PSE Alumni Magazine

Spring 2004

New PSE Department Head: Professor Shaw Ling Hsu

Dear Alumni,

Todd Emrick asked that I report on recent events in PSE. First, let me encourage you to contribute to this Magazine. It is a magazine for YOU, and we are delighted to have articles from PSE Alumni describing their careers, experiences, and lives since leaving PSE. I find these articles fascinating, and this issue features PSE Alum Dr. Ho Tao. Two more articles are waiting in the wings, from alums working in the pharmaceutical and chemical industries. Please keep these coming - we really appreciate them!

PSE Department Head
Professor Shaw Ling Hsu

It has been a tremendous experience for me to serve as Department Head. I have become better acquainted with graduate students, our future alumni. Several students have recently received awards and recognition, including Ticora Jones, Rebecca Breitenkamp, Habib Skaff, Julie Leisten-Belanger, and Sian Fenessey. As a result of student nominations, Professor Muthukumar has received the Northeast Graduate Schools Best Teacher Award. The PSE Club solicited supporting letters during the Christmas holidays, and I was truly moved by the letters I read. I am astounded by the efforts of PSE faculty in student teaching and mentoring, and was moved by student testimonies regarding how PSE education made a difference in their lives. I sincerely hope these letters are representative of the education you received at PSE.

I should also note numerous faculty awards. All of our assistant professors have received early career awards from various agencies, including NSF and DOD. Assistant Professor Gregory Tew received the Presidential Early Career Award, presented at a White House ceremony. Honors received by senior faculty include Sigma Xi (David Hoagland) and the Dutch Polymer Award (Thomas Russell). Professor Russell has also been awarded the Chancellor's Medal, and appointed Distinguished University Professor! Congrats to all!

We have closed the 2003-2004 faculty search. Two individuals were selected from an exceptional group of applicants, and Dr. Ryan Hayward (currently U.Cal., Santa Barbara) will join us in 2005. A second offer is pending and we hope for a second acceptance. The fact that these high caliber individuals will join PSE bodes very well for our future; we will continue to grow, and we seek additional individuals for an upcoming search.

The PSE course offerings have expanded considerably in recent years, as traditional core courses are supplemented by Special Topics courses, including *Biopolymers* (Tew), *Polymers in Nanotechnology* (Emrick), *Polymer Brushes* (Santore), *Polymers in Electro-optical Applications* (Karasz), and *Management of Research Projects* (Crosby). These courses have been received extremely well, as they illustrate new applications in polymer science and engineering to augment the foundation provided by our core courses. Due to the high student enrollment in these courses, and the joy of our faculty in teaching them, these special courses will continue in the coming years.

PSE will host the ***Graduate Student Research Conference, June 15-17, 2005***. This American Chemical Society Conference has been held on five previous occasions, at various locations around the country. We solicited this conference for many reasons, most especially as this will contribute to the future development of polymer scientists and engineers. We bring them together in an informal atmosphere to exchange and share ideas regarding research accomplishments and future aspirations. I have contacted several previous coordinators of this conference, and the aspect of the Conference that attracts the most interest is job opportunities. We have a year to plan for this Conference, and I am requesting your help in making it a success. If possible, please let me know whether you are able to attend. In addition, I am soliciting a number of firms to help finance this conference, so as to minimize student costs. Please let me know whether your firm, or you as an individual, would be willing to participate in this extremely worthwhile effort. The Conference will be of great benefit to graduate students, and the student run PSE Club will help organize the talks, posters, and recreational activities. There will be many opportunities for informal discussion in the evenings, and I hope that students will have the opportunities to meet PSE Alums!

I hope you will continue to correspond with PSE, and I wish you the very best in all your endeavors.

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Upcoming PSE Events

Alumni Social Event at the Fall ACS Meeting

A room is reserved in the POLY/PMSE hotel at the upcoming American Chemical Society meeting in Philadelphia, PA (August 22-26, 2004). This is scheduled for 5:00 pm in Room 413 of the Marriott on Monday, August 23. Alums, as well as all current faculty, students, and postdocs are invited; we hope to see you in Philadelphia!!!

CUMIRP/MRSEC Meeting and PSE Poster Session

The Fall 2004 CUMIRP-MRSEC Meeting will be held in PSE from October 5-7, 2004.

