

The New Steel?

*Enabling the Carbon Nanomaterials Revolution:
Markets, Metrology, Safety, and Scale-up*

**Center for Nanoscale Science and Technology
National Institute of Standards and Technology, Gaithersburg, MD**

February 28 – March 1, 2011

Adding nanostructured forms of carbon, (CNTs, graphene, nanoparticles) to many host materials can dramatically enhance the resulting composite mechanical, thermal, and electronic properties. While this potential has been recognized for some time, the commercial development of carbon nanomaterial composites has been slow. Among the reasons for this delay, the most significant are: 1) technical challenges in the cost-effective manufacture and quality control of the raw nanomaterial; 2) difficulties in integrating carbon nanomaterials effectively into composites; and 3) uncertainty over potential environmental health and safety (EH&S) and associated regulatory issues. This two-day workshop is being held under the auspices of the National Nanotechnology Initiative (NNI) Signature Initiative on Sustainable Nanomanufacturing, and will support NIST's broad-based effort to identify technical challenges to the commercial development of high-performance, carbon-based nanomaterials.

Monday, February 28th, 2011

7:30 am – Registration

- Coffee and continental breakfast

8:45 am – Welcome and opening remarks

- Charles Romine, Acting Associate Director for Laboratory Programs at NIST
- Travis Earles for OSTP
- J. Alexander Liddle – Workshop Chair

9:00 am – **Perspective of a Start-up that has moved thru Scale-up into Commercialization** – David Arthur, CEO SouthWest NanoTechnologies. *Chair, Brent Segal, Lockheed Martin*

9:30 am – Plenary Session I. *Chair, Bill Carter, HRL*

- CNT composites for high-performance applications
 - **Aerospace Structural Materials Certification** – David Furdek, Boeing
 - **Manufacturing Process for Carbon Nanostructure Infused Fibers to Fabricate Multifunctional Composites** – Tushar Shah, Applied Nanostructured Solutions
 - **CNT composites for high-performance structural applications: Development, Measurement and Scale-up** – Larry Carlson, Director of Advanced Materials at the Easton Institute for Technology Advancement at UCLA

10:45 am – Break

11:00 am – Plenary Session II – *Chair, Wade Adams, Rice*

- **Multifunctional Carbon Nanomaterials** – Nolan Nicholas, Matric
- **Carbon Nanostructures for Energy Storage** – Bingqing Wei, U. Delaware

12:00 pm – Lunch & **“Partnering for Success in the Semiconductor Industry”**, George Scalise, President Emeritus of the Semiconductor Industry Association. *Chair: Bob Doering, TI*

1:30 pm – Plenary Session III – *Chair, Brent Segal, Lockheed Martin*

- **Carbon Nanotube Metrology for Science and Manufacturing** – John Hart, U. Michigan
- **Nanotechnology - too small to see, too big to ignore** – Michael Valenti – Emerging Technologies Research Analyst - Technical Insights, Frost and Sullivan

2:30 pm – Panel of all speakers for open discussion to identify – *Moderator, Sha-Chelle Manning*

- What are the *most* important drivers for advancements in nanoscale carbon-based materials and their use over the next two decades? (any driver – economic, technical, societal, political)
- What is our vision for the future? Where could carbon-based nanocomposites be in 20 years? What will they replace, and at what cost?
- What radical advances/improvements do we want to achieve in the future that will define the goals of the industry? (e.g. In the future we will be able to... or technology will have advanced to the state where...)

3:00 pm – Break

3:15 pm – Breakout session instructions and directions to breakout rooms.

3:30 pm – Breakout session I – Broad Technology Challenges and Barriers

- What are the broad technical barriers (i.e., general technology barriers, not measurement barriers) to development and adoption of critical technologies and systems integral to advances in nanoscale carbon based materials technologies?
- What are the key technical issues preventing technology from moving forward and reaching nanoscale carbon materials industry goals?
- How important is life cycle uncertainty for these materials to customers of nanotechnology products?
- Are there areas that have not been addressed that you can identify which would hasten adoption of the technology?
- Do you view the current adoption of this nanotechnology as applicable to niche markets, or do you view the costs becoming acceptable for larger scale applications? What are the primary barriers to expansion in these areas (uncertainty, lifecycle, property improvement uncertainty, economics, lack of early adopters etc...)?

