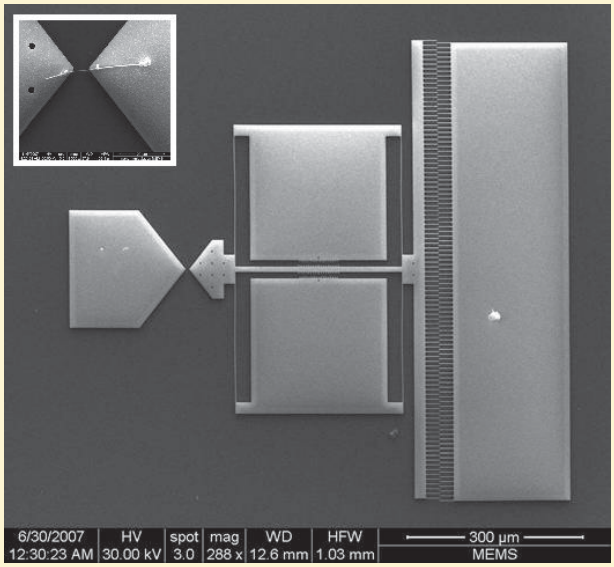
Nanotechnology News from the University of Minnesota

University of Minnesota

Fall 2008

Fall 2008 Nano Image



This image shows a MEMS platform for testing the mechanical properties of nanoscale structures such as nanowires, carbon nanotubes and biological fibers. The inset shows a Nickel nanowire specimen loaded in tension by the electrostatic force provided by a comb drive.

This research, funded by NSF, is a collaboration between Roberto Ballarini (Professor of Civil Engineering) and Jun Lou and Boris Yakobson (Professors of Mechanical Engineering and Materials Science, Rice University). The device was fabricated by Rice University graduate student Yogeeswaran Ganesan.

2 - 3 *Center for Nanostructure Applications Feature*

4 *Upcoming Nano Events*

5 - 7 *News from CharFac, NFC and PTL*

Welcome to the Fall 2008 issue of the Minnesota Nano Newsletter. I am very pleased to take this opportunity to introduce Jim Marti to you. Jim has a long background in technology, receiving his PhD in Physics from Minnesota, and then doing a postdoc in Mechanical Engineering with Peter McMurry. Jim then went into industry. His resume includes acting as the President of the Minnesota Particle Society as well as serving as a Vice President for R+D at MSP Corporation. Jim will provide external user outreach for the NNIN-funded laboratories. External usage is a key benchmark in our role as a NNIN node. Jim's responsibilities will include making sure our current users are happy with the service that we provide and helping us to recruit additional users.

This issue continues our recent format, offering the opportunity for Center for Nanostructure Applications sponsored groups to provide a glimpse of their work. This issue will cover work by faculty in Electrical Engineering, Mechanical Engineering, Chemistry, and Chemical Engineering & Materials Science to develop quantum dot light emitting devices, using Silicon dots for the visible range and compound semiconductors for IR sources.

Finally, I have two plugs for upcoming events. Mike Roco, the principle architect of the National Nano Initiative will be on campus on October 8. University faculty have a special opportunity to meet with him to discuss the future of NNI. A talk on nano manufacturing is open to all on the same day. Also, this fall (November 11 - 13) we will host our fourth annual nano workshop. This year a third day, dedicated to nanomedicine, has been added. As always, you can find out what is going on in nano by visiting our website: www.nano.umn.edu.

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:

Quantum Dot Light Emitters

Steve Campbell, PhD, Electrical & Computer Engineering
Uwe Kortshagen, PhD, Mechanical Engineering
Wayne Gladfelter, PhD, Chemistry
Russ Holmes, PhD, Chemical Engineering & Materials Science
Graduate students: Rick Liptak, Kai-Yuan Cheng, Rebecca Anthony, Margret Broz, Ryan Gresback and Ryan Hue

One of the CNA projects involves the use of semiconductor quantum dots to make light emitting devices. Quantum dots are very small (1 to 10 nm) single crystal semiconductor nanoparticles. They allow one to adjust the emitting wavelength by adjusting the particle size.

