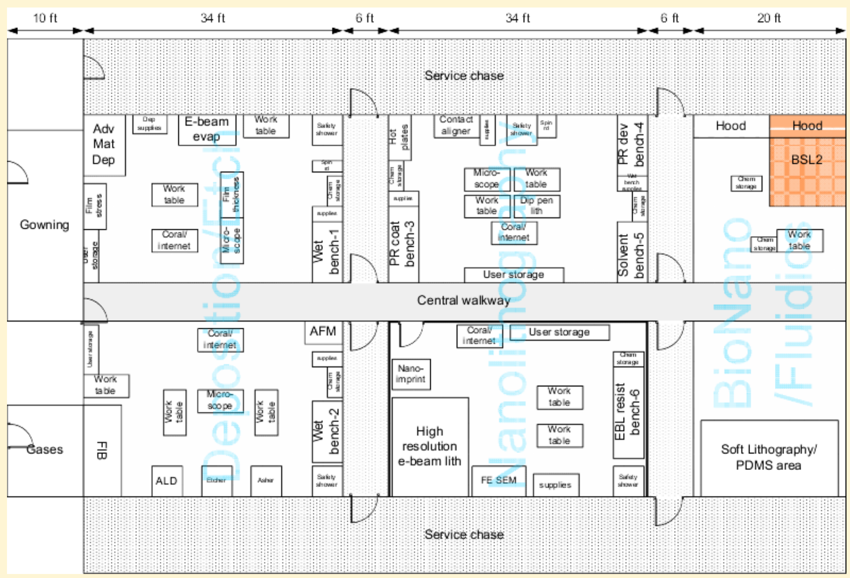
Nanotechnology News from the University of Minnesota

Winter 2009

Welcome to the January 2009 issue of the University of Minnesota Nano Newsletter. The Center for Nanostructure Applications is now in its third year. Last fall we once again held a very successful workshop. The event covered new nano research in materials, sensors, MEMS, energy, optics, characterization, and, with joint sponsorship from the Institute for Engineering in Medicine, provided a full day on nanomedicine. With more than a dozen invited speakers, this three day event drew more than 200 attendees. CNA currently has its third request for proposals out for seeding new opportunities in nano applications. This issue provides brief introductions to the seed projects which began last summer. These projects generally involve a single graduate student working with a multidisciplinary team of faculty. As always, you can find out what is going on in nano by going to the website: www.nano.umn.edu.

The University is currently in the planning stages for a new Physics and Nanotechnology building. The building is to be located just north of the Washington Avenue ramp, and would open in late 2012 if funded by the legislature in 2010. The details of the building are still taking shape, but current plans call for 20% of the space in the building to be dedicated for nano-related research. This will include a home for CNA and a set of labs that will be available for interdisciplinary research on a project basis. The plans also call for a new 5000 square foot clean room. This facility will be in addition to the existing facility in EE/CS. We plan to make the new facility focus primarily on nano, while the existing facility will specialize in MEMS and other work that does not require high resolution lithography. The figure shows an early schematic of the planned facility. The major areas will be deposition/etch, nanolithography, and bionano. As always, we welcome your input for this new facility.



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

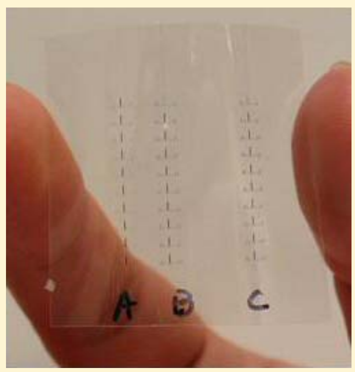
Nanotechnology News from the University of Minnesota is published by the University of Minnesota's Center for Nanostructure Applications and made possible by:

