Tuesday Afternoon, November 8, 2016

Manufacturing Science and Technology
Room 103A - Session MS-TuA

Working with National Labs and User Facilities
Moderator: Bridget Rogers, Vanderbilt University

2:20pm **MS-TuA1 Southeastern Nanotechnology Infrastructure Corridor (SENIC) – A Nano Fabrication and Characterization Resource as part of the National Nanotechnology Coordinated Infrastructure (NNCI)**, ***Paul Joseph****, D. Gottfried, G. Spinner, O. Brand,* Georgia Institute of Technology

The Southeastern Nanotechnology Infrastructure Corridor (SENIC) is a partnership between two state-of-the-art nanofabrication and characterization facilities located at the Institute for Electronics and Nanotechnology (IEN), an interdisciplinary research institute at the Georgia Institute of Technology, and the Joint School of Nanoscience and Nanoengineering (JSNN), an academic collaboration between North Carolina A&T State University (NCA&T) and the University of North Carolina at Greensboro (UNCG). SENIC is one of 16 members of the National Nanotechnology Coordinated Infrastructure (NNCI), supported by the National Science Foundation, and coordinated by the NNCI Coordinating Office at Georgia Tech. NNCI is an integrated networked partnership of academic nanotechnology user facilities across the US, serving the needs of nanoscale science, engineering, and technology. The NNCI is a research facilitator, providing state-of-the-art equipment, staff expertise, and training to nanotechnology researchers. The shared-user, fee-based laboratories are open to academic, industry, and government clientele, offering a unique and comprehensive nanotechnology laboratory and teaming environment.

At Georgia Tech, the IEN has dedicated expertise and facilities for a broad range of micro and nanofabrication and characterization projects, including a focus on applications to bioengineering and biomedicine. IEN supports cleanroom and characterization facilities used by more than 700 researchers annually, with 20% from external institutions. The external users (off-campus users) can access the desired tool set after training (on-site work) or can send their samples for processing or analysis by IEN staff (remote work). IEN offers unique capabilities in e-beam lithography, photolithography, soft lithography, thin film deposition, etch processing, metallization, packaging, micro scale printing, imaging, metrology, and microanalysis. IEN-supported research themes include nanostructures, nanoelectronics, bio-MEMS, biological/chemical sensors and systems, biomaterials, photonics, materials growth and synthesis.

During this presentation, an overview of NNCI and SENIC will be given. Subsequently, we will discuss shared user lab resources, external user services, and education programs available at IEN.

2:40pm **MS-TuA2 The Cornell NanoScale Science and Technology Facility (CNF)**, ***Michael Skvarla,*** Cornell NanoScale Science and Technology Facility

The Cornell NanoScale Science and Technology Facility (CNF) is a member of NNCI, a network of open-access facilities partially subsidized by the US National Science Foundation to provide researchers with rapid, affordable, shared access to advanced nanofabrication tools and associated staff expertise. Hundreds of researchers worldwide (from academia, industry, and government) utilize CNF to make structures and systems from the nanometer scale to the centimeter scale. CNF offers unique capabilities in electron-beam lithography, advanced stepper photolithography, dedicated facilities for soft lithography, and direct-write tools for rapid prototype development, along with the flexibility to accommodate diverse projects and to deposit, grow, and etch a wide variety of materials. CNF's technical staff are dedicated full-time to user support, providing one-on-one help with process development, tool training, and troubleshooting. They can offer expertise for a very wide range of fabrication projects, including electronics, nanophotonics, magnetics, MEMS, thermal and energy systems, electrochemical devices, fluidics, and the life sciences and bioengineering (more than 30% of CNF's users now focus on biology). All users are welcome; no experience in nanofabrication is necessary and a central part of CNF's mission is to assist users from "non-traditional" fields seeking assistance to implement nanofabrication techniques for the first time. CNF's user program is designed to provide the most rapid possible access (typically 2 weeks) with the lowest possible barriers to entry (users retain full control of their IP, with no entanglement by CNF or Cornell University). Many of CNF's external academic users come from institutions with their own local cleanroom facilities, but still utilize CNF for advanced capabilities, staff expertise, or tool availability.

This talk will explore the tools and the types of services and advice available to CNF users, and present examples of ongoing work with the hope of stimulating ideas and possibilities. We will also provide the latest details on the National Nanotechnology Coordinated Infrastructure (NNCI), a new NSF-sponsored network of shared facilities similar to CNF.

We invite you to explore the CNF and NNCI and discuss ways we can help bring your research visions to fruition. As a first step, CNF's User Program Managers will at no cost provide detailed processing advice and cost estimates for potential new projects. The CNF technical staff also meets every Wednesday afternoon for conference calls where we welcome questions about any topic related to nanofabrication. Visit cnf.cornell.edu to contact us and get started.