Graduate Research Conference

The Graduate Student Research Conference of the American Chemical Society will be held at UMass Amherst from June 15-17, 2005.

Alumni Profile

Dr. H.J. Tao

Taiwan Semiconductor Manufacturing Company

My daily life in Taiwan is quite different from that at UMASS. Here we have no snow, no clear sky, and no autumn. In Taiwan, all four seasons look the same so there is no surprise for the season change (except for the unexpected earthquake). Also, everyone goes crazy for elections and politics in Taiwan, which is a little different from the lovely town of Amherst. In my daily work, we have no beakers, no hoops, no vacuum oven, and no safety goggles. Our equipment costs about 5 million U.S. $$, and I have plenty in my department. The materials we are processing are called "wafers," which are like a 12" pizza but not as tasty, and our engineers fine-tune the "recipe" (believe me, it is better to stay in the kitchen to get a good recipe). No matter how different the business I am working on is from fundamental polymer science, 90% of my daily judgment is still based on my training in PSE! It really helps! It may be a surprise, but actually I was awarded a "2002 Best Young Engineer Award in Taiwan."

Dr. Tao with his wife and two children in Taiwan

My current job is Department Manager of the advanced etch department in TSMC R&D. All etch recipes below 0.25 micron technology in TSMC are developed by this Department. Right now we are working on the 65 nm technology and beyond. "Etch" is always a counterpart of "lithography". Lithography uses photoresist to put a "virtual pattern" on the wafer, while etch has to duplicate and create the final pattern on the wafer, and remove the photoresist. Thus, interaction with the lithography group on the resist selection is important to the etch department. In this aspect, it seems like destiny for me to continue my work with polymers.

As a Department Manager, my major focus is on management rather than on process details. My daily work starts from the review of our "big pizza" (what we called "turn-ratio"). Our development is all conducted on the pizza so it is very critical to check when they are ready. It normally takes 1.5 months to get a well-done pizza, which requires 200-300 process steps. However, for our daily work, we use "short loop wafers" which take about 1-2 weeks to prepare.

The most challenging aspect is technical management. More than 50% of my time is spent in meetings for problem solving or progress update. The IC business is cooperation of many modules, thus cross-department discussion is very important. About 30% of my meetings fall into this category; the remaining 70% is technical discussions on etching. As the only R&D etch department in TSMC, we need to define our technology roadmap yearly, mostly following Moore's law. Furthermore, there is always unexpected trouble in the development stage, sometimes fatal, in which we have very little time (one week or two) to resolve problems. That is the reason people get exhausted in this business and burn-out after their daily work. In this business, what we talk about is counted by days or hours. Compared to the plastics business I used to work in, the clock goes much faster in the IC business!

Most of our engineers have domestic master's degree, and the inherent hard-working Chinese nature. We never worry about working hours and actually we never monitor working hours. However, due to the culture difference between Chinese and Americans, this generation has less training in using scientific methods to identify and resolve issues. For this part, PSE's training helped me a lot. I am still using the scientific background trained by PSE to handle my daily work and to teach our young engineers problem solving. The impact of my education in PSE is forever.

From the technical side of semiconductors, the process flow is structured by circuit design, device, process module, integration, and packaging. The process module block can be further divided into mask and lithography, etch, thin film, CMP (chemical mechanical polish), and metallization. The process module elements and the packaging block more or less have direct interaction with polymer technology. Among them, the lithography has the most correlation.

Generally speaking, there are two basic elements in the lithography process, one is photoresist and the other is anti-reflection coating layer (ARC). For the photoresist, the 248 nm and 193 nm are currently the key projects. The photoresist is composed of foundation resin, photosensitizer, quencher, and sometimes dye. The very basic requirement of foundation resin is to avoid the absorption of incident light (248 nm or 193 nm) while still keep the good homogeneity with all other additives. The side group design of the foundation resin is very critical to have the best optical resolution with the best profile feature during the development stage. Furthermore, its resistance to etching plasma is also very crucial. Recently, since the device gate length has been reduced to 40 nm or further, the reduction of line-edge-roughness (LER) associated with the resin microphase separation during the development and drying stage is getting important. There are still many un-explored areas in resist technology that need major efforts from polymer community.

