NNIN www.nnin.org Nanoscale Science, Engineering & Technology

UNIVERSITY OF MINNESOTA

NANOTECHNOLOGY NEWS FROM THE UNIVERSITY OF MINNESOTA

ISSUE SIX SUMMER 2006

Dakota County Technical College Nanoscience Technology A. A. S. Degree Program

Over the last three years, the University of Minnesota, in partnership with Dakota County Technical College (DCTC), has been developing an A.A.S. Degree in Nanoscience Technology. Students complete their first three semesters at DCTC and the final capstone semester here at the University of Minnesota in our Nanofabrication Center, Characterization Facility, Particle Technology Laboratory and BioTechnology Institute. This program emphasizes equipment training and is expected to provide outstanding experience for technicians in a broad range of industries. Specific competencies include electron microscopy, x-ray diffraction, scanning probe microscopy, thin film deposition, photolithography, etching, aerosol measurement and filtration, and biotechnology.

The initial group of DCTC Nanoscience Technology degree students completed the first capstone semester in May 2006. This issue will cover some of the subjects and projects in which students were involved at our various facilities. We are now preparing for the summer semester when we will welcome students from Chippewa Valley Community College for their capstone semester. We look forward to it as another successful collaboration.

Minnesota is only the second state to offer a two-year degree in Nanoscience Technology, building on the Penn State model which more heavily emphasized electronics. The University of Washington is now working on a similar program. We expect to see this trend continue as more of today's students become interested in and excited by the career opportunities in nano.

Reminder: If your work uses PTL, NFC, or CharFac, please add the following in the acknowledgements section of any publication: "Parts of this work were carried out in the Minnesota (Particle Technology Lab, NanoFabrication Center, or Characterization Facility) which receives partial support from NSF through the NNIN program."

4th Nano Training Bootcamp July 10 – 14, 2006

The Minnesota NNIN node is pleased to sponsor of this year's ASME Nano Training Bootcamp. The event offers a detailed tutorial-based account of advances in fundamentals related to Nanoscience in a wide variety of fields, and prospects for translating these advances into useful Nanotechnologies. Participants will be challenged with open-ended questions and opportunities in engineering nano systems. Given by experts in academia and industry, the ASME Nano Training Bootcamp will provide intense sessions on characterization, solids and devices, and fluids/synthesis/devices.

Any individual with a science/engineering background should have the necessary skills to gain much from the 4th Nano Training Bootcamp. We begin the week by providing some background lectures on the fundamentals first before proceeding to tools, and then to devices and more application specific topics.

The depth and breadth of the NNIN labs, allow Minnesota to offer a wide variety of hands-on experiences. These lab practicals will be held on Tuesday, July 11th and Wednesday, July 12th at the University of Minnesota's Nanofabrication Center and Characterization Facility as part of the overall Nano Training Bootcamp program. A separate optional tour of the Particle Technology Lab will be held after the conclusion of the program on Friday, July 14th.

Visit http://www.asmeconferences.org/nanobootcamp06/index.cfm for complete information and registration.

Tech Tuneup: Nano VLSI Design Course
Three day course focusing on applications and problem areas associated with the very near future nano VLSI generation.
June 26, 27 & 28
402 Walter Library - DTC 117, Pleasant St. SE, Minneapolis
http://www.umn.edu/~harjani/techtuneup/

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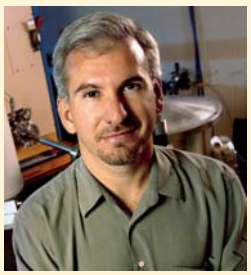
Characterization Facility News

CharFac Director's Message



CharFac Director, Greg Haugstad

We are happy to report two more successful Grant-in-Aid proposals, which will leverage other contributions to enable the purchase of (1) a more modern X-ray photoelectron spectrometer (XPS, also known as ESCA), and (2) the Anton Paar SAXSess combination wide- and small-angle X-ray scattering spectrometer (which has resided in the CharFac on loan).

