

Materials News

2008-2009

MATERIALS SCIENCE PROGRAM

In UW-Madison's interdisciplinary Materials Science Program, you will find opportunities to conduct unique graduate research in a range of areas and draw on the expertise of faculty from departments campuswide. Read about some of the program's activities here, E-mail Diana Rhoads at rhoads@engr.wisc.edu to learn more about materials science graduate study, or visit www.engr.wisc.edu/interd/msp.

Message from Ray Vanderby, MSP Director



The Materials Science Program (MSP) was established more than 35 years ago, a time when the metallurgical engineering department focused primarily on what its name implied. At that time, many scientific techniques were emerging, which led to a robust growth in materials research. At the University of Wisconsin-Madison, activity was widely dispersed in many locations and departments.

The MSP, an interdisciplinary Graduate School degree program, was therefore created to bring together materials researchers from chemistry, physics, chemical engineering, electrical engineering, metallurgy, and others. Advantages of the program included the

ability to obtain and share expensive equipment, a framework for joint seminars and research collaboration, and a visibility and flexibility that could attract interested graduate students from diverse scientific and technical backgrounds.

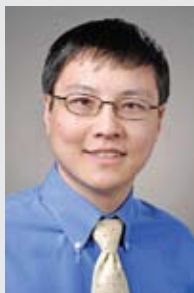
The MSP grew to dozens of participating faculty from all across the campus. In 1996, the MSP had 41 participating faculty (29 from departments outside of materials science and engineering) and 70 graduate students. In the last decade there has been another flurry of materials research, including broad applications in nanotechnologies and many novel biomaterials. The program's interdisciplinary advantages still exist, now more than ever, so the MSP is undergoing another rapid expansion. Currently, we have 70 faculty representing 17 departments and 114 graduate students.

In this issue of our newsletter, we show part of this growth by featuring articles on three of our newer faculty, each of whom has received a prestigious NSF Faculty Early Career Development Award. Izabela Szlufarska, William Murphy, and Hongrui Jiang were selected for their creative projects in materials science that integrate education and research.

Speaking of awards, more than 15 of our students have recently received fellowships from outside of our program. Congratulations to all!

Three MSP faculty receive NSF CAREER awards

The National Science Foundation has awarded three Materials Science Program faculty with 2008 Faculty Early Career Development Award (CAREER). The NSF CAREER awards, among the most prestigious given to faculty members who are just beginning their academic careers, are granted to creative projects that integrate research and education effectively. Faculty recipients include Electrical & Computer Engineering Assistant Professor **Hongrui Jiang** (*also biomedical engineering*), Biomedical Engineering Assistant Professor **William Murphy** (*also materials science*) and Materials Science & Engineering Assistant Professor **Izabela Szlufarska** (*also engineering physics*). *Profiles of these three are on the other side of this newsletter.*



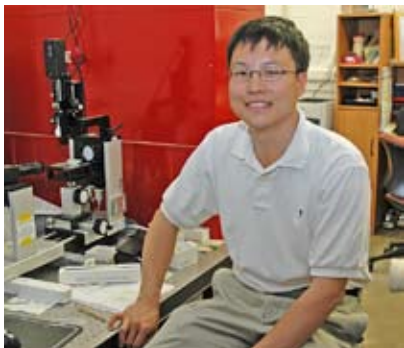
Jiang



Murphy



Szlufarska



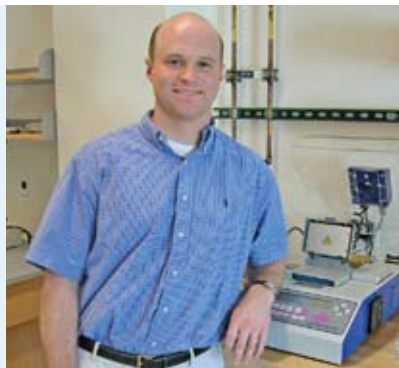
Minimally invasive medical procedures, while beneficial for patients, create a unique challenge for surgeons: operation without sight. To see inside a patient without open surgery, doctors use a laparoscope, or a camera attached to a small tube that is inserted into the body cavity. However, the surgeon's view is limited to the camera angle. The operating team must stop the procedure to move or turn the laparoscope whenever it needs to adjust the view. Electrical & Computer Engineering Assistant Professor **Hongrui Jiang** will use his award to give doctors a dragonfly's-eye view of surgery.

