

MSE News

SPRING 2012

*The Newsletter of the Department of
Materials Science and Engineering*



The Newest Faces of the Second Decade in Materials Science & Engineering

Front row: John E. Allison, Emmanuelle A. Marquis, Akram Boukai.
Back row: Emmanouil S. Kioupakis, Anish Tuteja, Pierre Ferdinand Poudeu-Poudeu.

To read about their background and research, visit: <http://www.mse.engin.umich.edu/people/faculty>

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Dear Alums & Friends:

Enrollments in our undergraduate and graduate programs continue to grow and the size of our graduating classes at the bachelor and doctoral levels continue to increase. This past year the largest number of students, fifty, graduated with BSE degrees. We also welcomed the largest class of students into our graduate program, thirty-nine, during Fall 2011. The number of applicants to our graduate program has continued to increase each year for the past three years and, most recently, totaled over 500. Our graduate program is now the largest that it has been in years. Our assessment by the Accreditation Board for Engineering and Technology (ABET) occurred in September; it went extremely well. There were no deficiencies or concerns; the report also highlighted a number of strengths in our program including the curriculum and the “undergraduate community spirit.” Professor Steve Yalisove, who was responsible for organizing the department’s efforts in preparation for this visit, has written a brief summary of the visit for our newsletter. Below I provide an update on new developments and activities in the department.

It is interesting to note that the most recent recipients of BSE degrees in Materials Science and Engineering differ from those of prior generations. Most of them were engaged in entrepreneurial activities, either through a course in the department and/or through participation in extra curricula activities, during their tenure here at the university. This year our seniors had an opportunity to take an expanded version of the senior design course MSE 489. This course, co-taught by Associate Professor Max Shtein of our department in collaboration with faculty from Art and Design and Architecture, is the most highly rated interdisciplinary course offered by the university. The curriculum included a significant entrepreneurial component. This past year a group of seniors, enrolled in the undergraduate capstone design course (MSE 480) taught by Professor John Halloran, competed nationally. Their project was based on a lightweight bumper system for a high performance vehicle. We are also pleased to mention that MSE students were among a very small and select group of students who were recognized for noteworthy entrepreneurial accomplishments by the college and the university.

The news regarding faculty accomplishments are particularly exciting this year. Professor Sharon Glotzer was elected to the American Academy of Arts and Sciences. Sharon is the first

MSE faculty member to receive this honor, and one of only two members of the Michigan faculty to be elected this year. Professor John Allison was elected to the National Academy of Engineering; he was recognized for contributions to automotive casting technology and computational materials engineering. Assistant Professor Anish Tuteja was awarded the Air Force Young Investigator Award, bestowed on the most creative young scientists. Associate Professor Anton Van der Ven was promoted to the rank of Associate Professor.

We also welcomed new members of our faculty. Assistant Professor Pierre Ferdinand Poudeu-Poudeu, an inorganic chemist whose research is in the area of thermoelectrics, became a member of the MSE faculty September 2011. His work is directed toward the design and discovery of new high efficiency thermoelectric materials. Assistant Professor Emmanouil Kioupakis, a condensed matter theorist, also joined our faculty in September 2011; his research revolves around understanding fundamental mechanisms responsible for energy conversion in photovoltaics and solid state light emitters. While both Assistant Professors Emmanouil Kioupakis and Ferdinand Poudeu-Poudeu are at early stages of their careers, they are widely recognized for original and fundamental contributions in the area of energy conversion.

The University of Michigan was awarded a \$13-million National Science Foundation Materials Research Science and Engineering Center (MRSEC) to develop new materials that manipulate light in new ways that would potentially enable advances such as invisibility cloaks, nanoscale lasers, high-efficiency lighting, and quantum computers. MSE faculty Sharon Glotzer, Rachel Goldman, and Joanna Mirecki Millunchick, are collaborating with faculty across the university in this endeavor. A brief overview of the research and educational activities in this center is provided in this newsletter. Also appearing in this newsletter is a brief overview, by John Allison, of The University of Michigan’s activities that will contribute to the Materials Genome Initiative (MGI) and the Advanced Manufacturing Partnership, announced last year by President Barack Obama. The University of Michigan faculty members, Professor John Allison, Professor Sharon Glotzer and former MSE faculty member Professor Tresa Pollock played a key role in developing the foundation that enabled this initiative which has the goal “to discover, develop, manufacture, and

deploy advanced materials at twice the speed than is possible today.”

This newsletter includes a number of articles on select scientific advances made by faculty in the department. One article includes the design and synthesis of the world’s first organic phosphorescent material by Associate Professor Jinsang Kim’s research group. The research from Professor John Kieffer’s group, in collaboration with a group from Taiwan, for the computational design and synthesis of an organic material that exhibits the world’s highest efficiency fluorescence. Reporting work from the Professor Xiaoqing Pan group, published in *Science*, on a discovery regarding mechanisms of ferroelectricity and at the nanoscale; this discovery may enable

the development of these materials for memory applications.

Finally, you will also learn about what Professor Emeritus Wilbur Bigelow has been doing since his retirement nearly 20 years ago. I was quite fascinated, and I am certain that you will be as well.

Go Blue!



Peter Green

New Faculty



Pierre Ferdinand Poudeu-Poudeu joined the Department as an assistant professor in 2011.

Poudeu studied chemistry at the University of Yaounde-I in Cameroon and earned his doctoral degree in inorganic solid-state chemistry from the Dresden University of

Technology in Germany in 2004. He held postdoctoral research positions at Michigan State University and Northwestern University and subsequently served as an assistant professor of chemistry and materials science at the University of New Orleans (UNO).

For more information on Assistant Professor Pierre Ferdinand Poudeu-Poudeu, please visit:

<http://www.mse.engin.umich.edu/people/faculty/poudeu>



The MSE Department welcomes Emmanouil (Manos) Kioupakis, who has joined the faculty as an assistant professor in 2011.

Kioupakis uses parallel first-principles computational methods and high-performance computing to study the structural, electronic and optical properties of materials at the atomic scale.

For more information on Assistant Professor Manos Kioupakis, please visit:

<http://www.mse.engin.umich.edu/people/faculty/kioupakis>

Lighting Up Organic Phosphors

Jewel-toned organic phosphorescent crystals: A new class of light-emitting material

Pure organic compounds that glow in jewel tones could potentially lead to cheaper, more efficient and flexible display screens, among other applications. The University of Michigan Associate Professor Jinsang Kim and his colleagues have developed a new class of material that shines with phosphorescence—a property that has previously been seen only in non-organic compounds or organometallics.

Kim and his colleagues made metal-free pure organic crystals that are white in visible light and radiate blue, green, yellow and orange when triggered by ultraviolet light. By changing the materials' chemical composition, the researchers can make them emit different colors.