The XPS will have a monochromated X-ray source, smaller spot (tens of microns), and angle-resolved measurements. Also pertinent to this development is the now-operational time-of-flight secondary ion mass spectrometer (ToF-SIMS) that was donated to the CharFac by 3M. Together the XPS and ToF-SIMS will access new regimes of chemical sensitivity via complementary surface analysis. XPS provides elemental identification, chemical-state information (via peak shifts) and quantification of composition (via peak intensities). ToF-SIMS provides extremely high sensitivity (sub ppm), high mass resolution (e.g., distinguish Si and C_2H_4 at 27.97 and 28.03 amu), and large mass range (from ^1H to greater than 1000 amu). The ToF-SIMS also provides spatial imaging down to ~1 micron, which could for example be compared with qualitative chemical imaging by atomic force microscopy (i.e., frictional force, tip-sample adhesion, and phase) that can be further enhanced by functionalizing tips (a service provided by the CharFac). Our ToF-SIMS is also capable of dynamic SIMS for depth profiling, which can complement depth profile information obtained via Rutherford backscattering or Auger sputter profiling.

In early summer a new confocal Raman microscope will be installed, providing spatial resolution of ~200 nm lateral and ~500 nm vertical. Differences in chemical composition, although completely invisible in the optical image, will be apparent in the Raman image. The system provides full spectroscopic imaging, meaning a Raman spectrum acquired at each pixel location. (See www.witec.de). In typical experiments the acquisition time for a single Raman spectrum is significantly less than 100 milliseconds. This results in complete images consisting of tens of thousands of spectra being collected within a few minutes. The Raman microscope uses AFM-grade, closed-loop scanning control (allows future AFM add-on).

Remote access of nano-techniques has shown strong potential with first clients. It is clearly advantageous to not only remotely run imaging software but also view specimens and interact with local personnel. A combination of web cam and whiteboard has proven useful for remote AFM training. AFM's are available on campuses large and small, but in-depth training is lacking at many institutions. Even first-tier research universities are known to staff AFM core labs with graduate students or instructors lacking AFM research backgrounds, who likely provide minimal training services. (This also does not lend itself to the development of broad yet in-depth applications expertise.) The educational impact of core research facilities is of increasing emphasis in peer review of instrumentation proposals. Indeed a recent report from the National Academies, entitled "Midsized Facilities: The Infrastructure for Materials Research" (readable on-line at http://darwin.nap.edu/books/0309097029/html/), recommends *peer review* of core facilities including the explicit evaluation of educational programs.

CharFac at the University of Minnesota

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Greg Haugstad, Director
Mike Boucher, Lab Manager

Upcoming Events

IPRIME Annual Meeting: May 30-June 2
Includes a morning workshop on nanocharacterization of biomedical coatings and a 1.5-day master class on nanomechanical probes. For complete info: www.iprime.umn.edu

New confocal Raman microscope: Mid-June
The installation of the new confocal Raman microscope will be followed immediately by a one-day open house and workshop with demos and presentations by the instrument company (Witec) as well as invited speakers. For further information, e-mail Greg Haugstad: haugs001@umn.edu

Dakota County Technical College Capstone Semester at the Characterization Facility

DCTC students attended the Introduction to Materials Characterization lecture and laboratory course (MT 3131-2) in the Characterization Facility. Throughout the semester they listened to lectures on the underlying principles of different analytical techniques, completed homework assignments, received hands-on lab instruction, and completed lab exercises in the characterization of engineering materials by scanning and transmission electron microscopy, atomic force microscopy, nanoindentation, x-ray diffraction and FTIR spectroscopy. Activities further included methods of specimen preparation, data collection and analysis, and the all-important task of maintaining a good lab notebook. Students were instructed by a number of staff specialists including Stuart McKernan, Greg Haugstad, Linda Sauer, John Nelson, Ryan Wold, Jinping Dong and John Thomas. This course derived from the Materials Characterization Laboratory course offered each fall to juniors in the Materials Science program, modified to make appropriate for two-year students.

Greg Haugstad instructing Kassim Abdille, David Michael, and Arturo Terrazas in AFM techniques.

Steve Anderson and Kevin Cleare learn about nanoindentation from John Nelson.

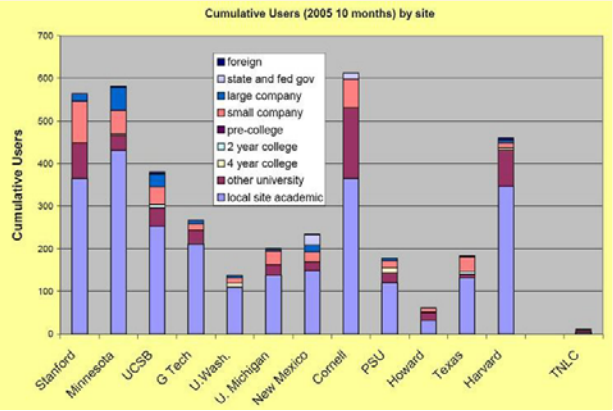
Terry Solom setting up a sample for x-ray diffraction analysis.