3:00pm **MS-TuA3 The CNST NanoFab at NIST: *Nanofabrication for US Commerce*,** ***Vincent Luciani,*** NIST Center for Nanoscale Science and Technology

The NIST Center for Nanoscale Science and Technology (CNST) supports the U.S. nanotechnology enterprise from discovery to production. As part of the CNST, the shared-use NanoFab provides its users rapid access to a comprehensive suite of tools and processes for nanoscale fabrication and measurement. The CNST NanoFab at NIST is part of the Department of Commerce and therefore puts a high priority on operating a business friendly, easily accessible facility. The same rates are applied to all users, whether from industry, academia or NIST. Applications are accepted at any time and are reviewed and processed every week. Also, NIST does not claim any inherent rights to inventions made in the course of a NanoFab project. Your intellectual property rights are not affected. The NanoFab features a large, dedicated facility, with tools operated within an ISO 5 (class 100), 750 m^2 (8,000 ft^2 cleanroom and in adjacent laboratories that have superior air quality along with temperature, humidity, and vibration control. Over 80 major process tools are available, including but not limited to e-beam lithography, 5x reduction stepper photolithography, nano-imprint lithography, laser writing for mask generation, scanning and transmission electron microscopy, 3 Focused Ion Beam (FIB) systems, metal deposition, plasma etching, chemical vapor deposition, atomic layer deposition, deep silicon etching, ion beam etching and a soft-lithography lab. The NanoFab staff consists of scientists, engineers and technicians that specialize in all areas of nanofabrication and provide training and ongoing technical assistance to users. Our goal is to be a catalyst to our users' success and to help nurture nanotechnology commerce in the Unites States. Project applications and instructions are easily available on the web at www.nist.gov/cnst/nanofab. Users inside NIST and from all around the country are provided on-line access to tool schedules and the tool reservation system. From physicists, engineers and biologists to medical researchers, users find common ground at the nanoscale in the CNST NanoFab.

3:20pm **MS-TuA4 In-Situ Characterization Tools for Materials Growth and Processing at NSLS-II**, ***Klaus Attenkofer****, E. Stavitski, K. Evans-Lutterodt, C. Nelson,* Brookhaven National Laboratory

Driven by the needs of sub-15nm integrated chip design, power electronics, and energy conversion devices, a wide range of coating and etching processes are in development which allow single layer growth or removal controlled by complex chemical processes on the substrate and/or in the gas phase resulting in self-limiting growth/etching approaches. The invention of new processes for conventional and spatial Atomic Layer Deposition (ALD) is one of the most prominent applications; even if it has a potentially high impact on the technology, used by everybody in future, it faces the challenge of an enormously large parameter space and costly and lengthy experiments developing the various precursor compounds. A theory inspired approach, combining combinatorial methods with computational modeling, may significantly reduce the risks and costs of the development process; however, to connect both approaches, an in-situ characterization tool will be required characterizing structure, and chemistry of the surface compounds, the gas and the film itself. X-ray spectroscopic and scattering/diffraction techniques may be the probes which provides chemical and structural sensitivity under complex reaction conditions.

NSLS-II had developed a set of beamlines which combine high-end state-of-the-art beamline design with optimized endstation design for materials growth. Specifically, the talk will provide an overview on the scattering and spectroscopy capabilities at In-Situ and Resonant scattering (ISR) beamline and the Inner Shell Spectroscopy beamline (ISS); two instruments build to study the growth of amorphous and crystalline films from the early seed formation to the bulk-like film. Next to an introduction into the beamline and its endstation equipment, we will also present experimental data which demonstrate the power of in-situ chracterization.

4:20pm **MS-TuA7 The Center for Nanophase Materials Sciences***, Michael Simpson,* Oak Ridge National Laboratory

The Center for Nanophase Materials Sciences (CNMS) at Oak Ridge National Laboratory (ORNL) is a multidisciplinary user facility that provides the research community with access to expertise and equipment to address the most challenging issues in nanoscience. Industrial, government and academic researchers from around the world may access capabilities in functional imaging, atom-precise synthesis, and nanofabrication. The CNMS is a leader in a range of advanced nanofabrication techniques including electron beam assisted deposition on the sub-10 nm level using both gas and liquid precursors as feedstock material, 3D fabrication and atomically precise material sculpting, as well as direct matter manipulation on the atomic level by electron beams to induce material functionality. Spatially resolved quantitative measurements of physical and chemical properties of materials are available to users through unique measurement capabilities of band excitation scanning probe microscopy, scanning transmission electron microscopy, helium ion microscopy, and atom probe tomography. Furthermore, theoretical and computational approaches are available to CNMS users, as frameworks for deep-data analytics methods for imaging, and computational prediction of functional and physical properties in nanostructures, benefiting from the broad ORNL computational capabilities. Located adjacent to the Spallation Neutron Source at ORNL, CNMS acts as a gateway for the nanoscience community to ORNL's world-class neutron science facilities, by providing diverse complementary capabilities such as selective deuteration, sample environments for multi-modal measurements, fabrication of templates for neutron reflectivity experiments, and many other materials science capabilities to complement neutron results. As one of the five Department of Energy Nanoscale Science Research Centers (see nsrcportal.sandia.gov), CNMS makes all of these capabilities, and the staff expertise to fully benefit from them, available free of charge to users who intend to publish the results, or at-cost for proprietary research, as described at cnms.ornl.gov. [*The CNMS at Oak Ridge National Laboratory is a DOE Office of Science User Facility.*]