The anti-reflection material can be separated into dielectric ARC and organic ARC. And both materials have equal importance, but different applications. From the integration point of view, the dielectric ARC is easier to manage and its etching performance is better than organic ARC. However, organic ARC has one very unique feature - planarization capability that is very critical to the device dimension control on the substrate with some topography. Again, the polymer resin is also the major component of the organic ARC while some other additives will be included to reduce the reflection. To understand and control micro-phase separation in resist and organic ARC is clearly very important!

For etching, there are two areas that we need to deal with polymer science in the daily work. Etching performance of the photoresist is the first one. Normally, etching team will work very closely with the lithography team to evaluate the new resist - this is very complicated work. As a rule of thumb, the

photoresist must have good "etching selectivity". The etching selectivity is defined as the etch rate ratio between the material to etch and the etch rate of the photoresist. The etching team loves to have selectivity of 5:1, or even higher. Normally, this is difficult to achieve. Besides this blanket etch rate difference, the final test on the patterned feature is more challenging. The line-edge roughness and feature distortion are what we try to avoid. Furthermore, improper photoresist will induce defects before and after etching, which is normally one of the major yield killers. The photoresist will also impact the final etch result for different feature environment, for example to the different local pattern density. And this effect is what we call "proximity effect". Sometimes the proximity effect is intrinsic to one photoresist, and difficult to adjust by etching process. Thus, if one photoresist has very good lithographic performance but poor etching performance, that resist is still useless. In the polymer community for resist development or study, the etching-related work is still little addressed.

A second part of daily work for the etching community is the etch-induced sidewall polymer. Normally, fluorocarbons such as CF_4 or CHF_3 are used to etch dielectric materials. In order to control the etch feature, it is important to balance etch and deposition. Here what we called the deposition actually is the control of formation on the fluorocarbon polymer. There are some sophisticated studies on the formation and control of this kind of sidewall polymer during etching in chemical engineering community. It is still very rare, though, in the polymer science Department which could be lack of the infrastructure to setup a mini-IC lab.

For the thin film area, there was little linkage between the organic polymer and the insulation layer until the emergence of "low K material". In the IC chip, we need to fill in the dielectric material between the metal lines and a separation layer. After the 0.13 micron technology, since the metal-to-metal spacing is getting closer, the signal cross-talk issue associated with this separation material is getting crucial. To reduce cross-talk, one proposal is to change the separation material from dielectric oxide into some other "low K materials". Generally speaking, there are two categories of low K materials. One is CVD based and one is spin-on organic based. The spin-on organic based low K was once very hot due to its lower K value compare to CVD type, especially when IBM announced its selection of organic SiLK as their low K material several yeas ago. However, the organic low K material gets less attention in recent years due to its poor mechanical property and poor reliability performance. The worldwide low K main stream has been migrating to CVD.
Finally the CMP has a strong correlation to advances in polymer research. One of the key elements of CMP is the abrasive in CMP slurry. To keep the slurry stable, surface treatment of the CMP abrasive is very crucial, and this field is certainly highly relevant to the polymer community.

Alumni Notes

Dr. Raymond J. Lo, PSE entering class 1981. I wanted to take this opportunity to say what a wonderful job the PSE Alumni Club is doing, from this electronic database to the periodic newsletters I receive in the mail. It's great to see this progress and innovation at UMASS! My wife Sue and I were married in 1986, two months after my dissertation. We moved to Cincinnati, where I began work at Procter & Gamble. At P&G, I have worked on polymeric latexes in Corporate Research, and analytical method development for hair styling polymers, and anti-perspirant gels in Beauty Care, which has resulted in three patents. I left R&D in 1998, and spent 5 years as Senior Purchasing Manager - beginning in Beauty Care, where I managed $100 MM of raw materials. I spent three years in Global Information Technology Purchases, where I led the training and development of several internet-based e-sourcing tools, such as reverse auctions and competitive bidding, resulting in a cumulative savings of $35 MM to the company! In 2003, I transferred back to R&D Baby Care, where I am the Lead Analytical Chemist for new product test methods and laboratory information management systems. I am also a certified inclusion trainer and a member of the Asian Pacific American Leadership Team, which allows me to use my passion for organizational excellence to benefit the company. We reside in suburban Cincinnati with our three children, Heather (16), Christopher (13), Nicholas (10), and our golden retriever Shiny (12). I look forward to hearing more about PSE's successes in the future!