Nanofabrication Center News

NFC Director's Message

NFC Director, Steve Campbell

As many of you know, NFC, along with Charfac and PTL, serve as the Minnesota node of the NSF National Nano Infrastructure Network (NNIN). One of the primary metrics for such a node is the number of users that we serve. The plot below shows the user numbers for the first ten months of the current fiscal year. Our number of users is second only to Cornell. I bring this to your attention to underscore the recognized excellence of these Minnesota core labs and to thank you for your continued patronage. One might think that, given these strong numbers, the labs are in good shape. Unfortunately this is not the case. Income from lab fees is down more than 10% this year. I am working hard to recruit new users, both internally and externally. I hope that you will help me in this effort by recommending all of the Minnesota labs to your friends and colleagues.



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Steve Campbell, Director
Greg Cibuzar, Lab Manager

Thin Film Deposition Techniques

An important aspect of many micro- and nanofabrication processing sequences is the deposition of thin films. The films may be conductors, insulators, semiconductors or magnetic materials. At the Nanofabrication Center we have several different process tools for deposition of a wide variety of thin films using the techniques of evaporation and sputtering. We currently have 3 different electron beam evaporation systems in our facility. Two of these evaporators, the CHA system and the Temescal system, are inside the cleanroom. The CHA is a newer tool with complete automation capability for the deposition, a six pocket gun, fixturing for both planetary and lift-off deposition, and heated deposition capability. The Temescal is an older, manual operation system with a four pocket gun and lift-off fixturing. Both systems can support four inch wafers and smaller. Commonly deposited films include Cr, Ti, Ni, Al, Au, Pt, Pd, Ag, Mo, Cu, and Ge. NFC sputtering capabilities are centered around the AJA International system. This tool has both RF and DC guns (2 each), load lock loading, single wafer deposition up to 8 inch diameter, and heated deposition. Common materials include Al, Al2O3, Au, Cr, Cu, Ge, ITO, Ni, SiO2, Ta, Ti and W. If thin film deposition is needed for your project, consider having the work done at NFC on these excellent systems.

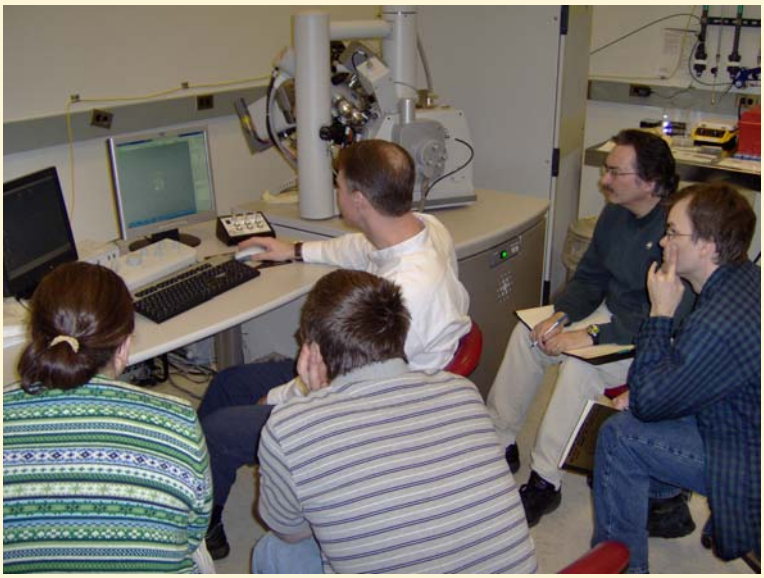
The AJA International Sputter Deposition System at the Nanofabrication Center

Dakota County Technical College Capstone Semester at the Nanofabrication Center

DCTC students attended the Elements of Micro and Nano Manufacturing Laboratory course, MT 3112, at the Nanofabrication Center. This hands-on lab experience dealt with the basic process steps to make top-down micro- and nano-scale structures.