While organic light emitter diodes (OLEDs) have made considerable progress as visible light emitters, inorganic materials such as quantum dots offer some unique advantages including increased reliability, better color purity, and potentially, higher efficiency. Professor Campbell's group has found that by treating the surface of silicon nanoparticles in an SF_6 plasma, we are able to obtain dots with emission across the visible and near infrared (NIR) spectrum. In addition to passivating the surface, exposure to the plasma etches the dots. Very lightly etched particles emit in the NIR, lightly etched dots emit in the red, and aggressively etched particles are smaller and so emit at shorter wavelengths. Photoluminescent efficiencies for these etched dots are air-stable and as high as 55%, a remarkable value for an indirect gap semiconductor like silicon.

Under an excitation at 365 nm
PL emission peaks are at 652 nm, 582 nm, 572 nm, 441 nm, respectively.

Fig 1 – Photoluminescence of etched silicon quantum dots

OLED devices are not generally effective in the infrared. While silicon dots can be used in the NIR, silicon is not appropriate for applications with wavelengths greater than one micron. Professor Gladfelter's group has been exploring the synthesis and characterization of direct band gap III-V semiconductor nanoparticles; specifically InP, InAs, and $InAs_xP_{1-x}$. Initial work focuses on synthesizing air-stable, highly monodisperse, highly photoluminescent InP nanocrystals, which emit from visible to infrared wavelengths. In a synthesis adopted from Peng, [1] indium trifluoroacetate is reacted with tris(trimethylsilyl) phosphine in solution, then a successive ion layer adsorption and reaction (SILAR) is performed to deposit a zinc sulfide shell to stabilize the core. Particles have been produced from 1-4 nm, which display UV/Vis absorption peaks between 350 and 600 nm. The

SILAR method precisely controls the thickness of the shell deposited based on the number of monolayers added and can be done in one pot. This core/shell structure stabilizes the core against oxidation and also increases the photoluminescence quantum yield. Figure 2 shows a disappearance of the UV/Vis absorption peak when the bare InP particles are left in air overnight compared to the coated particles and an increase in the photoluminescence.