4:15 pm – Break

4:30 pm – Breakout session II – Technology Measurement Issues & Grand Challenges

Discussion

- Considering the major technology barriers, what do we need to measure?
- What are the major barriers preventing key measurements?
- Where do you think the lack of measurement could most likely impede technology progress?

- Do you believe measurement technology needs for nanotube fillers and *in situ* grown nanotube materials are the same, or are there important differences that should be addressed separately for the different technologies?
- What measurements do you view as necessary, but that are too onerous or ill defined to be industrially applicable (composition, size distribution, etc...)

5:15 pm – Day one report outs in main conference room

5:30 pm – Adjourn & proceed to reception

Tuesday, March 1st, 2011

8:00 am – Coffee and continental breakfast

9:00 am – Breakout session III – Towards a strategic plan to address measurement issues

- Prioritize the measurement solutions that must be developed.
- Major barriers to the measurement solutions
 - Performance targets or aspects
 - Applications – to what sectors or technologies can it be applied
 - Activities, R&D, etc. that need to be done
 - Timing (near, mid, long) of approaches
 - Potential stakeholders and roles
 - Benefits/ advantages of the approach

10:00 am – Break

10:15 am – EH&S Panel Discussion I: *Chair, Debra Kaiser, NIST*

- Treye Thomas, CPSC
- Jim D’Arcy, GM
- **Acicular Nanoparticles - Metrology Needs for Product Stewardship and Nanocomposite Performance** – Lee Silverman, DuPont

11:15 am – Break

11:30 am – EH&S Panel Discussion II: *Chair, Debra Kaiser, NIST*

- **Which material properties and features determine the biological response to carbon nanotubes?** – Bob Hurt, Brown University
- **EPA Approach to Regulating Carbon Nanomaterials** – Zofia Kosim, EPA
- Mark Hoover NIOSH

12:30 pm – Lunch & **“The Advanced Energy Consortium”** – John Ullo, Consultant. *Chair, Sha-Chelle Manning*

1:30 pm – EH&S Breakout session I – EH&S life-cycle risk assessment

- What are the exposure scenarios for humans and the environment during a carbon nanomaterial lifecycle, *i.e.*, raw material production, consumer product manufacturing, consumer use, and product end-of-life (recycling, disposal)?
- What is known about hazards to humans and the environment? What are the knowledge gaps?
- What is known about the physico-chemical properties that determine exposure and hazards? What are the knowledge gaps?

2:30 pm – Break

2:45 pm – EH&S Breakout session II – Prioritization of EH&S measurement needs

- What are the technology measurement priorities that must be addressed?
- How can the Federal government work with carbon nanomaterial developers and manufacturers to address EH&S concerns, particularly within the context of the NNI 2011 EH&S Research Strategy?

3:45 pm Day two report outs in main conference room

4:15 pm Adjourn

Abstracts:

Perspective of a Start-up that has moved thru Scale-up into Commercialization – David Arthur, CEO, SouthWest NanoTechnologies

SouthWest NanoTechnologies (SWeNT) is a leading manufacturer of single-wall carbon nanotube materials. The Company was founded in 2001 as a spinout of Professor Daniel Resasco's research at the University of Oklahoma. In 2008, SWeNT built a large scale manufacturing plant capable of producing single-wall carbon nanotubes with consistent quality, in commercial quantities, at low cost. In 2011, SWeNT is focused on commercializing carbon nanotube ink products for printed electronics and also nanocomposite paste products for battery materials. In my talk, I will provide a historical perspective on SWeNT's evolution from laboratory to production scale, as well as discuss the commercialization challenges that we are facing and how we are addressing them.

Aerospace Structural Materials Certification – David Furdek, Boeing

Manufacturing Process for Carbon Nanostructure Infused Fibers to Fabricate Multifunctional Composites – Tushar Shah, Chief Technology Officer, Applied Nanostructured Solution(ANS), Baltimore.MD

ANS has matured a revolutionary, continuous, in-line process to grow (infuse) carbon nanostructures (CNSs) directly on multiple fiber surfaces like glass, carbon, ceramic. This manufacturing process was developed specifically to create multi-functional composites that provide not only enhanced mechanical performance but also thermal and electrical properties heretofore not possible with the current fiber/polymer composites. The ANS process provides the capability to manufacture fibers with CNS-infusion as high as 40% by weight.