“Purely organic materials haven't been able to generate meaningful phosphorescence emissions. We believe this is the first example of an organic that can compete with an organometallic in terms of brightness and color tuning capability,” said Kim.

In Kim's phosphors, the light comes from molecules of oxygen and carbon known as “aromatic carbonyls,” compounds that produce phosphorescence, but weakly and under special circumstances such as extremely low temperatures. What's unique about these new materials is that the aromatic carbonyls form strong halogen bonds with halogens in the crystal to pack the molecules tightly. This arrangement suppresses vibration and heat energy losses as the excited electrons fall back to the ground state, leading to strong phosphorescence. The new phosphors exhibit “quantum yields” of 55 percent. Quantum yield, a measure of a material's efficiency and brightness, refers to how much energy an electron dissipates as light instead of heat as it descends from an excited state to a ground state. Current pure organic compounds have a yield of essentially zero.

Organic light emitting diodes are lighter and cheaper to manufacture than their non-organic counterparts, which are made primarily of ceramics. Today's OLEDs still contain small amounts of precious metals, though. These new compounds can bring the price down

even further, because they don't require precious metals. This new method also offers an easier way to make high-energy blue organic phosphors, which are difficult to achieve with organometallics.

“This is in the beginning stage, but we expect that it will not be long before our simple materials will be available commercially for device applications,” Kim said. “And we expect they will bring a big change in the LED and solid-state lighting industries because our compounds are very cheap and easy to synthesize and tune the chemical structure to achieve different colors and properties.”

This work entitled “Activating efficient phosphorescence from purely organic materials by crystal design.” was recently published in *Nature Chemistry* and featured as the journal cover. The paper has been highlighted in many news media including *C&EN News of the Week*, *RSC ChemistryWorld News*, *SPIE Newsroom*, *EE Times*, and *ScienceDaily*. The university is pursuing patent protection for the intellectual property, and is seeking commercialization partners to help bring the technology to market.

The Future of Display Technology

OLEDs are the next generation display technology. They are already used in TVs, cell phones, computers, and they are candidates for a vast array of light sources from advertising billboards to indoor and outdoor illumination. In organic molecular materials, predominantly two light emission mechanisms are encountered: fluorescence and phosphorescence. Fluorescent OLEDs typically are less efficient at emitting light per unit area than phosphorescent ones, because triplet states are not accessible in the former. Based on simple statistics, the higher spin multiplicity is expected to result in three times higher emission efficiency in phosphorescent than in fluorescent OLEDs. Nevertheless, fluorescent OLEDs have certain advantages, such as longer chemical stability, the ability to accommodate higher

current densities, better color definition, and lower materials cost.

Considering other factors, the theoretical limit for fluorescent light emission efficiency has long been believed to be about 5%. However, that has changed after a team comprised of Professor John Kieffer and his graduate student C.G. Zhen of the Department of Materials Science and Engineering, and collaborators Y.F. Dai, W.J. Zeng, Z. Ma and Z. Chen from the Institute of Materials Research and Engineering in Singapore released findings in the journal “Advanced Functional Materi-

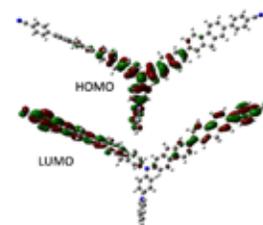


Figure 1: Ball and stick representation of the oligofluorene molecule that yielded record emission efficiency showing the highest occupied (HOMO) and lowest unoccupied molecular orbitals (LUMO) localized on the donor and acceptor groups, respectively.

Watching a Next-Gen Switch into Real Time

The continuing demand for increased memory capacity, performance, and efficiency has driven a strong interest in ferroelectric materials. Using atomic resolution Transmission Electron Microscopy (TEM) with a unique in situ scanning probing holder Professor Xiaoqing Pan and his colleagues have succeeded in observing the nanoscale switching process between ferroelectric memory states in real-time. Their work, published in the Nov. 18, 2011, edition of *Science*, highlights the direct visualization of the operation of ferroelectric memory and the findings of new phenomena in the nucleation and switching of ferroelectric domains under applied electric field in real time.

Ferroelectric materials, which have a rewritable electric rather than a magnetic dipole, which can offer greater storage capacity than magnetic media, faster writing speed, and longer lifetimes than flash memory. Unlike the CMOS or DRAM memory used in contemporary computers, ferroelectric memory is nonvolatile, which doesn't require power to retain data. Replacing or incorporating ferroelectric materials into these low-level memories can provide a substantial decrease in energy usage in computers – especially while idle.

The ability of an electric field to switch the spontaneous polarization in a crystal between energetically degenerate orientation states is the defining characteristic of a ferroelectric material. This provides the underlying storage mechanism in an important class of nonvolatile memories. The switching of the spontaneous polarization occurs via the nucleation and growth of favorably oriented domains through a highly inhomogeneous process, whereby local variations in free energy caused by defects dominate switching kinetics. Macroscale ferroelectric switching models aggregate this behavior, but an understanding of the role of defects and boundary conditions is necessary in order to engineer ferroelectric devices, including mollifying fatigue, imprint, and aging effects and to scale devices down to the size of the defect spacing where a statistical treatment is not applicable.

To image the domain nucleation and growth process at the nanoscale, the research team led by Professor Pan incorporated a surface scanning probe within a

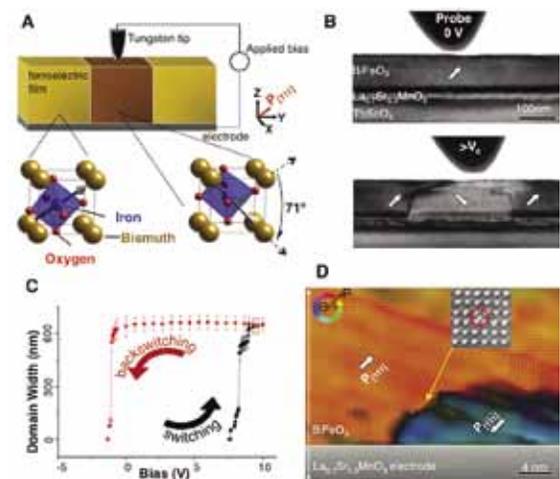


Figure 1: Nanoscale polarization switching of a ferroelectric thin film within a TEM. (A) Local 71° switching of BiFeO₃ is induced using a voltage probe. The switched region is imaged directly (B) and the domain area can be used to create nanoscale versions of classic polarization vs. field hysteresis loops (C). (D) Polarization mapping of atomic-resolution images identifies a separate 180° switching event at the interface.