4:40pm **MS-TuA8 User Opportunities at the Center for Nanoscale Materials***, Kathleen Carrado Gregar,* Center for Nanoscale Materials at Argonne National Laboratory

The Center for Nanoscale Materials (CNM) at Argonne National Laboratory is a premier user facility providing expertise, instrumentation, and infrastructure for interdisciplinary nanoscience and nanotechnology research. Academic, industrial, and international researchers can access the center through its user program for both nonproprietary (at no cost) and proprietary research.

The CNM is at the forefront of discovery of new materials, visualizing events with high resolution as they occur, understanding the physics and chemistry of energetic processes at the nanoscale, and manipulating nanoscale interactions to create useful, energy-efficient structures with new functionalities. Goals include the hierarchical integration of materials across the nanoscale to the mesoscale, in order to create energy-efficient and affordable functionality that advance the public good.

Unique capabilities at CNM include a premier clean room with advanced lithography and deposition capabilities, expansive synthesis and nanofabrication resources, a hard x-ray nanoprobe at the Advanced Photon Source synchrotron, myriad scanning probes including low temperature, ultrahigh vacuum STMs, TEMs with in situ holders and chromatic aberration-correction, a 30 TFlop supercomputer, and ultrafast optical probes. A key CNM asset includes outstanding staff with expertise in synthesis, nanophotonics, scanning probe and electron microscopy, nanofabrication, and theory, simulation and modeling. Core technological materials range from 2D layered materials to nanocrystalline diamond. All capabilities and expertise are available through peer-reviewed user proposals; access is free of charge for non-proprietary research in the public domain. CNM is one of DOE's premier Nanoscale Science Research Centers serving as the basis for a national program encompassing new science, new tools, and new computing capabilities for research at the nanoscale (https://nsrcportal.sandia.gov). Recent staff and user research highlights will be presented, painting a picture of present and future nanoscience and nanotechnology at the CNM (www.anl.gov/cnm).

The Center for Nanoscale Materials, an Office of Science user facility, is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under contract no. DE-AC-02-06CH11357.

5:00pm **MS-TuA9 The Center for Integrated Nanotechnologies--Resources and Capabilities***, Dale Huber,* Sandia National Laboratories

A decade ago, five new Department of Energy user facilities, the Nanoscale Science Research Centers (NSRCs), entered full operations. These facilities offer unique capabilities, at no cost, to qualified researchers in the field. I will describe the Center for Integrated Nanotechnologies (CINT), its capabilities, and where it fits into the broader landscape of the NSRCs and the other major user facilities in the US. While this will necessarily be a broad overview, I will provide details for where and how to obtain further information including important online references, points of contact for general information, and will provide an opportunity to make connections for detailed interests. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

5:20pm **MS-TuA10 Using EMSL Capabilities in Combination with those from other User Facilities to Address Fundamental and Applied Problems***, Donald Baer, M.H. Engelhard, T.J. Law,* Pacific Northwest National Laboratory

Increasingly a wide range of advanced research tools and expertise are needed to address important scientific and societal questions. The Environmental Molecular Sciences Laboratory, EMSL, is one of several US Department of Energy user facilities provided to facilitate cutting-edge research. This talk will highlight the focus of EMSL, recent efforts to integrate activities at multiple user facilities and efforts being made to increase industrial use of user facilities. The vision of EMSL is to pioneer discoveries and mobilize the scientific community to provide the molecular science foundations that will address research priorities of the DOE Office of Biological and Environmental Research (BER) and our nation's critical biological, environmental and energy challenges. To accomplish these aims, EMSL science is focused in four areas: biosystem dynamics and design, atmospheric aerosol systems, terrestrial and subsurface ecosystems and molecular transformation. Molecular transformations that occur at surfaces and interfaces are critical in each of these areas, and EMSL provides a wide range of unique and state-of-the-art spectroscopy, microscopy, magnetic resonance and computational capabilities to advance science on these topics (www.emsl.pnnl.gov). Similar to all DOE user facilities, researchers typically use resources at EMSL for little to no cost if results are shared in the open literature, and access is provided by a proposal and peer review process. As a multi-disciplinary facility, we encourage proposals that combine instrumentation across our capability groups to advance scientific understanding. Increasingly, we are focusing on real-time *in situ* measurements in a variety of environments. Efforts over the last few years to enable cross facility access through a single proposal to examine novel ways for scientific user facilities to work together has resulted in the FICUS program—Facilities Integrating Collaborations for User Science. With the opportunity to pursue one research project at two or more institutions under FICUS, scientists can leverage disparate resources, shave years off their project times and amplify the impact of their work. Additional efforts are underway to address access policies and training reciprocity that will further streamline the user's experience and increase industrial use of these facilities as well.

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