

GN10: reducing principles to practice

16 – 18 June 2010

The Historic White Stag Building
Portland, OR



Conference Presented by the Oregon Nanoscience and Microtechnologies Institute's (ONAMI)
Safer Nanomaterials and Nanomanufacturing Initiative (SNNI)



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Welcome to SNNI's 5th Annual Greener Nano Conference

During the first annual conference the concepts of 'greener nano' and 'nanoEHS' were just emerging. Since that time much has been done to advance these concepts and to define and refine the research agendas to move them forward. SNNI, in collaboration with our industrial, NGO and government partners, has become a leader in this emerging field and has provided critical leadership in developing the research agenda. SNNI researchers have significantly influenced the way the field approaches the design, characterization, biological assessment of new nanomaterials and has made key contributions to the emerging field on nanomanufacturing.

Today, 'nanoEHS' and 'green chemistry' have become staples in just about every undertaking or conversation involving nanotechnology. Is this change in mindset helping the community make progress designing greener materials and processes and supporting effective policy? Is the promise of nanomaterials innovation for energy, security, medicine and for resource conservation and environmental protection being advanced or slowed down by all this attention? It appears that, although many have embraced the principles of green chemistry and recognize the need for sound science to inform policy, the difficulty is reducing these ideas to practice.

The theme for the 5th annual conference is 'reducing the principles to practice'. We will focus on three key research areas where reduction to practice has the most potential to advance the field significantly. Experts from across the country and within SNNI will describe the latest developments in the design, characterization and production of greener nanomaterials. We will discuss and debate how to move the technology forward while developing environmentally sound products and processes and policies that advance innovation while protecting human health and the environment. We hope that you find the presentations, including the keynotes, interactive rapid-fire presentations and poster presentations, informative and thought provoking.



Conference Organizers

Program Committee

Bettye L.S. Maddux, chair
University of Oregon and SNNI
Jim Hutchison, co-chair
University of Oregon and Director, SNNI
John Frazier
Nike Corporation
Mark Lonergan
University of Oregon
Cheryl Moody-Bartel
Life Technologies
Vincent Remcho
Oregon State University
Skip Rung
Oregon Nanoscience and Microtechnologies
Institute (ONAMI)
Scott Sweeney
Life Technologies
Robert Tanguay
Oregon State University
Janet Teshima
ONAMI

Organizing Committee

Carol Hanson, chair
University of Oregon and SNNI
Jim Hutchison
University of Oregon and SNNI
Bettye Maddux
University of Oregon and SNNI
Scott Sweeney
Life Technologies
Janet Teshima
ONAMI

GN101 Workshop Team

Scott Sweeney, chair
Roundtable moderators:
Jason Carriere
University of Oregon
Brandi Dickinson
University of Oregon
Aaron Fix
University of Oregon
Rick Montgomery
University of Oregon
Ian Pilgrim
University of Oregon
Josh Razink
University of Oregon
Sara Tepfer
University of Oregon
Wei Wang
Oregon State University

Conference Registration and Coordination

Oregon State University Conference Services
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Conference Chair

Dr. Bettye L.S. Maddux
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Program

Wednesday, 16 June 2010

- 12:00 – 5:00 PM Registration for workshop, conference and tours. Posters can be set up.
- 1:00 – 5:00 PM **Greener Nano 101 Workshop**
- 1:00 PM **Introduction and Opening Remarks**
Dr. Scott Sweeney (Nanoscience Division, Life Technologies)
- 1:15 PM ***“Introduction to Nanotechnology and its Critical Importance to the Pacific Northwest and National Economies”***
Mr. Robert D. “Skip” Rung (Oregon Nanoscience and Microtechnologies Institute)
- 1:45 PM ***“Greener Nanoscience: Defining Principles and Practices to Maximize Benefit and Minimize Harm”***
Dr. James E. Hutchison (Department of Chemistry, University of Oregon and Safer Nanomaterials and Nanomanufacturing Initiative)
- 2:15 PM Break
- 2:30 PM ***“Building green nanoscience from the bottom up”***
Dr. Lallie McKenzie (Department of Chemistry, University of Oregon)
- 3:00 PM ***“Opportunities and Implications for Green Nanotechnology in Industry for the 21st Century.”***
Dr. John Miller (Dune Sciences)
- 3:30 PM ***“The Relevance of Chemicals Policy Reform to Greening Nano”***
Dr. Richard Denison (Environmental Defense Fund)
- 4:00 PM Break
- Round Table Discussions
- 4:15 PM ***“Environmental Lifecycle Analysis: A Mini-Tutorial”***
Mr. Scott Butner (Pacific Northwest National Laboratory)
- 4:25 PM Moderated Round Table Discussions
- 5:00 PM Workshop concludes
- 5:30 – 6:30 PM **Opening Reception at the White Stag Building**

For attendees already familiar with nanotechnology, FEI Corporation will sponsor a fascinating tour of their facilities in conjunction with the workshop.

- 3:30 – 5:00 PM **Tour and microscope demonstration at FEI Corporation**
A complimentary tour of the NanoPort facility at FEI's World Headquarters in Hillsboro, Oregon will showcase SEM, DualBeam and TEM instruments where an application specialist will provide a system overview and demonstrate the system performance. Registration is required. Limited transportation will be provided.

FEI is a leading diversified scientific instruments company. With a 60-year history of technological innovation and leadership, FEI's transmission electron microscopes (TEM), scanning electron microscopes (SEM) and DualBeams™, which combine a SEM with a focused ion beam (FIB), provide data critical for nano and bio-materials characterization.

Thursday, 17 June 2010

- 7:30 – 5:00 PM Registration
- 7:30 – 8:00 AM Coffee/continental breakfast, poster set-up.
- 8:00 – 8:45 AM **Opening Remarks, Dr. James Hutchison**, Director of the Safer Nanomaterials and Nanomanufacturing Initiative, Professor, Department of Chemistry, University of Oregon
- 8:45 – 9:30 AM **Opening Keynote Address**
“Nanotechnology at AFRL: Problems, Opportunities and Challenges for Successful Development and Manufacture of Nanomaterials”
Dr. John Busbee (Air Force Research Laboratory)
- 9:30 – 9:45 AM Break
- 9:45 – 12:30 PM **Session I: Meeting Characterization Challenges to Support Greener Nanomaterials and Nanomanufacturing**
Session Chair: Dr. Jim Hutchison (University of Oregon and SNNI)
- Keynote Presentations**
- 9:45 – 10:30 AM ***“A Perspective on Measurement Challenges and Needs for EHS Assessment of Engineered Nanomaterials”***
Dr. Debra Kaiser (Materials Science and Engineering Laboratory, National Institute for Standards & Technology)
- 10:30–11:15 AM ***“Nanotechnology for Cancer Therapy: Lessons Learned from NCI's Nanotechnology Characterization Lab”***
Dr. Scott McNeil (Nanotechnology Characterization Laboratory, National Cancer Institute)
- 11:15–12:30 PM **Rapid-Fire Discussion Session**
An innovative series of shorter “rapid-fire” presentations that aim at the state-of-the-art thinking in this session. These sessions are designed to encourage audience participation. 7-minute presentations, 3-minute questions, followed by an in-depth discussion.
- 11:15 AM ***“Bridging Bioscale to Nanoscale”***
Dr. Erik Richman (SNNI and Materials Science Institute, University of Oregon)
- 11:25 AM ***“Physico-chemical characterization of nanoparticles in relevant conditions”***
Dr. Robert MacCuspie (Nanoparticle Metrology Ceramics Division, Materials Science and Engineering Laboratory National Institute of Standards and Technology)
- 11:35 AM ***“Characterizing Dynamics at Nanoparticle Interfaces”***
Dr. Michael Jespersen (Nanostructured and Biological Materials, Air Force Research Laboratory)
- 11:45 AM ***“Surface characterization of nanoparticles: challenges and opportunities”***
Dr. Donald Baer (Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory)
- 11:55 AM TBA
- 12:05 PM Discussion
- 12:30 – 1:30 PM Lunch

- 1:30 – 4:30 PM **Session II: Nanotechnology Innovation and Governance: Moving from “Natural Enemies” to “Partners for Nature”**
 Session Chair: Dr. Robert Tanguay (Environmental and Molecular Toxicology, Oregon State University and Safer Nanomaterials and Nanomanufacturing Initiative)
- Keynote Presentations**
- 1:30 – 2:15 PM **“Nanotechnology Innovation: Shared Goals, Shared Responsibilities”**
Mr. Travis M. Earles (Office of Science and Technology Policy)
- 2:15 – 3:00 PM **“The Relevance of Chemicals Policy Reform to Greening Nano”**
Dr. Richard Denison (Environmental Defense Fund)
- 3:00 – 3:15 PM Break
- 3:15 – 4:30 PM **Rapid-Fire Discussion Session**
- 3:15 PM **“Nanomaterial In Vitro Toxicity Screening: The Risk Assessor's Little House of Horrors”**
Dr. Justin Teeguarden (Pacific Northwest National Laboratory)
- 3:25 PM **Nanobioinformatics: data integration strategies that support innovation and governance**
Dr. Stacey Harper (Environmental and Molecular Toxicology & Center for Biological and Environmental Engineering, Oregon State University)
- 3:35 PM **“In search of a roadmap for new nanomaterial registration with the EPA”**
Dr. Jay Lindquist (Dune Sciences)
- 3:45 PM **“What to Expect from the EPA in the Next 2-5 Years & What You Can Do About It”**
Mr. Brian King (Schwabe Williamson and Wyatt Attorneys at Law)
- 3:55 PM **“Model Policies to Promote Green Nanotech Diffusion.”**
Dr. David E. Adelman (University of Texas School of Law)
- 4:05 PM Discussion
- 4:30 – 7:00 PM **Poster Session and reception**
Sponsored by FEI Corporation
- 7:00 – 9:00 PM **OMSI Science Pub at the Mission Theater, presenting “Our Journey to the Nanoscale” by Dr. Mike Thompson (FEI Corporation) – Map on p.29**
 Columbus, Frodo, Neil Armstrong, Lindberg, Kirk, Earhart, Lewis and Clark, Tom Sawyer, and Darwin are names we know. Their travels, real and imaginary, on land, sea, air, and outer space are part of our lives. But there is another long and real road much less traveled, a journey over 2,000 years in the making: from the idea of an atom to its direct visualization.
 Scientific and industrial labs now have the ability to visually explore down to the level of atoms that make up everything in existence. Seeing things and manipulating them on the atomic level, the “nanoscale,” is opening up a whole new world of exploration and potential, including creation of life-saving medical treatments, development of alternative energies, and new environmentally safer materials. At this Science Pub we will take a visual journey, an elevator ride with stops along the way, down to the atoms that form the foundation of the universe.
 Dr. Thompson has been engaged in the development, application, sales, and marketing of electron optical systems. He has lectured internationally, participated in the organization and advisory boards of nanotechnology conferences, and acted as technical advisor to the National Science and Technology Committee on Nanotechnology.