TEM. Applying a bias between the probe and a conducting layer beneath a BiFeO₃ ferroelectric film induces a local reorientation of the polarization (shown schematically in Fig. 1A and experimentally in 1B). This process can be imaged directly in real-time and used to derive polarization versus electric field hysteresis loops at the nanometer scale, which is inaccessible to electrical measurements (Fig. 1C). In the prominent multiferroic BiFeO₃, which

Continued on page 6

als" that unequivocally surpassed this barrier. Kieffer and his collaborators have produced fluorescent OLEDs with close to 10 percent efficiency.

This was accomplished by redesigning a material that was previously utilized by Professor John Kieffer's collaborators in Singapore. Using computer simulation-based predictive design, Professor John Kieffer and his student revised an improved molecular blueprint for the device material. By adding specific functional groups to molecular sites in a systematic way, and by predicting the optoelectronic properties of these new concept molecules using first-principles quantum mechanical calculations, they identified the mechanisms that control the performance of OLEDs. Using this approach they methodically advanced to the optimum molecular design (Fig. 1) for improved materials performance. Based on these new blueprints the experimental col-

laborators realized a device that yielded 9.4% external quantum efficiency (Fig. 2), a new world record for fluorescent OLEDs.

John Kieffer's research is significant in two respects: First, it demonstrated the effectiveness of simulation-based predictive design; it allows one to narrow the choice of candidate materials before high-cost and time-consuming synthesis of materials is attempted in the laboratory. Second, the results clearly supersede the previously believed theoretical efficiency limit for fluorescent light emission, thus providing new incentives for research and new optimism for the development of more energy efficient lighting technologies.

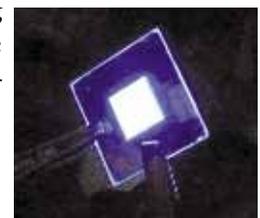


Figure 2: Blue light emission from the OLED device fabricated by collaborators in Singapore

New MRSEC: Center for Photonic & Multiscale Nanomaterials

New NSF center explores new ways to manipulate light at the nanoscale

A new \$13-million National Science Foundation center based at The University of Michigan will be developing high-tech materials that manipulate light in new ways. The research could enable advances such as invisibility cloaks, nanoscale lasers, high-efficiency lighting, and quantum computers.

The Center for Photonic and Multiscale Nanomaterials (C-PHOM), involves Materials Science and Engineering (MSE) faculty and students in collaboration with others from The University of Michigan, College of Engineering and College of Literature, Science, and the Arts as well as close collaborators at Purdue University and several other institutions. Furthermore, under the leadership of C-PHOM Education Director and MSE Professor Rachel S. Goldman, C-PHOM is engaged in an ambitious educational outreach program aimed at bringing high school students from Southeast Michigan to participate in C-PHOM research, followed by participation in regional, state, and national science fair competitions. The publicity generated by high school student participation in science fairs is expected to increase public awareness and interest in science, technology, engineering, and mathematics (STEM) in the region, state, and nation!

Photonics is the study and use of light to transmit and store information, as well as to image things humans cannot see with unaided eyes. Photonics provides the high-speed backbone of the Internet through fiber optics. It serves as a ubiquitous tool for medical imaging. And it enables the study of the most exotic ideas in quantum physics, such as entanglement and quantum computing.

The center has two thrusts. One group will focus on improving

“wide bandgap semiconductors” such as gallium nitride, which could make possible quantum emitters that release one photon, or light particle, at a time and could advance quantum computing and quantum information processing.

Quantum computers could vastly improve computer security. They could theoretically factor numbers dramatically faster than conventional computers, they could allow for the creation of fool-proof security codes. This research thrust also has applications in high-efficiency lighting and imaging. Participants in this group include MSE Professors Rachel S. Goldman and Joanna M. Mil-lunchick.

A second group of researchers will develop better metamaterials, uniquely engineered mixtures of substances that enable scientists to make light act in ways it does not behave in nature. For example, metamaterials make it possible to focus light to a speck smaller than its wavelength. They could potentially be used to bend light around objects, making them invisible. They could also bring about “ultra subwavelength imaging” to see inside biological cells with unprecedented resolution. Participants in this group include MSE Professors Sharon C. Glotzer and Nicholas Kotov.

The C-PHOM Education program aims to enhance the recruitment and retention of a diverse student population in science via focused research-related educational activities. For undergraduates, the center will expand upon the successful international research experiences for undergraduates (i-REU) program, “Optics in the City of Light”, developed by MSE Professor Steve Yalisove. The center will also develop an on-site research experience for the undergraduate (REU) program, and a new research program for high school students within 50 miles of Ann Arbor.

Real Time, Continued from page 5

esses both ferroelectric and magnetic properties, the nucleation of ferroelectric domains occurs at a different site than expected, the bottom interface, and this switching can be sparked with a lot less power than they had hypothesized. Both of these behaviors result from built-in electric fields created by a Schottky junction formed between the BiFeO₃ film and bottom electrode. Furthermore, the atomic scale polarization mapping by aberration corrected TEM revealed a heretofore unknown near-interface 180° switching at the bottom ferromagnetic electrode (Fig. 1D). This finding is

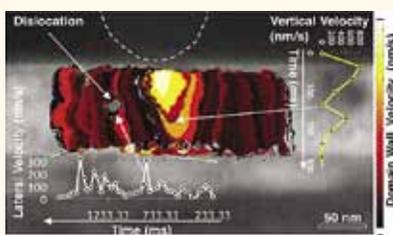


Figure 2: Domain wall velocity for 180° switching of a PbZr_{0.2}Ti_{0.8}O₃ (PZT) film. Two distinct pinning events are observed, one in the early vertical expansion and one in the lateral expansion as the left-side domain wall passes through a dislocation.

significant for such multiferroic structures since 180° switching does not couple across the ferroelectric/ferromagnetic interface.

Using the similar techniques the ferroelectric switching in a PbZr_{0.2}Ti_{0.8}O₃ (PZT) film, which is a key material for nonvolatile ferroelectric memories, was also studied. It was found that the intrinsic electric fields formed at interfaces and defects determine the nucleation sites, growth rates of domains, and the orientation and mobility of domain walls (Fig. 2). These studies also show that localized 180° polarization switching initially forms domain walls along unstable planes due to the inhomogeneous electric field from the small switching electrode. After removal of the external field, they tend to relax to low energy orientations. In sufficiently small domains this process results in complete backswitching. These findings suggest that even thermodynamically favored domain orientations are still subject to retention loss, which must be mitigated by overcoming a critical domain size.

The Materials Genome Initiative @ Michigan

The U.S. President Barack Obama, announced the Materials Genome Initiative (MGI) along with the Advanced Manufacturing Partnership earlier this year. The aim of MGI is “to discover, develop, manufacture, and deploy advanced materials at twice the speed than is possible today.” This initiative will develop integrated computational tools, experimental tools and a materials information infrastructure to enhance US competitiveness in development of advanced materials and manufacturing.

