introduction of registry markers at specific sites in DNA where a large change in current blockage can be used as a reference point in the sequence.

DS-P38

Long-term reliability of atomic layer-deposited Al_2O_3 and Parylene C bilayer-encapsulated Utah electrode array-based neural interfaces

Presenter: Xianzong Xie

Loren Rieth, Sandeep Negi, Rohit Sharma, Prashant Tathireddy, Florian Solzbacher, Ryan Caldwell
University of Utah: Departments of Electrical and Computer Engineering; and Bioengineering

Rajmohan Bhandari
Blackrock Microsystems, Salt Lake City, Utah

The long-term stability and functionality of neural interfaces is a significant challenge for their chronic implantation and use. We evaluated the long-term reliability of Utah electrode array (UEA)- based neural interfaces encapsulated by atomic layer-deposited (ALD) Al_2O_3 and Parylene C, and compared these to devices with the baseline Parylene encapsulation. The wired and wireless UEAs were coated with 52 nm of ALD Al_2O_3 and 6 µm of Parylene C and immersed in phosphate saline solution (PBS) at 57 °C for accelerated lifetime testing. The median tip impedance of the bi-layer encapsulated wired UEAs increased from 60 kΩ to 160 kΩ during the 960 days of equivalent soak testing at 37 °C, the opposite trend as typically observed for Parylene encapsulated devices. The lifetime of wireless UEAs were also tested using accelerated lifetime measurement techniques. The bi-layer-coated devices had stable power-up frequencies at ~910 MHz and constant RF signal strength of -50 dBm during up to 1044 days of equivalent soaking time at 37 °C, indicating their continue function *in-vitro*. This is a significant improvement over the lifetime of 5 months achieved with Parylene-only encapsulation. The bilayer coated "active" UEA with a flip-chip bonded ASIC chip had a steady current draw of ~ 3 mA during 228 days of soak testing at 37 °C and was implanted for *in-vivo* experiment. The trends for increasing electrode impedance and performance stability of wireless devices support the significantly greater encapsulation performance of this bi-layer encapsulation compared with Parylene-only encapsulation.

Energy & Environment

ECE-P39

Quantum dots for use as novel geothermal tracers
Presenter: Eric Brauser

Michael Bartl, Peter Rose
University of Utah: Departments of Chemical Engineering; Chemistry; and the Energy and Geoscience Institute

Fluorescent nanocrystals are promising candidates for a range of applications, from biomedical imaging and sensing to solar energy conversion and lighting. Recently, these nanometer-sized semiconductor crystals have also shown potential to be used as novel geothermal reservoir tracer particles. These nanocrystals, also called "quantum dots", have size-dependent, tunable electronic and optical properties that make them candidates for use as tracers in high temperature environments. Surface-stabilizing organic ligands were studied in order to create water-soluble quantum dots that behave as conservative tracers in these geothermal media. There is extensive potential for modifying the surface chemistry of the nanocrystals, making them attractive materials for novel reactive tracers. The performance of prototype quantum dots to act as tracers has been tested in flow-through reactors packed with surrogate geothermal media, and measured using in-line fluorometers, as per conventional tracer experiments. The characteristic emission of each quantum dot sample provided a suitable method for detecting it in the reactor effluent, although mass balance analyses suggest that there is partial retention of quantum dots within the reactor.

ECE-P40

Controlled porous glass beads in nanofluidics systems for the purpose of energy absorption

Presenter: Ozkan Fidan

David Britt, Ling Liu
Utah State University: Departments of Biological Engineering; and Mechanical and Aerospace Engineering

Despite the great developments in the energy conversion systems, they still have the problems of low efficiency and lack of multipurpose. These challenges are most likely to be overcome by nanoporous particle suspended liquid (NPSL) systems, which gives an opportunity to convert one form of energy (electrical, thermal or mechanical) into another.

In particular, we investigate the conversion of mechanical energy in the form of pressure into thermal energy to improve material impact resistance through energy absorption and dissipation through nanofluidics. This novel system can play a significant role in development of advanced materials for military and aerospace applications due to multifunctional properties and unprecedented absorption capacity compared to conventional ones. In this study, inorganic controlled porous glass (CPG) is explored as a solid phase in NPSL because CPG is incompressible, readily rendered hydrophobic, durable, does not shrink or swell in distinct solutions, and has a narrow pore size distribution with a large surface area. Rendering CPG beads hydrophobic using organo- or fluoro-silanes increases the energy barrier to force water into the pores, thus increasing the energy absorbing/dissipating ability of an aqueous NPSL. For both silanized and native CPG beads, the water contact angle measurements were conducted and compared to prove the increase in hydrophobicity by silanization. Bead sizes and surface roughness were analyzed by optical microscopy and atomic force microscopy, respectively.

ECE-P41

Dissolution of ZnO nanoparticles in wheat plant root exudates solution

Presenter: Abul Bashar Mohammad Giasuddin

Anne Anderson, Joan Mclean, Christian Dimkpa, David Britt
Utah State University: Department of Biological Engineering

The commercial production of ZnO nanoparticles (NPs) has increased greatly due to their applications in various areas such as pharmaceuticals, electronics, catalysts, and textiles. With increased production and uses of these NPs, their potential exposure to the environment has also increased. These NPs ultimately can end up in agricultural lands posing threats to the rhizospheric microorganisms and plants with their potential toxic effects. The toxicity of ZnO NPs arises primarily from the release of Zn^{2+} ions. In the soil environment, the chemical composition of the soil matrix can significantly affect NP solubility. The complex chemical components in soil that may interact with NPs and released ions can vary with the types of plants grown in the soil and their root exudates. In our study, we investigated the dissolution behavior of commercial ZnO NPs in exudates from wheat roots, and compared that to dissolution behavior in nano-pure water. After collecting root exudate solutions from lab grown wheat plants, we analyzed their chemical components using ICP-MS. Our chemical analysis showed that wheat root exudates have a wide range of components such as proteins, sugars, anions, cations, phosphates, and organic acids that may influence NP dissolution. The equilibrium amount of dissolved Zn^{2+} decreased from 4.68 mg/L in nano-pure water to 3.53 mg/L in the root exudate solution. The equilibrium time for ZnO NP dissolution in the root exudate solution was six hours compared to twelve hours in the nano-pure water.

ECE-P42

Robust material for fast and sustained water splitting

Presenter: Rebecca E. Hansen

Sid Das
Utah State University: Department of Chemistry and Biochemistry

A molecular water oxidation catalyst containing the earth-abundant element Manganese is encaged in pores of a chromium-based Metal-Organic Framework (MOF), MIL-101(Cr) to give a well-defined material-catalyst. This material-catalyst performs water oxidation with a turnover frequency (TOF) of 40 hr^{-1} using a non-oxygen donating oxidant, Cerium Ammonium Nitrate (CAN); this is >4 times faster than the currently known fastest material for water oxidation. Isolation of one molecule of catalyst per MOF pore prevents destructive interactions of the catalyst, allowing the catalyst to be active for days at pH = 1 compared to molecular catalysts that are active for ≤2 hours.