Friday, 18 June 2010

- 7:30 – 8:00 AM Registration and coffee/continental breakfast
- 8:00 – 8:15 AM Director's Comments
- 8:15 – 11:30 AM **Session III: Advancing Greener Nanomanufacturing: Additive processes and Greener Nanomaterial Production**
Session Chair: Dr. Vincent Remcho (Department of Chemistry, Oregon State University and Safer Nanomaterials and Nanomanufacturing Initiative)
- Keynote Presentations**
- 8:15 – 9:00 AM ***Some Recent Progress in Soft Lithographic and Fluidic Approaches to Nanomanufacturing***
Dr. John Rogers (Departments of Chemistry and Materials Science and Engineering, University of Illinois at Urbana-Champaign)
- 9:00 – 9:45 AM ***"25 years after the magic bullet: Lessons learned in biologics product development that can be applied to the next round of emerging biotechnology markets."***
Dr. Bryan Monroe (BioProduction Business Unit, Cell Systems Division, Life Technologies)
- 9:45–10:15 AM Break
- 10:15–11:30 AM **Rapid-Fire Discussion Session**
- 10:15 AM ***"Nanomagnetism and biomedicine: challenges and opportunities"***
Dr. Kannan M. Krishnan (Materials Science, University of Washington)
- 10:25 AM ***"Growth, Integration, and Application of "Greener" Nanowires"***
Dr. John Conley (Oregon State University)
- 10:35 AM ***"Adapting Metal Nanoparticle Syntheses for Use in Microfluidic Devices"***
Mr. Sam Lohse (Department of Chemistry, University of Oregon)
- 10:45 AM ***"Toward greener processing of inorganic thin films and nanolaminates"***
Dr. Matt Beekman (University of Oregon)
- 10:55 AM ***"Nanomanufacturing Prospects for Large Scale Electronics"***
Dr. Paul Schuele (Sharp Laboratories of America)
- 11:05 AM Discussion
- 11:30 AM Wrap-up Discussion
- 12:00–2:00 PM Lunch
- 2:00 – 5:30 PM **Tour Nike!**
Registered participants are invited to join us for a fascinating tour of Nike's famous World Campus in Beaverton. In presentations, Nike participants will discuss:
1. **John Frazier and Lorrie Vogel:** Their approach to sustainability of Nike's product lines, including Nike Considered
 2. **John Frazier:** How Nike views the potential use of nanomaterials in their products and how product safety influences this potential

Transportation will be provided but space is limited. Signup for transportation will be available at the registration table. *The tour is sponsored by Nike.*

GN101 Speakers

Mr. Scott Butner is a Senior Research Scientist in Knowledge Systems Group at the US Department of Energy's Pacific Northwest National Laboratory. Scott received his B.S. degree in Chemical Engineering from the University of Washington in December 1983, and joined Pacific Northwest National Laboratory in January 1984. For the past 26 years he has been involved in a wide array of renewable energy, pollution prevention and sustainable technology research projects for the Laboratory and its clients. Many of his research projects examine ways of better utilizing information technologies to improve environmental decision making by business. In recent years, Scott has also supported the Laboratory's Homeland Security mission, working on novel forms of knowledge representation to support efforts to better manage intelligence data. Scott is the past chairman of the Environmental Division of the American Institute of Chemical Engineers (AIChE) and has participated as a speaker or session organizer at more than 20 national AIChE meetings.



Dr. Richard A. Denison is a senior scientist at the Environmental Defense Fund. Dr. Denison has 25 years of experience in the environmental arena, specializing in chemicals policy and hazard, exposure, risk assessment and management for industrial chemicals and nanomaterials. He has published extensively and has testified before Congress many times regarding these issues. Dr. Denison is a member of the NRC Board on Environmental Studies and Toxicology, and currently serves on the National Research Council's Committee to Develop a Research Strategy for Environmental, Health and Safety Aspects of Engineered Nanomaterials. He is also a member of the Green Ribbon Science Panel for California's Green Chemistry Initiative. Previously, Dr. Denison was an analyst and assistant project director in the Oceans and Environment Program, Office of Technology Assessment, United States Congress. Dr. Denison received his Ph.D. in Molecular Biophysics and Biochemistry from Yale University.



Dr. James E. Hutchison joined the faculty at the University of Oregon (UO) in the fall of 1994 where he is currently the Lokey-Harrington Professor of Chemistry and Associate Vice President for Research and Strategic Initiatives. His research interests are in green chemistry, materials chemistry and nanoscience. He led the development of the UO's nation-leading curriculum in "green" (environmentally-benign) organic chemistry, launched the university's pioneering Center in Green Nanoscience and is a member of the Governing Board of the ACS Green Chemistry Institute. He is a member of the leadership team for the Oregon Nanoscience and Microtechnologies Institute (ONAMI) and founded, and now directs, the ONAMI's Safer Nanomaterials and Nanomanufacturing Initiative (SNNI). The SNNI is a virtual center that unites 30 principle investigators at University of Oregon, Oregon State University, Portland State University and Pacific Northwest National Laboratory around the goals of designing greener nanomaterials, greener nanomanufacturing and the integration of green materials into clean tech applications. He has won a number of awards, including an NSF-CAREER award and the 2003 Oregon Academy of Science Outstanding Teacher of Science and Math in Higher Education. Hutchison is an Alfred P. Sloan research fellow and a Camille Dreyfus teacher-scholar. He is the author of more than 90 refereed publications, three book chapters and a text book ("Green Organic Chemistry: Strategies, Tools and Laboratory Experiments").



Dr. Lallie McKenzie is a postdoctoral research associate at the Nanoscience Open Research Initiative, a collaborative research endeavor of the University of Oregon and Sony Corporation. Her research merges nanoscience, materials chemistry, and green chemistry and focuses on developing and understanding nanomaterials for future energy applications. In 2009, she completed her Ph.D. in chemistry at the University of Oregon under the guidance of James E. Hutchison. In the final year of that program, she received the ACS/GCI Kenneth G. Hancock Memorial Student Award, which honors outstanding student contributions to furthering the goals of green chemistry through research or education. Dr. McKenzie also has been actively involved in green chemistry education and has developed and published several green organic laboratory experiments. Prior to her Ph.D. work, she received B.S. and M.S. degrees in Chemistry from the University of Oregon.



Dr. John M. Miller is the Cofounder and Chief Operating Officer of Dune Sciences, Inc. in Eugene, OR. Dune Sciences specializes in the development and commercialization of materials and tools that enable greener nanoproducts including its LinkedON Antimicrobial coatings and SMART Grids imaging platform. Dr. Miller has more than 15 years experience in the development and commercialization of nanotechnology enabled products in fields ranging from energy storage to the life sciences. He has extensive technical expertise in the processing/production and characterization of new nanomaterials and devices. Prior to founding Dune Sciences, Dr. Miller served as Director of Fuel Cell Technology at World Energy Labs in San Francisco, CA where he led a team developing state-of-the-art embedded diagnostics for fuel cell technology. Prior to that he served as Technical Director for T/J Technologies, Inc. (now A123 Systems) in Ann Arbor, MI where he was responsible for the development of new battery materials that are presently being used in commercial high rate Li ion batteries.



Mr. Robert D. "Skip" Rung is a senior high technology R&D executive with over 25 years of R&D management experience in CMOS process technology, application-specific integrated circuit (ASIC) design and electronic design automation (EDA), IC packaging, MEMS, microfluidics, and inkjet printing. Until his retirement in 2001, he served as Director of Advanced Research for the Imaging and Printing Technology Platforms business at Hewlett-Packard's Corvallis, OR facility. Mr. Rung was asked in December 2003 to lead Oregon Nanoscience and Microtechnologies Institute (ONAMI), Oregon's first "Signature Research Center" and an unprecedented collaboration among Oregon's research universities and the Pacific Northwest National Laboratory. ONAMI's dual mission is to grow "small tech" research in Oregon and commercialize technology in order to extend the success of Oregon's world-leading "Silicon Forest" technology cluster, which includes the most advanced R&D and manufacturing operations for leading companies such as Intel Corporation, Hewlett-Packard Company, FEI Company, Invitrogen, Electro Scientific Industries, Planar Systems, Xerox Office Products, Tektronix, ON Semiconductor and many dynamic smaller firms. ONAMI has so far received \$42M in state investment and approximately tripled Oregon's annual federal and private research awards in the fields of nanolaminates and transparent/printed electronics, green nanotechnology, nanoscale metrology, and microtechnology-based energy and chemical systems (MECS). The ONAMI gap fund has helped launch or enable over 12 new startup companies since late 2006.



Keynote Speakers

Dr. John Busbee currently serves as Manager, Nanomaterials Technology Base Program at the Materials and Manufacturing Directorate of the Air Force Research Laboratory at Wright-Patterson AFB, Ohio. This program is responsible for the development, management and strategic direction of foundational, multi-disciplinary nanomaterial and nanotechnology efforts for the Directorate. Dr. Busbee has also previously served as the Leader of the Materials Process Design Team and Research Leader of the Manufacturing Science and Nanomanufacturing Programs in the Manufacturing Technology Division. John received his Ph.D. in Materials Science and Engineering from the University of Illinois at Urbana-Champaign, M.S and B.S. degrees in Electrical Engineering from Wright State University and a B.S. in Aerospace Engineering from Texas A&M University.



Richard A. Denison is a senior scientist at the Environmental Defense Fund. Dr. Denison has 25 years of experience in the environmental arena, specializing in chemicals policy and hazard, exposure, risk assessment and management for industrial chemicals and nanomaterials. He has published extensively and has testified before Congress many times regarding these issues. Dr. Denison is a member of the NRC Board on Environmental Studies and Toxicology, and currently serves on the National Research Council's Committee to Develop a Research Strategy for Environmental, Health and Safety Aspects of Engineered Nanomaterials. He is also a member of the Green Ribbon Science Panel for California's Green Chemistry Initiative. Previously, Dr. Denison was an analyst and assistant project director in the Oceans and Environment Program, Office of Technology Assessment, United States Congress. Dr. Denison received his Ph.D. in Molecular Biophysics and Biochemistry from Yale University.