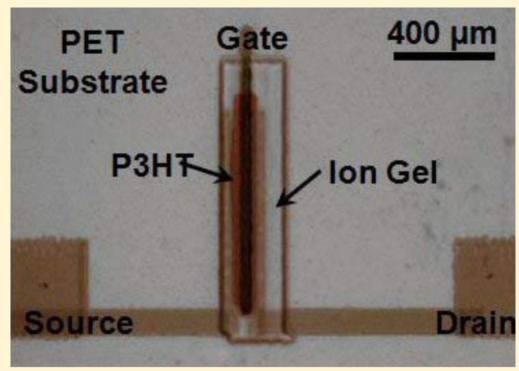
UNIVERSITY OF MINNESOTA
CENTER FOR NANOSTRUCTURE APPLICATIONS
FEATURED RESEARCH

Low Voltage, Printed Transistors on Plastic Employing High Capacitance, Nanostructured Gate Dielectrics

Professor C. Daniel Frisbie (Chemical Engineering & Materials Science), Professor Timothy P. Lodge (Chemistry) and Keun Hyung Lee (Chemical Engineering & Materials Science)

By virtue of rapid development of flexible electronics, we can realize electronic paper, foldable displays, flexible solar cells, and so on. Since the transistor is one of the basic building blocks of electronic devices, a key step to make flexible electronic devices is finding appropriate, solution processable components of transistors: electrodes, semiconductors, and gate dielectrics. Printing is a proper method for realizing flexible electronics because it enables mass production with low cost and substrate compatibility. For all printed devices, there is a challenge to discover new dielectric materials with better processability and functional properties. High specific capacitance is desired for gate dielectric materials, since it allows more charge carriers in the semiconducting layer. Several methods for increasing capacitance have been used, such as decreasing the dielectric layer thickness, or finding new materials with high dielectric constants. Recently it has been shown that traditional dielectrics may be replaced with ionic liquids (ILs) which consist entirely of ions. In order to give mechanical strength to ILs, triblock copolymers are added. The resulting soft solid, which has a physical network, is called an ion gel. By using ion gels as dielectric materials, we can realize solution processable inks without leakage problems. Printed organic thin film transistors show low-voltage operation (around 1~2 V) and high ON current (around 1 mA), due to exceptionally high specific capacitance of electrolytes. Operating speed is also greatly enhanced up to the kilohertz range due to mobile free ions in the ion gel. Further research is going on to improve device performance and to understand the working mechanisms.





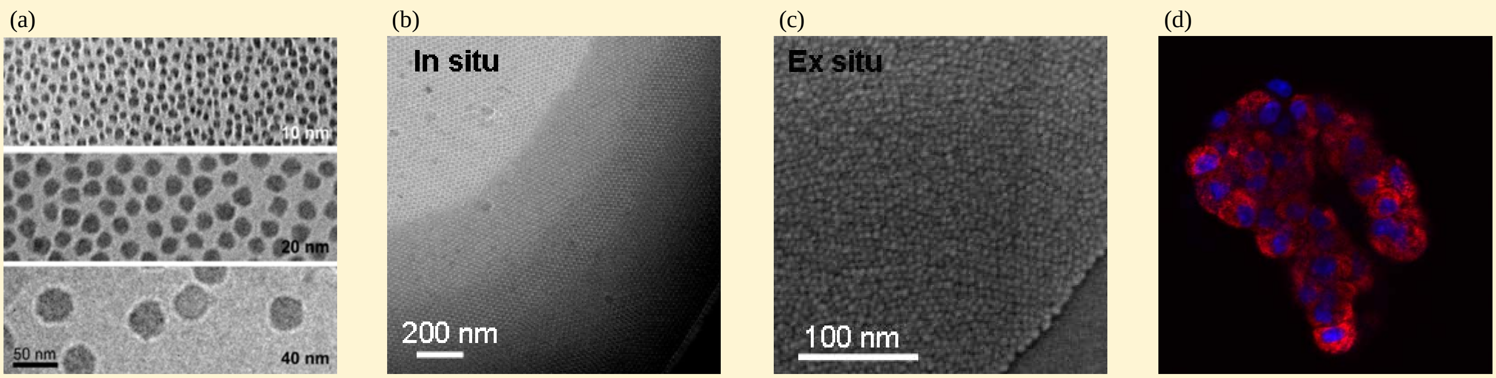
All printed organic thin film transistors on a flexible substrate (left) and an individual image of a device (right).

