University of Connecticut
Institute of Materials Science

IMS Associates Program Newsletter

Vol. 10, No. 1 January 2006

Connecticut's Nanotechnology Efforts

A recently completed Battelle report provides a comprehensive examination of the significance to and relative position of Connecticut in nanotechnology. Based on this comprehensive review and analysis, the report lays out a strategic framework for Connecticut to guide future investments and activities in nanotechnology.

In setting the context for understanding nanotechnology development, this report points out the following:

- The stakes for Connecticut in nanotechnology are high.... estimated employment impacts for Connecticut are expected to reach nearly 31,000 jobs.
- Nanotechnology faces commercialization challenges.…
- The National Nanotechnology Initiative (NNI) is an asset, but not a program.…
- Other states are taking the lead in nanotechnology development. By assessing states that have been successful in winning federal nanotechnology research centers, the Battelle team identified their best practices, including leveraging upfront state and local investments to build competitive nanotechnology programs, matching funds to attract federal R&D centers, using state funds to activate linkages with industry, establishing university consortiums, and integrating nanotechnology education and training.

Seven priority actions were identified. An implementation plan is being formulated. Of particular interest is the establishment of a state-of-the-art Connecticut Nanotechnology Characterization Facility.

To see the complete report and the priority items go to http://ctinnovations.com/documents/AdvancingNanotechnologyDevelopmentinCT.final_000.pdf. Contact Dr. Harris Marcus (860-486-4623, hmarcus@mail.ims.uconn.edu) for more details.

Inside this issue:

Nanovan Pioneers New Ground	2
Symposium Honoring Arthur McEvily	3
SPE Tours Top-Flite	3
Focus on Research - Leon Shaw	4
Zhu Awarded DuPont Young Professors Grant	5
Chiu Captures Three Major Awards	6
Stwalley Named Fellow of AAAS	6
Failure Presentations	6
Department Seminars	7
Spring Semester Starts	7
IMS Short Course	7
Membership Fee Changes	8
Sample Preparation	8

Nanovan Pioneers New Ground

In the early morning hours of November 15, 2005, three scientists from the University of Connecticut packed up a computer and several boxes with sensitive equipment (including an Atomic Force Microscope, or AFM). They braved the rush hour traffic heading down to Staples High School in Westport, CT, in order to set up and make two presentations to students in the Science Research Program. The scientists were Dr. Fotios Papadimitrakopoulos (Associate Director of UConn's Institute of Materials Science), Dr. Bryan D. Huey (Assistant Professor in the Institute of Materials Science), and David J. Shuman (one of Dr. Huey's graduate students). Several of the students in Staples' research program had already studied topics related to nanotechnology, including the optimal synthesis of carbon nanotubes and the possibilities for future space elevators using such technologies.

It is believed by Professor Papadimitrakopoulos that this is the first time that an AFM has ever been brought into a high school. Because it is such a sensitive instrument, it must be moved with great care and re-calibrated each time it is moved. The AFM, with an original price tag of over one hundred thousand dollars, operates by placing a cantilevered scanning probe very close to the surface of a sample. In the presentations given to the students, the AFM was used to examine the surfaces of a DVD and a synthetic opal. Dr. Papadimitrakopoulos forecasts that the AFM will eventually come down in price to about five thousand dollars, at which point it will become possible for high schools to have their own models and offer elective courses in nanotechnology.

The concept of the Nanovan was originally proposed three years ago as a way to reach out to K-12 schools across the state. Dr. Papadimitrakopoulos, a board member of the Connecticut Nanotechnology Initiative, began to develop a series of lab experiments that could be conducted in middle and high school classrooms. These experiments will use the AFM to "see" what could not previously be seen and expose students to the sort of technology that will affect all of our lives in the coming decades. For this initial visit, the actual Nanovan that transported the scientists and their equipment from Storrs to Staples wound up being a rented Chrysler minivan. A high school science teacher somewhat jokingly suggested using a Mini Cooper in the future.

In an article from NSTA Reports May/June 2005 entitled "Science Laboratories on Wheels", it was noted that there are currently three other mobile science classrooms in use across the US. The Connecticut BioBus promotes biotechnology, and has visited nearly 200 schools since its debut in 2001. Iowa's Project SEMI (Science Education Mobile Instruction) is a tractor trailer that accommodates at least 21 students in its state-of-the-art biotech/life sciences laboratory including a botany growing station. Philadelphia's Educational Advancement Alliance launched the Fattah Learning Lab (named after Representative Chaka Fattah) this past March with computers, science equipment, and a state-of-the-art video and audio system including wireless internet access. What separates the Nanovan apart from these other concepts is that the equipment is rolled out of the van and into the schools so that students learn science in their own classrooms.