ECE-P43

Size-dependent oxygen activation efficiency over $Pd_n/TiO_2(110)$ and catalyst deactivation for the CO oxidation reaction

Presenter: Matthew D. Kane

F. Sloan Roberts, Scott L. Anderson
University of Utah: Department of Chemistry

The effects of Pd_n cluster size (n = 1-7, 10, 15, 20, 25, 27, 30) and alumina support film thicknesses on oxygen activation and the CO oxidation reaction over $Pd_n/Al_2O_3/Re(0001)$ were examined using temperature-programmed reaction (TPR) mass spectrometry, X-ray photoemission spectroscopy (XPS), ultraviolet photoemission spectroscopy (UPS) and ion scattering spectroscopy (ISS). The thickness of the vapor-deposited alumina films was shown to affect the chemistry for Pd_{20}, as probed by TPR, and show that both the core- and valence-level electrons in the alumina were modified via band bending resulting from the interaction between the alumina and the base Re(0001) single crystal. Further band bending was experienced via Pd deposition. The Pd surface area was also shown to be

controlled by the alumina support thickness, which has a large effect on the overall CO oxidation reactivity.

It is important to ensure that all effects other than film thickness were performed on samples with the same film thickness (4.5 ± 0.5 nm) so there would be no confusion from compounding effects. TPR was conducted over Pd/Al_2O_3 using constant O_2 and CO exposures, but varied O_2 temperature and Pd_n cluster size. The difference in cluster size between the least and most reactive clusters showed a 90% increase in CO oxidation. It can be seen that CO oxidation reactivity for Pd_n clusters is highly correlated to variations in the expected electron binding energies caused by a change in Pd_n cluster size.

ECE-P44

Novel SPE materials with highly ordered hybrid nanostructured architectures for lithium rechargeable batteries

Presenter: Amir Khabibullin

Charles Liggett, Emily Fulwood, Ilya Zharov
University of Utah: Department of Chemistry

In this work we prepare and investigate novel nanostructured lithium-conducting solid polymer electrolyte (SPE) materials, the key components of rechargeable lithium batteries. Lithium batteries are used or proposed for use in a wide variety of demanding applications, such as electric vehicles, start-light ignition, portable electronics and personal communication. Due to some serious disadvantages of liquid electrolyte batteries, the SPE materials have been recognized as a promising material for the production of lithium batteries. Most commonly used SPEs are based on complexes formed between polyethylene glycol (PEG) and various lithium salts.

In our design, inorganic colloidal membranes are surface-modified with well-defined polymers capable of facile lithium transport. Our materials possess unique features that are fundamentally different from the traditional polymer electrolyte or composite organic-inorganic materials. The inorganic materials with continuous networks of nanopores that we investigate are highly-ordered silica colloidal crystals and close-packed silica colloidal glass membranes. They serve as solid matrixes providing mechanical stability and supporting the lithium conducting polymers. Poly(ethylene glycol)methacrylate brushes grown on the silica surface and impregnated with Li^+ salt are responsible for lithium ion conductivity. Electrochemical impedance spectroscopy was used to study ion conductivity of the material. Due to precise control over every parameter, such as pore size, polymer brush length, Li^+ concentration, etc., the architecture of the studied materials makes them particularly suitable for systematic studies needed to understand the lithium transport through polymer brushes inside the nanopores.

ECE-P45

Electrocatalysis of nicotinamide adenine dinucleotide at multiwalled carbon nanotube/polymer sandwich on glassy carbon electrodes

Presenter: Lindsey N. Pelster

Shelley D. Minteer
University of Utah: Departments of Chemistry; and Materials Science and Engineering

Nicotinamide adenine dinucleotide (NADH) oxidation has been investigated with carbon nanotubes, although studies into the polymer effect on the anodic characteristics are needed to fully understand their effects with carbon nanotubes. This work details the electrocatalysis of NADH at glassy carbon electrodes modified with multiwalled nanotubes and selected polymer films. NADH oxidation has not been characterized with these polymers and shows a decrease in the overpotential needed for electrochemical oxidation. NADH is shown to be oxidized at a lower potential than at a bare glassy carbon electrode, and the different polymers are shown to affect oxidation potential. Nafion and tetrabutyl ammonium bromide-modified Nafion have been previously used, specifically for immobilizing dehydrogenase enzymes at an electrode. Linear poly(ethylenimine) (LPEI), octyl-modified LPEI, and polyvinylpyridine hydrogel polymers are studied for their behavior with carbon nanotubes and NADH catalysis. Each experiment demonstrates different capacitance and current from the combination of the nanotubes and polymer coatings. Concentration studies were performed with up to $1x10^{-3}$ mol L^{-1}

NADH and cyclic voltammetry was carried out with scan rates of 5, 20, 50, 100, 200 mVs^{-1}. This data will be used to examine the effect of the different polymers on the potential of NADH oxidation and catalytic characteristics.

ECE-P46

The importance of metal cluster size in the Pt/alumina heterogeneous catalyst system

Presenter: F. Sloan Roberts

Matthew D. Kane, Scott L. Anderson
University of Utah: Department of Chemistry

With heterogeneous catalysts involved in about 20% of the US GDP, there is strong interest in basic and applied research to improve catalyst performance. Most heterogeneous catalysts typically consist of a transition metal deposited on a metal oxide support. It has been shown that for the catalytic reactions of interest, nano-sized metal clusters behave differently than the bulk metal, and are in fact the active species in typical supported catalysts. In particular, clusters below about 50 atoms exhibit unpredictable catalytic behavior with even single atom variation, reflecting changes in the physical and electronic structure of the catalyst. Recently our group has studied the CO oxidation reaction catalyzed by platinum nanoclusters supported on a thin film of alumina, and found a very strong dependence between catalyst activity and cluster size. For example, clusters consisting of fourteen atoms (Pt_{14}) were eight times more catalytically active than clusters consisting of only two atoms (Pt_2). Using surface analysis techniques, the physical and electronic structure of the clusters were analyzed to answer the question of why Pt_{14} is so much more active than Pt_2. The same techniques were also used to determine the binding sites of the reactant gases (CO and O_2) to further explain the reactivity of the nanoclusters. A combination of changes in the physical and electronic structure along with the number of available binding sites can begin to explain the large differences in catalytic activity exhibited between cluster sizes.

ECE-P47

Doped quantum dot sensitized photoelectrochemical cell for enhanced solar fuel generation

Presenter: York R. Smith

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

Ruchi Gakhar, Dev Chidambaram
University of Nevada, Reno: Department of Chemical and Materials Engineering

Nanocrystalline metal chalcogenides (*i.e.*, S, Se, Te) have received considerable interest within the last decade due to their unique optical properties and the ease in the ability to precisely tune their optical properties for specific catalytic and technical applications. For example, when used as a sensitizer/absorber layer with wide band gap semiconductors (*e.g.,* TiO_2 and ZnO) in solar energy conversion systems, the visible light/near infrared absorbance can be modulated by changing the particle size as a result of quantum confinement effect. However, simply changing the particle size of the deposited nanocrystal semiconductors can have its practical limitations, and often in some applications the quantum confinement effects vanish due to particle agglomeration and/or sintering either through synthesis techniques or over extended use. One method to alter the intrinsic electronic properties of small band gap semiconductors is by introducing optically active metal dopants. By invoking electronic states in the mid gap through doping, the charge carrier dynamics can be altered, potentially extending their lifetimes.