Benign, permselective encapsulation of porcine islets: Active nanomaterials solutions for xenotransplantation

Professor Michael Tsapatsis (Chemical Engineering & Materials Science), Klearchos K. Papas (Diabetes Institute for Immunology & Transplantation, Wei Fan (Chemical Engineering & Materials Science, Postdoctoral Fellow) and Nicole Atchison (Chemical Engineering & Materials Science, Graduate Student)

In collaboration with: B.J. Hering, M.D., Professor of Surgery, E.S. Avgoustiniatos, Assistant Professor, Department of Surgery, and E. Kokkoli, Assistant Professor, Department of Chemical Engineering & Materials Science

The infliction of more than twenty million Americans with diabetes has spawned concerted research seeking novel therapeutics and treatments. Transplantation of islets, clusters of cells which secrete insulin, is attractive given their autonomous glucose sensing, insulin producing, and controlled release capabilities; yet immunological rejection and donor availability remain as challenges. An alternative is xenotransplantation of pancreatic islets from non-human mammalian sources (e.g. pigs). As recognized decades ago, the viability of xenotransplanted cells could be dramatically improved through immunoisolation by benign permselective encapsulation. The ideal capsule would simultaneously protect the islet cells from immunological attack, efficiently transport nutrients, and rapidly release therapeutic proteins (e.g. insulin). Recently, we have developed a benign and controllable method for synthesizing stable silica nanoparticles from 10 to 50 nm (Figure a) which order in situ and ex situ into colloidal crystal arrays and thin films (Figures b & c). Encapsulating cells within nanoparticle films of controllable thickness (i.e. tens of nanometers) in lieu of bulk encapsulation should translate to a higher flux of chemical species. In addition, the porosity of such ordered nanoparticle films, imparted by the interstitial spacing between particles, can be tuned through particle size control and functionalization to dimensions commensurate with the passage of nutrients and insulin and rejection of immunological triggers. Toxicity testing of silica nanoparticles is being performed on INS-1 cells (the insulin secreting cells in the islet) and formation of nanoparticle coatings on porcine islets is being studied. Figure d shows the confocal microscope image of an islet contacted with fluorescent silica nanoparticles. The red fluorescence originates from silica nanoparticles, and the blue is from the nuclei of cells. In order to coat the silica nanoparticles on the surface of islets, we are studying the effects of particle size and surface charge on particle internalization.



(a): Cryo TEM images of silica nanoparticles(10, 20 and 40 nm); (b): *in situ* nanoparticle ordering; (c): *ex situ* nanoparticle ordering on silicon supports; and (d): confocal microscope image of an islet after coating with fluorescent silica nanoparticles.

Magnetic Susceptibility of Subcellular Organelles

Professor Bruce Hammer (Radiology), Professor Susan Mantell (Mechanical Engineering), Staff Scientist Phillip Williams and Graduate Research Assistant Emily Gras

In this project a MEMS based cantilever will be developed to measure the magnetic susceptibility of cells, subcellular organelles and molecular compounds. The material of interest will be affixed to the cantilever tip and placed in a strong magnetic field and magnetic field gradient. Cantilever deflection or resonant frequency, which will be measured using an optical technique, is proportional to the magnetic susceptibility of the material. Our goal is to catalog the magnetic susceptibility of cells and subcellular organelles that scientists can access to develop new methods to modify or modulate internal cellular forces. Classifying the magnetic susceptibility of cells, subcellular organelles, drugs, etc. is useful to investigators that want to target compounds or manipulate cell function by inducing internal stresses within cells through an external magnetic field.