ANS Labs continuous, in-line process is evolving from pilot production into the mainstream composites market for high-volume manufacture at low cost. Currently the CNS-infusion process is at TRL-6 and MRL-5; ANS pilot production lines are producing 100+ lbs per week of CNT-fibers and fabrics. Since the CNSs are infused on the fiber/fabric surface as opposed to a CNT powder added to the resin a much greater percentage of CNS loading is possible in the final composite. The resulting composites possess not only improved mechanical properties but also enhanced physical properties which in turn provide a foundation to custom design fibers based composites for specific mechanical and physical properties, based on the end-use/application. This presentation will describe the CNS-infusion process at ANS but will also discuss the growing need for developing next generation analytical tools needed for in line monitoring of CNS infusion processes.

CNT composites for high-performance structural applications: Development, Measurement and Scale-up – Larry Carlson, Director of Advanced Materials at the Easton Institute for Technology Advancement at UCLA

Increasing mechanical demands of sporting goods and aerospace markets can be met by the inclusion of Carbon nanotubes as a resin enhancement, as a fiber enhancement, and as the fibers themselves. While the potential for strength and toughness gain is huge, technical problems can reduce or even reverse the rewards.

Attention must be given not only to cost, but to dispersing methods, stability, quality of CNT and the resulting composite, and measurement methods and their relevance to the finished product. Here we discuss one case history of an effective supplier value chain, from CNT production to end use. Scale-up issues are discussed, with process continuity from the US-based development lab to a foreign plant.

Multifunctional Carbon Nanomaterials – *Nolan Nicholas, Matric*

Though the potential for nanostructured materials to enhance materials properties is by now well appreciated, their potential to not only improve individual properties but to combine several desirable properties into a single material to enable “multifunctional” performance is sometimes overlooked. This key benefit enabled by emerging nano-based materials lies in the ability to create capabilities for one material to perform roles that would traditionally have taken a system of multiple combined materials to achieve. This can lead to significant savings in weight, volume and cost for nano-enabled systems. This talk will introduce concepts of multifunctional carbon nanomaterials including challenges in manufacturing and technological integration.

Carbon Nanostructures for Energy Storage – *Bingqing (B.Q.) Wei, Department of Mechanical Engineering, University of Delaware*

Electricity storage is a growing challenge among a broad range of renewable energy sources. Of the many types of rechargeable power sources that are currently being investigated, carbon nanotube-based supercapacitors have attracted much attention due to their capability to generate energy and power densities much higher than conventional dielectric capacitors and lithium ion batteries, respectively. In the meantime, flexible/stretchable electronics have attracted considerable attention very recent years and have opened the door to many important applications that current, rigid electronics cannot achieve. In order to accommodate these needs, power source devices must be flexible and stretchable in addition to their high energy and power density, light weight, miniaturization in size, and safety requirements.

I will report our research efforts in assembling 2-D CNT macrofilms using CVD method and their applications for supercapacitors and Li-ion batteries. I will also discuss our understandings of compressive stress and temperature effects on electrochemical behavior of supercapacitors.

Partnering for Success in the Semiconductor Industry – *George Scalise, President Emeritus of the Semiconductor Industry Association*

Where does the semiconductor industry stand today?

How did we get here?

What do we need to do to lead the NANO Era in the years ahead as we have the Semiconductor Era for the past sixty years?

What are the challenges that must be addressed to accomplish that objective?

How has the semiconductor industry been able to establish consortia (e.g., SRC and SEMATECH) and a technology roadmap (the ITRS)?

How was the SIA able to coordinate these initiatives? – i.e., “what were the obstacles, what were the key ingredients for success, how was consensus built, and how have the companies benefitted?”