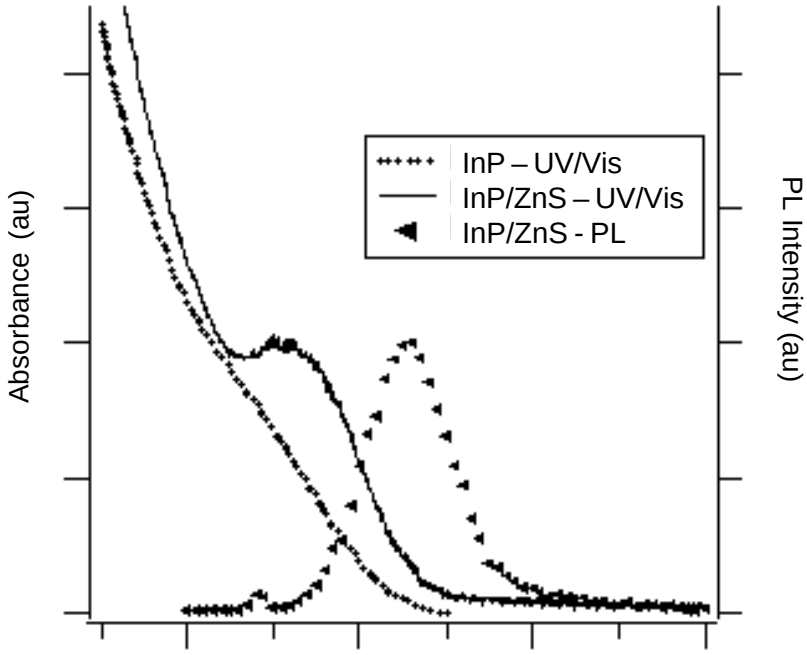


Fig 2 – UV/Visible absorbance and PL of Bare InP and InP/ZnS in air

Professor Kortshagen's group has engaged in two projects. The first is to understand the effect of plasma conditions on the behavior of nanoparticles. They have shown that the as-synthesized nanoparticle crystallinity and the chemical bonding at the surface, specifically the concentration of various silicon hydrides, is an excellent predictor of optical performance after passivation. They have also successfully made InP nanoparticles in the gas phase using plasma processes similar to the silicon quantum dot synthesis work described above. Although these processes have definite advantages compared to solution-based synthesis, forming a passivating shell on the surface of the active core is more challenging. Never the less, surprisingly good photoluminescent efficiencies have been achieved.

Finally, one would like to use quantum dots to make electroluminescent devices. Hybrid nanoparticle-organic LEDs that combine silicon nanoparticles with conductive polymers have been demonstrated with near infrared emission at 880 nm by Professor Holmes and his group. The emissive layer consists of 5 nm diameter silicon nanoparticles deposited onto a conductive polymer by spin coating. This layer provides a zone for the radiative recombination of injected charge. During device operation, the injected charge is carried by the conductive polymer, recombining at the silicon nanoparticle layer leading to light emission. Devices show an average external quantum efficiency of 0.07% obtained in the forward emitted direction, which rivals the most efficient nanoparticle-based infrared LEDs. More recently, improved structures have resulted in efficiencies that are much higher.

1 R. Xie, D. Battaglia, and X. Peng, *J. Amer. Chem. Soc.*, **2007**, vol. 129, p. 15432.

Upcoming Nano Events

4th Annual Nanotechnology Conference at the University of Minnesota
November 11 – 13, 2008

This three-day workshop offers presentations and discussions on topics including Nano Sensors, Energy, Optics, Microfluidics, Materials and Medicine.

The conference will feature speakers from around the country and from the University of Minnesota. Some of this year's invited speakers include:

Vladimir Aksyuk, NIST
Stanley Pau, University of Arizona
Craig Grimes, Penn State
Sossina Haile, Cal Tech
Yeshaiahu Fainman, Univ. of California, San Diego
Henri Lezec, NIST
Eric Lagally, University of British Columbia
Alex Brolo, University of Victoria
Yi Cui, Stanford
David Seidman, Northwestern
Gang Bao, Georgia Tech
Warren Chan, University of Toronto
Donald Payne, NanoSpectra Biosciences
Darrell Irvine, MIT
Shyam Rele, Calando Pharmaceuticals
Jason Hafner, Rice University

This year's conference will also include a reception and poster session after Tuesday's talks. The reception will be a wonderful opportunity to network, enjoy refreshments and view the poster exhibit while talking one-on-one with researchers about their work.

For a complete event schedule and details about registration, visit **http://www.nano.umn.edu/conference2008/.**

Center for Nanostructure Applications Seminar Series

4 – 5pm, every other Friday throughout the Fall 2008 Semester
Walter Library, room 402

Previously known as the Nanoparticle Science and Engineering (NPSE) Seminar Series, these Friday afternoon seminars will be continuing in Fall 2008 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 http://www.nano.umn.edu/cna_seminar/.

Mike Roco
National Science Foundation
October 8, 2008

Mike Roco is the Senior Advisor for Nanotechnology at the National Science Foundation and a key architect of the National Nanotechnology Initiative (NNI).

University of Minnesota faculty are welcome to join him for a discussion on the future of the NNI taking place October 8 from 1:30pm – 2:30pm at the Digital Technology Center, room 402 (Walter Library).