The magnetic susceptibility of the subcellular organelles is expected to be <0.1 nN. To achieve the desired sensitivity, we are designing a flexible polymer microcantilever beam with an integral piezoresistive element. The subcellular organelles will be isolated and placed on the beam tip. The beam will be resonated within the bore of a superconducting magnet. In the presence of the strong magnetic field gradient (on the order of 100 T/m), the resonant frequency of the beam will shift, corresponding to the magnetic susceptibility of the organelles. Either an optical measurement system (see Figure 1) or the piezoresistive element will be used to sense cantilever deflection and resonant frequency. We are also investigating nano and microscale techniques for achieving the desired magnetic field gradient.

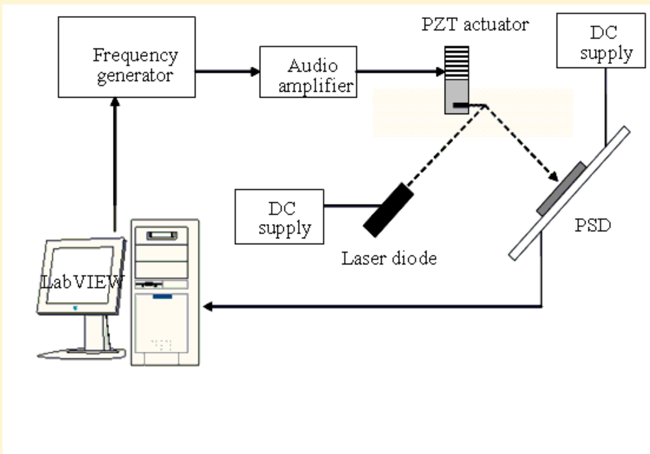


Figure 1: Illustration of optical sensing with PZT actuation of a cantilever beam.

UPCOMING NANO EVENTS

Center for Nanostructure Applications Seminar Series

4 – 5pm, every other Friday throughout the Spring 2009 Semester
Walter Library, room 402

Previously known as the Nanoparticle Science and Engineering (NPSE) Seminar Series, these Friday afternoon seminars will be continuing in Spring 2009 through the Center for Nanostructure Applications (CNA).

All seminars take place on Fridays from 4-5pm in Walter Library, room 402 at the University of Minnesota. Seminars begin with refreshments at 3:45pm.

To add your e-mail to the list to receive announcements and reminders about seminars, email Becky von Dissen at vondi001@umn.edu.

For complete information and schedule, visit **www.nano.umn.edu/cna_seminar**.

Industrial Partnership for Research in Interfacial and Materials Engineering 2009 Annual Meeting

May 26 – 28, 2009

At this meeting, each research program offers presentations on the previous year's work. A poster session and reception provide the opportunity for informal interactions and discussions about ongoing projects.

The three-day meeting, which is open to IPrime member companies, invited guests, and University of Minnesota faculty, students, and staff, also often includes a master class and special topic workshops.

Annual Meeting schedule details will be available in March. Please visit **www.iprime.umn.edu** for complete information and updates.

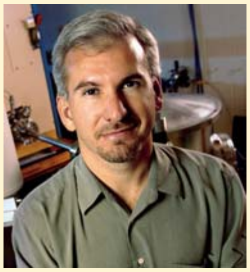
Please remember to visit us online for the most up to date nanotech event, activities and research information at **www.nano.umn.edu**.