Students worked with NFC staff members Greg Cibuzar, Mark Fisher, Kathy Burkland, Tony Whipple, Kevin Roberts and Suzanne Miller throughout the course of the semester. They dealt with such topics as CAD, photomasks, thermal processing, thin film characterization, vacuum and gas delivery systems, dry and wet etching, standard and advanced lithography, thin film deposition and nanoscale process techniques.

The course is meant to provide students with proper cleanroom etiquette and protocols, an understanding of the processes and equipment involved in nano-scale device fabrication, and expertise in photolithography. At the end of the semester, students independently completed the fabrication of simple devices and structures.



Kathy Hough, Kevin Cleare, Steve Anderson, and Bill Fish observe instructor Kevin Roberts at the FIB station during week nine's session. This week's topics included both the FEI FIB and the Raith E-Beam Lithography Tool.

Kathy Hough with instructor Kevin Roberts aligning a wafer to a mask on the MA/BA-6 aligner. This was part of week ten's Final Project during which students made cantilever beams in silicon nitride.

Steve Anderson and Kevin Cleare record wafer preparation information, while Kathy Hough observes Bill Fish (seated behind instructor Kevin Roberts), aligning a wafer and mask with the MA/BA-6 aligner.

PARTICLE TECHNOLOGY LAB NEWS

PTL DIRECTOR'S MESSAGE

Distinguished McKnight University Professor,
David Y.H. Pui

The Particle Technology Laboratory, as a component of NNIN Minnesota Node, has hosted and/or co-sponsored a number of exciting conferences to highlight the environmental, health and societal impacts of nanotechnology. The 2nd International Symposium on Nanotechnology and Occupational Health was held on UMN campus, October 3-6, 2005. It attracted 420 international attendees presenting and discussing the latest breakthroughs and activities on nanotechnology and worker safety and health. Some of the selected papers are now being reviewed for publication in a Special Issue of the Journal of Nanoparticle Research. Meanwhile, the final program and the proceedings may be downloaded from the following website:http://www.cce.umn.edu/nanotechnology

The report of another relevant workshop, "The Nanotechnology-Biology Interface: Exploring Models for Oversight," held on UMN campus September 15, 2005 can now be downloaded from the website:http://www.hhh.umn.edu/centers/stpp/nanotechnology.html

The next major event, the 7th International Aerosol Conference, will be held in St. Paul, Minnesota's capital city on the banks of the Mississippi River. This IAC will bring together much of the worldwide aerosol research community to share the results of recent research. More than 1,200 abstracts have already been received.

There will be a series of technical sessions on nanotechnology throughout the week, including a Special Symposium on Nanotechnology and Occupational Health. Other topics include atmospheric aerosols, instrumentation, control devices, aerosol dynamics, nanotoxicology and health effects, all relevant to impacts of nanotechnology/nanoparticles. A detailed conference program may be found on the following website: http://www.aaar.org/iac2006

More in-depth training on instrumentation and measurement techniques is provided in two short courses that will be held August 14-18, 2006 on UMN campus. The Aerosol and Particle Measurement Short Course will be offered for the 31st offering and the Air and Gas Filtration for the 10th offering. The Filtration Short Course is offered biennially and provides practical information on filtration technology. On-line registration is available on: http://www.cce.umn.edu/aerosol

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NEW NANOPARTICLE SURFACE AREA MONITOR FROM TSI INCORPORATED

Occupational health risks associated with using and manufacturing nanoparticles are not clearly understood. Leading experts contend that surface area, rather than mass, should be measured for nanoparticles, because nanoparticles have far more surface area for the same amount of mass. This increases the chance of reaction with the body. As a result, there is a growing need to study health effects and assess workplace conditions and personal exposure to nanoparticles, based on the measurement of particle surface area.