In this study, we examine various synthesis methods for depositing Mn^{2+}- or Co^{2+}-doped CdS nanocrystals on titania nanotubular arrays synthesized by electrochemical anodization technique for photoelectrochemical hydrogen generation. The addition of the dopants within the CdS nanocrystals demonstrate enhanced photoelectrochemical responses over plain CdS-TiO_2 nanotube systems. The effects of dopant-deposited CdS homogeneity and crystallinity have been correlated with

photoelectrochemical responses and other electrochemical analysis techniques such as electrochemical impedance spectroscopy and open-circuit voltage decay.

ECE-P48

In-depth ligand-surface interaction studies of oleic acid-capped aluminum nanoparticles produced using high throughput ball milling

Presenter: Jiang Yu

Brandon McMahon, Scott L. Anderson
University of Utah: Department of Chemistry

Studies on unoxidized high energy metal such as boron and aluminum have long been of interest because of their potential to serve as energetic fuel additives. The addition of zero-valence state metals to a fuel has the potential to both increase the energy release during combustion and improve ignition parameters. However, the highly reactive nature of zero-valence state metal surfaces poses hurdles for harvesting energy from these metals. One method for overcoming these hurdles is to produce nanoparticles for suspension in fuels. This alone can be challenging because an inert metal oxide layer will form immediately when exposed to air or oxidizing conditions. Among known studies aimed at overcoming this issue, surface functionalization seemed to be the most promising way. This method involves exposing different ligands to the nascent metal surfaces such that they bind to the metal surface and prevent oxidation. It is important to understand how the surface properties of the particles change and how these ligands interact with the metal surface. Here, we present a new powerful FTIR method to study these interactions. In this instrument, a resistive heating system has been employed in an inert gas flow-cell to study ligand bond structure as a function of temperature. In this study, aluminum nanoparticles prepared by "homogeneous media ball milling" (HMBM) and coated with a layer of oleophillic ligands have been used. Data was gathered from the heating experiments up to 400 C under nitrogen gas flow conditions. Distinctive bond structure changes involving ligand interactions with the surfaces have been observed, providing a better understanding of both how ligands bind to the surface and their stability throughout a range of temperatures. Although at this proof-of-concept stage we have expanded our knowledge of carboxylic acid interaction with aluminum surfaces, this technique has the potential to open doors for understanding the chemistry of ligands on surfaces and under a wide range of conditions. Other techniques have been applied to confirm the synthesis of these particles as well as further characterizing their composition and morphology such as X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), dynamic light scattering (DLS), and thermogravimetric analysis (TGA).

ECE-P49

Inhibition of growth of the plant pathogens Pythium aphanidermatum *and* Pythium ultimum *by CuO and ZnO nanoparticles*

Presenter: Zac Zabriskie

Anne J. Anderson, Christian O. Dimkpa
Utah State University: Department of Biology

Members of the oomycete genus *Pythium* are common plant pathogens. Many isolates cause blight or damping off in turfgrasses and seedlings of agriculturally important crops, such as wheat and tomato. Isolates of *Pythium insidiosum* are pathogenic to animals and humans. Because these pathogens are eukaryotic, it can be difficult to control and prevent infection by *Pythium.* CuO or ZnO nanoparticles (NPs) have reported antifungal activity, and this work addresses the responses of two strains of a significant oomycete: *Pythium ultimum* obtained from the American Type Culture Collection originally from diseased wheat, and *Pythium aphanidermatum* from diseased tomato plants. Both CuO and ZnO nanoparticles caused dose-dependent reductions in radial growth on potato dextrose agar: *P ultimum* was more sensitive to CuO NP inhibition than *P aphanidermatum*. Growth inhibition also occurred in potato dextrose broth where absorbance of the NPs to the hyphal mass was apparent. This removal of the NPs occurred with both live and heat-killed mycelium. In transfer of the mycelium to plate medium, the NPs were not biocidal but caused stasis: CuO NPs were more inhibitory than the ZnO NPs. These responses in liquid media occurred with little change in pH due to pathogen growth. Because *Pythium*

growth was slowed by contact with the NPs, such treatments could be integrated into strategies to afford protection for seedlings from pathogen attack.

Nanomedicine

NM-P50

Thermosensitive progesterone hydrogel: A new formulation for vaginal application

Presenter: Aliyah Almomen

Sungpil Cho, Elke A. Jarboe, Andrew P. Soisson, Mark K. Dodson, C. Matthew Peterson, Margit M. Janát-Amsbury
University of Utah: Departments of Obstetrics and Gynecology; Pharmaceutics and Pharmaceutical Chemistry; and Pathology

Zhengzheng Li, Kang Moo Huh
Chungnam National University: Department of Polymer Science and Engineering

Progesterone (P4) has a role in the conservative management for endometrial hyperplasia (EH), which in some cases can coexist with, or be a precursor for, endometrial carcinoma. Due to its short half-life (3-5 min), natural P4 has mostly been replaced by synthetic progesterone (progestin) preparations, which are applied through different routes of administration and are often associated with various adverse effects. Vaginal P4 administration poses a viable alternative and has proven to be as effective as, or even superior to, intramuscular P4. However, commercial vaginal P4 formulations such as suppositories or creams tend to be messy and leak out of the vaginal cavity due to liquefaction at body temperature. Based on the discomfort caused, patient compliance is hampered, resulting in loss of active drug and therefore negative therapeutic outcomes.

The goal of this work is to design, characterize, and evaluate an improved vaginal formulation for P4 using Glycol Chitin (GC). GC is an amphiphilic chitosan-based polymer synthesized by selective *N-acetylation* of glycol chitosan. This polymer is biocompatible, biodegradable, and exhibits thermosensitive and mucoadhesive properties. This new formulation was evaluated for gelation temperature (T_{gel}), mechanical and viscoelastic properties, mucoadhesive properties, *in vitro* drug release, and *in vitro* and *in vivo* safety. GC-P4 gel showed T_{gel} near body temperature and maintained stable gel characteristics in vaginal-like environment. Local residence times were observed to extend past four hours for continuous P4 release. The new formulation is safe and non-toxic *in vitro* and to mouse vaginal tissues after repeated application. GC-P4 formulation follows standard operating procedures, which are replicable and scalable. Therefore, we believe this method offers an effective, new alternative for the management of EH that potentially will expand to other gynecological and obstetrical disorders.