Prof. Fotios Papadimitrakopoulos (UConn), Prof. Bryan Huey (UConn), David J. Shuman (UConn) and Dr. Harry Rosvally (Science Dept. Chairman, Staples HS) with the Nanovan.

Students in Dr. A.J. Scheetz's Science Research Program at Staples High School were fascinated by the presentations given by Dr. Papadimitrakopoulos and Dr. Huey, as Mr. Shuman operated the AFM to provide additional visuals. It's an interesting look into the future!

Symposium Honoring Arthur McEvily, Professor Emeritus, Materials Science and Engineering

The ASM/TMS Mechanical Behavior of Materials Committee is sponsoring a "Symposium in Honor of Art McEvily's 80th Birthday: Fatigue and Fracture of Traditional and Advanced Materials" to be held at 2006 TMS Annual Meeting in San Antonio, Texas in March.

This symposium will honor the seminal contributions of Arthur J. McEvily to the theoretical and experimental aspects of fatigue and fracture over the last 50 years. His many contributions in the areas of fatigue crack growth and fracture have dealt with topics such as constitutive relations for fatigue crack growth; the effect of overloads, underloads and R ratio on fatigue crack growth; crack closure; variable amplitude loading; small fatigue crack growth; multi-axial loading; striation formation; and thermal and environmental effects.

The symposium will address recent advances and challenges in science and technologies related to fatigue and fracture of nanocrystalline materials, fine and coarse-grained alloys, amorphous materials, and their composites. Specific topics include, but are not limited to: mechanisms of fatigue crack initiation and small crack growth, large crack growth near the fatigue threshold and in the high ΔK regime, crack closure, crack initiation and growth ahead of stress concentrations, fatigue life prediction, fatigue fracture, variable amplitude loading, overloads, multi-axial loading, fracture behavior, and environmental effects.

Professor McEvily is still active at IMS and continues to be a valuable resource person for the Associates Program.

SPE Tours Top-Flite

Top-Flite Golf, an IMS Associates Program member, was the host on November 14, 2005 for a tour of their plant in Chicopee, Massachusetts and for a talk after dinner on Polymers in Golf Balls. It was attended by 12 UConn Polymer graduate students and 10 from UMass. The UConn students are in the UConn Student Chapter of SPE (Society of Plastics Engineers). Several members of the Western New England Chapter of SPE were there also.

The tour included all of the processing steps that go into making a golf ball, including injection molding, coating and printing. There are several different layers of polymers including the rubber core. Golf balls use polymers in a sophisticated technical way that can enhance how far balls are driven and the extent to which they roll after landing on the green.

Michael Tzivanis, Director R&D Materials, and coordinator for Top-Flite in the IMS Associates Program, was the speaker after dinner. His talk and answers to questions included some of the history of golf balls. An early version, going back a couple of centuries, was made of wood.

IMS Professor Robert Weiss is a consultant to the company. He and Tom Kennedy, VP of R&D, were quoted in a July 18, 2005, p. 34, article in "Chemical & Engineering News," "Golf Balls -- Polymer Chemistry has played a key role in the evolution of the golf ball." See http://pubs.acs.org/isubscribe/journals/cen/83/i29/html/8329golfballs.html.

Focus on Research: Leon Shaw

In each issue of this newsletter we profile one of the active research areas at IMS. In this issue we focus on the research being led by Leon Shaw, Professor of Materials Science and Engineering.

Prof. Leon L. Shaw received a B.S. in Materials Engineering and a Master of Engineering in Mechanical Engineering from Fuzhou University (China), as well as a Master of Science and a Ph.D. in Materials Science and Engineering with a Minor in Mechanics and Engineering Science from the University of Florida. He worked as a Research Scientist at Systran Corporation and as a Visiting Scientist at Air Force Wright Laboratory for 2 years before joining the University of Connecticut faculty in 1995.