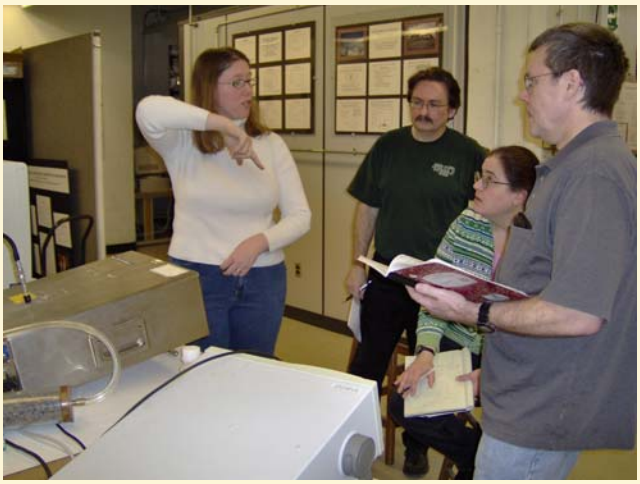
PTL Prof. David Pui and visiting Prof. Heinz Fissan have worked with TSI, Inc. to develop the Nanoparticle Surface Area Monitor (NSAM). The Model 3550 measures the human lung-deposited surface area of particles (reported as µm2/cm3) corresponding to tracheobronchial (TB) and alveolar (A) regions of the lung. It provides a simple and fast solution for measuring the surface area equivalent dose in the lung with applications in the fields of inhalation toxicology, health effects and epidemiology, and for measuring and monitoring workplace exposure.

The NSAM provides for simple operation, fast set up, and the ability to run continuously for unattended, long-term exposure monitoring. It is sensitive down to 10 nm over five decades of concentration, from 0 to 10,000 µm2/cm3, spanning a wide range of exposure dosages. A data rate of one measurement per second detects short periods of high-intensity exposure. The PTL is proud to offer this new technology for use by our clients in our laboratories or in your workplace.

Dakota County Technical College Capstone Semester at the Particle Technology Laboratory

The Nanoparticles and BioTech Protein Self-Assembly Laboratory course (MT 3142a and MT3142b) was split between the Biotechnology Institute (a) and the Particle Technology Laboratory (b). Professor Michael Flickinger and Dr. Marc von Keitz began the semester familiarizing students with biotechnology methods, equipment and approaches. Students received an introduction to the production and purification of microbial S-layer proteins, bacterial growth medium preparation, monitoring growth kinetics by optical density, *in vitro* self-assembly of S-layer proteins and characterization of S-layer proteins by SEM.

The second half of the semester was spent with Dabrina Dutcher at the Particle Technology Laboratory. Here students gained experience in the use of practical equipment in detecting particle formation and performing aerosol size and chemistry measurements. Laboratory activities covered topics including aerosol transport, optical particle counters, and particle size distributions. Students spent two labs on the single particle mass spectrometer, of which there are less than fifty in the world – an extraordinary educational opportunity.



Dabrina Dutcher instructing Bill Fish, Kathy Hough and Kevin Cleare in particle counting techniques.

Kevin Cleare changing the sample on ATOFMS. Photo courtesy of Kathy Hough.

Tim Leisio and David Michael prepare to analyze air samples with instructor Dabrina Dutcher.

The IT Characterization Facility mission relates directly to the core teaching, research and outreach missions of the University

- Provide centrally accessible materials characterization instrumentation for researchers, maintained and upgraded by experts.
- Build, preserve and upgrade the knowledge and skills required for the optimal and research capability of the instrumentation.
- Teach University researchers to apply the above instrumentation, knowledge and fruitfully.
- Make the instrumentation, knowledge, skills and training available to entities the University of Minnesota, to a degree that does not detract from the preceding clauses.

The JEOL 6500 FEG-SEM at CharFac

The NanoFabrication Center's goal is to provide reliable access to tools that enable the research needs of its user base at as low a cost as possible.

The NanoFabrication Center (NFC), a research lab on the Minneapolis campus of the University of Minnesota, is an interdisciplinary facility that supports faculty and industrial research within the Institute of Technology to support education, research and industrial collaboration in microelectronics and other related research involving nanofabrication.

Bay 3 of NFC, some of the plasma processing tools in the cleanroom

The Particle Technology Laboratory mission is to foster research and educate students and the greater community in the following areas:

- Fundamental Aerosol Research and Instrumentation
- Engineered and Environmental Nanoparticles
- Air, Gas and Liquid Filtration
- Cleanrooms and Microcontamination Control
- Air Pollution and Environmental Studies
- Ventilation and Bioaerosols Studies
- Materials Synthesis in Reacting Flows

Sampling platform for jet engine exhaust aerosol characterization experiment

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Contact: Becky Von Dissen at vondi001@umn.edu or 612-625-3069

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