NM-P51

Synthesis and characterization of spider silk microparticles as drug delivery vehicles

Presenter: Steven Ban

Randy Lewis, David Britt
Utah State University: Departments of Biology; and Biological Engineering

In this study, spider-silk protein MaSp1 was investigated for its applicability as a drug delivery particle. Our aim was to determine whether MaSp1 microparticles could be synthesized, and if so, characterize them and determine whether small-molecule drugs could be loaded and released. Particles were synthesized by a precipitation method using potassium phosphate, and their physical and chemical properties were then characterized. Dynamic light scattering (DLS) and atomic force microscopy (AFM) were used to determine whether particles have been formed, and to characterize size and morphology. It was found that particles were spherical with diameter ~200 nm. Surface charge was then determined using zeta potential analysis, and it was determined that the microspheres have a negative surface charge. Particles were then incubated with small-molecule drug kanamycin sulfate and zeta potential was used to determine whether drugs have diffused into the particle matrix. Loaded particles were

tested against *E. Coli* in order to evaluate the particles as a controlled-release mechanism for drug delivery. This study is the first at USU to study the formation of microspheres with spider-silk protein MaSp1. These microparticles could be potentially used in the medical field as a biocompatible drug delivery vehicle.

NM-P52

Development of a point-of-care system to quantify vitamin D metabolites from whole blood

Presenter: Benjamin W. Blackley

Nicholas A. Owens, Megan E. Buelte, Michael C. Granger, Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Chemical Engineering; Chemistry; Bioengineering; Pathology; and Surgery

Brian Dixon
USANA Health Sciences, Salt Lake City, Utah

Tanya Sandrock
ARUP Laboratories, Salt Lake City, Utah

Vitamin D is a secosteroid. Its primary role is to aid the intestinal absorption of calcium and phosphate, which promotes the healthy development of osteoid tissue. Vitamin D can be ingested (*i.e.,* ergocalciferol) as a supplement or synthesized in the skin (*i.e.*, cholecalciferol) upon exposure of a cholesterol precursor to ultraviolet light. Maintaining an optimal blood concentration of vitamin D and its metabolites (*e.g.*, 25-hydroxyvitamin D) is essential to good health. The typical circulating level for 25-hydroxyvitamin D in a healthy adult is 20-50 ng/mL. Due to the increased awareness of vitamin D's importance to human health and recent implications of its role in cardiovascular disease and immune system activation, the ability to monitor vitamin D levels rapidly and at low cost has emerged as an unanswered need in point-of-care (POC) settings.

Current approaches to vitamin D quantitation rely on a competitive immunoassay format or high-performance liquid chromatography-mass spectrometry (HPLC-MS), neither of which meets the requisite characteristics for POC deployment. This presentation describes the development and preliminary results from an investigation of an approach that utilizes surface-enhanced Raman scattering (SERS) as the basis for screening large patient populations for circulating levels of vitamin D. Our approach: (1) separates vitamin D from whole blood by solid phase extraction (SPE); (2) deposits the processed sample onto a SERS-active substrate; and (3) measures vitamin D levels by interrogation with a portable SERS instrument. The focus of the work presented herein will be on SPE techniques for sample preparation and on in-line derivatization methods to increase the SERS signal. The prospect of this approach to serve as an effective means for the low cost, rapid measurement of vitamin D in serum will also be discussed.

NM-P53

Gold nanorod-mediated hyperthermia in combination with radiotherapy via 90Y-Ytrrium HPMA copolymers

Presenter: Brandon Buckway

Nick Frazier, Adam J. Gormley, Abhijit Ray, Hamid Ghandehari
University of Utah: Utah Center for Nanomedicine, Nano Institute of Utah; and Departments of Pharmaceutics and Pharmaceutical Chemistry; and Bioengineering

The treatment of prostate cancer using a radiotherapeutic ^{90}Y labeled *N*-(2-hydroxypropyl) methacrylamide (HPMA) copolymer can be enhanced with localized tumor hyperthermia due to increased permeability and blood flow to the tumor. HPMA copolymers containing 1,4,7,10-tetra-azacyclododecane-1,4,7,10-tetraacetic acid (DOTA) were synthesized by reversible addition-fragmentation transfer (RAFT) copolymerization and subsequently labeled with either ^{111}In for imaging or ^{90}Y for efficacy studies conducted in DU145 prostate tumor-bearing mice. HPMA copolymer-DOTA conjugates demonstrated efficient labeling and stability for both radionuclides. Localized mild tumor hyperthermia was achieved by applying plasmonic photothermal therapy using gold nanorods. Imaging

of the biodistribution and pharmacokinetcs of the HPMA copolymers were performed using single photon emission computerized tomography (SPECT). Imaging analysis showed a marked increase of radiolabeled copolymer within the hyperthermia-treated prostate tumors, with no significant accumulation in non-targeted tissues. The greatest reduction in tumor growth was observed in the hyperthermia-treated tumors in combination with systemically administered ^{90}Y HPMA copolymer conjugates. Histological analysis confirmed treatment efficacy and safety of the HPMA copolymer conjugates. Results demonstrated HPMA copolymer-DOTA conjugates radiolabeled with both the imaging and treatment radioisotopes when combined with hyperthermia can potentially serve as an image-guided approach for efficacious treatment of prostate tumors.

NM-P54

Reduction of the foreign body response for chronic neural implants through local release of the tyrosine kinase inhibitor masitinib

Presenter: Ryan Caldwell

Mahender Avula, Loren Rieth, Florian Solzbacher
University of Utah: Departments of Bioengineering; and Electrical and Computer Engineering

Implanted neural interfaces are valuable tools for research and prosthetics. However, the foreign body response (FBR) to such devices results in reduced neuron density and an insulating sheath of glial cells around the implant, limiting long-term functionality. Reducing the FBR is seen as a path to improved chronic function, and we have previously shown that controlled release of the tyrosine kinase inhibitor (TKI) masitinib around subcutaneous implants reduces the thickness of the FBR-induced cellular sheath. Furthermore, breach of the blood brain barrier (BBB) is widely accepted to strongly contribute to neural FBR, and TKI action against platelet-derived growth factor receptor (PDGFR)-α has been shown to improve BBB integrity. We therefore hypothesize that masitinib will reduce the FBR and glial sheath around indwelling neural interfaces. To test our hypothesis, we will first fabricate masitinib-loaded micro- and nanospheres from poly(lactic-co-glycolic acid) (PLGA) using previously developed water-in-oil techniques. Release kinetics of alginate-suspended spheres will be measured *in vitro* over a 4 week period using high performance liquid chromatography. Second, implant-delivered masitinib dosages of 30 to 100 μg/kg-day will be tested in rat cortex. Analyses will be performed to determine neuronal health, glial cell activation and glial sheath thickness at post-operative time points of 2 and 4 weeks. Anticipated results are a near-zero order release of masitinib for 4 weeks *in vitro*, and an increasing neural density, as well as reduction in glial activation and sheath thickness, for experimental groups of increasing dosages with respect to controls.