On December 11, 2011, an MGI Workshop was hosted by The University of Michigan in conjunction with a Regional Workshop on the Advanced Manufacturing Partnership. A keynote by Dr. Cyrus Wadia of the White House Office of Science and Technology Policy provided an overview of the MGI to an audience of nearly 100 attendees. The initiative began with a \$100M appropriation in Fiscal Year 2012 and is anticipated to be a ten year initiative. Dr. Wadia stressed that, in addition to technological and scientific advances, accomplishing the goals of MGI will require a shift in the manner in which research is accomplished, moving from performing as individual researchers to being part of a powerful research network collectively using and analyzing data developed by the broader community.

Dr. Charles Ward, Chief of the Metals and Ceramics Division of the U.S. Air Force Materials Directorate, provided an overview of a major MGI initiative at the Materials Directorate

called Integrated Computational Materials Science and Engineering (ICMSE). According to Dr. Ward, ICMSE has become a central pillar for all research conducted by this major DOD laboratory as well as a major external initiative in metals and polymer composites.

A high point of the workshop was industrial participation, which included a talk from Dr. Robert Schafrik, General Manager of Materials Research at General Electric Aviation, and a panel of industry leaders including Dr. Jerry Young, Director of Materials & Fabrication at Boeing Aerospace Corporation, Dr. Matt Zaluzec, Senior Technical Leader in Materials & Manufacturing, Ford Motor Company and Dr. Mary Lee Gambone, Head of Materials Engineering, Rolls-Royce Corp. This panel provided an important perspective on the needs of industry and opportunities for academic researchers. According to Dr. Schafrik, “Integrated Computational Materials Engineering (ICME) is the way of doing business now and there’s no turning back”.

Finally, a number of faculty within the College of Engineering provided an overview of the current ICME and computational materials science efforts at The University of Michigan. This included presentations by John Allison, Katsuyo Thornton, Anton Van der Ven and John Kieffer from MSE and Veera Sundaraghavan from Aerospace Engineering.

In other MGI news, The University of Michigan has been awarded one of the first major MGI-funded programs. A \$3.2M Office of Naval Research Basic Research Challenge grant was awarded to a cross-functional team of faculty in MSE, Mechanical Engineering and Aerospace Engineering. The Principal Investigator for this grant is Professor John Allison, from the department of Materials Science and Engineering.

The core concept of this major program will be the development of computationally efficient reduced order random field descriptors, which capture microstructural and property information. These descriptors will be linked with manufacturing process simulations to provide a capability for predicting the influence of processing history on microstructural evolution and properties and for the optimization of manufacturing processes.

Poster Session

Materials Science and Engineering will sponsor an annual Materials Research Poster Session and Contest open to all undergraduates, graduate students and postdoctoral fellows engaged in research projects with MSE faculty.

The inaugural event will be held in early Fall 2012, and is intended to be an integral component of our continuing efforts to build and maintain a vibrant materials research com-

munity within our department. It will also help to communicate the quality and achievements of our excellent students and postdoctoral fellows who are engaged in a very diverse portfolio of cutting edge research.

An announcement of the venue and dates will be posted on the MSE website in the future at <http://www.mse.engin.umich.edu/>

SmartSurfaces Class Update

SmartSurfaces is a “multidisciplinary, hands-on, think-tank” – a cross-disciplinary studio course that is team taught by professors from different university units (Art and Design, Materials Science & Engineering and Architecture).

Twenty-four students are accepted into the course, divided into four teams of six, with a roughly equal number of students on each team from each unit. The twenty-four students and three professors meet once a week for six hours, while the teams continue to meet outside of class to work on their projects, designing and building within a specified budget physical systems and structural surfaces that have the capability to adapt to information and environmental conditions. All three professors attend each class period, advising, critiquing and contributing to all team projects.



Left to right: Payton Spaller (MSE), Micaela McCabe (A&D), and Maria Galarza (Arch), members of a SmartSurfaces team, testing out their multifunctional, heated, lighted, interactive floor mat and pillows during the final project review at the PowerHouse in Hamtramck, Detroit.

The course has been offered three times (Fall 2009, 2010 and 2011), with the latest edition focusing on a collaboration with the PowerHouse Project (www.powerhouseproject.com) – an off-the-grid house in Detroit that hosts artists-in-residence from around the world, working on neighborhood rejuvenation projects, concepts of energy independence and efficiency, community-building, and related issues.

The course has been featured in several online and print publications, serving as inspiration to several similar initiatives at universities in the United States and worldwide. The instructors, Assistant Professor John Marshall (A&D), Associate Professor Karl Daubmann (Arch), and Associate Professor Max Shtein (MSE) have been collecting their observations, giving lectures and writing academic manuscripts describing the central concepts behind the initiative, the process and outcomes of this highly interdisciplinary, collaborative, and atypical educational experience.

For more information and sponsorship opportunities, please contact:
Max Shtein (mshtein@umich.edu)

Teacher's Camp

2011 marked the tenth anniversary for the ASM Teacher's Camp hosted by the Department of Materials Science and Engineering at The University of Michigan. This week-long camp gives K-12 teachers from across the country an intense exposure to materials and how to integrate them into their classroom curriculum. Teachers who previously attended the year one camp were invited back and exposed to an even deeper understanding of the materials that surround them. While the year two camp was a huge success, we will return to the year one format in 2012 to continue to spread materials science concepts into as many K-12 classrooms as possible.



Pouring molten metal at Joyworks Studio under the supervision of owner/alum John Keough.

Michigan Clean Energy Venture Challenge

The University of Michigan Arbor Solar Technologies Team



Receiving a \$5,000 award at the Michigan Clean Energy Venture Challenge. They are standing with DTE Energy vice president Knut Simonsen (left) and Bob Lutz, retired vice chairman of GM. Friday, Feb 17, 2012 at Blau Auditorium at U-M The Ross School of Business.

Photo by Marcin Szczepanski/University of Michigan, COE Multimedia Producer

The members of the team from left to right are:

Allessandra McGinnis, John Strader, Tyler Austin, James Detelefs, Ashwin Betrabet, and Eric Jones.

The University of Michigan Team M-Wrap

Accepting a \$5,000 award at the Michigan Clean Energy Venture Challenge. They are standing with DTE Energy vice president Knut Simonsen (left) and Bob Lutz, retired vice chairman of GM. Friday, Feb 17, 2012 at Blau Auditorium at U-M The Ross School of Business.

Photo by Marcin Szczepanski/University of Michigan, COE Multimedia Producer



The members of the team from left to right are:

Weidong Chen, Shwetha Maddur, Rachel Rademacher, Heather Wilsher, Grace Hsia, and Devon Triplett.

Undergraduate Committee Update

Our undergraduate program now has over 140 students. With the solid establishment of the design sequence, we are now focusing on the third-year laboratory sequence. The sequence is coordinated to develop strong laboratory skill sets and to provide hands-on learning through well-defined lab modules, followed by more open-ended

laboratory experiences that provide real-life engineering training.