His teaching and research interests are in processing and mechanical properties of nanostructured materials, solid freeform fabrication, and energy materials for hydrogen storage and fuel cell applications. He is a Fellow of ASM International, and a Fellow of the Academy of Materials and Manufacturing Engineering, Poland. He has authored or co-authored over 160 publications (2 edited books, 5 book chapters, 92 archival refereed journal articles, and 64 conference proceedings), and made 150 plus conference presentations including 34 invited talks or keynote presentations. He holds US patents for large quantity production of nanostructured materials. He is a guest editor for several journals including Metallurgical and Materials Transactions and Materials Science and Engineering. He also serves as a reviewer for federal funding agencies (e.g., NSF, DOE, AFOSR and CRDF) and leading journals in the field. He is an executive committee member of ASM Nanomaterials Technology Task Force and the Chairman of ASM Materials Synthesis and Processing Committee. He is cited in *Who's Who in America* and *Who's Who in Science & Engineering*. He is also an award-winning faculty advisor to the UConn ASM/TMS Student Chapter from 1998 to 2004 with the following international awards.

- ASM/TMS Chapters of Excellence for Technical Programming in 1999
- ASM/TMS Chapters of Excellence for Technical Programming in 2001
- ASM/TMS Chapters of Excellence for Promotion of the Field in 2003
- The First Place Winner of the 2003 ASM, ISS, TMS World Materials Outreach Award
- The First Place Winner of the 2004 ASM, ISS, TMS World Materials Outreach Award

At the Institute of Materials Science Shaw conducts research in the following areas.

Surface Nanocrystallization and Hardening (SNH) Process:

SNH is a new process developed recently at the University of Connecticut. It entails impacting metallic parts such as turbine blades and machine components with high-energy balls under a controlled atmosphere. This novel process can produce metallic engineering components with a nanocrystalline surface and coarse-grained interior along with the compositional hardening and the introduction of a desired residual stress distribution. Components with such engineered microstructures and strengthening are expected to offer superior fatigue, wear and erosion properties derived from the synergy of the tailored microstructure, the smooth gradients of both composition and grain size, and the desired residual stress distribution. (Sponsored by the National Science Foundation)

Rapid Prototyping of Dental Restorations:

There are currently more than 10,000 dental laboratories in the US and a majority of these laboratories use porcelain-fused-to-metal (PFM) restoration for permanent fixed prosthodontics. PFM restoration is a very time consuming and labor intensive work. This study is to develop a novel slurry micro-extrusion (SME) process for dental restorations. The SME process utilizes the solid freeform fabrication (SFF) principle to fabricate artificial dental units layer-by-layer directly from a computer model without part-specific tooling and human intervention. As such, the labor cost will be substantially reduced, and better and faster dental restorations will be achieved. (Sponsored by the National Science Foundation)

Advanced Hydrogen Storage Materials via Mechanical Activation and Nanostructures:

The objective of this project is to establish a scientific foundation for developing mechanically activated, nanoscale, hydrogen storage materials that can meet DOE's FreedomCAR requirements (i.e., store and release ~ 10 wt% hydrogen at temperatures below 100° C with near ambient pressures). A system approach integrating comprehensive experiments and quantum-chemical modeling has been taken in this project with a focus on Li3N-based materials. At the end of this project, a prototype hydrogen delivery system with Li3N-based materials possessing ~ 10 wt% reversible hydrogen and capable of delivering 1 kg of hydrogen at ambient temperature and near ambient pressure will be demonstrated. If successful, this program will lead to novel hydrogen storage materials needed to make hydrogen vehicles a reality. (Sponsored by the Department of Energy)

Carbon-Filled Polymer Blends for Applications of PEM Fuel Cell Bipolar Plates:

A novel concept of a triple-continuous structure to provide carbon-filled polymer blends with high electrical conductivity and tensile strength simultaneously has been proposed. Low cost fabrication of such a triple-continuous structure through injection molding has been demonstrated using several different polymer blends. The concept proposed has the potential to produce low cost conductive polymers with superior conductivity and strength for bipolar plate applications of PEM fuel cells. Such a potential has been investigated in the carbon-nanotube (CNT)-filled PET/PVDF blend which exhibits 2,500% improvement in electrical conductivity, 36% increase in tensile strength, and 320% improvement in elongation over the CNT-filled PET at the same carbon loading. (Sponsored by U.S. Army through the Connecticut Global Fuel Cell Center)

Selected recent publications include:

1) A. Xu and L. Shaw, "Equal Distance Offset Approach to Representing and Process Planning for Solid Freeform Fabrication of Functionally Graded Materials," Computer-Aided Design, 37 [12] 1308-1318 (2005).

2) X. Li and L. Shaw, "Microstructure of Dental Porcelains in Laser-Assisted Rapid Prototyping Processes," Dental Materials, 21 [4] 336-346 (2005).