Travis Earles serves as Assistant Director for Nanotechnology in the White House Office of Science and Technology Policy. He co-chairs the National Science and Technology Council Subcommittee for Nanoscale Science, Engineering and Technology (NSET), facilitating interagency coordination through the National Nanotechnology Initiative (www.nano.gov) and reaching out to the science and technology community across academia, government, and industry to foster responsible development of nanotechnology. Formerly at the National Cancer Institute, Earles helped plan, coordinate, and implement the five-year, \$144 million Alliance for Nanotechnology in Cancer (nano.cancer.gov) launched in 2005. He holds a bachelors degree in biomedical engineering from Catholic University of America as well as an MBA and MS in technology management from the University of Maryland.



Debra L. Kaiser is Chief of the Ceramics Division in the NIST Materials Science and Engineering Laboratory. Her research at NIST as a Staff Member and Group Leader focused on establishing processing-structure-property linkages in thin film and single crystal oxide materials, including high temperature superconductors for energy systems and perovskites for optoelectronic and memory storage devices. For the past four years, Dr. Kaiser has coordinated a NIST-wide partnership with the National Cancer Institute's Nanotechnology Characterization Laboratory (NCL), whose mission is to perform preclinical efficacy and toxicity testing of nanoparticles for cancer treatment. NIST's role in this ongoing partnership is to provide advanced physico-chemical measurement methods, standards, and data on relevant nanoparticles. As part of this project, MSEL led the production of three gold nanoparticle reference material (RM) standards (10 nm, 30 nm, and 60 nm), the first nanoparticle standards for biomedical applications. Dr. Kaiser is also the Technical Coordinator for a NIST-wide Program on the Environmental, Health, and Safety Implications of Manufactured Nanomaterials.

Bryan Monroe is a Process Science Fellow for Life Technologies. For 23+ years he has had responsibilities in Discovery, Process Development and Manufacturing with Genetic Systems, Bristol-Myers Squibb, ZymoGenetics and Dendreon, where his group was responsible for antigen PD and Manufacturing in the soon to be approved (May 1st) cancer vaccine Provenge. He has had the opportunity to take both diagnostics and biologics projects expressed in mammalian, insect, and microbial systems into clinical investigation and market approval.

Scott McNeil serves as Director, Nanotechnology Characterization Laboratory for the National Cancer Institute at Frederick where he coordinates pre-clinical characterization of nanomaterials intended for cancer therapeutics and diagnostics. He advises Industry and State and US Governments on the development of nanotechnology and is a member of several governmental and industrial working groups related to nanotechnology policy, standardization and commercialization. Prior to joining NCI-Frederick (i.e. SAIC-Frederick), he served as Senior Scientist in the Nanotech Initiatives Division at SAIC where he transitioned basic nanotechnology research to government and commercial markets. Dr. McNeil's professional career includes tenure as an Army Officer, with tours as Chief of Biochemistry at Tripler Army Medical Center, as a Combat Arms officer in the Gulf War. He is an invited speaker to numerous nanotechnology-related conferences and has six patents pending related to nanotechnology and biotechnology. He received his bachelor's degree in chemistry from Portland State University and his doctorate in cell biology from Oregon Health Sciences University.



Professor John A. Rogers obtained BA and BS degrees in chemistry and in physics from the University of Texas, Austin, in 1989. From MIT, he received SM degrees in physics and in chemistry in 1992 and the PhD degree in physical chemistry in 1995. From 1995 to 1997, Rogers was a Junior Fellow in the Harvard University Society of Fellows. He joined Bell Laboratories as a Member of Technical Staff in the Condensed Matter Physics Research Department in 1997, and served as Director of this department from the end of 2000 to 2002. He currently holds the Lee J. Flory-Founder Chair in Engineering at University of Illinois at Urbana/Champaign with a primary appointment in the Department of Materials Science and Engineering. Rogers' research includes fundamental and applied aspects of nano and molecular scale fabrication as well as materials and patterning techniques for unusual format electronic and photonic systems.



Rapid-Fire Speakers

Meeting Characterization Challenges to Support Greener Nanomaterials and Nanomanufacturing

Don Baer is a Laboratory Fellow at Pacific Northwest National Laboratory (PNNL), Lead Scientist for Interfacial Chemistry and Interim Chief Scientist at EMSL—the Environmental Molecular Sciences Laboratory, a U.S. Department of Energy national scientific user facility located at PNNL. Dr. Baer received a B.S. in physics in 1969 from Carnegie-Mellon University and a Ph.D. in experimental physics in 1974 from Cornell. Since 2002 he has led a US Department of Energy project on the reactivity of nanoparticles with environmental contaminants. He currently leads an ISO TC201 working group preparing a technical report on the application of surface analysis tools to characterize nanostructured materials. He is a fellow of the AVS and the AAAS and an adjunct professor of physics at Washington State University, Tri-Cities and of chemistry at the University of Washington.



Mike Jespersen is a National Research Council postdoctoral fellow at the Air Force Research Laboratories in Dayton, Ohio. His research interests include directed self-assembly and in-situ modification of nanoparticle monolayers, in addition to employing surface analysis techniques and NMR to characterize self-assembly and dynamics at nanoparticle interfaces. Mike completed his Ph.D. in 2008 at the University of Oregon with Professor Jim Hutchison. While a graduate researcher, Mike was an NSF-IGERT trainee for three years. His dissertation research focused on tuning the interactions of gold nanoparticles with surfaces and with the macroscopic environment in order to exploit their unique size-dependent properties.

Robert MacCuspie studies the stability of silver nanoparticles under “relevant” conditions, and the role of metal nanoparticle surface coatings on fate, transport, and stability to facilitate better nanomaterial risk assessment by the environmental, health, and safety community. Other topics include developing measurement methods to quantify surface coatings with single nanoparticle resolution, evaluating the feasibility of developing new nanoparticle Standard Reference Materials, and systematically validating transferrable measurement methods to determine the kinetics of ligand exchange reactions and silver nanoparticle dissolution. He is a Research Chemist in the Nanomechanical Properties Group at the National Institute of Standards and Technology. Before joining NIST, he earned two bachelor’s of science degrees from the University of Central Florida in Chemistry and Molecular Biology, his Ph.D. in Nanotechnology and Materials Chemistry from The Graduate Center of the City University of New York, and was a National Research Council postdoctoral fellow at the Air Force Research Laboratory’s Nanostructured and Biological Materials Branch.



Erik Richman received his Ph.D from the University of California, Los Angeles studying and manipulating the composition and morphology of mesoporous, micelle directed self assembled thin films of inorganic oxides. He has published articles characterizing the mesoporous systems, including measuring the thermal conductivity of porous films, reducing an ordered cubic mesoporous silica film to silicon, and designing oriented inorganic films without large external fields. In February 2009, he joined SNNI as a Materials Characterization Specialist postdoctoral scholar. His primary interests are in investigating the bottleneck that stands between nanoscience and nanotechnology: efficient characterization. Currently, the focus is on mapping zebrafish embryos exposed to very small nanoparticles in dilute solutions.



Nanotechnology Innovation and Governance: Moving from “Natural Enemies” to “Partners for Nature”

David E Adleman teaches and writes in the areas of environmental law, intellectual property law, and climate change policy. Professor Adelman’s research focuses on the many interfaces between law and science. His articles have addressed such topics as the implications of emerging genomic technologies for toxics regulation, the tensions between legal and scientific evidentiary standards in regulatory decision making, and development of effective policies for promoting innovation relevant to addressing climate change. Professor Adelman clerked for the Honorable Samuel Conti of the United States District Court for the Northern District of California. Before entering academia, he was an associate with the law firm Covington & Burling in Washington, D.C., where he litigated patent disputes and provided counsel on environmental regulatory matters, and a Senior Attorney with the Natural Resources Defense Council also in Washington, D.C. Professor Adelman was an Associate Professor of Law at the University of Arizona Rogers College of Law from 2001 to 2009.



Stacey Harper studies how very small substances, called nanomaterials, interact with cells, tissues and systems of plants and animals. Her goal is to determine how the widely used particles in manufacturing and consumer products affect the health of living organisms. Stacey is a Signature Researcher of the Oregon Nanoscience and Microtechnologies Institute, working under the Safer Nanomaterials and Nanomanufacturing Initiative. She holds a joint position at OSU between the Department of Environmental and Molecular Toxicology and the School of Chemical, Biological and Environmental Engineering at Oregon State University. She earned her bachelor’s degree in natural sciences and mathematics from Mesa State College, CO and her master’s and doctoral degrees in biological sciences from University of Nevada Las Vegas, NV. Stacey is co-chair of ASTM International E56 Committee on Nanotechnologies and serves as a representative of the ANSI-Accredited U.S. Technical Advisory Group for ISO/TC 229 which functions to formulate positions and proposals on behalf of the U.S. with response to ISO standardization activities on environmental health and safety of nanotechnologies.



Brian King received his BA, Phi Beta Kappa from Colorado State University and his Juris Doctorate from University of Colorado School of Law. His practice focuses on environmental and worker safety law. He has represented clients in environmental and OSHA enforcement proceedings, environmental permit appeals and Superfund litigation. He also is very active in the areas of environmental permitting, environmental auditing and general environmental compliance. He currently is studying the environmental and worker safety legal issues associated with nanotechnology. Prior to joining Schwabe, Williamson & Wyatt in 1999, Mr. King practiced law in a private firm and served for 12 years as associate general counsel for Boise Cascade Corporation. Mr. King is the author of numerous publications and coauthored a resource book for environmental managers, *Fundamentals of Environmental Management*, John Wiley & Sons. He also is a contributing author to the *Environmental and Natural Resources Law Handbook* published by the Oregon State Bar. His latest scholarly article, "Creating Incentives for Sustainable Buildings," was published by the *Virginia Environmental Law Journal* in 2005.





Jay Lindquist brings to Dune 20 years of experience developing nanotechnology based businesses across industries ranging from semiconductor capital equipment, to aerospace, to advanced materials. Jay is also President of Technology Business Development, a consulting firm specializing in valuation expansion of nano- and microtechnology based companies. Jay earned his Ph.D. in Physical Chemistry from the University of California, a B.Sc. in Chemistry and Biology from the University of Puget Sound, and Executive MBA from Stanford University.