With the increase in enrollment, we are planning to purchase additional equipment for the LH Van Vlack Undergraduate Laboratory in order to continue to provide a high-quality educational experience to our undergraduates. For example, funds from the College and the department were used this year to

purchase a tabletop SEM that will be used by our students, at ASM Teachers' Camp, and in our outreach efforts.

Our Undergraduate Committee, chaired by Professor Katsuyo Thornton, has recently established several subcommittees to streamline and accelerate activities. Below are some recent highlights:

The **Undergraduate Experience Subcommittee**, led by Professor Joanna Millunchick, who is also the Michigan Materials Society (MMS) Advisor. Through this double role, she has become the conduit for receiving input from our undergraduate students. Based on input so far, we are working toward providing increased flexibility to pursue courses in business and entrepreneurship. We are also encouraging students to consider engaging in co-ops and study-abroad to expand their experience beyond traditional university education.

The **Continuous Improvement Subcommittee**, led by Professor Steve Yalisove, oversees accreditation and improvements to curriculum. We will be holding a one-day retreat in May to discuss our courses and their outcome.

The **Undergraduate Committee** is working closely with the **Curriculum Committee**, chaired by Associate Professor Max Shtein, which was founded to examine the overall effectiveness of our undergraduate and graduate curricula. Through careful examination, we hope to offer new courses covering today's groundbreaking topics in materials science and engineering, while keeping our core program strong.

ICME Curriculum Development

Classroom Integration of Computational Tools

As computational tools become more reliable and prevalent, engineers of the future must be skilled and comfortable with using these tools. In addition to being a part of continuous improvement, we are one of the first materials science programs to implement computational tools into the undergraduate curriculum.

Last semester, an undergraduate-level special topics course, Computational

Approaches in Materials Science & Engineering (MSE 493), was offered for the first time, which covered a combination of computational methods and tool utilization. The students learned to use MATLAB, Thermo-Calc, and COMSOL in the context of materials science and engineering.

This semester, students in Materials Laboratory II (MSE 365) are also utilizing computational tools along with the experimental laboratory. They are revisiting a cast aluminum alloy they experimented on last semester but now

using Thermo-Calc, and COMSOL simulations will provide them an insight behind the material choice and geometry design for light bulbs that they are studying experimentally.

These tools are also being integrated into graduate courses, including a special topic course and Advanced Mechanical Behavior (MSE 520).

Graduate Committee Update

During the past four years, under the leadership of the Materials Science and Engineering Graduate Chair, Professor Rachel Goldman, the Graduate Committee has set graduate recruiting and continuous improvement of the graduate experience as its top priorities. Continued focus on these areas is planned as the baton is passed to Associate Professor Jinsang Kim by Fall 2012.

Perhaps the most critical factor for recruiting top talent to our graduate program is the timing of the admissions process. Considering that we now receive in excess of 500 applications, this is indeed an onerous task. Thus, we have streamlined application processing, leading to a remarkably quick turnaround time for the PhD admissions. These changes have led to a paradigm shift in our graduate program, with increasing enrollment of students from top schools with record high grades and GRE scores. We are hopeful that this trend will enable the MSE graduate program ranking to continue its upward trajectory.

We have also ramped up recruiting efforts on several fronts. For example, we hosted “alumni & friends” receptions at

the 2009 and 2010 Fall Meetings of the Materials Research Society. In addition, in Fall 2010, Assistant Professor Akram Boukai visited Cooper Union (CU) College, a highly selective undergraduate institution in New York City, to participate in their annual Engineering Graduate School Panel. To follow up, we hosted CU students at the College of Engineering Graduate Symposium and individual visits. Three CU students applied and were admitted to our graduate program, two of whom enrolled in Fall 2011.

During the 2011-2012 recruiting season, we expanded our efforts to establish talent pipelines. In September 2011, we co-hosted a UM booth at the 2011 Joint Annual Conference of the National Society of Black Physicists and the National Society of Hispanic Physicists in Austin, Texas. Professor Rachel Goldman and an MSE Ph.D. candidate, Antonio Osorio, shared the hosting duties with the Director and Program Coordinator of UM Applied Physics, Professor Cagliyan Kurdak and Charles Sutton. In October 2011, Associate Professor Jinsang Kim visited the Rose-Hulman Institute of Technology, a top ranked non-PhD granting engineering

school in Terre Haute, Indiana. He was the invited speaker at their Interdisciplinary Research Collaborative Undergraduate Student Research Symposium. In pursuit of continuous improvement of the graduate experience, several subcommittees have been established:

The Mathematics Abilities subcommittee, led by Associate Professor Anton Van der Ven, is reviewing the need to teach a mathematics course in MSE, in which students would acquire the skills necessary for advanced MSE courses.

The Oral Exam/Candidacy subcommittee, led by Professor Xiaoqing Pan, is reviewing the requirements and policies associated with achievement of candidacy in the MSE graduate program.

The student-faculty matching process subcommittee, led by Associate Professor Jinsang Kim, is reviewing the process by which incoming graduate students are matched with faculty advisors.

The International Partnerships subcommittee, led by Assistant Professor Emmanuelle Marquis, is exploring avenues for enhancing partnerships with overseas institutions, especially those in Europe.

ABET Audit Update

The Materials Science and Engineering Department was visited by ABET this past fall to evaluate our program for accreditation. Our department was recommended for accreditation by the visiting team. The final accreditation action is always performed in the summer following a visit. Our evaluator did not find any shortcomings during our visit. This is the best possible outcome for our department. In fact, his ending comments were:

“...The strong undergraduate community spirit allows this knowledge and experience to pass among all students in the program and results in one of the best overall materials engineering educations in the nation.”

Since there were no shortcomings (deficiencies, weaknesses, concerns, or observations) there will not be any editing of these comments which means that our accreditation is a pro forma conclusion. We will be reevaluated in 6 years, the longest time permitted by ABET. We are very proud of our department and very fortunate that our faculty and staff, as a group, were extremely well prepared for our visit.

2012 CoE Education Excellence Award



Associate Professor Max Shtein has been recognized with the highest teaching award given by the College of Engineering. Associate Professor Max Shtein is an innovative educator who is extremely effective at motivating high school, undergraduate and graduate students to learn and to perform research. He has taught and developed graduate and undergraduate courses that have been well received by the students. Most recently he co-taught a new course with colleagues from the department of Art and Design and the school of Architecture; it has become the most highly rated interdisciplinary course offered by the University. Students in his capstone design course, MSE 489, were recently recognized with awards in the Michigan Clean Energy Venture Challenge competition, in which the Governor of Michigan participated.