3) K. Dai, J. Villegas, Z. Stone and L. Shaw, "Finite Element Modeling of the Surface Roughness of 5052 Al Alloy Subjected to a Surface Severe Plastic Deformation Process," Acta Mater., 52 [20] 5771-5782 (2004).

4) M. Wu and L. Shaw, "On the Improved Properties of Injection-Molded, Carbon Nanotube-Filled PET/PVDF Blends," J. Power Sources, 136, 37-44 (2004).

5) H. Luo, D. Goberman, L. Shaw and M. Gell, "Indentation Fracture Behavior of Plasma Sprayed Nanostructured Alumina – 13wt.% Titania Coatings," Mater. Sci. Eng., A346, 237-245 (2003).

More information regarding Dr. Shaw's research interest can be found at http://www.engr.uconn.edu/mse/mselshaw.html or by contacting Professor Shaw directly (leon.shaw@uconn.edu).

Zhu Awarded DuPont Young Professors Grant

Assistant Professor of Chemical Engineering Lei Zhu has been awarded one of just eight 2005 DuPont Young Professor Grants presented to North American researchers. Dr. Zhu's research investigates the synthesis and self-assembly of carbon nanotube-based liquid crystalline materials, and characterization and design of useful nanotechnology devices for the development of novel photovoltaics and nanotransistors. Dr. Zhu will receive $25,000 yearly for three years.

Recipients of the prestigious award are nominated by DuPont personnel based upon the originality of their research programs. Through the award, DuPont assists young faculty members who are within five years of their tenured appointment. The grants are intended to encourage highly original research of value to DuPont while helping the recipients begin their academic research careers.

Dr. Zhu joined the Chemical Engineering Department in fall 2002 with a specialty in polymer science. He earned his Ph.D. in polymer science from the University of Akron in 2000.

To see the complete article go to http://www.engr.uconn.edu/soe.php?pId=lzhu-su-05.

Chiu Captures Three Major Awards

Dr. Wilson K.S. Chiu, Assistant Professor of Mechanical Engineering, recently received an Army Research Office (ARO) Young Investigator Award. Dr. Chiu won the $150,000 three-year award for his proposed work in the area of optimization of solid oxide fuel cells (SOFCs) for field use by Army personnel.

Dr. Chiu received his Ph.D. in Mechanical Engineering from Rutgers University in 1999 and joined the University of Connecticut the same year. He previously received a National Science Foundation CAREER Award as well as the Young Investigator Award from the Office of Naval Research. Competition for the awards is intense, and Dr. Chiu has achieved a rare distinction in winning all three.

To see the complete article go to http://www.engr.uconn.edu/soe.php?pId=chiu-su-05.

Stwalley Named Fellow of the American Association for the Advancement of Science

William Stwalley, Board of Trustees Distinguished Professor and Head of the University of Connecticut's Physics Department, who was recently awarded the Connecticut Medal of Science, has been named a Fellow of the American Association for the Advancement of Science (AAAS). AAAS Fellows are nominated and elected by their peers. The organization is the publisher of a leading academic journal, *Science,* and awards the title to scientists across the nation in recognition of their "scientifically or socially distinguished efforts to advance science or its applications."

Stwalley joins 376 other scientists (28 in physics) who have been awarded the title this year at a ceremony on Feb. 18, 2006 during the AAAS annual meeting in Saint Louis, Missouri.

See http://www.uconn.edu/newsmedia/2005/november/rel05112.html for more complete information.

Failure Presentations

Two current papers by Mike Ezrin may be of interest and are available on request to him, tel. 860-486-4628 or myer.ezrin@uconn.edu. Both are review papers; one on adhesion failure was presented as a keynote paper October 2005 at an SPE Conference on Medical Plastics Bonding in Providence, Rhode Island. The other, on unexpected failures, will be presented as a keynote paper May 2006 at the SPE Annual Technical Conference, Charlotte, North Carolina, in the Failure Analysis and Prevention Special Interest Groups sessions. Titles are: "Adhesion Failures of Plastics Bonded to Various Materials" by M. Ezrin and G. Lavigne; "Unexpected and Unusual Failures of Polymeric Materials" by M. Ezrin and G. Lavigne.

Department Seminars

Spring seminar schedules have not been finalized at this time. This information, and the seminar schedules for most departments, will also be available on the web (Materials Science and Engineering: http://www.engr.uconn.edu/mse/mseseminars.html; Polymer Program: http://www.ims.uconn.edu/poly/component/option,com_wrapper/wrap,Seminars/Itemid,91/).