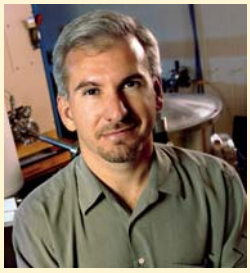
Later that day, Dr. Roco will be giving a talk open to everyone titled "Frontiers In Nanomanufacturing" as part of the LM Fingerson/TSI Inc. Distinguished Lecture Series. This lecture will be held from 4pm – 5pm in Moos Tower 2-470.

Electron Energy Loss Spectroscopy & Energy Filtered Transmission Electron Microscopy Workshop

A fee-based workshop on EELS and EFTEM at the Characterization Facility is planned for late fall semester. This workshop will have both lectures and hands-on training taught by invited leaders in the field. Check www.nano.umn.edu or www.charfac.umn.edu for schedule information.

Characterization Facility News

CharFac Director's Message



CharFac Director, Greg Haugstad

Staffing developments dominate news in the CharFac in recent weeks. We are thrilled to welcome two new staff members into our electron microscopy labs in Nils Hasselmo Hall ("CharFac South"), Dr. Wei Zhang and Fang Zhou.

Wei Zhang is now our lead Research Associate active in cryo-TEM on biological and soft materials systems. She will chiefly oversee the new FEI F30 FEG TEM in Hasselmo, together with staff member Dr. Ozan Ugurlu who joined CharFac in December 2007. Her principal activity on that microscope will include not only cryo-TEM of biological and soft synthetic materials but also tomography, a process that produces three-dimensional models from large numbers of TEM images acquired at different sample tilt angles. Wei holds a joint position, Assistant Research Professor, in the Department of Diagnostic and Biological Sciences within the University's School of Dentistry. Her research program focuses on the fundamental mechanisms of virus-cell interactions. She uses cryo-TEM to determine the structure of the virus/cell membrane complex, with the long-term objective to

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outline the detailed steps of viral protein conformational changes correlating with membrane remodeling and fusion.

Wei Zhang

Wei joins us from Purdue University where she previously held the position of Associate Research Scientist in collaboration with Professors Jue Chen, Richard Kuhn and Michael Rossmann. Before that, she was trained in Professor Timothy Baker's laboratory and received her PhD in 2001 from the Department of Biological Sciences at Purdue. Her Bachelor and Master degrees are in Biophysics from Nankai University and Institute of Biophysics, Chinese Academy of Science in China, and Computer Science from Purdue.

Fang Zhou is now Assistant Scientist active in biological specimen preparation (including work on a new ultramicrotome as well as other systems) together with imaging on and oversight of the JEOL 1200 TEM in Hasselmo, a scope with a growing clientele since a new CCD camera was added in recent years. Along with hands-on activities she will supervise work performed by undergraduate lab assistants.

Fang Zhou

Fang joins us from the State University of New York – ESF in Syracuse, where in August she received her Masters in Mycology from the Department of Environmental & Forest Biology. She also received a MS in Plant Ecology from Nankai University and a BS in Biology Education from Hebei Normal University, both in China.

The Energy Dispersive Spectroscopy (EDS) system on the FEI T12 TEM in Shepherd Labs is now operational. Network communication problems have been fixed and data can now be transferred easily from the Digital Equipment Corporation (DEC) EDS computer to a dedicated data server via File Transfer Protocol (FTP) using a simple interface. Two copies of the Desktop Spectrum Analyzer (DTSA) software from NIST have been installed on a PC and a MAC. They are both accessible to users for post processing of EDS data.