Carbon Nanotube Metrology for Science and Manufacturing – *John Hart, Assistant Professor, University of Michigan*

Reliable and repeatable metrology is essential to continued advances in both the science and manufacturing of CNTs and CNT-based materials. I will review methods for characterizing CNTs and related production parameters, from both an academic and commercial perspective. Emphasis will be placed on capabilities and limits of these techniques for probing the fundamental mechanisms of CNT growth, and for enabling online characterization of CNT product quality at high speed and low cost.

Nanotechnology - Too Small to See, Too Big to Ignore – *Michael Valenti, Emerging Technologies Research Analyst, Technical Insights, Frost and Sullivan*

This presentation will focus on the markets for nanotechnology in advanced materials, electronics, and authentication. Each of these opportunities is subdivided into market segments that themselves offer promising applications for nanotechnology. This research was conducted by analysts for Frost & Sullivan, a 50-year-old advanced technology market research firm that specializes in tracking emerging technologies such as nanotechnology from laboratory through commercialization.

Treye Thomas – CPSC

Jim D’Arcy – GM

Acicular Nanoparticles - Metrology Needs for Product Stewardship and Nanocomposite Performance – *Dr. Lee Silverman, DuPont Nanocomposite Technologies, Central Research and Development*

Characterization of nanoparticle size, size distribution and shape has product stewardship implications, and effects the property entitlement of polymer nanocomposite materials. This presentation discusses why non-spherical particles are interesting from a polymer nanocomposite property perspective, and how we need additional characterization methods to fully characterize and describe nanoparticle characteristics in order to better address safety, health and environmental issues.

Which material properties and features determine the biological response to carbon nanotubes? – *Robert Hurt, Director of Brown University's Institute for Molecular and Nanoscale Innovation*

The carbon nanotube industry has been given a window of opportunity to develop methods for managing environmental and health concerns before CNT-based products become truly widespread in the marketplace. One of those methods is, in principle, the design of nanotubes for safety, but this requires solid mechanistic links between the fundamental material properties we can control and the adverse biological responses we wish to avoid. This talk describes recent efforts, rooted in materials science, to identify and control the fundamental CNT properties that trigger biological responses, considering hydrophobic surface area, surface chemistry, bioavailable metals content, and geometry.

EPA Approach to Regulating Carbon Nanomaterials – *Zofia Kosim, EPA*

The paper presents information-related challenges the EPA encounters while regulating carbon nanomaterials. Included is discussion of typical data gaps, parameters the Agency needs, and the recommended measurement methods for these parameters.

Dr. Mark Hoover, National Institute for Occupational Safety and Health

The Advanced Energy Consortium – *John Ullo, Consultant*

The Advanced Energy Consortium (AEC), which is based at the Bureau of Economic Geology, the oldest research unit at the University of Texas at Austin, is currently supporting a multi-year portfolio of projects at universities around the world. Consortium members comprised of seven major oil companies and three oilfield service companies fund and direct the effort of nearly two hundred researchers working on pre-competitive, high risk research projects aligned with the development of novel micro- and nanoscale sensors that can be used to advance the exploration and production of oil and gas. Global energy demand supports high industry interest in exploring novel technologies that promise to improve the surprisingly low recovery rates from existing oil

fields (typically 25-40%). The mission, processes, research challenges and some emerging research results will be discussed.

Speaker Bios:

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 and oversight of 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 played a key role planning, implementing, and coordinating the five-year, \$144 million Alliance for Nanotechnology in Cancer (nano.cancer.gov) launched in 2005 (extended in 2010 for another five years). 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.

Charles H. Romine – Dr. Charles (Chuck) H. Romine serves as the Acting Associate Director for NIST Laboratory Programs. He is responsible for oversight and direction of NIST's six laboratory programs and is the principal deputy to the NIST Director. The position of Associate Director for Laboratory Programs was created in October 2010 as part of the first major realignment of NIST programs in 20 years.

NIST's six laboratories include the Physical Measurement Laboratory, Material Measurement Laboratory, Engineering Laboratory, Information Technology Laboratory, the Center for Nanoscale Science and Technology, and the NIST Center for Neutron Research. The NIST Laboratories collaborate with U.S. industry and universities to conduct measurement, standards, and technology research that advances the nation's R&D infrastructure. The overarching goal of the NIST laboratory programs is to accelerate U.S. innovation, which is a major driver of economic growth and job creation.