Alumni Lecture

Professor John Reynolds, University of Florida, Gainesville, presents PSE Alumni Lecture

Professor John Reynolds (PSE entering class 1980) delivered the first "official" Alumni lecture on April 23, 2004, entitled "*Variable Band Gap Conjugated Polymers: Controlled 'Color' States*". John is both Chemistry Professor and Associate Director of the Center for Macromolecular Science and Engineering, at the University of Florida Gainesville. A native Californian, John obtained a B.S. in Chemistry at San Jose State University (1979), followed by a Master's (1982) and Ph.D. (1984) in PSE. While at UMASS, John's research was co-advised by Professors Frank Karasz and James Chien in PSE, along with Professor Peter Lillya in Chemistry. John's research at UMass touched a number of topics, including the electronic properties of poly(*para*-phenylene vinylene) oligomers, the electronic and electrochemical properties of polyacetylene, and the synthesis and characterization of poly(metal tetrathiooxalates). John went on to develop his own research program, first in the Department of Chemistry at the University of Texas, Arlington (1984-1991), and now at the University of Florida, where he supervises a very active group in the area of conjugated polymers, especially oligothiophenes, for electronic and display applications.

Professor John Reynolds (bottom right) and his research group at the University of Florida, Gainesville.

PSE Awards & Recognition

PSE students and faculty have received a number of well-deserved awards in recent months, many of which are listed below. Alums, please note that we would like to add an Alumni Awards & Recognition section in future Magazines, and we ask that you keep us informed so we can advertise your accomplishments!

Student Awards

Julie Leiston-Belanger (3rd year, T. Russell)
IBM Graduate Student Fellowship (2004-2005)

Dr. Ting Xu (Ph.D. 2004 with T. Russell)
2003 Materials Research Society Graduate Award

Rui Hong (4th year, T. Emrick and V. Rotello (Chem))
Poster Award at the 2004 UMASS Amherst Chemistry Symposium

Matthew Kade (Junior, Chemistry Major, T. Emrick)
Poster Award at the 2004 UMASS Amherst Chemistry Symposium

Qingling Zhang (3rd year, T. Russell & T. Emrick)
Santos Go Award

Habib Skaff (4th year, T. Emrick)
Excellence in Polymer Chemistry Award Symposium Speaker, American Chemical Society POLY Division (Philadelphia ACS Meeting, August 2004)

Manuel Garcia-Leiner (4th year, A. Lesser)
PerkinElmer Instruments Graduate Scholarship

Ticora Jones (4th year, G. Tew)
Ford Foundation Travel Grant

Faculty Awards

Greg Tew
- Presidential Early Career Award
- DuPont Young Investigator Award

Al Crosby
- National Science Foundation CAREER Award: "Adhesion of Patterned Polymer Interfaces"
- CUMIRP Exploratory Research Award: "Topographically Tuning Polymer Adhesion"

Todd Emrick
University of Massachusetts Commercial Ventures & Intellectual Property (CVIP) Development Award for work towards commercialization of polymer microcapsules

Richard Farris
Recipient of two Army Awards (Natick Soldier Center) for Electrospinning and Balistic Shields

Thomas Russell
- The Dutch Polymer Award from The Dutch Polymer Society for outstanding accomplishments in polymer science.
- Named "Distinguished University Professor" of the University of Massachusetts Amherst

Maria Santore
Named to the Editorial Boards of the ***Journal of Colloid & Interface Science*** *and* ***Langmuir***