NM-P55

Comparison of hydrodynamic and geometric size distributions of exosomes

Presenter: Vasiliy S. Chernyshev

Yen Hsun Tseng, Yunlu Jia, Mikhail Skliar, Rakesh Rachamadugu, Philip S. Bernard, David M. Belnap
University of Utah: Departments of Chemical Engineering; Pathology; Biochemistry

The Huntsman Cancer Institute, Salt Lake City, Utah

Exosomes are stable membrane-bound nanoparticles released into the circulation by many cell types, including cancer cells. These small vesicles are budded from the endocytic pathway during the formation of multivesicular bodies, and contain membrane and cargo (nucleic acids and proteins) derived from the cell of origin. The size distribution of exosomes is an important biophysical property that differentiates them from other membrane particles and may be different depending on the cells of origin. In this study, the size distribution of exosomes isolated from serum samples was measured by several techniques that fall into one of two broad categories. Dynamic light scattering (DLS) and Nanoparticle Tracking Analysis (NTA) estimate the hydrodynamic size of exosomes based on their apparent diffusivity that is influenced by such factors as shape asphericity, surface decoration and charges, and species dissolved in the buffer solution. On the other hand, the analysis of transmission electron microscopy (TEM), scanning electron microscopy (SEM), and cryoTEM images give information on the geometric size of exosomes, as does the dynamic mobility analysis. Our results

indicate that techniques measuring hydrodynamic size of nanoparticles inflate the size of exosomes by as much as a factor of 2 compared to their geometric sizes.

NM-P56

Incorporating negatively charged side chains into PNA improves binding affinity and selectivity with RNA

Presenter: N. Tilani S. De Costa

Jennifer M. Heemstra
University of Utah: Department of Chemistry; and the Center for Cell and Genome Science

Peptide nucleic acid (PNA) is an oligonucleotide mimic having unique physicochemical properties, which can largely be attributed to the fact that PNA has an achiral, peptide-like *N*-(2-aminoethyl)glycine backbone in place of the sugar-phosphate backbone found in DNA and RNA. PNA shows tremendous potential as a biomolecular tool in genetic diagnosis and disease management due to its greater binding affinity, selectivity, and strand-invasion capability relative to native nucleic acids, as well as its increased resistance to degradation by nucleases and proteases. However, the therapeutic potential of this versatile molecule is hampered by its poor solubility, as well as its limited cellular uptake and bioavailability. We hypothesize that incorporation of negative charge into PNA would make it compatible with the charge-based delivery methods that have been developed for native nucleic acids.

Here, we modify the γ-position of PNA with negatively and positively charged side-chains and investigate the effect of the charged side chains on binding affinity and selectivity with DNA and RNA. At physiological salt concentrations, negatively charged PNA binds more strongly and selectively to RNA than does positively charged PNA.

The ability to incorporate negative charge without sacrificing binding affinity and selectivity is anticipated to enable the development of PNA diagnostics and therapeutics that take advantage of both the inherent benefits of PNA and the multitude of delivery technologies recently developed for DNA and RNA. Studies investigating cellular delivery of negatively charged PNA using charge-based delivery methods are currently underway in our lab.

NM-P57

Transepithelial transport of PAMAM dendrimers across isolated intestinal tissue

Presenter: Dallin Hubbard

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

David Brayden
University College: School of Veterinary Medicine

Oral delivery of drugs is marked by higher patient compliance, lower health care burden and reduced stringency in drug manufacturing. Nevertheless, oral delivery of therapeutic molecules can be hampered by low permeability through the intestinal epithelium. In this study we evaluated the transepithelial transport of Poly(amido amine) (PAMAM) dendrimer-fluorescein isothiocyanate (FITC) conjugates. The Ussing chamber model was used to test PAMAM dendrimer transport across isolated rat jejunum. Toxicity of the dendrimers to the isolated tissues was tested electrochemically through transepithelial electrical resistance and carbachol ion responses. Histological evaluation of the tissue and permeability of ^{14}C mannitol were also tested. 4 kDa and 10 kDa Dextran permeability was measured as a comparator polymer. 1.0 mM G3.5-FITC and G4-FITC dendrimers were observed to permeate the jejunum 11 fold and 4 fold higher than free FITC, respectively. Permeability of 4 kDa and 10 kDa FITC dextran trended lower than PAMAM dendrimers. Stability of the FITC label was monitored by gel permeation chromatography post experiment. Mannitol permeability, histological evaluation and carbachol ion response data confirmed the integrity of the isolated tissue for the duration of the experiment. A transient decrease in transepithelial electrical resistance was only observed during

treatment with G3.5-FITC. Results point toward promising transepithelial delivery of drugs using PAMAM dendrimers.

NM-P58

Advancements in zinc ion delivery from PEG-silanized ZnO nanoparticles for use in neurological disorder treatment

Presenter: Kyle J. Isaacson

Brianne Smith, Rachael Johnson, Sean Bedingfield, Arther Hart, Josh Israelsen, David W. Britt, Anne Anderson, Joan McLean
Utah State University: Department of Biological Engineering

Localized zinc ion dyshomeostasis in the brain remains one pertinent symptom of many neurodegenerative disorders without a current treatment. Since dietary zinc supplementation has failed to positively influence this imbalance, a zinc ion delivery vehicle to targeted locations in the human brain may prove the most feasible route to restore ionic equilibrium. This research addresses the use of poly(ethylene glycol) (PEG)-silane surface encapsulation of zinc-oxide nanoparticles (ZnO NPs) as a potential delivery mechanism of zinc ions within the human body. The stability and biocompatibility of PEG-silanized ZnO NPs was assessed through UV-vis absorbance spectrophotometry, fluorometry, dynamic light scattering, Fourier transform infrared (FTIR) spectrometry, and pH analysis. Zinc ion release monitored using an ion conductivity meter and inductively coupled plasma mass spectrometry (ICP-MS) demonstrates a controlled, sustained release profile for PEG-silane-capped ZnO NPs compared to the uncapped NPs.

NM-P59

Automatic extraction of nanoparticle properties using natural language processing: NanoSifter, an application to acquire PAMAM dendrimer properties

Presenter: David E. Jones

Julio C. Facelli, John F. Hurdle, Sean Igo
University of Utah: Department of Biomedical Informatics

Databases and repositories containing information relevant to biomedical nanoparticles, especially their biochemical and biophysical properties, are critical for both primary research as well as secondary uses such as data mining and predictive modeling. To our knowledge, there is no authoritative, up-to-date database; therefore, the only way to retrieve this information is by manual extraction from the primary literature. Manual extraction is a very time consuming and resource-intensive process; however, little research has been done to apply computational methods to obtain nanoparticle property data from the vast biomedical literature on nanoparticles.

In this study, we demonstrate the use of natural language processing methods to extract, from nanomedicine literature, numeric values of properties of poly(amidoamine) dendrimers. We have developed a method for extracting these values for properties taken from the NanoParticle Ontology, using the General Architecture for Text Engineering. We also created a method for associating the identified numeric values with their corresponding dendrimer properties, called NanoSifter.