Prior to his appointment as the Acting Associate Director for Laboratory Programs, Romine served as the Senior Policy Advisor to the NIST Director and as the Associate Director for Program Implementation within the NIST Information Technology Laboratory. He joined NIST in 2009 after serving for five years in the White House Office of Science and Technology Policy as the Senior Policy Analyst responsible for providing expert technical and policy advice to the President's Science Advisor for all areas related to information technology.

Romine began his career in 1986 with the Department of Energy after receiving a Ph.D. in applied mathematics and a B.A. in mathematics, both from the University of Virginia. He spent 15 years conducting research at Oak Ridge National Laboratory on advanced algorithms for supercomputers and four years at the Department of Energy Office of Science as program manager for the Office of Advanced Scientific Computing Research.

David Arthur - David J. Arthur has 30 years experience commercializing products utilizing advanced materials, including work at Rogers Corporation, A.T. Cross, TPI Composites, Helix

Technologies, and Eikos. He holds a bachelor of science degree in chemical engineering from Tufts University, master of science degree in chemical engineering from the University of Connecticut and a master of business administration degree from Northeastern University. In 2005, Arthur co-founded Chasm Technologies, a consulting firm that helps its clients commercialize new products through smart application of materials science and process technology. For the past four years, he has been CEO of SouthWest NanoTechnologies (SWeNT), a leading producer of specialty carbon nanotube materials for coatings and composites applications.

David Furdek – Dave Furdek manages the Next Generation Composite Materials and Labs group for Boeing Research and Technology (BR&T). Dave's group spans three sites including Seattle, St. Louis, and Huntington Beach, has over 60,000 sq ft of lab space, and is responsible for developing future generations of composite materials for the Boeing Defense Systems and Boeing Commercial Aircraft business units. Dave has over 22 yrs experience with the Boeing Company in a variety of Materials and Processes and Manufacturing Research and Development assignments. Recently, Dave led the Materials Technology team in St. Louis where he established the Emerging Materials portfolio. In a previous assignment as the Phantom Works (now BR&T) Enabling Technology program manager, he was responsible for the long range technology development plans for over 15 core technology focus areas. Dave also has a significant background supporting Boeing's F/A-18 E/F, C-17, and F-15 production programs. He started his career focused on polymer matrix composites materials and processes including thermoplastic composites, composite tooling, and automated fabrication technology development. Dave has significant background in aircraft materials and structures, polymer matrix composites materials, processes and fabrication, advanced manufacturing technology, assembly operations, automation/ robotics for both assembly and fabrication. He received his BS in Chemical Engineering from the University of Illinois-Urbana/Champaign and his MBA from the Olin School of Business, Washington University - St. Louis.

Tushar Shah – Dr. Tushar Shah was appointed as “Chief Technology Officer” of ANS in 2010. In this position he is responsible for indentifying, researching and developing advanced nanomaterial technology solutions that can resolve complex customer challenges and in turn create a competitive advantage for ANS in developing next generation products. He is currently leading a team of engineers in developing “Carbon Nanotube” infused fibers that will revolutionize their use in advanced fiber reinforced composites for multiple current and future product applications. He received “Technology Innovation” award from Lockheed Martin Corporation in 2010 for his research in this area.

Dr. Shah joined Lockheed Martin Laboratories in 1981 as a research and development specialist in materials department and has spent large portion of his carrier as an innovator in this area of advanced materials. He currently has 15 issued patents under his name with 26 pending. He also has 18 technical publications. He is recipient of two “Jefferson Cup Awards” from Lockheed

Martin Corporation and three outstanding achievement awards from Lockheed Martin Laboratories. He was named “Inventor of the Year” by MS2 in 2007 for his work on advanced composites.

Dr. Shah holds B.S. in Chemistry/Physics from Gujarat University/India. He has M.S. in Textile Sciences from M.S. University/India and in Chemistry from N.C. A. & T. State University. His doctorate is in Organic Chemistry from Gujarat University/India.