Justin Teegarden has been engaged in the field of toxicology since the late 80's. Since that time he has worked in a variety of capacities most of which involved some aspect of risk assessment and computational modeling. He received his Ph.D. in 1999 from the University of Wisconsin, Madison in Toxicology and went on to private industry to develop physiologically based pharmacokinetic (PBPK) models for a variety of compounds. Most of these models were used to evaluate the relationship between external exposure, target tissue dose and response. The motivation has been that quantitative models of dose-response that characterize the underlying physiological and biochemical processes are more sound, more flexible platforms for conducting interspecies, dose and dose-route extrapolations. He has received a number of awards, including two for publications advancing the science of risk assessment. Justin now works at Pacific Northwest National Laboratory in Richland, WA where he came to continue following interest in the fundamental biology underlying dose-response relationships by developing models of signaling networks involved in important human environmental diseases. He currently serves on the National Toxicology Program Board of Scientific Councilors and previously served on the NRC panel reviewing the federal strategy for researching the environmental health and safety of nanomaterials.

Advancing Greener Nanomanufacturing: Additive processes and Greener Nanomaterial Production

Matt Beekman is a postdoctoral researcher in the group of Prof. David Johnson at the University of Oregon and a member of the Center for Green Materials Chemistry. He received his B.S. and M.S. in Physics, and Ph.D. in Applied Physics from the University of South Florida. His research interests and efforts have ranged broadly in the synthesis and characterization of new inorganic solid state materials, with particular focus in the areas of unconventional synthetic routes to crystalline compounds and crystal growth techniques, structure-property relationships, and electrical and thermal transport properties of both bulk and thin film materials. An underlying motivation for Matt's past and present work has been to understand the interplay of the above aspects in new materials for thermoelectric and other solid state energy conversion applications.

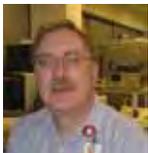
John Conley, Jr. earned the B.S. in electrical engineering in 1991 and Ph.D. in engineering science and mechanics in 1995 from The Pennsylvania State University where he won a 1996 Xerox Prize for his Ph.D. dissertation. Dr. Conley has been a senior member of the technical staff at Dynamics Research Corporation and the Jet Propulsion Laboratory (NASA / Cal Tech), an adjunct professor at Washington State University – Vancouver, and Leader of the Novel Materials and Devices Group at Sharp Laboratories of America. He is currently a Professor and an ONAMI Signature Faculty Fellow in both the School of Electrical Engineering and Computer Science and the Intercollege Materials Science

Program at Oregon State University. Dr. Conley has authored or co-authored over 90 technical papers (including several invited) and over 100 conference presentations. He holds seventeen U.S. patents. Dr. Conley has presented tutorial short courses on high-k dielectrics at two international conferences and was a guest editor of three special issues of IEEE Transactions on Device and Material Reliability. He has also served on the technical and management committees of several IEEE conferences including the IRPS, SOI, and Nuclear and Space Radiation Effects Conference, was technical program chair of the 2000 IEEE Microelectronics Reliability and Qualification Workshop and general program chair of the 2006 IEEE International Integrated Reliability Workshop. His research interests include atomic layer deposition, high-k dielectrics for transparent electronics, directed integration of nanomaterials and nanodevices, defects, reliability, and radiation effects in novel electronic materials.

Kannan M. Krishnan received his B. Tech in Mechanical Engineering from IIT, Kanpur (1978), his MS in Materials Science from SUNY, Stony Brook (1980) and his Ph.D in Materials Science from the University of California, Berkeley (1984). He subsequently held various scientific and teaching positions at Lawrence Berkeley National Laboratory and UC, Berkeley before joining the University of Washington, in 2001, as the Campbell Chair Professor of Materials Science and Adjunct Professor of Physics. He has also held visiting appointments at the Hitachi Central Research Laboratory (Japan), Tohoku University, Danish Technical University, University of Sao Paolo, University of Western Australia and Indian Institute of Science. Prof. Krishnan is well recognized for both research and teaching. His many awards include the IEEE Magnetics Society Distinguished Lecturer (2009), Guggenheim Fellowship (2004), the Rockefeller Bellagio Residency Fellowship (2008), the Burton Medal (Microscopy Society of America, 1992), Japanese Society for the Promotion of Science Senior Scientist Fellowship (2002), the University of Washington, College of Engineering Outstanding Educator Award (2004) and an appointment as the Professor-at-large at the University of Western Australia (2006-8). He is a Fellow of the American Association for the Advancement of Science, the American Physical Society and the Institute of Physics (London). He has served on the editorial boards of the Journal of Materials Science, Acta Materialia, Journal of Physics D: Applied Physics and IEEE Magnetics Letters. Prof. Krishnan's inter-disciplinary research interests are in magnetic nanostructures and thin film heterostructures, biomedical nanomagnetism, oxide spin electronics, advanced materials characterization and structure-property correlations at relevant length scales. All the projects are vertically integrated from the underlying science to their engineering (information storage, MEMS, magneto-electronic devices) and biomedical (diagnostics, imaging and therapeutics) applications.



Sam Lohse is a PhD candidate in the University of Oregon Chemistry department and works in the Hutchison laboratory. His research focuses on understanding gold nanoparticle surface chemistry and how that surface chemistry can be exploited to make more effective nanoparticle syntheses. The principal focuses of his research involve working with protected thiols to produce direct syntheses for large functionalized gold nanoparticles, using biomolecules to synthesize gold nanorods, and studying microfluidic nanoparticle syntheses. He has been an NSF-IGERT trainee for the past three years.



Paul Schuele has done process integration and development in 13 different fabs including the lead lots in four start-ups. His Ph D. is in Solid State Physics from Montana State and he holds 37 US patents. At Sharp Labs his research is on nanomanufacturing for LCD display, biosensor and solar applications.

Poster Abstracts

Presenting authors are listed in **bold**

Risk Assessment and Nanomaterial Regulation: A life cycle investigation of federal health and environmental regulations

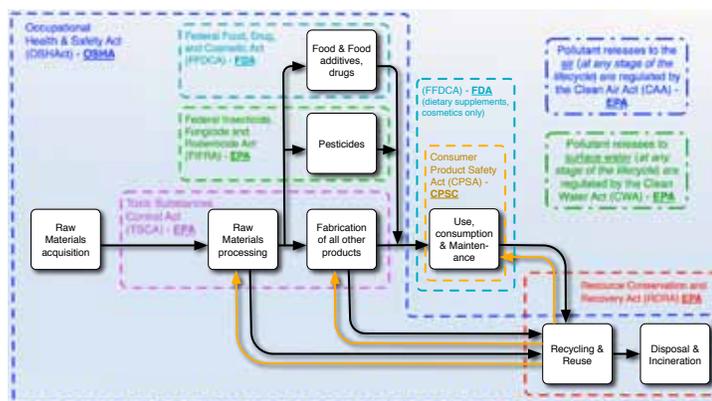
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Nanomaterials promise many benefits for society, from modest improvements in consumer products to revolutionary changes in drug delivery and medical treatments. There are over a thousand nano-enabled products currently on the market in the US, and billions invested in future nanotechnologies (Woodrow Wilson International Center for Scholars, Project on Emerging Nanotechnologies, Consumer Products Inventory: <http://www.nanotechproject.org/inventories/consumer/>). While nanotechnologies offer tremendous benefits for society, they may also pose significant risks. The same properties that make nanomaterials promising – that they can behave quite differently from bulk forms of the same material – may lead to negative health and environmental consequences. These novel properties, coupled with a relative scarcity of information on nanomaterial hazards, make risk assessment and regulation a difficult task.

This research investigates the challenges that nanomaterials pose for risk assessment and regulation by investigating the applicability of federal health and environmental regulations that may apply to nanomaterials (and products containing nanomaterials) over their life cycle, from initial production to end-of-life. This study found that a high degree of uncertainty over hazards, a lack of nanomaterial-specific risk information, and low production volumes that do not surpass applicability thresholds, mean that federally mandated risk assessments may not be conducted for many nanomaterials. Furthermore, many regulations are hindered by problematic definitions, a default assumption that no risk information means no risk, and a deficit of resources in the relevant regulatory agencies for adequately managing the growing influx of nanomaterials and nano-enhanced products. As a result of these challenges, many nanomaterials will not undergo a risk assessment at any point in their life cycle, and will escape regulatory oversight. For those materials that do undergo a risk assessment, a lack of consistent

oversight at later stages of the life cycle mean that many nanomaterials will become less regulated or entirely unregulated as they move from one life cycle stage to another. This life cycle investigation of federal regulations highlights the many ways in which nanomaterials may fall through gaps at specific life cycle stages, and as they move from one stage to another. This work highlights the need for improved consistency in regulatory oversight along the entire life cycle, as well as changes to definitions and applicability thresholds, and an increase in agency resources directed at the growing field of nanomaterials and nano-enabled products.



New classes of nanostructured materials and implications for direct thermal-to-electric energy harvesting

M. Beekman, C. Heideman, M. Smeller, N. Nguyen, A. Taylor, K. Hill, R. Atkins, D. Moore, D.C. Johnson
Department of Chemistry, University of Oregon, Eugene, OR

The utilization of energy ejected as waste heat from conventional energy conversion processes represents an immense opportunity to improve overall energy efficiency. This utilization can be done by

direct thermal-to-electric energy conversion using thermoelectric (TE) technology. Recent advances in the field have resulted in the proven ability to achieve unprecedented TE properties *via* nanostructured approaches, constituting significant progress toward the longstanding challenge of identifying more efficient thermoelectric materials. Ultimately, one desires materials systems in which composition and nanostructure can be controlled such that the mechanisms for TE enhancement can be studied, understood, and applied. Toward this aim, we have been developing new nanostructured multilayers and intergrowth compounds using the modulated elemental reactants synthesis approach. We will discuss the implications of these new materials for the science and technology of TE, which originate in part from the wide variety of chemical compositions that is accessible, offering a platform for new materials discovery. This includes the synthesis of materials comprised of Earth abundant elements that are needed for greener thermoelectric materials design as well as more widespread use in waste heat recovery and cooling applications.

Supercritical Fluids for Advancing Green Nanoparticle Processing

Brad J. Busche

Pacific Northwest National Laboratory

Supercritical fluids (ScF) exhibit many manufacturing advantages compared to conventional wet processing methods. Many of these compressible fluids are nontoxic, inexpensive, easily removed after processing, and have a density that can be adjusted with pressure or temperature to provide tunable properties such as solubility. The ability to manipulate solubility allows control maximize the conditions for synthesis, purification, and deposition of nanoparticles. Factors that affect nanoparticle solubility include the ScF media, ScF density, stabilizing ligand shell, and nanoparticle size. Understanding and manipulating these dynamic solubility parameters will enable development of green processing of the nanoparticles.