From the graduate student PSE Club

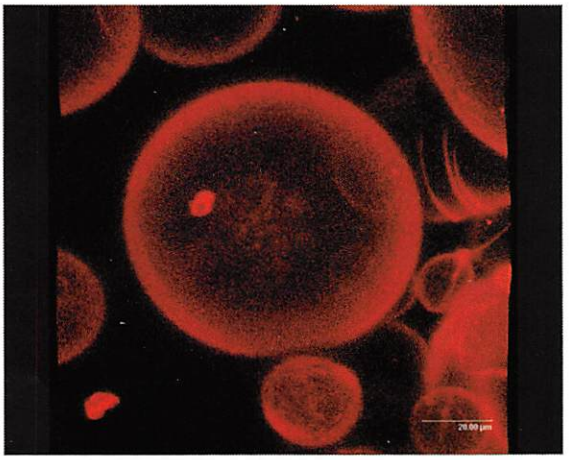
Remember your graduate days in PSE….the joy of science, intramural sports, informal gatherings, picnics, and the annual holiday party. You survived the first year classes with help from the older and sometimes wiser graduate students. Ah, cumulative exams and the post-cume evenings… those were the times. Today, the PSE club, an organization run for and by the PSE graduate students, sponsors and organizes all of these activities (except for the cumulative exams, of course). In addition, we organize the *MRSEC-sponsored Outreach* and *ASPIRE* activities that target K-12 students to help generate their enthusiasm for science in general, and polymers in particular. We also help organize the *Excellence in Polymer Education Program*, also known as $(EP)^2$, a program designed to build professional skills and prepare students for life after PSE. The PSE Club would like to enlist your support, both professionally and financially, in these endeavors. We are always looking for speakers eager to share their insight at $(EP)^2$ events. We would be most pleased to hear from Alumni, and we especially encourage your participation in $(EP)^2$ events. Please contact CUMIRP director Jim Capistran (capistran@polysci.umass.edu) for more information about $(EP)^2$. We also encourage you to visit our website, www.pse.umass.edu/students/club.html for updates concerning the missions and activities of the PSE Club.

PSE Club Officers (left to right): Peter Walsh, Ticora Jones, Melissa Light and Kevin Wier

PSE Graduate Student Research

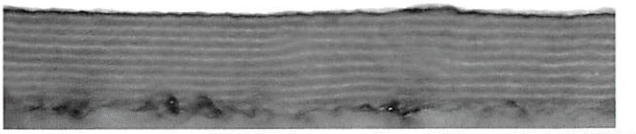
PSE Ph.D. candidates Habib Skaff & Ting Xu are highlighted for their excellent research efforts in the areas of polymer nanostructures and composite materials. Habib Skaff, currently a fourth year student with Professor Todd Emrick, has studied the surface functionalization chemistry and interfacial assembly of quantum dots. Habib will present his work, as one of seven lectures chosen by the POLY Division of the American Chemical Society, in the Excellence in Graduate Polymer Research Symposium at the Philadelphia ACS Meeting in August 2004. Ting Xu recently finished her thesis work in Professor Thomas Russell's group, working in the area of microdomain orientation in polymer thin films. Ting was the recipient of a University of Massachusetts graduate school fellowship in 2002, and also received a Materials Research Society (MRS) graduate student award in 2003. She is now engaged in postdoctoral studies at the University of Pennsylvania and the National Institute for Standards and Technology (NIST).

Habib Skaff. **My research has focused on the** surface functionalization of CdSe nanocrystals, also known as quantum dots, to enable their dispersion, organization, and assembly in a variety of environments, especially in polymer materials. Quantum dots hold enormous technological potential as components of light emitting materials for sensors, displays, and fluorescent bio-tags, but critical to quantum dot chemistry is a tailoring of the surface to prevent classic problems of colloidal aggregation, as well as to enable dispersion and self-assembly in polymer thin films, in fluids, and in templated materials. My work has focused on organic ligand encapsulants for quantum dots that provide a means by which polymerization chemistry can be performed radially outward from the quantum dot surface. I have found that CdSe nanocrystals are compatible with two extremely useful polymerization techniques, namely Ring Opening Metathesis Polymerization (ROMP), and Reversible Addition Chain-Transfer Fragmentation (RAFT). This gives access to quantum dot dispersion in a very wide variety of polymer materials, from polyolefins to vinyl polymers including those that can be used in self-assembly. Further studies with my classmate ***Yao Lin*** (4th year, T. Russell) have focused on the assembly of quantum dots at fluid-fluid interfaces. I have been especially interested in using *functionalized* quantum dots in these interfacial assemblies, which allows for their interfacial cross-linking, and thus the preparation of ultrathin films of quantum dots or other kinds of nanoparticles, as shown below in the confocal micrograph.