We demonstrate that our system can correctly extract numeric values of dendrimer properties reported in the cancer treatment literature with high recall, precision, and f-measure scores. The micro-averaged recall was 0.99, precision was 0.84, and f-measure was 0.91. Similarly, the macro-averaged recall was 0.99, precision was 0.87, and f-measure was 0.92. To our knowledge, these results are the first application of text mining to extract and associate dendrimer properties and their corresponding numeric values. The work method presented here can be expanded to any nanoparticle class used for nanomedicine.

NM-P60

The role of immobilized heparin in reducing platelet activation

Presenter: Dwight Lane

Vladimir Hlady
University of Utah: Department of Bioengineering

Cardiovascular disease remains one of today's most prevalent health concerns. In many cases therapeutic devices are the only suitable form of intervention. Serious drawbacks to this type of approach include the tendency for these materials to induce coagulation and thrombus formation. There exists a need to develop biomaterials that will reduce these complications and promote hemostasis.

We have investigated how transient upstream surface contacts between platelets and the surface-exposed agonists influence downstream platelet behavior. It has been shown that platelets will make contacts with the material upstream and become activated or "primed" for downstream adhesion.

By utilizing our unique flow device, we can test a variety of nano-inspired biomaterials and determine their ability to reduce platelet activation. Heparin plays an important role in maintaining hemostasis and is our initial material for investigation. Heparin is found naturally attached to vasculature walls; accordingly, a biomaterial with immobilized heparin has potential to reduce upstream platelet activation.

We plan to carry out perfusion experiments with whole blood and observe if the rates of downstream platelet adhesion change in the presence of the heparinized biomaterial.

NM-P61

Design and development of a novel in vitro *tumor model for nanoparticle transport*

Presenter: Seiji Miura

You Han Bae
University of Utah: Departments of Pharmaceutics and Pharmaceutical Chemistry

Fuji Research Laboratories, Shizuoka, Japan

A handful of intravenously injectable nano-sized drug carriers in various forms such as polymeric micelle and liposome have been approved by the FDA for cancer treatment. The nano-sized drug carriers are expected to improve drug solubility, pharmacokinetics and toxicity. However, unlike impressive preclinical results, their clinical efficacy is not as significant as anticipated. A limited distribution of nanoparticles in a solid tumor is known to be in part responsible for this gap between preclinical and clinical studies.

The mobility of nanoparticles in the tumor is intrinsically limited by various factors such as their large size, interactions with biological components, dense cell population and extracellular matrix. Moreover, there are unique characteristics of the tumor microenvironment, elevated interstitial fluid pressure (IFP), acidic pH and hypoxia.

In order to understand the nanoparticle transport under the tumor microenvironment, we developed a novel *in vitro* tumor model using a two-chamber diffusion cell: Ussing chamber and a multilayered cell culture (MCC). The MCC cultured on a membrane is mounted into the Ussing chamber and exposed to nanoparticles. A distribution of nanoparticles in the MCC is then analyzed by confocal microscopy. This system is designed to enable the control of hydraulic pressure, pH and pO_2 in each chamber separately, resulting in physicochemical gradients established throughout the MCC. We have started to study small molecular drugs, silica nanoparticles and polymeric micelles with this model, and recent results will be exemplified.

We anticipate that the model, when fully established, may save animals employed for *in vivo* investigation.

NM-P62

Imaging and analysis of vascular eruptions at tumor periphery

Presenter: Joseph W. Nichols

You Han Bae
University of Utah: Departments of Bioengineering; and Pharmaceutics and Pharmaceutical Chemistry

Yu Matsumoto, Kazunori Kataoka
University of Tokyo: Graduate School of Medicine

Intravital Real-Time Confocal Laser Scanning Microscopy (IVRTCLSM) is a powerful imaging tool that provides the ability to see capillary blood flow in real time and allows us to peer directly into the inner workings of cancer drug delivery. Observations of capillaries within and surrounding tumors have revealed catastrophic pressure-driven extravasation events or eruptions from the blood vessels. This phenomenon may provide a unique mechanistic explanation of enhanced permeability (EP) in tumor models.

Green fluorescent protein (GFP)-expressing human BxPC3 tumors were induced in the dorsal skinfold chambers embedded in nude mice and grown to 3 mm in diameter before imaging. The IVRTCLSM system consists of a rapid scanning confocal microscope, a warmed stage, tail vein catheter, pulse oximeter and isoflurane pump to maintain the mouse in an anesthetized state for long periods. 30 and 70 nm doxorubicin-containing micelles were used at tracers. The tumor was imaged every 10 minutes for 10 hours. Image analysis was performed using ImageJ software. Computational fluid dynamics (CFD) modeling was done using an in-house program. Pressures and fenestration sizes were estimated by varying simulation parameters until eruption sizes matched observation.

Blood flow imaging in and around the tumor revealed eruptions from the blood vessels measuring between 10 and 100 μm in diameter (average 60 μm) and occurring stochastically. Eruptions generally persist for less than 30 minutes before cessation, after which tracer particles slowly disperse. CFD modeling reveals that most of these eruptions can occur at physiological vascular pressures. This phenomenon may greatly impact our understanding of EP.

NM-P63

Detection of luteinizing hormone using a surface-enhanced Raman scattering-based immunoassay

Presenter: Nicholas A. Owens

Colin C. Young, Michael C. Granger, Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Chemistry; Chemical Engineering; Bioengineering; Pathology; and Surgery

Joely A. Straseski
ARUP Laboratories, Salt Lake City, Utah

This presentation will describe the progress on the development of an ultrasensitive detection method for Luteinizing Hormone (LH) via a surface-enhanced Raman scattering (SERS)-based immunoassay. LH is a glycoprotein that plays a key role in the growth and function of the male and female reproductive systems. LH levels in serum are used in the diagnosis of dysfunctions of the pituitary-gonad system, *e.g.*, the genetic disorder Kallmann syndrome in pediatric patients. Early diagnosis of these disorders can lead to effective treatment via hormone replacement therapy, improving patient outcomes. The prevalent assay to measure LH is based on chemiluminescence and has a limit of detection of 4.7 pg/mL, which is insufficient for effective pediatric testing.

We are attempting to address this shortfall through the realization of an easy-to-use, ultrasensitive, selective, and rapid detection platform for LH. This assay involves the selective binding of LH to an antibody-functionalized capture substrate and subsequent labeling of captured LH with an extrinsic Raman label (ERL). The ERL is composed of gold nanoparticles modified with a monolayer of a Raman reporter molecule and then a layer of tracer antibody. This presentation will describe the design and testing of this assay strategy in a simple sample matrix (buffer) using fluorescence anisotropy to

characterize and screen for possible LH-specific antibodies, and ellipsometry to investigate the importance of incubation time in both the capture and labeling steps, as well as examine the need for exhaustive labeling of the captured antigen before SERS interrogation. Future plans will also be briefly discussed.