Identification of RNA aptamers for use as Ligands in Nanoparticle Synthesis

Brandi Dickinson

University of Oregon, Eugene, OR

The goal of this collaborative project between the Berglund and Hutchison labs is to merge the disciplines of Inorganic Nanomaterials and Molecular Biology to synthesize and characterize novel materials appropriate for use in the fields of biosensing and therapeutics. We intend to exploit the large variety of available RNA sequences/structures and their exquisite binding specificity to identify unique approaches to making materials with precisely controlled properties. By performing SELEX (Systematic Evolution of Ligands by EXponential enrichment) on nanomaterials made using established methods, we intend to identify RNA aptamers that can bind specific crystal faces of developing nanoparticles, thereby templating their growth into anisotropic shapes of interest. Since RNA is biocompatible and environmentally benign, this project will allow us to develop a greener approach to producing these materials. Analysis of the specific interactions between these aptamers and their substrates will also allow us to more systematically approach the design of future synthetic methods, improving the efficiency of their development.

Morphological and chemical evolution of noble metal nanoparticles in biologically relevant conditions

Richard Glover, Dr. John Miller, and Dr. Jim Hutchison

Department of Chemistry, University of Oregon, Eugene OR

In recent years, there has been a significant increase in awareness of the potential risks associated with the fate and transport of nanomaterials into the environment. A key challenge to investigating these phenomena is the ability to capture/sequester and subsequently analyze these nanomaterials after exposure to environmental stimuli. This poster presentation highlights studies undertaken in Prof. Jim Hutchison's lab (UO) to address this challenge for gold and silver nanoparticles. In this work, we employ an electron transparent platform to investigate changes to size, shape, and chemistry in biologically/environmentally relevant conditions. The substrate, Si wafers with SiO₂ windows, allows us to

use TEM to understand how different conditions affect individual particles and their stability. The platform also allows for surface analysis using XPS to understand chemical changes. Conditions used were water, dilute acid, oxidants, and glutathione. Understanding these changes to nanomaterials we can extrapolate reactivity to toxicity trends seen in zebrafish bioassays done at OSU in the Tanguay lab to ultimately help design safer nanomaterials.

Application of Life Cycle Assessment for Greener Synthesis of Nickel Nanoparticles

Malcolm O. Brown¹, Karl R. Haapala¹, and Brian K. Paul¹, Richard D. Glover² and James E. Hutchison²

¹*School of Mechanical, Industrial, and Manufacturing Engineering Oregon State University Corvallis, OR;*

²*Department of Chemistry, University of Oregon Eugene, OR*

In spite of the many potential benefits and applications of nanoparticles, concerns have been raised regarding their production, use, and ultimate fate due to poor process yields and uncertain health and environmental impacts. Production of commercial nanoparticles is growing as they find increasing use in industrial and consumer products. Nickel nanoparticles (NiNPs) have shown promise as a single element braze material, but the energy and material efficiencies of NiNP production remain uncertain. Life cycle assessment (LCA) is employed to compare three different NiNP synthesis methods reported in the literature in terms of environmental impact. The study reveals challenges in using LCA to assess nanomanufacturing processes. Sensitivity analysis is performed across several process parameters to demonstrate an approach for addressing data uncertainties. The relative performance of the NiNP synthesis processes is reported, and potential environmental implications for other NiNP synthesis processes are introduced. This study demonstrates that, due to uncertainties inherent to analysis, changes may be necessary to provide adequate transparency in assessing nanotechnologies for engineering applications.

Mechanistic and *In Situ* Investigations of Nanoparticle Formation Utilizing Microreactors

Patrick M. Haben

University of Oregon, Eugene OR

Utilizing a continuous-flow microreactor we have demonstrated that simultaneous *in situ* small angle x-ray scattering (SAXS) patterns and UV-visible spectra can be collected for dynamic Au nanoparticle growth reactions. These combined techniques provide both quantitative size distribution information and optical absorbance spectra. The microfluidic reactor allows us to view various reaction times for extended durations, allowing ample data collection time. Utilizing mercapto-ethoxy-ethoxy-ethanol Bunte Salt (MEEE) as a passivating ligand and NaBH₄ as reducing agent, we have observed nanoparticle formation and growth between 1- and 60-second residence times for two reductant ratios. These data suggest that after rapid initial growth the average nanoparticle diameter decreases, possibly due to a coarsening or ripening mechanism. Future experiments will focus on elucidating potential mechanisms of material transfer, probing earlier reaction times, and identifying mechanistic differences when disparate ligand functionalities are utilized. Specifically, we have incorporated both citrate- and thiol-mediated syntheses into flow and are beginning mechanistic investigations.

The Knowledgebase of Nanomaterial-Biological Interactions

Katherine E. Cleveland¹ and Stacey L. Harper^{1,2,3}

¹*Department of Environmental and Molecular Toxicology,* ²*Environmental Health Sciences Center,*

³*Oregon Nanoscience and Microtechnologies Institute, Corvallis, OR*

A risk characterization framework to classify nanomaterials based on their physical or chemical properties as well as their biological impacts is necessary to reduce the uncertainty around potential nanomaterial hazards. Structure-property relationships that can be used to predict nanomaterial impacts in lieu of empirical data can provide significant support for the nanotech industry in developing safer nanomaterials. Knowledge on the governing principles of nanomaterial-biological interactions can more effectively be utilized once computational tools are available for data integration and consensus analysis. The Nanomaterial-Biological Interactions (NBI) knowledgebase was developed to consolidate and integrate disparate data on nanomaterial effects in model systems and provide unbiased informatics

approaches to identify the relative importance of characterization parameters on biological effects. The NBI serves as an open-source data repository for nanomaterial characterization, synthesis, and biological interactions, and houses a reference dataset from embryonic zebrafish evaluations on over 200 distinct nanomaterials. Various data mining and computational tools are used to organize the existing body of data in a systematic and logical way. The goal is to identify nanomaterial structure-property relationships that can be used to determine which material features can be altered to gain functionality in a predictable manner.

Formation and Characterization of Zinc Oxide Nanostructures Using Zinc Nanoparticle Precursors

Meena Suhanya Rajachidambaram, Jaana Suhanya Rajachidambaram, **Gregory S. Herman**,

School of Chemical, Biological, and Environmental Engineering, Oregon State University

Zinc oxide has an assortment of interesting chemical, electrical, piezoelectric, and optical properties which makes it of use for numerous technological applications. Zinc oxide nanoparticles can be synthesized by a variety of approaches with considerable richness in shape, size, and structure. In this presentation, we will describe an alternative approach of forming nanostructured zinc oxide materials via the oxidation of metallic Zn-nanoparticles. We will also contrast the role of the initial zinc nanoparticle size (35 and 130 nm diameter) on the resulting zinc oxide nanoparticle properties. For example, we have found that there is a significant size effect for the onset of thermal oxidation, where smaller Zn nanoparticles, are fully oxidized ~100K lower in temperature than the larger Zn nanoparticles. Furthermore, there are significant differences in the shape of the resulting materials as well. We will discuss challenges in characterizing these nanomaterials, and potential opportunities for hydrogen production via the water splitting thermochemical cycle via the Zn/ZnO redox reaction.

Progress towards the development of an in-line method for purification of PbS nanoparticles by nanofiltration

Taehyeong Kim and Vincent T. Remcho

Oregon State University, Corvallis OR

Nanofiltration is an effective means of purification of nanoparticles, though it is labor intensive and membrane materials are expensive. We have developed in-line (post-reactor) nanofiltration tools that enhance membrane longevity and speed purification. Our current method enables size-based separation of lead sulfide nanoparticles initially synthesized with a 2-5nm size distribution. PbS nanoparticles have received considerable attention given their promise as semiconducting materials, in particular owing to their tunable near-infrared emission properties and narrow bandgaps. The distinct physical and chemical properties of PbS nanoparticles are size- and shape-dependent, thus highly selective synthetic methods and/or post-synthetic separations methods are critical considerations. We will share recent results from our work on nanofiltration of organic-soluble PbS nanoparticles. We have developed a method by which to purify and refine post-synthetic PbS nanoparticles to achieve a narrow size distribution (S.D. 20-36%) after filtration on StarmemTM122 (Membrane Extraction Technologies, London, UK) as well as achieve rejection values >90%. This was done as a continuous process using a tangential flow filtration system to generate uniform, predictable flow distributions on the membrane and enhance membrane performance to prevent caking (particle buildup) and surface fouling; we have demonstrated enhanced performance and membrane longevity which will be reflected in our presentation.

Dynamic nature of the cerium oxide nanoparticles – influence of aging and local environment

Satyanarayana V.N.T. Kuchibhatla¹, A.S. Karakoti², Ch. F. Windisch Jr, P. Nachimuthu¹, S. Seal², S. Thevuthasan¹, D. R. Baer¹

¹EMSL, Pacific Northwest National Laboratory, Richland, WA 99352, ²Advanced Materials Processing and Analysis Center, University of Central Florida, FL 32816

Cerium oxide nanoparticles (CNPs) are a subject of increasing attention in the biomedical field in addition to many traditional applications such as catalysis, sensors and fuel cells. Most of the applications of CNPs are driven by the oxygen buffering capability, which in turn is guided by the ability of cerium to switch between 3+ and 4+ oxidation states. The thermodynamic stability of oxygen vacancies in the

particles below 10 nm makes this switching more efficient. Motivated by this fact, the CNPs have been used to study their biological response (cell longevity, toxicity and related aspects) and the preliminary results have shown excellent radical scavenging ability. It has also been noted that the CNPs can effectively regenerate the active redox state. However, an unequivocal mechanism is still not reported. We have studied, in situ, the influence of time (aging) and local environment (chemistry) on the chemistry and structure of CNPs. With the help of UV-Visible and Raman spectroscopy along with microXRD measurements, we have observed that the CNPs are highly dynamic in nature and respond, through changes in chemical state and possibly structure, to the variations in their local environment as a function of time. Raman data with support from XRD and some XPS results suggests that the CNPs undergo the transformation between 3+ and 4+ oxidation state through the formation of a “peroxide-complex” in presence of hydrogen peroxide, which as a function of time leads to the formation of cerium oxide nanoparticles, regeneratively. Interaction of CNPs with hydrogen peroxide was used as a model system for explaining the regenerative nature of CNPs in biological applications. Various results from this study, along with the size dependence of the transitions, will be presented while discussing the merits of the findings and their implications to the bio-medical applications.