4th Annual Minnesota Nanotechnology Conference Recap

In November 2008 the University of Minnesota hosted the 4th Minnesota Nanotechnology Conference, which offered presentations and discussions on Nano Sensors, Energy, Optics, Microfluidics, Materials and Medicine. Visit the Conference webpage for a recap, photos and links to many of the day's presentations: **www.nano.umn.edu/conference2008**

Characterization Facility News

CharFac Director's Message



CharFac Director,
Greg Haugstad

The recent renewal of the Materials Research Science and Engineering Center has provided critical funding (along with other contributors) for capital equipment in the form of add-ons and replacements/upgrades to existing instruments in Shepherd Labs. Funding has been approved for five items including add-ons to transmission electron microscopes as well as data acquisition system upgrades to two Veeco scanning probe microscopes and the NEC ion beam analysis system. These are investments to add high-end capabilities as well as extend the lifetime and improve the user friendliness of workhorse systems. All of these capabilities are central to nanoscale research and development by both internal and external users and clients of the Characterization Facility.

A new energy dispersive spectroscopy (EDS) system will be attached to the FEI T12 TEM. EDS is one of the most standard and frequently used analytical techniques for elemental analysis of materials. The interaction of the incident beam electrons with those in the sample material produces electronic energy level transitions that yield X-rays; EDS quantifies the energy and intensity of these emitted X-rays. Because each element emits an X-ray "fingerprint" that is unique, it is possible to perform compositional analyses. Both quantitative and qualitative analyses are possible. The new EDS will replace a 24-year old system that is only partially functional and has energy resolution 2-3 times poorer.

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A new electron energy loss spectroscopy (EELS) system will be attached to the FEI F30 TEM, fully enabling it as an analytical scientific instrument in scanning TEM (STEM) mode. Coupled with the annular dark field (ADF) detector, STEM will provide the ability to position the fine electron beam over any spot on the specimen and measure EELS spectra from that point. Because EELS and ADF imaging can be performed in parallel, spectroscopy with atomic-level precision is achievable. When core-level electronic transitions are recorded with EELS, it is possible to carry out an analysis of the local chemistry and electronic structure that is element- and site-specific. The low-loss region of the energy-loss spectra contains a vast amount of information regarding the interactions of the incident electron with the solid, such as losses due to solid-state excitations caused by bulk and surface plasma oscillations, electronic inter-band and excitonic transitions, phonon excitations and more.

Data acquisition computer systems are being upgraded on both Veeco AFMs from vintage 1999 Pentium II Win NT systems. This will enable access to ongoing software developments, higher image processing speeds, more reliable network access and USB data transfer. A complete data acquisition upgrade is being purchased for ion beam analysis, to replace a vintage 1994 Intel 486 DOS system. This will apply to all analytical methods: Rutherford backscattering and forward recoil spectrometry (elemental depth profiling including hydrogen), particle-induced X-ray emission (like EDS except much more sensitive, but not with high lateral spatial resolution), ion channeling analysis of disorder in crystalline/epitaxial systems (depth-resolved and element-specific, unlike XRD), and nuclear reaction analysis (e.g., gamma ray detection for lithium composition).

For the coming months CharFac is planning a seminar series (ad hoc in timing) wherein lead technical staff members and intensive users will speak on advanced applications of CharFac systems. Announcements of individual talks will be posted to the CharFac web site. Users should contact Greg Haugstad if interested in presenting.