Holt Award



Professor Steve Yalisove received the 2011 Jon R. and Beverly S. Holt Award for Excellence in Teaching from the College of Engineering. Professor Yalisove arrived at U of M in 1989 and has taught both graduate and undergraduate courses, developed new courses in thin film science, characterization, and ultrafast materials science. He has also revamped MSE 250/220 several times in the past sixteen years. Professor Yalisove has pioneered many innovations in engineering education including the first use of audience response devices (now called clickers) at the University, development of one of the first web based in-class lectures in 1996, and the first use of screencasts for homework and supplemental lecture material in the department. Currently Yalisove is exploring the use of the inverted classroom in yet another refresh of MSE 220 to be launched in Fall 2012. He plans to completely replace lecture with action based immersive learning experiences (having the students do homework in class) after watching screencast versions of the lecture the evening before. He is also initiating a national effort to develop meaningful metrics for assessing student learning via a senior level materials concept inventory test. This effort will be launched at the MS&T Fall 2012 meeting and will include MRS, TMS, ACerS and the University Materials Council.

ASM Teacher's Camp Board



Keith McIntyre, Materials Science and Engineering's Facility Manager, has been appointed to the ASM Teacher's Camp Committee, whose charge is to advise ASM on what measures are needed to continue delivering important learning experiences for camp participants. As the committee evaluated causes for less than stellar camp performances, it was determined that attendance and facilities were indicators for why some camps failed. McIntyre's role is to advise the committee regarding facility requirements for the various camps held around the country to help guarantee future success.

Faculty Spotlight

National, regional, and local awards continue to recognize our outstanding faculty

John Allison

Honorary Professor at University of Science and Technology Beijing, Beijing, China
 Guest Professor at Shanghai-Jiao Tong University, Shanghai, China
 2011 Morris E. Fine Lecturer, Northwestern University

Richard M. Laine

ACS Division of Polymer Chemistry Fellow

Sharon Glotzer

Elected to the American Academy of Arts and Sciences
 2011 IBM Distinguished Lecturer, Rensselaer Polytechnic Institute
 2012 Maddin Lecturer, University of Pennsylvania

Peter F. Green

Recognized by Physical Review Letters/Physical Review as an "Outstanding Referee." The program annually recognizes 150 of approximately 60,000 active referees from around the world, like Fellowship in the APS, this is a lifetime award.

Nicholas Kotov

2012 College of Engineering Ted Kennedy Family Team Excellence Award

Peter X. Ma

2012 Fellow of Biomaterials Science and Engineering (FBSE), International Union of Societies of Biomaterials Science and Engineering

Jyoti Mazumder

Elected to the National Academy of Engineering

Xiaoqing Pan

2011 Fellow of The American Ceramic Society
 Guest Professor at Xiangtan University, Xiangtan, China

Max Shtein

2012 College of Engineering Education Excellence Award

Gary S. Was

Elected Fellow of the Materials Research Society

Steven M. Yalisove

2011 Jon R. and Beverly S. Holt Award for Excellence in Teaching

*Professional Service***John Allison**

Member, Benchmarking the Technology and Applications of Lightweighting, National Materials Advisory Board
 Co-Organizer, First World Congress on Integrated Computational Materials Engineering, The Minerals, Metals and Materials Society (TMS)
 Member, Scientific Council, Madrid Institute for Advanced Studies of Materials
 Member, Editorial Board, *International Journal of Fatigue*
 Speaker, Materials Genome Initiative Luncheon, Sponsored by The Minerals, Metals & Materials Society (TMS) and the Materials Research Society (MRS), Washington D.C.

Ronald Gibala (Emeritus Faculty)

Commissioner, ABET Engineering Accreditation Commission
 Chair-designate, TMS Accreditation Committee
 Member, Board of Directors, ASM International Materials Education Foundation

Sharon Glotzer

Member, Nominating Committee, American Physical Society
 Member, Oak Ridge National Laboratory (ORNL) Neutron Advisory Board
 Member, Provost's Committee on Foundations and Development

Rachel S. Goldman

Member, Editorial Board, *Materials Research Society News*
 Associate Editor, *Journal of Electronic Materials*
 Member, Provost's Committee on Capital Projects

Peter F. Green

Inaugural Editor-in-Chief MRS Communications (Cambridge University Press)
 Member-at-Large, United States Liaison Committee of the International Union of Pure and Applied Physics, The National Academies

John F. Mansfield

Microanalysis Editor, *Microscopy and Microanalysis*
 President, Microanalysis Society

Katsuyo Thornton

Member, Condensed Matter and Materials Research Committee, National Research Council's Board on Physics and Astronomy (2012-2014)
 Member, Study Committee on Societal Benefits from Condensed Matter and Materials Research, National Research Council's Board on Physics and Astronomy (2012)

Michael Thouless

Member, Editorial Board, "Proceedings of the Institution of Mechanical Engineers, Part L, Journal of Materials: Design and Applications," (2011-2014)

Materials Science and Engineering Alumni

Alumni Updates

Keith J. Bowman (PhD '87) is Chair of the Department of Mechanical, Materials, and Aerospace Engineering at the Illinois Institute of Technology. He moved to IIT in August 2011 from Purdue University where he served as Head of the Purdue School of Materials Engineering.

James Hwang (MSE '85, PhD '88) was appointed as President of Leotek Electronics USA Corp. in Milpitas, CA in October 2011. Dr. Hwang joined Leotek in 2002 after working at Dow Chemical, Highlight Optoelectronics Corporation, and Harvartek Corporation.

Steven Jonas (BSE '01, MSE Biomed '02) will receive MD and PhD degrees as part of the UCLA Medical Scientist Training Program in spring 2012. He hopes to pursue a career that combines his clinical interest in pediatrics with his engineering background and is applying to pediatric residency programs to complete the next phase of his training as a physician scientist.

John Mardinly (BSE '72, MSE '74, PhD '82) has joined Arizona State University, working with some of the most advanced aberration corrected microscopes in the world. John was one of the first graduate students working in the EMAL under Professor Wilbur C. Bigelow, who started the EMAL.

Lindsay Shuller-Nickles (BSE '05, PhD '10) and **Blake Nickles** (BSE '05) recently married and started new jobs in South Carolina. Lindsay is an Assistant Professor in Environmental Engineering and Earth Science at Clemson University. Blake is a patent attorney with GE Energy.

Alumni Merit Award



From left: Corey Brooker, Dean David Munson, Dawn Bonnell, and Peter Green at the 2011 Alumni Society Awards Dinner, held on October 28, 2011. Photo courtesy of Dwight Cendrowski.