Structural-Mechanical Characterization of Nanoparticle Exosomes in Human Saliva, Using Correlative AFM, FESEM, and Force Spectroscopy

Cliff Mathisen, Michael Schmidt

FEI Company, 5350 NE Dawson Creek Drive, Hillsboro, Oregon 97124

All living systems contain naturally occurring nanoparticles with unique structural, biochemical, and mechanical characteristics. Specifically, human saliva exosomes secreted by normal cells into saliva via exocytosis are novel biomarkers showing tumor-antigen enrichment during oral cancer. Here we show the substructure of single human saliva exosomes, using a new ultrasensitive low force atomic force microscopy (AFM) exhibiting substructural organization unresolvable in electron microscopy. We correlate the data with field emission scanning electron microscopy (FESEM) and AFM images to interpret the nanoscale structures of exosomes under varying forces. The quantitative nanoscale morphological, biomechanical, and surface biomolecular properties of single saliva exosomes are critical for the applications of exosomes for cancer diagnosis and as a model for developing new cell delivery systems.

Green nanoscience at NORI: Investigation of greener nanomaterials through collaborative fundamental research

Lallie C. McKenzie¹, Keiichiro Masuko¹; Daisuke Ito^{1,2}, James E. Hutchison¹

¹Nanoscience Open Research Initiative, Materials Science Institute and Department of Chemistry, University of Oregon, Eugene, OR; ²Nano Science Research Laboratory, US Research Center, Sony Electronics Inc., Eugene, OR

Importance of Ligand Head Group in Determining Stability of Lead Sulfide Nanoparticles and Biological Responses in Embryonic Zebrafish

Ian Moody and Dr. Mark Lonergan

University of Oregon, Eugene OR

Semiconductor nanoparticles are of great interest for their size-tunable optical properties and ability to be solution-processed. These properties make them ideal candidates for low-cost photonic devices (e.g. light-emitting diodes and photovoltaics) and fluorescent biological imaging agents. Key to these properties is the presence of an organic ligand shell, which coats the surface of the inorganic cores, quenching defect sites and imbuing the nanoparticles with solubility. However, this ligand-nanoparticle interface is also the weak link in many decomposition processes. Oxidation of surface ligands can lead to ligand desorption, nanoparticle precipitation, and leaching of potentially toxic metal ions from the exposed inorganic core. In this study, lead sulfide nanoparticles (PbS-NPs) functionalized with two similar short-chain, thiol ligands were compared in terms of their resistance to precipitation and toxicity in embryonic zebrafish models. Embryos exposed to PbS-NPs functionalized with a chelating dithiol ligand (PbS-DT) exhibited less mortality and sub-lethal malformations than those exposed to structurally-analogous,

monothiol-functionalized nanoparticles (PbS-MT). The data suggests a correlation between nanoparticle stability and biological response. The results show how relatively minor changes in surface functionalization can have major implications for the design of robust nanoparticle systems that are less toxic and more environmentally benign.

The 5 Principles of “Design for Safer Nanotechnology”

Gregory Morose

Toxics Use Reduction Institute, University of Massachusetts Lowell

Nanoparticles have been incorporated in hundreds of different types of products, and the novel properties of nanomaterials offer great promise to provide new technological breakthroughs. However, nanotechnology is an emerging technology which has potential health and safety risks throughout its product life cycle. The health risk of a nanoparticle is a function of both its hazard to human health and its exposure potential. It is prudent for companies to try to mitigate the potential risks of nanoparticles during the design stage rather than downstream during manufacturing or customer use. The intent of this poster is to propose five design principles for product designers to use during the design stage for products that contain hazardous nanoparticles. These principles include changing nanoparticle size, shape, and structure, identifying safer alternative materials, functionalization, encapsulation, and reduction techniques. By using these design principles, the health risk of the nanoparticle may be mitigated by potentially lowering the hazard and/or the exposure potential of the nanoparticle. These proposed design principles are largely untested and are offered as an initial framework that will require more testing, validation, and refinement.

Reverse oscillatory flow mixing for scaling the reactive precipitation of CdS nanoparticles

B.K. Paul, A. Garrison, C. Chang, W. Su and **B. Palanisamy**

Oregon State University, Corvallis OR

In past studies, microcapillary mixers have been used to reduce cycle times, reduce solvent usage and increase yields associated with the synthesis of undecagold nanoparticles. Further, we have shown that these reaction chemistries can scale-up by increasing the number of microchannels and microchannel layers without loss in yield. Concerns with the process scale-up of nanoparticle chemistries within microchannel mixers include the control of particle size distribution and clogging. In this study, we demonstrate uniform, subsecond mixing in the reactive precipitation of semiconductor nanocrystals using pulsed, reverse oscillatory flow through a 450 micrometer serpentine channel. Pulsed flows with forward and reverse components provide a new mechanism for controlling residence time distribution. Larger microchannel dimensions make the device cheaper to fabricate, less likely to clog and easier to clean. Computational fluid dynamics (CFD) was used to identify pulsed flow parameters and channel geometries of interest. Wire electrodischarge machining was used to produce an acceptable mixer geometry quickly and cheaply. Temporal evolution of the average particle size is studied using in-situ flow cell measurement techniques for estimating bandgap and particle size based on the deconvolution of the ultraviolet-visible absorbance spectra. Precipitated particles are analyzed by transmission electron microscopy to produce particle size distributions. The data are used to validate CFD metrics showing mechanisms for improving particle size distribution as well as to validate in-process diagnostics.

Decreased Bacterial Toxicity to Single Walled Carbon Nanotubes (SWNTs) Through the Addition of Surface Functional Groups

Leanne Pasquini

Yale University, New Haven, CT

Single walled carbon nanotubes (SWNTs) are among the abundance of nanomaterials currently utilized for their unique properties such as high surface area to volume ratio, semi conducting and metallic characteristics, and incredible tensile strength. Due to their varied applications across numerous industries, SWNTs are entering the consumer market at an increasing rate. Yet, there remains uncertainty surrounding SWNT toxicity to both humans and the environment. Current literature supports the toxic nature of SWNTs ranging from carcinogenic effects on lung tissue to loss of cell viability in

Escherichia Coli bacterium. The current research intends to explicate the potential for decreased SWNT toxicity by evaluating the magnitude of percent viability loss of Escherichia Coli (E.coli k-12) bacterium post exposure. Pristine (unfunctionalized), hydroxy (-OH) and carboxy (-COOH) SWCNTs are explored to determine whether the addition of surface functionalizations alter the toxic results.

Characterization of silver nanoparticle inhibition on the ammonia oxidizing bacterium

Nitrosomonas europaea

Tyler S. Radniecki, Dylan Stankus, Jeff Nason and Lewis Semprini

School of Chemical, Biological and Environmental Engineering, 102 Gleeson Hall, Oregon State University, Corvallis, OR 97331

The widespread use of silver nanoparticles (Ag-NP) in consumer products may lead to increased concentrations of Ag-NP in wastewater treatment plants (WWTP) due to their observed release from commercial products. Ammonia oxidizing bacteria (AOB) are widely considered to be the most sensitive bacterium found in WWTP and their inhibition by Ag-NP is of great concern. This study characterized the inhibition of *Nitrosomonas europaea*, a model AOB, by silver ions (Ag⁺), 20 nm Ag-NP and 80 nm Ag-NP. In 3 hour exposure assays, *N. europaea* was found to be extremely sensitive to Ag⁺, 20 nm Ag-NP and 80 nm Ag-NP with concentrations of 0.1, 0.5 and 1.5 ppm, respectively, resulting in a 50% decrease in nitrification rates. The inhibition was correlated with the amount of Ag⁺ released into solution with 25% (mass based) of 20 nm Ag-NP and 6% of 80 nm Ag-NP being released as Ag⁺. Ag⁺ inhibited the initial step of the ammonia oxidation pathway involving the ammonia monooxygenase (AMO) enzyme, which was more highly inhibited than the hydroxylamine oxidoreductase (HAO) enzyme used in the latter step. Divalent cations limit the inhibition of *N. europaea* by potentially promoting the aggregation of the Ag-NP and preventing cell up-take of Ag⁺.

Reducing formaldehyde use in the synthesis of metal nanoparticles

Scott Reed

Department of Chemistry, University of Colorado, Denver

Given the interest in medical applications of nanomaterials, it is particularly concerning that many of the synthetic routes to nanoshells and core-shell metal nanoparticles use a large excess of the toxic reagent formaldehyde as a reducing agent. In the case of silver nanoparticles, the methods used stem from Zsigmondy's original synthesis reported in 1927 and as a result most syntheses use a 1000-fold excess of formaldehyde or greater. We have discovered a previously unnoticed function of formaldehyde through a careful analysis of its role in the preparation of silver nanomaterials. The reaction conditions commonly used for providing a silver coating also produce a polymer by reaction of formaldehyde with ammonium hydroxide. This polymer changes how silver attaches to and coats a substrate and results in a near-infrared (near-IR) localized surface plasmon resonance (LSPR). Deposition of silver onto gold nanoparticles in the presence of this polymer results in a thin asymmetric silver coating. We demonstrate that this polymer is responsible for creating core-shell nanoparticle with a near-IR LSPR. Understanding this second role of formaldehyde allowed us to decrease the amount used 100-fold compared to previous methods, providing a greener synthesis.

High resolution automated crystallite orientation & phase mapping

S. Rouvimov¹, P. Moeck¹, E. F. Rauch², S. Nicolopoulos³, and D. Bultreys³

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The electron backscatter diffraction (EBSD) technique in a scanning electron microscope (SEM) is often employed for structural characterization of thin polycrystalline films. This technique is, however, sensitive to the plastic deformation state of the crystals as well as to structural damage or contamination of the crystal surfaces. In addition, its spatial resolution is limited to somewhere between 20 to 80 nm. Electron diffraction in the nano-probe mode in a transmission electron microscope (TEM) that is equipped with a

field emission gun, on the other hand, delivers a significantly higher spatial resolution as compared to EBSD in a SEM and is also less sensitive to the plastic deformation state and the surface of nanocrystals. An automated technique for the mapping of crystallite phases and orientations of polycrystalline materials in a TEM has, therefore, been developed recently (S. Rouvimov et al., Proc. 2009 NSTI, Vol. I (2009) 421) and is now also available to all ONAMI researchers. This technique is based on template matching of experimental electron diffraction spot patterns to their pre-calculated theoretical counterparts. Promising results have so far been obtained with this technique for polycrystalline metal films, microelectronic composite structures, and inorganic nanocrystalline powders.