Larry Carlson – Larry Carlson served as Vice President – Research and Development, at Easton Sports Inc. from 1995-2008, working on new materials, products, and processes for sporting goods. Much of his involvement was in getting nanomaterials effectively into products for strength and toughness enhancement. He is now Director of Advanced Materials at the Easton Institute for Technology Advancement at UCLA. In this position he leads a research group involved in producing stronger composites, fibers, and resins through nanotechnology.

Nolan Nicholas – Nolan Nicholas received his PhD (2009) and MS (2007) degrees in Applied Physics from Rice University under the tutelage of Dr. Richard Smalley and Dr. Robert Hauge and B.S. (2004) degrees in Physics, Metallurgical Engineering and Materials Science Engineering from the University of Idaho. Starting with his thesis work on the topics of graphenic and carbon nanotube based materials synthesis and application his research has focused on carbon nanomaterials. His ongoing research at MATRIC Inc. focuses on the application of carbon nanotubes and related materials for high-performance and multifunctional applications including transparent, high-performance polymer composites and self-assembled, multi-functional nanotube materials.

Binqing Wei – Binqing Wei received his Bachelors degree (1987), M.S (1989), and Ph.D. (1992) in Mechanical Engineering from Tsinghua University, China. His research expertise lies in nanomaterials and nanotechnology.

Dr. Wei is currently an Associate Professor in the Department of Mechanical Engineering at the University of Delaware. He was an Assistant Professor in the Department of Electrical & Computer Engineering and Center for Computation & Technology at Louisiana State University from 2003 to 2007. He had worked as a Research Associate at Rensselaer Polytechnic Institute, Department of Materials Science and Engineering and Rensselaer Nanotechnology Center from 2000 to 2003. Dr. Wei was a visiting scientist for Max-Planck Institut für Metallforschung, Stuttgart, Germany in 1998 and 1999. He was a faculty at Tsinghua University in Beijing from 1992 to 2001.

Dr. Wei is a member of The Materials Research Society (MRS), The Electrochemical Society (ECS), The International Society for Optical Engineering (SPIE), and The American Society of Mechanical Engineering (ASME). His scholarly achievements in the field of nanomaterials and nanotechnology and, particularly in the research of carbon nanotubes are fully reflected from his

176 papers published in refereed international journals, including *Nature* and *Science*, more than 94 scientific conference presentations and 80 plus invited talks and seminars in academia and industry worldwide. His research work has been cited more than 6300 times by peer scientists with *h*-index of 44 and has also been highlighted many times in scientific journals, web journals and public media. His recent research focuses on controllable synthesis of macroscale nanotube architectures with 1-, 2-, and 3-dimensions; physical, chemical, electrochemical and mechanical property characterizations of nanotubes; and nanotube device applications.

George Scalise - George M. Scalise has served as President of the Semiconductor Industry Association, an association of semiconductor manufacturers and suppliers, since 1997. Mr. Scalise served on the Board of Directors of the Federal Reserve Bank of San Francisco from 2000 to 2005, including as Deputy Chairman from 2001 to 2003 and as Chairman from 2003 to 2005. Mr. Scalise served as Executive Vice President and Chief Administrative Officer of Apple Computer, Inc. (now Apple, Inc.), a company that designs and manufactures consumer electronics and software products, from 1996 to 1997. Mr. Scalise also served as Senior Vice President of Planning and Development and Chief Administrative Officer of National Semiconductor Corporation, a semiconductor company, from 1991 to 1996. Mr. Scalise served on President George W. Bush's Council of Advisors on Science and Technology from 2001 to 2009. Mr. Scalise also serves as a director of MindTree Ltd. As the President of the Semiconductor Industry Association, a former board member of the Federal Reserve and a former Chief Administrative Officer of Apple Computer, Inc. (now Apple, Inc.), Mr. Scalise has significant semiconductor and financial expertise and substantial international experience.