Dawn Bonnell (PhD '86), is a Trustee Professor of Materials Science at the University of Pennsylvania and the Director of the Nano/Bio Interface Center. She received her PhD from The University of Michigan and was a Fulbright Scholar to the Max-Planck-Institute in Stuttgart, Germany; after which she worked at IBM Thomas Watson Research Center. Her current research involves atomistic processes at oxide surfaces, nanometer scale electronic phenomena in materials, and assembly of complex nanostructures. She has authored or co-authored over 225 papers, edited several books, including *Scanning Probe Microscopy and Spectroscopy: theory, techniques, and applications*. Her work has been recognized by the Presidential Young Investigators Award, the Ross Coffin Purdy Award, the Staudinger/Durrer Medal, and several distinguished lectureships. Professor Bonnell serves on several editorial boards, national and international advisory committees, is a past President of AVS, served the governing board of the American Institute of Physics, and is a past Vice President of the American Ceramic Society. She is a fellow of the American Ceramic Society, the American Association for the Advancement of Science, and the AVS.

Wilbur C. Bigelow, Professor Emeritus



Dear Professor Green;

I realized the other day that I am now half way through my nineteenth year of retirement from active teaching in the MSE Department, and I thought it might be time to submit the usual annual report (covering 19 years). One very enjoyable activity made possible by retirement is traveling abroad. Accompanied by my dear friend, Ms. Bobby Ruffin, I have toured more than twenty countries, including a few rather exotic ones such as Thailand, Egypt, Tunisia, Peru, and Mexico's Yucatan. We have sailed on several great rivers, including the Amazon, Nile, Danube and Volga. I figure we have learned (and forgotten) how to say "Hello", "Thank you", "Please", and "Where's the toilet" in more than a dozen languages, from Thai to Russian to Arabic. I have also been very fortunate to have been able to maintain an association with Dr. L. F. Allard, who is one of our graduate alumni. He is now a Distinguished Research Staff Member at the Oak Ridge National Laboratory, and one of the top electron microscopists in the world. Working with him I have served as a consultant at ORNL, and several Universities and Industrial Companies, over the past sixteen years, designing and producing devices for electron microscopy. I've completed more than forty so far, including several types of special-purpose specimen rods, reactors for exposing electron microscope specimens to reactive gases at high temperatures, high speed electron beam shutters, an electron beam holography biprism, and a cryogenic pump to remove water vapors from the specimen chamber of a microscope. I am now working on a device to study cathodoluminescence from specimens inside an electron microscope. In recent years I have been included as a co-author on seven publications describing work in which these devices played a critical part. I am now completing a history of the first twenty years of the Electron Microbeam Analysis Laboratory, and am trying to help Prof. Hosford work up a history of the Department. I have also been able to keep in touch with several ex-students all these years. It has been interesting and very satisfying to hear from them occasionally. Most are doing very well. So, retirement has been very good to me, and I am very pleased to see that the Department has fared very well in spite of my retirement. I note that ABET recently stated that it provides "one of the best materials engineering educations in the nation."

Wilbur C. Bigelow
Professor Emeritus
(bigelow@umich.edu)

MMS: Students Connecting with Professionals

Following tradition, Michigan Materials Society has continued to hold weekly luncheon seminars as well as extending invitation to guest speakers. With hopes to expose students to new topics and to gain an alternative perspective to learning some of the hands-on industry applications taught in class, while giving them insight into potential career paths open to them. This year, seminars have emphasized topics related to life after college – both what it is like to work in the real world and how to build professional connections.

The Michigan Materials Society (MMS), has also been fortunate to have speakers from across the country and disciplines. To name a few: Dr. Gregg A. Zank's presentation on science based innovations at Dow Corning, Dr. Charles E. Reece's insight on current R&D work with next-generation materials for superconducting of applications. Dr. David Anderson & Ronald P. Krupitzer of Steel Market Development Institute's presentation of "Challenges of Using a New Class of Steels to Make the Next Generation of Cars and Trucks". Upcoming speaker events include Leo Baran's review of American Foundry Society (AFS). Half of the MMS' visitors have been Materials Science and Engineering alumni – a testament to the value of the Michigan connection.



Left to right: Satish Subramanian (Treasurer), Mike Abere (Grad Representative), Joyce Loh (President), and Guest speaker, Dr. Susan Hartfield-Wunsch (GM).

We wish to thank all our speakers for sharing their insights and expertise with us and the time they took out of their busy schedules in supporting the Michigan Materials Society.

The MMS has also collaborated with the professional society such as ASM International–Detroit to host the annual University Students' Night and Poster Competition. We recently reconstituted the American Foundry Society (AFS) Student Chapter at The University of Michigan and new students continue to register with Materials Advantage thanks to the generous support of Adjunct Professor John (Chip) Keough.

With over 30 events held- including social events like an Ice Cream Social, Fall and Spring picnics at Prof. Hosford's house, and Faculty/ Students Mixer at Pizza House, End of Year Banquet; and outreach events, such as Welcome Day, Tech Day, and Majors Fair. The MMS continues to expand on its services to the department and actively seeks feedback from the community.

MMS Speaker Series 2011 - 2012

John (Chip) Keough (BSE '77),
Applied Process Inc.

Mark Renius & James R. Harrison,
Metal Improvement Company

Clif Higdon and Alaa A. Elmoursi,
Eaton Corporation Innovation Center

Steve Coryell (BSE '08), PCC Energy Group -
Special Metals, Research & Technology

John J. Bonnen (MS '89), Ford Motor Co.

Gregg A. Zank, Dow Corning Corporation

Hongfei Jia and Debasish Banerjee,
Toyota Motor Engineering & Manufacturing

Robert C. McCune (Ph.D. '83), FASM

Aaron Crumm (PhD '00),
Ultra-AMI, Adaptive Materials

Charles E. Reece, Jefferson Lab's Institute for
superconducting radiofrequency (SRF) Science
and Technology

James M. Boileau,
Ford Research and Advanced Engineering

David Anderson and Ronald P. Krupitzer,
Steel Market Development Institute

Jeff Williams (BSE '98) and Andrew Sharp,
General Electric Aviation

Ron Radzilowski (PhD '77) and Joe Skubic,
Severstal North America

Sue Hartfield-Wunsch (Ph.D. '91),
General Motors

Leo Baran, American Foundry Society (AFS)

Joel Luckman, Materials Global Technology
Director, Whirlpool Corporation

MSE Image Contest

Materials research, because of its critical focus on structure-property relationships, offers abundant opportunities to capture or simulate images of microstructures that have visual impact and scientific significance. The Department of Materials Science and Engineering and the Electron Microbeam Analysis Laboratory have, over the last several years, sponsored an annual Imaging Microstructure Contest. Submissions are invited from graduate student researchers in materials science and a number of cash prizes are offered to the winners. The contest focuses on both visually stimulating and scientifically interesting examples of microstructure, ranging from atomic scale to micro and macrostructures.

In 2011, there were forty three submissions to the contest with subject matter ranging from high resolution electron microscopy to polarized optical microscopy. The Grand Prize Winner for Scientific Merit was Christopher Nelson, a graduate student in Professor Xiaoqing Pan's research group.