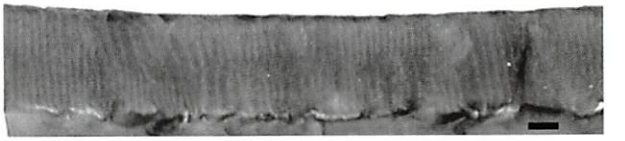
Scanning fluorescent confocal micrograph of cross-linked capsules of fluorescent quantum dots.

Ting Xu. **Block copolymer thin films are used as** templates and scaffolds for nanostructured materials. Control of microdomain orientation is crucial for these studies, and applied electric fields have proven to be one of the most effective methods for controlling orientation in polymer thin films. My research in PSE focused on mechanisms by which diblock copolymer microdomains are oriented in thin films under an electric field. This included a quantitative investigation of the effect of interfacial interactions, film thickness and ionic impurities on microdomain orientation, using both symmetric and asymmetric diblock copolymers. We found that in the presence of trace ionic additives, such as lithium ions, the electric field induces orientation much more effectively. This finding opened a new route for controlling microdomain orientation in diblock copolymer thin films, especially in systems where the two blocks possess similar dielectric constants. These studies were complemented by a study on electric field induced disordered sphere-to-cylinder transition in diblock copolymer thin films, and a new route to control the three dimensional microdomain orientation by use of orthogonal external fields. Since my dissertation defense in February 2004, I began a postdoctoral position on the *Cold Neutron for Biology and Technology* (CNBT) team, a collaborative effort between NIH, NIST, the University of California Irvine and the University of Pennsylvania. I hope I will bring polymer expertise into the biological world to gain better understanding of nature and take advantage of biological systems to assemble amazing nano-systems. In the future, I look forward to a career of academic research and education.



Above: Cross-sectional TEM image of a ~300nm PS-*b*-PMMA thin film annealed under ~40V/μm electric field. The copolymer has less than 1 ppm lithium and the interfacial interactions cannot be overcome.

Below: Cross-sectional TEM image of a ~300nm PS-*b*-PMMA thin film annealed under ~40V/μm electric field. The copolymer has 210 ppm lithium and complete alignment could be achieved regardless of the strong interfacial interactions.



Thanks to PSE Alumni Contributors!!!

We are extremely grateful for your financial contributions, including corporate matching funds. The most recent contributors are listed below, and we encourage you to join your fellow Alums!

$1,000-$5,000
Jim Capistran ('81)

$500-$999
An-Lou Chang ('78)
John Warakomski ('79)

$100-$499
Robert C. Bening ('86)
Douglas Cywar ('83)
Rosanna Falabella ('75)
Lorelle Pottick Gantt ('81)
Elbert Huang ('95)
Wendy Petka ('92)
John Reynolds ('80)
Kristi Kiick ('96) & Rick Beyer ('94)

Online Updates/Contact Info

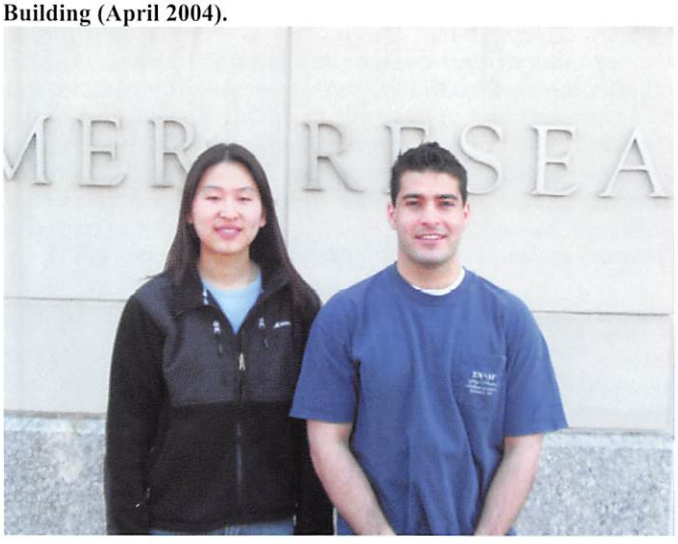
We are grateful to have received many responses to the PSE Alumni link www.pse.umass.edu/alum. Email addresses are especially welcome as this is the weakest part of our current database. We would also encourage you to spread the word among your fellow alums so that we may keep our database as up-to-date as possible! Aside from the online system, feel free to contact us by phone or email with your questions and suggestions. Todd Emrick (tsemrick@mail.pse.umass.edu, 413-577-1613); Jim Capsitran (cumirp@polysci.umass.edu, 413-577-1518); Jennifer Farner (jfarner@mail.pse.umass.edu, 413-545-2236).