John Hart - John Hart has Ph.D. (2006) and S.M. (2002) degrees from the Massachusetts Institute of Technology, and a B.S.E (2000) degree from the University of Michigan, all in Mechanical Engineering. John received the 2006 MIT Senturia Prize for best doctoral thesis in micro/nano technology, and graduate fellowships from the Fannie and John Hertz Foundation, National Science Foundation, and MIT Martin Foundation. Since joining the faculty at Michigan, John has been recognized by a DARPA Young Faculty Award (2008), two R&D100 Awards (2008, 2009), the American Society of Mechanical Engineers Pi Tau Sigma Gold Medal (2009), the Society of Manufacturing Engineers Outstanding Young Investigator Award (2010), the University of Michigan Mechanical Engineering Faculty Achievement Award (2010), and the Air Force Office of Scientific Research Young Investigator Program Award (2010). At the University of Michigan, John directs the Mechanosynthesis Group, whose research focuses on manufacturing and applications of nanostructured materials. John also teaches undergraduate and graduate courses in design and manufacturing, nanotechnology, and research methods.

Michael Valenti - Michael Valenti's 20 years of technological reporting, data gathering, and information analysis expertise includes 7 years as a research analyst for Frost & Sullivan. There he has covered a broad range of sectors, including energy, aerospace & defense, environmental technologies, and advanced materials, including nanotechnology. Michael has presented customized research to international audiences on topics that include graphene versus carbon

nanotubes, medical adhesives, and concentrated solar power. Michael launched, contributed to and edited Frost & Sullivan's Homeland Security Technology Alert.

Trey Thomas – Dr. Thomas is a toxicologist and leader of the Chemical Hazards Program team in the U.S. Consumer Product Safety Commission's (CPSC) Office of Hazard Identification and Reduction. His duties include establishing priorities and projects to identify and mitigate potential health risks to consumers resulting from chemical exposures during product use. Dr. Thomas has conducted comprehensive exposure assessment studies of chemicals in consumer products and quantified the potential health risks to consumers exposed to these chemicals. Specific activities have included conducting exposure and/or health hazard assessments of flame retardant (FR) chemicals, combustion by-products, indoor air pollutants, and other compounds. Dr. Thomas is the leader of the CPSC nanotechnology team, and is responsible for developing agency activities and policy for nanotechnology. Dr. Thomas has served as a CPSC representative on a number of nanotechnology committees including the ILSI/HESI Nanomaterial Environmental, Health, and Safety Subcommittee, the Federal NSET and NEHI sub-committees, and the International Council on Nanotechnology (ICON).

Dr. Thomas received a Bachelors degree in Chemistry from the University of California, Riverside, an MS in Environmental Health Sciences from UCLA, and a PhD in Environmental Sciences at the University of Texas, Health Science Center, Houston. He completed a post-doctoral fellowship in Industrial Toxicology at the Warner-Lambert Corporation (now Pfizer Pharmaceutical).

Jim D'Arcy – Dr. D'Arcy holds B.S. and M.S. degrees in chemistry from Oakland University and a Ph.D. in Industrial Health from the University of Michigan. He is certified in both toxicology and comprehensive practice by the American Board of Industrial Hygiene. Employed by General Motors for 31 years he is currently a Technical Fellow managing a research program on the control of health risks in the manufacturing environment including the development and introduction of safe biostable metal removal fluids. He is past chair of the AIHA Aerosol Technology Committee, a major contributor to ORC's *Management of the Metal Removal Fluid Environment* and to several ASTM metal removal fluid and aerosol standards. He has published 47 articles in the scientific literature. He is an AIHA Fellow and is the recipient of the Warren A. Cook and Frank A. Patty awards in industrial hygiene as well as the GM Safety Fellow award.

Lee Silverman - Lee received his B.S. from MIT in Materials Science and Engineering in 1981. He then worked for a two years doing process development for optical waveguide materials for telecommunication at Corning. Lee then went back to MIT, and graduated with a Ph.D. in Ceramic Science and Engineering in 1987. Following graduate school, Lee started work for DuPont, where he has been for the last 23 years. At DuPont, he has worked on materials intended for uses in structural, electronic, optical and sensing applications, and more. Lee is currently Research Manager for Nanocomposite Technologies in DuPont's Central Research and Development Laboratory in Wilmington, Delaware.