NM-P64

Improved understanding of non-pathogenic biophysical states in a class of neurodegenerative-related proteins

Presenter: Joe Passman

Riccardo Baron
University of Utah: Departments of Bioengineering; and Medicinal Chemistry

Neurodegenerative disorders and amyloidosis are thought to be a consequence of the misfolding of intrinsically disordered proteins (IDPs). In non-pathogenic states, IDPs are thought to manipulate their configurational ensembles (CEs) – through partially folding and/or forming secondary structure – to create binding sites for the multiple interaction partners necessary for cell-signaling, recognition, and regulation. An obstacle to accurate *in vivo* understanding of non-pathogenic mechanisms is that little is known about the impact of the crowded cellular environment on the global (*i.e.*, partial folding) and local structural characteristics (*i.e.*, secondary structure) of IDPs. It is difficult to understand why an IDP may misfold if little atomistic structural understanding exists regarding IDP functional mechanisms in non-adherent physiological states.

In order to test the hypothesis that IDPs become more globally compact and locally form a larger proportion of helical secondary structure at interaction sites upon crowding, 0.75 μs of aggregate atomistic molecular dynamics (MD) simulation was performed on the non-crowded 107 residue λ N model IDP. MD data were compared with NMR and SANS data from recent work of Goldenberg et al. The ensemble radius of gyration, a measure of global protein structural order, decreased during MD. Contrary to the hypothesis regarding local structural properties of IDPs, we found that the beta strand content at interaction sites is enhanced relative to other residues along the sequence during 0.75 μs of aggregate MD simulation. Future work will investigate the impact of macromolecular crowding on IDP CEs to more accurately model *in vivo* IDP biophysical mechanisms.

NM-P65

DNA cross-linked micelles as programmable materials for biosensing and responsive drug delivery

Presenter: Amberlyn Peterson

Jennifer Heemstra
University of Utah: Department of Chemistry

Amphiphilic monomers form three-dimensional structures such as micelles to minimize contacts between their hydrophobic regions and polar solvent molecules. Due to their unique properties, micelles can be used for applications such as hydrophobic drug delivery. However, the dynamic nature of hydrophobic interactions allows incorporated molecules to diffuse between the micelle interior and the solvent until reaching equilibrium with the solution. Additionally, without strong intermolecular interactions, micelles dissociate at low concentrations. Cross linking increases stability, maintaining micellar structure at low monomer concentrations and preventing guest molecules from leaving the interior of the micelle. Using DNA as the cross-linking agent gives an addressable template that can be used to control micelle assembly and dissociation in a stimuli-responsive manner. This research focuses on creating programmable micelles for biosensing and target-responsive drug delivery using DNA and hydrophobic polymers.

NM-P66

Silk-elastinlike polymers for transarterial chemoembolization

Presenter: Azadeh Poursaid

Robert Price, Andrea Davis, Erik Olson, Hamid Ghandehari, Joseph Cappello
University of Utah: Utah Center for Nanomedicine, Nano Institute of Utah; and Departments of Bioengineering; and Pharmaceutics and Pharmaceutical Chemistry

Hepatocellular carcinoma (HCC) is the third leading cause of cancer related death worldwide. Patients ineligible for surgery undergo treatments such as transarterial chemoembolization (TACE) to slow progression of disease and decrease tumor load. Patients are catheterized endovascularly via the hepatic artery to access tumor feeding vessels and are injected with a mixture of chemotherapeutics and an embolizing agent. We are investigating recombinant silk-elastinlike protein polymers (SELP) as a liquid-to-solid embolic with potential to serve as a drug carrier. Injected as a liquid, this novel embolic would penetrate tumors down to capillary levels and provide a broader range for drug delivery after gelling. The goal of this study was to determine an optimal SELP formulation such that the polymer is manually injectable through a microcatheter, gels within a predetermined time frame, and assembles into a robust gel within hepatic vessels to block blood flow. Rheological studies were conducted determining viscosity, transition time from liquid to solid, and gel stiffness over time. A microfluidics model of the capillary bed was designed and fabricated for *in vitro* performance testing. We determined that 16% w/w SELP 815K with a viscosity under 200 cP is injectable via microcatheter, gels under 3 min after injection, and results in gel stiffness over 1e5 Pascals. This formulation occluded the microfluidics model under simulated physiological flow conditions. This embolic candidate will next be tested with contrast dye and moved into pilot animal studies.

NM-P67

Effect of shear on physicochemical properties of silk-elastinlike hydrogels

Presenter: Robert Price

Azadeh Poursaid, Joshua Gustafson, Jordan Frandsen, Joseph Cappello, Hamid Ghandehari
University of Utah: Utah Center for Nanomedicine, Nano Institute of Utah; and Departments of Bioengineering; and Pharmaceutics and Pharmaceutical Chemistry

Silk-elastinlike protein polymers (SELPs) have been used as controlled delivery matrices for gene therapy of head and neck squamous cell carcinoma (HNSCC). In this application the need for an environmentally responsive, degradable polymer has arisen to improve treatment outcomes. In order to fill this need we have designed SELPs with matrix metalloproteinase (MMP) degradable sequences inserted in distinct regions of the polymer backbone. Following synthesis it was determined that the conditioning of the synthesized material was necessary for normalization of properties and to obtain a more robust polymer network. In the present work we have evaluated the effect of exertion of high shear forces post synthesis on the physiochemical properties of MMP responsive and non-responsive SELP hydrogels, namely the swelling ratio, soluble fraction, mechanical and gelation properties, and nanoparticle release.

NM-P68

A comparative study of gold nanorods and nanocages for targeted drug delivery

Presenter: Ryan Robinson

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

Gold nanoparticles are versatile due to their strong interaction with light, high biocompatibility and ease of surface modification. Gold nanorod-mediated plasmonic photothermal therapy increases the perfusion and permeability of tumor vasculature and enhances delivery of polymer therapeutics. While our results provide quantitative information supporting the notion that such a technique can increase the

delivery of polymeric drugs, the effects of nanoparticle shape on biodistribution, drug delivery characteristics, and biocompatibility are unknown. In this work, *in vitro* and *in vivo* models were utilized to gain a better understanding of the optical and thermal properties, cellular uptake, *in vivo* tumoral uptake and retention, biodistribution, and intracellular toxicity of gold nanorods and nanocages. It was found that optical properties of both particle types can be functionally matched in terms of providing means for photothermal therapies. Cellular toxicity was negligible at therapeutic doses for these two nanoconstructs. Gold nanocages were shown to exhibit stronger surface plasmon resonances at equal concentrations, providing a means for lower gold dosing for equivalent therapeutic effect. These constructs also had key biodistribution differences providing an apparent advantage over gold nanorods.

NM-P69

Increasing efficacy of antibiotics by their combination with Pluronics and quaternary ammonium surfactants

Presenter: Brian Smith

Ashlyn Tucker, James Murphy, Steven Houston, Anne J. Anderson, David W. Britt
Utah State University: Department of Biological Engineering

A challenge faced in modern health care is the development of antibiotic resistance in pathogenic bacteria strains. Resistance pathways are known to vary between bacteria but focus either on the removal or alteration of the antibiotic. Since very few new antibiotics are being developed and approved, an attractive alternative is to inhibit bacterial antibiotic resistance pathways through the use of an adjuvant.