Production of Potassium Manganese Oxide Nanowires with bird feather particles in their central membrane and a water repellent coating of silicone

Mohammad Bilal Samee

Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan

Oil is one of the basic and essential commodities required by humans in their daily life. Oil as in one case is a marvel simultaneously, also acts as, a menace if misused or if any technological mishap takes place. In the latter it readily affects our environment causing ample damage to our ecological system. In this study, it is proposed to reduce this menace, keeping in mind all the technological mishap's which result in the spillage of oil, there is a need to develop a material which can absorb oil readily from an oil and water mixture. Hence a similar material can be created if we use, (Potassium Manganese Oxide) interwoven mesh of nanowires as the central membrane, the pores of which will be mounted with bird feathers and finally this material will be covered with a water repellent coating of silicon which will refrain it from absorbing water. Here we present a self-assembly method for constructing thermally stable, free-standing nanowire membranes that exhibit controlled wetting behavior. This material if manufactured successfully will be able to absorb oil about 25-30 times of its own weight. Which can be used to revive our eco-system and millions of liters of oil can be regained from sea water and further it will also help us to eliminate other hydrophobic impurities from water. Further in this paper, the pros and cons, sustainability, feasibility and general principle of creation of such a membrane are also discussed.

High-temperature molecular dynamics simulation of POPE and POPC lipid membrane small fragments enforced by intercalated single-wall carbon nanotube

Sergey Shityakov and Thomas Dandekar

Department of Bioinformatics, Biocenter of the University of Würzburg, 97074 Würzburg, Germany

In this work we investigated the molecular dynamics of palmitoyl-oleoyl-phosphatidylcholine and palmitoyl-oleoyl-phosphatidylethanolamine membrane bilayers enforced by single-wall carbon nanotube using classical molecular dynamics simulation. We have considered that an insertion of a single-wall carbon nanotube in the center of lipid membrane "strengthens" ambient lipids and prevents whole system from further destabilization caused by high temperature. We implemented root mean square deviation of simulated structures from their initial states to emphasize the molecular dynamics behavior of these structures during 1000 ps simulation time at different temperature parameters. The data suggest that intercalated carbon nanotube has an impact on the membrane stabilization dynamics. On the other hand, different lipid membranes may have dissimilarities due to the different abilities to create a bridge formation between the adherent lipid molecules. The results derived from this work may be of importance in developing stable nanosystems for construction of novel biomaterials and delivery of various biomolecules in fields of biosensors, biomaterials, and biophysics.

Formation of gold nanocluster - cavity pairs in SrTiO₃

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Dispersion of gold nanoclusters in single crystal TiO₂, MgO, and SrTiO₃ have been found to influence the optical properties of the materials. One way to make these clusters in these oxide media is through Au ion

implantation followed by annealing at high temperatures for extended period of time. The Au clusters generated by this ion beam synthesis method often associated with vacancies as a cluster-vacancy pair in the matrix. These nanometer scale vacancy clusters are generally called quantum antidotes and they are believed to be spatially located at the interface between the Au clusters and the matrix. To verify this proposition, Au nanoclusters dispersed in SrTiO₃ single crystals were prepared using ion implantation at 975 K and subsequent annealing at 1275 K for 10 hours. We have used a suite of imaging capabilities including newly developed Helium ion microscopy (HIM) and scanning transmission electron microscopy (STEM) with high-angle-annular-dark-field (HAADF) imaging to understand the structural properties and spatial distribution of the Au and vacancy clusters. The results indicate that gold nanocluster-cavity pairs were formed uniformly throughout the implanted region. Size of the Nanocluster-cavity pairs ranges from 5 to 30 nanometers. In cluster free regions where the Au concentration is low, the HAADF results clearly indicate the substitution of Au for cations. The Au clusters and the cavity show spatial association, indicating a strong interaction during their respective clustering process.

Improved Characterization, Manipulation, and Control of Nanoscale Interfaces via Self-Assembled Arrays of Nanoparticles

Beverly Smith and Ed Elliott

University of Oregon

Understanding how metal nanoparticles change over the course of reactions and their interfacial interactions with the substrate has widespread importance in the future design of heterogeneous catalysts and nanoscale devices. Investigating ways of controlling transformations such as aggregation and migration could lead to the design of more ordered nanoparticle arrays. The order present in these arrays will allow for enhanced characterization of transformations and fabrication of nanomaterials with improved efficiency as well as allowing for post-synthetic transformations. Our research addresses these challenges through the use and modification of functionalized, self-assembled monolayers of metal nanoparticles. In one branch of current work, a co-assembly of ZnO and Au functionalized nanoparticles are self-assembled through electrostatic ligand-to-substrate interactions in order to investigate if ZnO nanoparticles act as barriers to aggregation and migration of the Au nanoparticles. This research also encompasses arrays of small functionalized gold nanoparticles assembled via covalent ligand attachment to a substrate. A dilute ozone treatment allows for the selective removal of exposed ligand. The revealed gold nanoparticle surface may then be covered with various oxides in order to examine the impact of oxide-metal interface formation.

Interactions between natural organic matter and gold nanoparticles with different capping agents

Dylan Stankus

Oregon State University

The adsorption of natural organic matter (NOM) to the surfaces of natural colloids and engineered nanoparticles is known to strongly influence, and in some cases control, their surface properties and aggregation behavior. As a result, the understanding of nanoparticle fate, transport and toxicity in natural systems must include a fundamental framework for predicting such behavior. Using a suite of ligand stabilized gold nanoparticles (AuNPs), the impact of surface functionality, presence of natural organic matter and aqueous chemistry (pH, ionic strength, and background electrolytes) on the surface charge and stability of AuNPs was investigated. Ligands used in this study were as follows: anionic (citrate, carboxylate, and tannic acid), neutral (2,2,2-[mercaptoethoxy(ethoxy)]ethanol (MEEE) and polyvinylpyrrolidone (PVP)), and cationic (N,N,N-trimethylammoniumpentanethiol (TMAPT)). Each AuNP appeared to adsorb Suwannee River Humic Acid (SRHA) due to a measureable decrease in zeta potential at 5 mg DOC L-SRHA. It was found that SRHA provided a stabilizing effect in the presence of only monovalent ions while divalent cations lead to enhanced aggregation. Results indicate that the environmental fate and transport of the AuNPs tested will be a function of capping agent, pH, presence of NOM, ionic strength and electrolyte valence.

3D Atom Probe Analysis of Embedded Nanoclusters in Oxide Matrix

Satyanarayana V. N. T. Kuchibhatla¹, V. Shutthanandan¹, B. W. Arey¹, R.M. Ulfing², T.J. Prosa², C. M. Wang¹, **S. Thevuthasan**¹, and P. H. Clifton²:

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The influence of embedded nanoclusters on the optical, magnetic and electrical properties of bulk and surface oxides has been an active area of investigation. The establishment of new atom probe tomography (APT) and related high-resolution chemical imaging facilities at EMSL, the Environmental Molecular Sciences Laboratory, provides a world-class user facility for performing nanoscale microscopy. In this study we report on Au-rich nanoclusters that have been embedded into MgO and TiO₂ substrates. The effect of high temperature annealing on the properties of the matrix and the secondary phase (Au) are studied in detail. Electron microscopy analysis has shown that the embedded metal particles are often associated with various defects, which further contribute to property modification. We report the first Local Electrode Atom Probe (LEAP[®]) analysis of bulk MgO and TiO₂ implanted with 2 MeV Au ions using the accelerator facility at EMSL. Both as-implanted and annealed samples were critically analyzed using a combination of APT and the results are compared with high-angular annular dark-field scanning transmission electron microscopy (HAADF STEM) imaging. High-resolution transmission electron microscopy (HRTEM) clearly resolves the Au-rich nanoclusters and allows observation of the pronounced vacancy clustering associated with these features [Wang et al., Applied Physics Letters **87**, 153104, 2005]. These Au-rich nanoclusters were also observed in the atom probe data with the average cluster size (~ 5 nm diameter) in good agreement with those seen using HRTEM. The APT technique, however, due to the high three-dimensional (3D) spatial resolution, is also able to detect the presence of finer-scale Au clusters. It can also directly measure residual Au composition within the MgO matrix and any MgO-Au mixing within the clusters. Besides variations in compositional microstructure, evolution of mass spectrum quality as a function of Au content is also observed. Efforts are ongoing in EMSL to confirm this observation and eliminate the possibility of any contribution from experimental artifacts. During the course of this presentation we will highlight the advantages of using 3D APT in combination with electron microscopy. Specifically, correlative microscopy provides a means to evaluate the capability of APT to detect the presence of the vacancy clusters.

Integrative Strategy to Develop Greener Nanotechnology

Lisa Truong^{1,2}, Tatiana Zaikova^{2,3}, Erik Richman^{2,3}, John Miller^{2,3}, Stacey Harper^{1,2}, Jim Hutchison^{2,3}, and Robert Tanguay^{1,2}

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Nanotechnology will have undoubtedly tremendous societal benefits. There are concerns that the assessment of the environmental, health and safety of these emerging novel nanomaterials is lagging behind product development. It is clear that multidisciplinary research strategies are needed to safely develop and advance nanotechnology. We have developed and integrated a research program that includes nanomaterial engineers, chemist, and computational scientists who are collectively focused on developing inherently “greener” nanoparticles. We have developed precisely engineered gold nanoparticle (AuNP) libraries where the composition of each member is precisely and efficiently controlled. To understand the role that specific nanoparticles attributes plays in biological responses, we have developed a high throughput embryonic zebrafish assays. Early life stages are often sensitive to chemical insult, which makes embryonic zebrafish an ideal platform to conduct mechanistic and developmental studies. Embryonic zebrafish were exposed to five-fold serial dilution of (0 - 250 µg/mL) of eleven AuNPs from the library with a combination of three different core sizes (0.8, 1.5 and 3.5nm) and eight surface functionalization (N,N,N trimethylammoniummethanethiol [TMAT], 2-(dimethylamino) ethanethiol [DMAT], 2-mercaptoethanesulfonic acid [MES], 2-mercaptoethylphosphonic acid [MEPA], mercaptoacetic acid [MCA], 3-mercaptopropionic acid [MPA], 2-(2-(2-mercaptoethoxy)ethoxy)ethanol [MEEE], and glutathione [GSH]). Differential developmental responses were elicited by these nanoparticles. Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) was used to determine the

AuNP tissue concentration in individually exposed embryos, and electron microscope and microCT approaches were exploited to determine the AuNP tissue localization in the embryo. Additionally, we have developed a knowledgebase of Nanomaterial-Biological Interactions (NBI) that houses, integrates and provides unbiased methods to identify relationships between the physico-chemical properties of nanomaterials and biological responses. A summary of the state-of-the-science from our multidisciplinary team will be presented. *Supported by NIEHS P3000210, EPA RD-833320, T32 ES07060, and Air Force Research Laboratory FA8650-05-1-5041.*

Dye-sensitized solar cell design incorporating titanium-catalyzed silicon nanostructures