Dragonflies, like other insects, have compound eyes—eyes made of thousands of tiny lenses, called ommatidia, arranged in a hemisphere. Each ommatidium captures light from one specific angle. The information from all the ommatidia combines to form an image, like pixels on a screen. The spherical shape gives dragonflies a very wide field of view and excellent motion detection. However, these eyes cannot focus. Without the muscles that tune our eyes to see objects at different depths, insects see things at low resolution.

Jiang's project combines the merits of compound and camera-type eyes. Leveraging liquid microlens technology he has developed, Jiang and his research team plan to build spherical arrays of tiny lenses that use hydrogels like artificial muscles to focus. "Each individual lens is tunable, so that we can zoom in and zoom out within a certain range to maintain the high resolution," says Jiang.

If successful, a laparoscope with one of these artificial compound eyes could cover a complete cavity while fixed in one place, making surgery even less invasive while giving surgeons better sight. "If you want to focus on a certain area, you can zoom that part of the lens," says Jiang. The technology also could be applied to other medical imaging, such as endoscopy, or to surveillance or military purposes.

MSP faculty receive NSF CAREER awards *(Continued from other side)*



Biomedical Engineering Assistant Professor **William Murphy** derives inspiration for his work as a tissue engineer from studying the complex processes through which human cells develop into tissue, limbs, organs and the like. "As these organs and limbs develop, cells on one end of the tissue have to differentiate into a different cell type than cells on the other end of the tissue," he says.

That's where protein concentration gradients do their work. For his NSF CAREER research, Murphy hopes to generate materials that deliver such gradients to stem cells—in this case, adult human stem cells isolated from bone marrow—in a controlled way.

He has developed an array-based approach that enables him to study, simultaneously, the effects of hundreds or thousands of different gradients on stem cells in three-dimensional culture. Thus, he is more likely to identify a gradient that will significantly affect cell behavior. "We have a better chance of collecting data that are relevant to *in vivo* development, and also data that are relevant for tissue engineering applications," he says.

Eventually, Murphy, who maintains affiliations with the Departments of Materials Science & Engineering, Pharmacology, and Orthopedics & Rehabilitation, hopes to mimic protein concentration gradients in his efforts to engineer tissue.

For now, he is attempting to create biomaterials in which the stem cells throughout initially are homogeneous, but are exposed to heterogeneous signaling environments. "If we can spatially control whether they're alive, first, in different parts of the material, and then second, whether they then differentiate into a particular mature cell type, then we have a pretty powerful approach for trying to engineer tissues," he says.



Like voice-sensing technology that can recognize an individual speaker, Assistant Professor **Izabela Szlufarska** hopes to perfect biosensors that can identify a specific molecule.

Each biosensor resonates at a characteristic frequency. When a molecule touches a biosensor, the frequency changes. Therefore, researchers know that when there is resonance, a molecule is present—but they don't know which molecule, like a sound sensor that registers a voice but can't identify the speaker. To unlock the science that could make biosensors more sensitive and specific, the National Science Foundation granted Szlufarska a Faculty Early Career Development Award.

She is using molecular dynamics simulations to study how resonance frequency depends on the type of molecule that the sensor detects. Working with carbon-coated sensor surfaces developed by Chemistry Professor Robert Hamers, Szlufarska studies specific molecular systems to determine the mechanisms responsible for energy dissipation at the sensor interface.

Armed with that knowledge, she can then create models that quantify the amount of resonance for specific molecules, like an acoustic expert could map the unique timbre of a person's voice. Her models will enable researchers to predict relative frequency changes caused by a specific target molecule. "The ability to predict relative resonance shifts will enable design of structures capable of real-time biosensing," says Szlufarska.

Real-time biosensors have many applications in healthcare, since carbon-based sensors could be implanted in the body to monitor levels of a specific protein or hormone. They also could have applications for the military and national defense.