Previous work out of our group has shown that Pluronics® have little effect on bacterial growth alone, but are known to interact with lipid bilayers, increase membrane permeability, and affect secondary metabolite production. These interactions could in turn increase local concentration of the antibiotic enough for it to be effective against the bacteria. The combination of the biologically inert Pluronic F127 (F127), with an antibiotic could synergistically increase the efficacy of the antibiotic.

The micelle and antibiotic combination's effectiveness has been tested with *Pseudomonas chlororaphis* (*Pc*O6), a non-pathogenic soil bacteria. This experiment focuses on Pluronic F127 and uses the quaternary ammonium surfactant, dodecyltrimethylammonium chloride (DTAC), as a positive control. Kanamycin was used as the antibiotic in this experiment.

Studies are being performed on the antibacterial properties of the surfactants alone, along with those of antibiotic-surfactant combinations. Preliminary results have shown that F127 alone has no significant effect on bacteria growth, and DTAC has been shown to be an effective positive control. There is some evidence to show a synergistic effect when the antibiotic kanamycin is combined with the surfactant micelles.

NM-P70

Development of an inexpensive, portable, easy-to-use lateral flow platform for screening underserved patient populations for heart disease using a single "pinprick" blood sample

Presenter: Matthew Smith

Jennifer H. Granger, Jill E. Shea, Michael C. Granger, Courtney L. Scaife, Marc D. Porter
University of Utah: Nano Institute of Utah; and Departments of Bioengineering; Chemical Engineering; Chemistry; Pathology; and Surgery

The Huntsman Cancer Institute, Salt Lake City, Utah

Routine testing of underserved populations at high risk of heart disease and other chronic illnesses require more accessible and less expensive screening methods than are available today. Lateral flow assays (LFAs) as point-of-care (POC) tests for treatable diseases represent an approach to potentially meet both requirements and contribute to improvements in global health. This presentation describes

the development of an inexpensive, portable, rapid, and easy-to-use LFA platform to detect C-reactive protein (CRP), a marker of cardiovascular health, in whole blood.

Aspects detailed in this presentation include:

- Identification and optimization of antibody pairs for CRP detection using ELISA
- LFA test strip design, construction, and antibody deposition
- CRP calibration curve development in LFA format

Ongoing efforts are focused on extending the dynamic range of the LFA to encompass clinically relevant CRP concentrations, integrating upstream components for serum separation from whole blood, developing new and/or modifying existing technology for portable colorimetric quantification, and expanding the platform for multiplex detection of cancer and diabetes markers.

NM-P71

Uterine fibroid model for study of intratumoral drug distribution

Presenter: Darren L. Stirland

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One of the chief challenges for solid tumor drug delivery is providing sufficient drug access and penetration, but the tools to study these phenomena are limited. Creating more clinically relevant models may be the key to better addressing this challenge. This study proposes the uterine fibroid model as a useful tool to evaluate drug delivery in solid tumors. Uterine fibroids are common non-cancerous tumors that develop in the smooth muscle of the uterus. They may also share some environmental characteristics with malignant tumors. Human hysterectomy specimens containing fibroids potentially offer valuable information unavailable in current animal models.

Following an approved IRB protocol, human uteri are obtained immediately after surgery. The uterine arteries are cannulated and flushed with a modified Krebs-Henseleit buffer for two hours. Next, the specimen is perfused isovolumetrically with buffer containing dyes or tracking particles for four hours. Temperature, pH, pO_2, and perfusion pressure are continuously monitored using a Microlab FS-522 instrument. Tissue viability is monitored by lactate dehydrogenase levels. After perfusion, specimens are fixed and then further analyzed by MRI or histological sectioning.

Early data show adequate perfusion of the specimen. Viability of the perfused tissues can be successfully maintained, but there is resistance to the dye solution penetrating into the uterine fibroids. Further study will enable this model to be used to evaluate the ability of drug delivery systems to penetrate into the most difficult-to-reach parts of solid tumors and provide some insight into one of the main challenges of cancer drug delivery.

NM-P72

Manipulating the modes of molecular encapsulation, cargo release and self-assembly in an engineered protein nanocage

Presenter: Geoffrey C. Thomas

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Protein capsids can serve as nanoscale containers for the storage and transport of various molecular cargoes. The highly symmetric and hollow supramolecular structures formed by protein capsids can be readily manipulated by genetic and chemical modification. Thus, such scaffolds represent an appealing platform for the development of novel systems for bioimaging and drug delivery. Lumazine synthase from *Aquifex aeolicus* (AaLS) forms dodecahedral capsids via the self-assembly of 60 identical subunits. Here, we exploit the thiol-disulfide exchange chemistry of an engineered cysteine in AaLS to

encapsulate small molecules. Cargo molecules are tethered to the capsid interior by a disulfide bond, and can be released by reducing agents such as glutathione. In wild-type AaLS, the largest pores are ~9 Å wide, and only sufficiently narrow molecules may enter the capsid. However, capsid porosity can be attenuated by introducing bulky residues into the middle of these pores via site-directed mutagenesis. In addition, we engineered a reversible, pH-dependent switch for AaLS capsid disassembly and reassembly, enabling the encapsulation of cargo molecules that are too big to squeeze through the pores, such as enzymes and RNAs. Further, the pH-dependence of the AaLS assembly state should allow for the controlled release of cargo molecules in acidic environments, such as endocytic vesicles, which is a desirable trait for targeted drug delivery. The tailoring of capsid reactivity, porosity, and self-assembly in AaLS demonstrates its potential for achieving precise command over loading and release of cargo molecules during biomedical and nanotechnological applications.

NM-P73

Sample treatment techniques for the detection of luteinizing hormone

Presenter: Colin Young

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Luteinizing hormone (LH) is a small glycoprotein (~30 kDa) and biomarker of several pediatric disorders such as Klinefelter's syndrome, Kallmann syndrome, and pituitary carcinoma. Today's gold standard for LH detection is an electrochemiluminescence-based immunoassay, which has a limit of detection (LOD) insufficient for effective pediatric testing. Our laboratory has been developing a surface-enhanced Raman scattering (SERS)-based immunoassay for the express purpose of overcoming this limitation. Work to date has demonstrated an LOD of 0.6 pg/mL for LH spiked in buffer solutions, (*i.e.*, phosphate buffered saline). However, the LOD for LH spiked in and directly analyzed from serum is only 100 pg/mL. We hypothesize that the loss of performance is due to the formation of immunocomplexes between LH, serum proteins, and other sample matrix constituents, which degrades the effectiveness of the capture and/or labeling steps. This presentation describes the results of efforts aimed at testing physical and chemical pretreatment methods as a means to disrupt these complexes, increase the free concentration of LH, and potentially lower the LOD. Physical methods include size exclusion filtration and lectin-based affinity extraction. Chemical methods include protein denaturation by acid and salt precipitation. Results from assessments of the efficiency of these methods by immunoblot and fluorescence labeling for LH quantitation will be described.