Abstracts of seminars are usually available about a week in advance. We can also put you in touch with the faculty member sponsoring the seminar to learn more about the specific seminar of interest. We suggest you call before attending to be sure the seminar has not been canceled due to illness or weather.

Spring Semester Starts

Spring semester classes start January 17, 2006. Some courses that may be of interest include the following.

CHEM-358	Polymer Composites	Parnas
CHEM-394-1	Spectroscopy	Utz
CHEM-384	Polymer Characterization II	Zhu and Asandei
CHEG-352	Polymer Properties	Papadimitrakopoulos
MCB-315	X-Ray Structure Analysis	Burkhard
BME-271	Biomaterials	Wei
MMAT-320	Physical Ceramics	Kattamis
MMAT-320A	Computational Materials Science	Ramprasad
MMAT-305	Phase Transformations	Alpay
MMAT-322	Microstructural Characterization of Materials	Aindow
MMAT-309	Transport Phenomena in Materials Science and Eng.	Brody
MMAT-277	Processing Materials in the Liquid and Vapor State	Kattamis
MMAT-311	Mechanical Properties	Shaw

IMS Short Course

Plans are in development for next summer's short course. We welcome your suggestions for future short courses. You will receive detailed information in the spring. All Associates Program member companies will receive one reduced price registration.

IMS Associates Program

Myer Ezrin, Ph.D., Director
Phone: 860-486-4628
Fax: 860-486-4745
myer.ezrin@uconn.edu

Edward Kurz, Ph.D., Associate Director
Phone: 860-486-4186
Fax: 860-486-4745
ekurz@mail.ims.uconn.edu

Research Assistants
Mark Dudley
Gary Lavigne
Laura Pinatti

Administrative Assistant
Nancy Borman

University of Connecticut
Institute of Materials Science
97 N. Eagleville Road
Storrs, CT 06269-3136

We're on the Web!
www.ims.uconn.edu/ims/content/view/32/41/

Membership Fee Changes

Some time ago a careful and detailed review of all of the finances associated with the IMS Associates Program revealed that the Program was not adequately recovering its true expenditures. After much thought, review, input from members, and discussion with the IMS external advisory board (many of whom are representatives of Associates Program members) the following changes in fee structure are being implemented.

Beginning January 1, 2004 all new Connecticut companies with more than 250 employees joining the Program are charged an annual fee of $25,000. Starting July 2004 all existing in-state members were offered continuing membership for one year at $20,000 if they pay in full within 30 days of their renewal date. As of July 2005 the one-year membership fee for all Connecticut companies with more than 250 employees is $25,000.

All existing out-of-state members were handled exactly the same, i.e. given an option of staying at $20,000 per year, for one year, if they paid in full within 30 days of their renewal date. In July of 2005 the annual membership fee for out-of-state companies increased to $30,000 per year. Again, for the year starting July 2005, all existing out-of-state member companies are able to delay this increase by paying $25,000 within 30 days of their renewal date.

Starting January 2004 new out-of-state members are charged an annual rate of $30,000 per year.

Finally, for existing small (less than 250 employees) in-state members, the annual fee has been increased in a fashion similar to that of the large in-state members but details will vary depending on the size of the company. As with large companies, new in-state small company members have been charged the new rates since January 2004.

We hope you understand the necessity of these changes and look forward to continuing to serve our members in the future.

Sample Preparation

In many projects that the Associates Program deals with, such as adhesion and coatings, surface analysis techniques are extremely important. The techniques used for such analysis, particularly GC/MS, Auger electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS) are extremely sensitive to small amounts of material on the surface. It is important to make efforts not to contaminate these surfaces during sample preparation, collection and shipment. **Shipment in common plastic bags should be avoided**! Common plastic bags typically contain significant amounts of additives used to prevent the plastics from adhering to themselves and other materials. These additives will migrate to the sample during shipment and at best make interpretation difficult and sometimes impossible. It is much better to ship such samples in common kitchen aluminum foil (not industrial aluminum foil which is often coated with an oil or other release agent). Samples can also be shipped in glass containers with aluminum foil over the opening under the cap.

Alternatively special polyester bags that do not contain such additives can be purchased. One source of such bags is the Kapak Corporation, 5305 Parkdale Drive, Minneapolis, MN 55416, 612/541-0730. Typical price is about $200 per thousand depending on the exact size. Be sure to specify non-contaminating/non-plasticized material.