Mohammad Atif Umar Usman, Brady Smith, Justin B. Jackson, Mark S. Miller, Jun Jiao

Portland State University

As the emergence of green technologies in the United States takes center stage the smarter integration of nanostructures, such as nanowires and nanotubes, will be closely evaluated and monitored for its ultimate design usage by the semiconductor and photovoltaic industries in the long-term. In this presentation, some of the key growth techniques involved in obtaining device quality titanium catalyzed silicon nanostructures for possible use in dye-sensitized solar cells will be considered and some of the practical design considerations outlined. Furthermore this growth study will outline titanium catalyzed silicon nanostructures grown at different conditions using an atmospheric pressure chemical vapor deposition (APCVD) system. In addition, the uniqueness of the APCVD setup in comparison with other vacuum based systems will be discussed to enhance growth cycle runs allowing for cost-effective integration. Previously, the use of zinc oxide nanowires in dye-sensitized solar cells have shown efficiency values varying from $\eta = 0.3 - 4.7\%$. A brief table of dye-sensitized solar cell efficiency values obtained for variety of different nanostructures will elaborate further the requirements for future experiments and also give future nanotechnology researchers a sense of the solar cell efficiencies that may possibly be obtained for grown titanium catalyzed silicon nanostructures. Q. Zhang et al. *Adv. Mater.* 2009, 21, 4087–4108

Nanofibrous conductive polymers integrated with nanostructured semiconductors for inverse dye-sensitized solar cells

Carl C. Wamser¹, Alexander B. Rudine¹, Rolf Koenenkamp², Athavan Nadarajah², Glen E. Fryxell³, and X. Shari Li³

¹*Department of Chemistry*, ²*Department of Physics*, *Portland State University*, ³*Pacific Northwest National Laboratories*

This research project integrates conductive nanofibers of polymeric porphyrins with nanoparticles of an inorganic semiconductor, most notably TiO₂, in order to assemble a novel architecture for a dye-sensitized solar cell. Tetra(p-aminophenyl)porphyrin (TAPP) is readily polymerized under oxidative conditions, either electrochemical or chemical. The resulting polymer, poly-TAPP, is found to be electronically conductive; polymer growth can be continued indefinitely to form a black film. The morphology of the poly-TAPP is found to be a dense mat of nanofibers, with diameters about 50-100 nm. To create a solar cell, we attach a complementary dye, such as tetra(p-carboxyphenyl)porphyrin, as a covalent monolayer on the surface of the poly-TAPP, then attempt to fill the pores with a semiconductor. TiO₂ is added by controlled hydrolysis of various titanium salts, such as Tyzor LA, a commercially available lactate salt. The results show good pore filling and modest solar cell activity. Optimization is underway.

Aqueous solution processed aluminum oxide dielectrics from novel inorganic chemistry

Wei Wang, Stephen T. Meyers, Rick E. Presley, John F. Wager and Douglas A. Keszler:

Oregon State University

Al₁₃(OH)₂₄(H₂O)₂₄(NO₃)₁₅ single crystals and polycrystalline powders have been synthesized from aluminum nitrate solution by zinc-metal addition. An aqueous-solution precursor for thin films deposition of Al₂O₃ dielectrics was produced by combining Al₁₃(OH)₂₄(H₂O)₂₄(NO₃)₁₅ and Al(NO₃)₃. The resultant films remain amorphous and atomically smooth following annealing up to 700 °C. Metal-insulator-metal

(MIM) devices were fabricated, yielding high breakdown fields (~5 MV/cm) and low leakage currents (<10 nA at 1 MV/cm). Thin films transistors (TFT) built by using zinc tin oxide (ZTO) as a channel layer exhibit high on-to-off ratio (>10⁶) and limited clockwise hysteresis (~2 V).

Tailored multi-component nanocomposite thin films via vapor phase co-deposition

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^a Applied Sciences Laboratory, Washington State University, Spokane, WA 99210 ^b Chemistry Department and Materials Science Program, Washington State University, Pullman, WA 99163

Composites consisting of polymers with embedded nanostructured metallic particles exhibit unique optical responses originating from the light-induced surface plasmon excitation of metallic nanoparticles. The resonance frequency is strongly dependent on metal geometry and surrounding medium. Wet-chemistry is widely used for nanoparticle synthesis of one nominal size distribution. However, the methodology is unsuitable for applications requiring an absorption covering broad and continuous wavelengths because of the enormous work required for individual synthesis of various sizes. Alternatively, we develop a vapor phase co-deposition technique combining the multiple chemical processes into a single step and avoiding the use of hazardous chemical solutions. We present significant progress in tailoring the optical, electrical and electronic properties of silver nanoparticles embedded in polymeric dielectrics and semiconductors for optoelectronics and solar energy conversion. Near the percolation threshold, the presence of silver nanoclusters with arbitrary sizes and shapes enable the unusual broadband absorption from visible to infrared regimes. This is of particular interest for developing multi-color photodetectors. At a relatively lower concentration, the absorption is tailored to closely match the solar spectrum. Along with their ability as photosensitizers, plasmonic silver nanoparticles are promising to overcome the limited wavelength response of present photovoltaic materials.

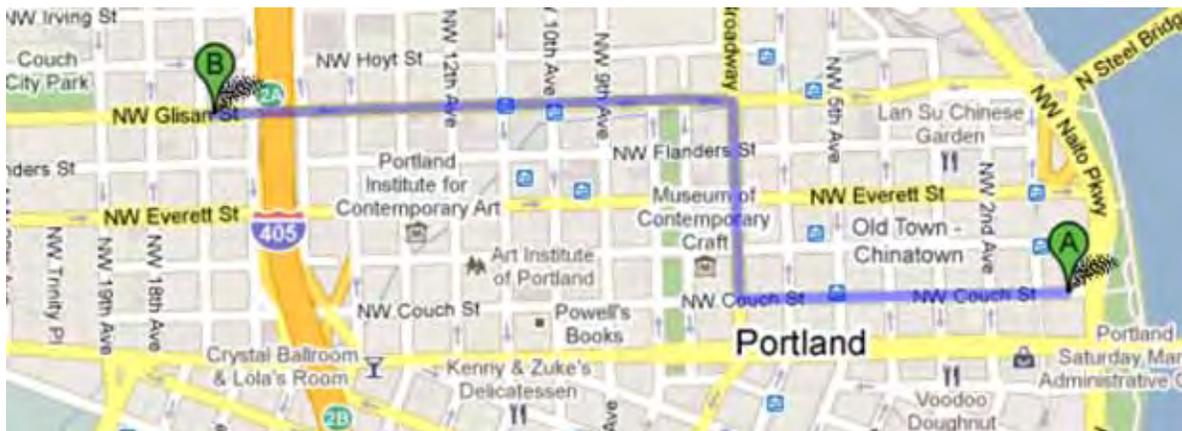
Comparative Assessment of Respiratory Epithelial Cells' Responses to Engineered Nanomaterials

Nolann Williams, Ana Tolic, William Chrisler, Yumei Xie, Galya Orr

Pacific Northwest National Laboratory, Richland, Washington

Inhaled nanomaterials are likely to interact with epithelial cells that line the respiratory tract, but the impact of these interactions on the fate and response of the cells is still unclear. Here we present a systematic evaluation of bronchial and alveolar epithelial cells' responses to TiO₂, ZnO and amorphous SiO₂ nanoparticles, which carry negative surface charge in growth media. By quantifying the degree of cell viability, death and oxidative stress in type II alveolar epithelial (C10 and RLE-6TN) and bronchial epithelial (BEAS-2B) cell lines, we find that the response patterns to the tested nanoparticles are largely the same across these cell types. TiO₂ nanoparticles are found to elicit relatively mild responses at concentrations as high as 100 µg/ml. In contrast, ZnO nanoparticles elicit toxic responses at concentrations as low as 10 µg/ml. Interestingly, ZnO nanoparticles at very low concentrations lead to enhanced cellular growth. It is also found that amine-modified amorphous SiO₂ nanoparticles tend to elicit cellular stress, which is in contrast to the response elicited by unmodified nanoparticles. The growth of the cells at the air-liquid interface has been established and their response to the nanoparticles is currently being evaluated under conditions that closely resemble the exposure *in vivo*.

Map to the OMSI Event Thursday evening at the Mission Theater



A. White Stag Building
70 Northwest Couch Street, Portland, OR 97209 - (503) 412-3696

1. Head **west** on **NW Couch St** toward **NW 1st Ave**
2. Turn **right** at **NW Broadway**
3. Turn **left** at **NW Glisan St**
Destination will be on the left ~ total 1.0 mi

B. Mission Theatre & Pub
1624 Northwest Glisan Street, Portland, OR 97209-2240 - (503) 223-4527

Conference Hotel

Embassy Suites Portland - Downtown

319 SW Pine Street, Portland, Oregon, United States 97204-2726

Tel: 1-503-279-9000 Fax: 1-503-497-9051



Directions to the Hotel

FROM THE AIRPORT: Airport way to I-205 S. Go 3 miles to I-84 West. Go 6 miles and take the Portland exit. Follow City Center signs, stay in right lane and go over the Morrison Bridge. Turn right at the first light onto 2nd Avenue. Go 4 blocks to Ash Street and turn left. Go 1 block to 3rd and turn left. Go 1 block to Pine and turn right. The hotel entrance will be on the right-hand side.

FROM THE NORTH: I-5 South to exit 302A (Rose Quarter). Follow City Center signs over the Broadway Bridge. Stay in the left lane, this will put you onto Broadway. Go 8 blocks to Burnside and turn left. Go 4 blocks to 3rd and turn right. Go 2 blocks to Pine and turn right. The hotel is on the right hand side.

FROM THE SOUTH: I-5 North. Stay in the Center lane when approaching the City, and take the Exit 1A Naito Parkway. Turn right onto Naito Parkway. Go 13 blocks to Pine Street. Turn left onto Pine Street. Go up 3 blocks and the Hotel Entrance will be on your right hand side.

FROM THE EAST: I-84 West. Follow the City Center signs over the Morrison Bridge. Turn right at the first stop light onto 2nd Avenue. Go 4 blocks to Ash Street and turn left. Go 1 block and turn left. Go 1 block to pine and turn right. The hotel entrance will be on the right hand side.

FROM THE WEST: Hwy 26 East. Follow Market Street signs (center land). Take Market Street all the way to 2nd. Turn left onto 2nd. Go approximately 14 blocks to Ash Street and turn left. Go 1 block to 3rd and turn left. Go 1 block to Pine and turn right. The hotel entrance will be on the right hand side.

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