Robert Hurt – Professor Hurt received his Ph.D. from M.I.T. in 1987 and before joining Brown held positions in the Central Research and Development Division of Bayer AG in Leverkusen, Germany, and at Sandia National Laboratories in Livermore, California. During 2002 he was a visiting professor at the University of Sydney, New South Wales, Australia. He currently serves as Editor of the materials science journal CARBON, and is on the editorial board of Progress in Energy and Combustion Science. He served as Technical Program Chair for the international conference, Carbon2004, and in the same year received the Graffin Lecture Award of the American Carbon Society. Prof. Hurt also received the Silver Medal of the Combustion Institute in Naples, Italy in 1996 and an NSF CAREER Award in the same year. He is a scientific founder of the environmental start-up firm Banyan Environmental. He currently serves as PI on the GAANN training grant "Interdisciplinary Training in the Applications and Implications of Nanotechnology", and is the Director of Brown's Institute for Molecular and Nanoscale Innovation.

Zofia Kosim - Zofia Kosim has a master degree in chemical engineering from the Technical University of Wroclaw in Poland. She is a registered Professional Engineer and has worked for the US EPA for over 20 years, most recently on nanotechnology-related issues under the Toxic Substances Control Act (TSCA).

Mark Hoover - Dr. Mark D. Hoover is a senior research scientist in the Division of Respiratory Disease Studies at the CDC's National Institute for Occupational Safety and Health, in Morgantown, West Virginia. Mark is a critical area leader in the NIOSH Nanotechnology Research Center and also serves as coordinator of the NIOSH Exposure Assessment Cross-sector Research Program. NIOSH is the leading federal agency conducting research and providing guidance on the occupational safety and health implications and applications of nanotechnology. Mark earned a BS degree in mathematics and English in 1970 from Carnegie Mellon University and MS and PhD degrees in engineering in 1975 and 1980 from the University of New Mexico. He is board certified in the comprehensive practice of health physics and in the comprehensive practice of industrial hygiene. Mark has developed improved approaches, techniques, and instrumentation for aerosol characterization, generation, and control; served as chairman or contributor to the development of many national and international standards; is a past chairman of the AIHA Nanotechnology Working Group; and is author or co-author of more than 180 open literature publications. He recently completed co-editing and writing a new CRC Press handbook on *Radioactive Air Sampling Methods*. Special emphasis areas for Mark's work in nanotechnology include a graded approach to exposure assessment and characterization of nanoparticles in the workplace, development of a prototype *Nanoparticle Information Library*, and promotion of opportunities to apply performance-based occupational exposure limits or control banding approaches to nanotechnology. Detailed information about the NIOSH nanotechnology health and safety research program is available at www.cdc.gov/niosh/topics/nanotech/.

John Ullo – John Ullo received his degrees in Physics (BS) from Rensselaer Polytechnic Institute and Nuclear Physics (PhD) from the Massachusetts Institute of Technology. Currently, he is a private consultant on future research initiatives after a career spanning thirty years with Schlumberger Technology Corporation. Several recent prior positions within Schlumberger include: Senior Management Advisor for research at the Schlumberger-Doll Research Center in Boston focusing on nanotechnology enabled applications for oil recovery and production, Vice President and General Manager of the Schlumberger Austin Technology Center from 2001 to 2004, Director of Research for Reservoir Evaluation at Schlumberger-Doll from 1996 to 2001 and Managing Director of Product Development for Seismic Processing and Evaluation at Schlumberger Geco-Prakla (now Western Geco) in the UK from 1993-1996. Earlier he held several R&D management positions in North America.

Steering Committee

Prof. Wade Adams, Director, Smalley Institute for Nanoscale Science & Technology, Rice University

Dr. William Carter, Manager, Bio and Nanomaterials Technologies, HRL

Dr. Robert Doering, Senior Fellow and Research Manager, Texas Instruments

Prof. John Hart, Assistant Professor of Mechanical Engineering, Applied Physics, Art + Design,
University of Michigan

Dr. J. Alexander Liddle, Group Leader, Nanofabrication Research, Center for Nanoscale Science &
Technology, NIST

Sha-Chelle Manning, Founding Partner at Manti Technologies

Dr. Brent Segal, Director & Chief Technologist, Lockheed Martin Nanosystems

Dr. John Ullo, Consultant

Breakout Sessions

We will divide into 4 groups for the breakout sessions, which will be located in rooms 217 H103, 217 H105, 217 H107 and 219 A045, marked on the diagram below.

Advanced Measurement Laboratory Complex