CharFac at the University of Minnesota

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Greg Haugstad, Director

NANOFABRICATION CENTER NEWS

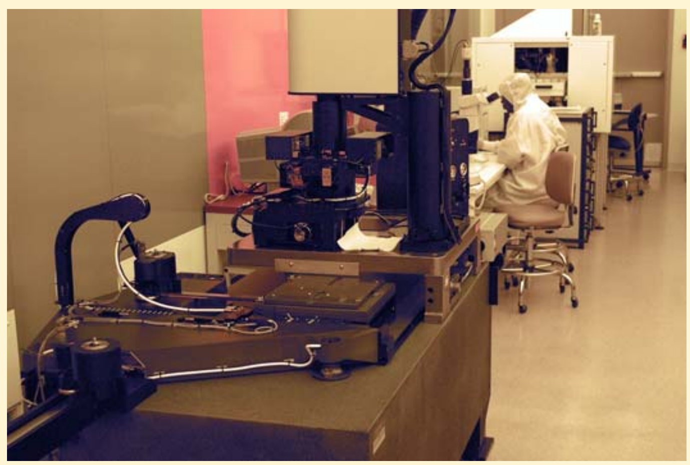
NFC DIRECTOR'S MESSAGE

NFC Director, Steve Campbell

In December, NFC took delivery of our new nanoimprint tool, a Nanonex NX-B200. This system supports feature size down to 10 nm if a suitable master is available and uses a flexible sample holder that accommodates substrates up to a maximum of 3". This type of technology is particularly useful when large numbers of identical nanoscale features are required. Typical applications include nano optics, nano bio, and nano magnetics. For more information on nanoimprint or on Nanonex, go to www.nanonex.com. The machine has now been facilitated and we have run through the initial check-out with the vendor. We have now resolved the problems that arose during this checkout. Mark Fisher (fishe024@umn.edu) is the staff member in charge of the system. Mark will be going to Nanonex for a day long visit in late January to get additional training on using the NX-B200. We expect that the machine will be available for users by the beginning of February. Contact Mark or Greg Cibuzar if you want to get more information, including how to make masters.

PHOTOMASK SERVICES

Many academic institutions and companies have some capability for thin film processing, such as deposition, etching and lithography. Photomasks, a key component of the lithography process, often consist of a glass plate with a patterned layer of chromium metal. The pattern corresponds to the design of the layer currently being processed. The fabrication of photomasks requires specialized equipment that many research labs do not have. At NFC we have the capability to make photomasks with feature sizes down to 1.5 microns. The masks can be made on soda lime or quartz plates, with mask sizes as large as 8 by 10 inches (4 and 5 inch square soda lime plates are stocked). Both darkfield and lightfield masks can be fabricated. The cost for academic institutions for darkfield/lightfield masks is $250/$285 (higher for more complex designs). If you are interested in learning more about having photomasks made at NFC, please send an email to nfcmasks@umn.edu.



NFC Criss-cross optical pattern generator and image repeater

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Steve Campbell, Director
Greg Cibuzar, Lab Manager

SAFETY TRAINING

NFC is offering safety training for new users twice each month. On the first Thursday of every month, the training sessions begin at 1:15PM, and on the third Thursday of the month sessions begin at 10:00AM. The training includes watching our safety video and taking a brief quiz. Also, a NFC staff member provides a tour showing some of the safety related equipment and the gowning process used for the NFC cleanroom. Finally, there is training on using the Coral lab software. The safety training takes about two hours to complete, and must be done before users will be granted access to NFC facilities.

PARTICLE TECHNOLOGY LAB NEWS

PTL DIRECTOR'S MESSAGE

Distinguished McKnight University Professor, David Y.H. Pui

Aerosol researchers inside and outside of UMN have benefited from the use of NNIN facilities at CharFac, NFC and PTL. During the past two years, a total of 7 papers (published or submitted) acknowledged the use of NNIN facilities. Two papers involving the use of NNIN-PTL facility have just been named as the most cited papers in the Journal of Nanoparticle Research in 2007-08. One paper addresses Nanoparticle Filtration 9:117-125 (2007) and the other addresses Nanoparticle Surface Area Monitoring 9:53-59 (2007). The availability of the well maintained tools at NNIN has greatly facilitated these studies.

The Particle Technology Laboratory purchased a NanoSight LM10 system in December, 2008, which can be used to visualize, size and count nanoparticles in liquid suspensions. The instrument employs a Nanoparticle Tracking Analysis (NTA) technology for characterization of polydisperse populations of nano-scale particles. The technique is based on the simultaneous tracking and analysis of trajectories of individual particles moving under Brownian motion when illuminated by a specially configured laser beam. The measurable particle size range is approximately 20 -