His image, entitled "Polarization Vortex" featured a colorized map of the electric dipole moment of a ferroelectric BiFeO₃ with a polarization spiral. Such dipole flux-closure vortex structures are well known in magnetic materials as a mechanism to reduce energy from stray fields. The micrograph in Fig.1 shows the interface a ferroelectric film and a strong insulator TbScO₃ (bottom). The arrows indicate the direction and magnitude of the displacement of the central Fe cation, which indicates polarization. The color and intensity corresponds to the angle and magnitude of the polarization respectively.

The Grand Prize Winner for Artistic Merit was Anne Juggernaut, a graduate student in Professor Brian Love's research group whose image Fig.2 entitled "Breaking free", was a false colored SEM image of large PMMA particles in a batch of commercial 1 μ m particles. Other winners included: in Optical and Scanning Electron Microscopy, Kevin Bergemann, Brian E. Lassiter and Sudip Bhattacharya; in Transmission Electron Microscopy, X-ray imaging and Surface Probe Techniques, Jennifer Dibbern, Jake Jokisaari and Robert Nidetz; in Digitally Enhanced or Colorized Images of Microstructures, Kevin Grossklaus. Our congratulations to all the winners.

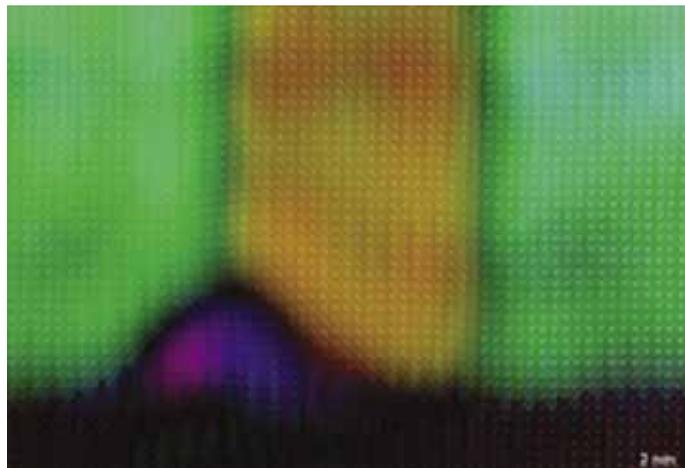


Figure 1. "Polarization Vortex", a colorized map of the electric dipole moment of a ferroelectric BiFeO₃ Christopher Nelson. Scientific Merit Grand Prize Winner.

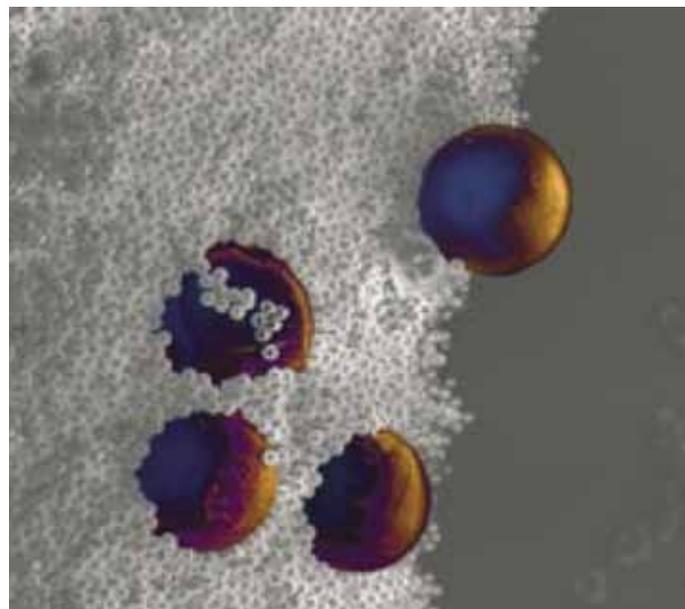


Figure 2. Anne Juggernaut, "Breaking free", an false-colored SEM image of large PMMA particles in a batch of commercial 1 μ m particles. This shows the imperfections and polydispersity size for commercial polymer micro-particles.

Scholarships and Awards

GRADUATE

Departmental Awards

MSE Graduate Service Award for Recruiting

Alexandra Emly,
Michael Kimiecik,
Andrew Pottebaum

Best Overall GPA

Xiao Ma

MSE Graduate Student First Publication Award

Jong Doo Ju and Yansha Jin

College/University Awards

2011-2012 Rackham Predoctoral Award

John Thomas

CoE Distinguished Academic Achievement Award

Christopher Nelson

CoE Outstanding Student Instructor Award

Shaurjo Biswas

CoE Distinguished Leadership Award

Alexandra Emly

External Awards

Best Poster Award at the 2011 Argonne National Laboratory Users Conference

Norman Meznarich

UNDERGRADUATE

Departmental Awards

Richard A. Flinn Scholarship

Philip Dodge

Fontana-Leslie Scholarship

Abigail Hall

James W. Freeman Memorial Scholarship

Jeff Haenke, Yipeng He,
Ian McDonald

John Grennan Scholarship

Caroline Lupini, Carrie Tamarelli

Jack J. Heller Memorial

Engineering Scholarship
Steven Griffiths, Suzanne Hardy

William F. Hosford Scholarship

Nadav Geva, Marissa LaFata,
Kevin Wayne

Schwartzwalder Memorial Scholarship

Ellen Dupler, Joyce Loh,
Justin Moyer

Clarence A. Siebert Memorial Scholarship

Marie Hoffman, Patricia McCormick, Kelly McKeon,
Heather Wilsher

Alfred H. White Memorial Scholarship

Afroze Ahmed, Nicholas Austin,
Kaelin Jensen,
Allessandra McGinnis,
Margaret Tantillo, Lifan Yan

Brian D. Worth Prize

Victoria Miller

MMS Anvil Award

Josiah Cornett

James P. Lettieri Undergraduate Award

Richard Johnson

College/ University Awards

CoE Distinguished Academic Achievement Award

Joyce Loh

Charles Barth Jr. Prize

Pengrui Wang

External Awards

MSE 489 Team M-Wrap

Grace Hsia, Weidong Chen, Shwetha Maddur, Rachel Rademacher, Healthier Wilsher were finalist in the Michigan Clean Energy Venture Challenge/University of Michigan Energy Institute, receiving a \$5,000 prize.

MSE 489 Team Arbor Solar Technology

Allessandra McGinnis, Eric Jones, Ashwin Betrabet, James Detlefs, John Strader, Tyler Austin were finalist in the Michigan Clean Energy Venture Challenge/University of Michigan Energy Institute, receiving a \$5,000 prize.

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Department Chair:
Peter Green

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Mary Sue Coleman *ex officio*

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