Fall 2004 preview

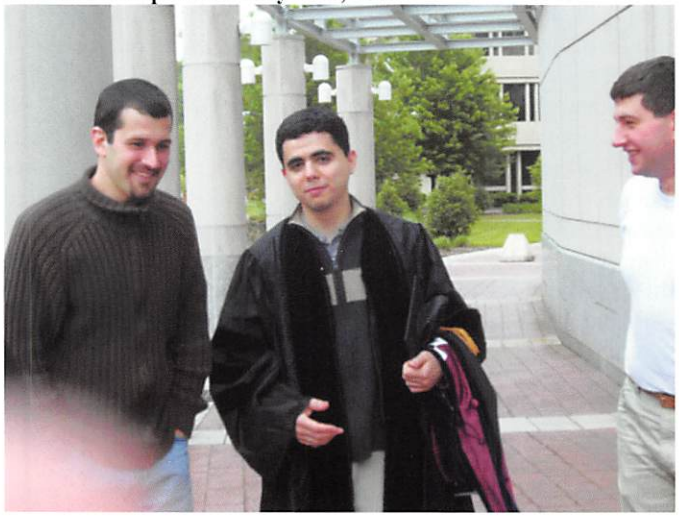
The Fall 2004 PSE Magazine will highlight recent additions to PSE, including new facilities directors, including Dr. Ted Atkins (MRSEC X-ray characterization facility), Dr. Evgenia Pekarskaya (MRSEC-Keck electron microscopy facility) and Dr. Sekar Thirunavukkarasu (MRSEC-Keck Nanostructures Laboratory).

Thanks to Eugene Kolnick, Andrea Skwirz, Caitlin Capistran, Jennifer Farner, and Ann Brainerd for their help with this Magazine and the Alumni mailing list!

Dr. Ting Xu and Habib Skaff, pictured in front of the Conte Building (April 2004).



New PSE Alum Javid Rzayev (middle) pictured with PSE students Firat Ilker (left) and Misha Kozlov (right) at the PSE Graduate reception on May 15th, 2004.



New PSE Alums Dr. James Goldback (left) and Ting Xu at the PSE Graduate reception.

UMASS Amherst Polymer Science & Engineering
FALL 2004 SEMINAR SERIES

(titles are TBA, and the completed schedule will be available soon on the seminar page at www.pse.umass.edu)

September 10	*Professor Karl Freed* *Department of Chemistry* *The University of Chicago*
September 17	*Professor Richard Parnas* *Chemical Engineering Department* *University of Connecticut*
September 24	*Jan Genzer* *Department of Chemical Engineering* *North Carolina State University*
October 1	*Professor Sanford Sternstein* *Materials Science & Engineering Department* *Rensselaer Polytechnic Institute*
October 8	*CUMIRP Week*
October 15	*Professor Orlin Velev* *Department of Chemical Engineering* *North Carolina State University*
October 22	*Professor Judy Riffle* *Department of Chemistry* *Virginia Polytechnic Institute & State University*
October 29	*Professor Eric Simanek* *Department of Chemistry* *Texas A&M University*
November 5	*Professor Uli Wiesner* *Materials Science & Engineering Department* *Cornell University*
November 12	*Professor George Newkome* *Department of Polymer Science* *University of Akron*
November 19	*Professor Anne Mayes* *Department of Materials Science & Engineering* *Massachusetts Institute of Technology*
November 26	*Thanksgiving Week -- no seminar*
December 3	*Dr. Karen Trentleman* *Detroit Institute of Arts*
December 10	*Professor Sanjeeva Murty* *Department of Physics* *University of Vermont*