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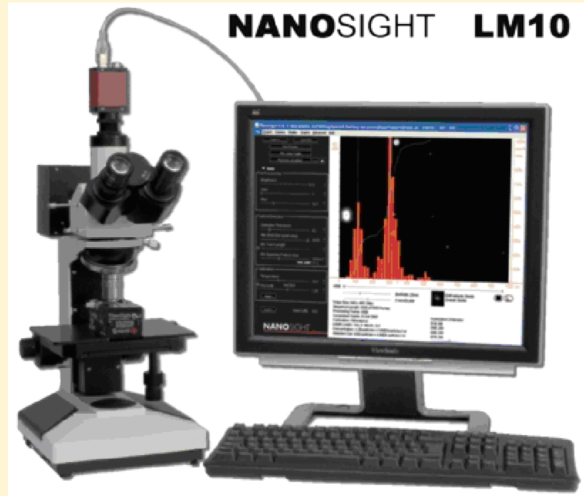

1000 nm. Though for exceptionally high refractive index particles, sizing of particles as small as 10 nm is possible. Analysis times can be as low as 10 seconds for optimum concentrations of particles, e.g. between 10^7 and 10^9 particles/ml. This instrument will be used for both research and teaching purposes. It will be used for teaching in the classes ME 5133 Aerosol Measurement Laboratory and MT 3142 Nanoparticle Technology and Engineering Laboratory in the 2009 spring semester. Students will gain first-hand experience of direct visualization and measurement of liquid-borne nanoparticles.

Dr. Kyoungtae Kim joined the Particle Technology Laboratory in Oct 2008 as a Postdoctoral researcher. Dr. Kim earned his PhD degree at Korean Advanced Institute of Science and Technology (KAIST) in 2008 in the field of aerosol science. He is currently conducting research on bio-diesel fuel filtration and electrospray decontamination study.

Dr. Jingxian Liu, associate professor of Northeastern University (NEU) in China, is coming to the Particle Technology Laboratory as a visiting scholar. Dr. Liu's titles include director of Filter Test Center of NEU, vice director of Safety Engineering Department of NEU; vice president of Industry Dust Prevention Committee of China Occupational Safety & Health Association, committee member of bag house committee of China Environment Protection Industry Association, and vice director of Metallurgy Safety Committee of China Metal Association. Dr. Liu has done significant work on high performance filter media for bag house, smoke emission control technology and equipment on large scale coal boiler power stations. Dr. Liu will bring new expertise to the Particle Technology Laboratory and potential opportunities for collaboration.

PARTICLE TECHNOLOGY LAB AT THE UNIVERSITY OF MINNESOTA

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David Y.H. Pui, Director
Jing Wang, Lab Manager

Center for Nanostructure Applications

The primary mission of the Center for Nanostructure Applications is to seed interdisciplinary nano research projects that will go on to attract external support. Active nanostructures include applications of nano as diverse as energy conservation and production, large area displays and lighting, printed electronics, smart fabrics, electronic noses, drug delivery, cancer therapy, and new types of medical imaging.

These applications often require significant participation across traditional disciplines and the Center is designed to foster the cross-disciplinary research necessary to bolster the nano applications area at the University.

The Center also organizes workshops, speaker series, and short courses, as well as serving as a focal point for nano at the University.

For more information, visit http://www.nano.umn.edu/

The Minnesota Nanotechnology Cluster

MiNTeC is an umbrella organization of three labs at the University of Minnesota that support the development of nano technology: the Characterization Facility, Nanofabrication Center, and Particle Technology Lab. As a node in NSF's National Nanotechnology Infrastructure Network (NNIN), MiNTeC provides access to advanced multi-user facilities to both industry and academic researchers, the latter at a subsidized rate. The MiNTeC facilities are at the University of Minnesota's Minneapolis campus.

For more information, visit http://www.mintec.umn.edu/ and www.nnin.org

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and the National Nanotechnology Infrastructure Network.
Comments and suggestions are welcome! Would you like to be added to or removed from our distribution?
Contact: Becky von Dissen at vondi001@umn.edu or 612-625-3069

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