CharFac at the University of Minnesota

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Greg Haugstad, Director

NANOFABRICATION CENTER NEWS

NFC DIRECTOR'S MESSAGE

NFC Director, Steve Campbell

Last fall we polled the faculty for their interests in new capabilities at the Nanofabrication Center. The capability that was mentioned most often was nanoimprint. This type of a system uses a hard mold, which is pressed into a soft material, to create an image. The soft material is then hardened by heat and/or light exposure, prior to the removal of the mold. This technique allows one to make many nano structures without the high cost and throughput issues of e-beam lithography, except to make the master. Using NNIN support, we have placed an order for a new Nano Imprint tool. The tool, a Nanonex NX-B200, supports feature sizes down to 10 nm if a suitable master is made. The NX-B200 incorporates a flexible sample holder that accommodates any size of substrate or mask including arbitrary shaped geometries, up to a maximum of 4 inches. We expect to take delivery of the system in October and to have it available for user training shortly thereafter. For more information on nanoimprint or on Nanonex, go to www.nanonex.com.

CHEMICAL VAPOR DEPOSITION

Deposition of high quality thin films is an important aspect of technologies such as MEMS. One of the best techniques for deposition of silicon nitride thin films is low pressure chemical vapor deposition (LPCVD). Our current LPCVD system has capability to deposit silicon nitride, polysilicon, and low temperature silicon dioxide on substrates up to 4 inches in diameter. We routinely deposit two types of silicon nitride, standard stoichiometric silicon nitride, and low stress (silicon-rich) silicon nitride. The low stress film is particularly desirable for MEMS applications requiring free standing beams or membranes. Plasma-enhanced CVD is a lower temperature deposition process for silicon nitride, polysilicon, and amorphous silicon, and is also available at NFC. Atomic layer deposition (ALD) is also a CVD process in which layers are deposited in conformal layers with controllable thicknesses from a few monolayers of atoms to thousands of angstroms. ALD films currently available at NFC include Al_2O_3 and HfO_2. These ALD films make outstanding insulating layers. Please contact us for more information at nfc@umn.edu.

Cambridge Nanotech Savannah 200 Atomic Layer Deposition System

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.

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Steve Campbell, Director
Greg Cibuzar, Lab Manager

Particle Technology Lab News

PTL Director's Message

Distinguished McKnight University Professor, David Y.H. Pui

During August 18-22, we successfully offered the Aerosol and Particle Measurement Short Course (33rd Offering) and the Air and Gas Filtration Short Course (11th Offering). Approximately 68 registrants, mostly from industry and national labs, attended the courses. We found that 80-90% of the attendees came as a result of recommendation by their colleagues who had taken the course in previous years. There is a steady demand for this short course to train professionals on aerosol measurement fundamentals and techniques. During the past few years, attendees have showed significant interest on topics of nanoparticle technology, bioaerosol measurement, Diesel engine emissions and control. To meet the demand of bioaerosol interest, Professor Thomas Kuehn will begin to offer a new Short Course on Bioaerosol Measurements. He will be assisted by Dr. Jim Ho of the Canada Department of National Defence, who is the inventor of the real-time

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bioaerosol detector commercialized by TSI. The Bioaerosol Measurement will be offered during the off-year of the Air and Gas Filtration that is offered biennially. For 2009, Aerosol and Particle Measurement will be offered August 24-26 and Bioaerosol Measurement August 27-28. Information will soon be available on the website: http://www.cce.umn.edu/aerosol.

Each year, I organize a LM Fingerson/TSI Inc. Distinguished Lecture during the Fall semester. Prominent scientists are invited to give lectures and network with faculty, students, and researchers from local companies. I am pleased that Dr. Mike Roco, Senior Advisor for Nanotechnology at the National Science Foundation and a key architect of the National Nanotechnology Initiative (NNI) has accepted my invitation to give this year's lecture. The title of his talk is "Frontiers in Nanomanufacturing." He will address the specific need in instrumentation and standards for nanoscale measurements in conjunction with simulations and design of productive process. I invite you to attend this timely lecture on the future of nanotechnology development. It will be held October 8, 4-5 pm, in Moos Tower 2-470. A wine and cheese reception, sponsored by TSI Inc., will be held at the Campus Club, Coffman Memorial Union, immediately following the lecture.

Dr. Mike Roco of the National Science Foundation

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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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