Research Review

Winter 2007

College of Engineering • University of Wisconsin-Madison

research advances • recent patents • new funding

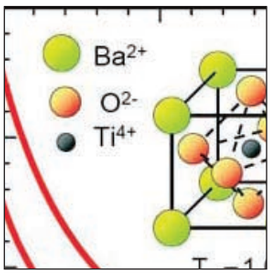
research advances

Nanotechnology meets biology and DNA finds its groove

UW-Madison scientists have developed a quick, inexpensive and efficient method for extracting single DNA molecules and positioning them for faster analysis and sequencing. Read more.

New composites are hidden gems

Using a unique combination of barium titanate and tin, UW-Madison researchers have made the first known material that's stiffer than diamond. Read more.

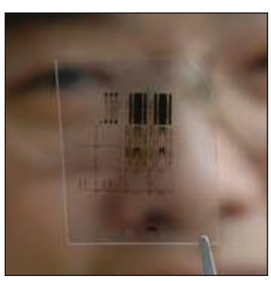


Proof expands limits of composite materials

In an advance that could lead to composite materials with virtually limitless performance capabilities, a UW-Madison scientist has dispelled a 50-year-old theoretical notion that composite materials must be made only of "stable" individual materials to be stable overall. Read more.

Stem cells used to create brain barrier in lab

UW-Madison chemical and biological engineers can cause blood vessel cells to assume properties of the blood-brain barrier, an advance that could help researchers devise new therapies to treat brain disease and to form a clear understanding of how the barrier forms. Read more.



Ultrafast thin-film transistors could revolutionize flexible electronics

A pair of UW-Madison researchers developed inexpensive, flexible thin-film transistors (TFTs) that can operate at a world-record speed of 7.8 GHz. Read more.

more research advances, next page

College of Engineering Distinguished Lecture Series

The College of Engineering is creating a model for leadership in research and higher education that meets the challenges of an increasingly global and interdisciplinary environment. These lectures unite the university community with leaders in technology, education and organizational transformation whose insights transcend disciplines.

These perspectives will inspire faculty, staff and students and enrich the ongoing conversation about shaping the future of the College of Engineering and the University of Wisconsin-Madison.

Inaugural lecture

Engineering education for the 21st century

by William A. Wulf

President, National Academy of Engineering

Wednesday, March 21, 2007 • 3:30 p.m.
1800 Engineering Hall • 1415 Engineering Drive

Accelerating change in the global marketplace has profoundly altered how we design and deliver goods and services. The practice of engineering has changed drastically in response, but with rare exception, the curriculum and the pedagogy by which it is delivered to engineering students has changed very little.

As professional engineering educators, we must address how and who we attract to engineering school, how we retain those students in the study of engineering and, once having graduated, in the profession. We must question the notion that the BS degree alone qualifies our graduates to practice engineering and examine the real-world experiences of the faculty we hire and the system of faculty rewards that sets our priorities.

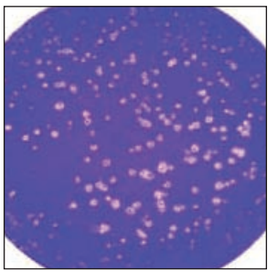
With technology impacting the everyday lives of every person nearly 24/7 and global technology issues impacting the well-being of our society in such monumental and unexpected ways, we as engineers must also concern ourselves with the technological literacy of all our people and especially of those we choose to represent us in making important public policy decisions impacting our future.

About the banner image: Harnessing the power of bacteria—Looking for alternatives to world reliance on fossil fuels for energy, an interdisciplinary team of UW-Madison researchers is studying ways to generate electricity by feeding a species of photosynthetic bacteria a steady diet of sunshine and wastewater. Read more.

(more) research advances

University of Wisconsin Energy Institute engages stakeholders in creative solutions

The University of Wisconsin Energy Institute is leveraging several renowned UW-Madison energy education and research programs in its multidisciplinary approach to understanding and addressing key global energy issues. Read more.



A new gold standard for measuring virus spread

Chemical and Biological Engineering Professor John Yin and graduate student Ying Zhu tweaked the standard system for measuring virus infectivity, digitized it, quantified it, analyzed it and discovered a method more than 10 times as sensitive. Read more.

The potential of personal health records

Led by Industrial and Systems Engineering and Nursing Professor Patricia Flatley Brennan, a $4.1 million Robert Wood Johnson Foundation project aims to develop tools to advance the field of personal health record (PHR) systems. Read more.

Help for honing nano outreach skills

A new study points nanotechnology researchers to strategies that help them more effectively communicate the scale, scope and "wow" of their work to nontechnical audiences. Read more.

Fouling a chronic shipping industry headache

UW-Madison researchers report promising results from early tests of their idea to stave off aquatic hitchhikers by shooting tiny electric jolts through the undersides of boats. Read more.

Hamstring findings may help injured athletes stay healthy

Athletes who strain a hamstring could avoid re-injuring the muscle by participating in targeted physical therapies and improving their running mechanics. Read more.

Space telescopes could have steadier view

UW-Madison research may help large-aperture space telescope engineers ensure that future multimillion-dollar instruments provide a clear view of objects in space and on Earth. Read more.

recent patents

Method and device for measuring electrical conductance of membranes with a radio-frequency probe

Ions and polar molecules can't permeate biological membranes such as cell membranes, so transporting ions through these membranes requires special channel or pump proteins whose function can be assessed by electrical conductance measurements. Current methods of measuring conductance across cell membranes are labor- and skill-intensive and not suitable for high throughput screening. Developed by Electrical and Computer Engineering Professor Daniel W. van der Weide, this invention provides a method for measuring the conductance of single channels from biochemical membranes, such as supported bilayers and cell membranes. A sharp-tipped probe, which creates a highly localized radio-frequency field, is positioned adjacent to the exposed surface of the biochemical membrane, where the field interacts with the membrane. Channel protein activities, such as transport and binding, are detected by changes in the electromagnetic field transmitted through the membrane. telecommunications, fiber optics and laser pumping. Read more.

Protectant mixture for use during freezing and drying of human platelets

Blood and blood products are continuously needed for medical uses. To extend the shelf-life of blood, preservation methods such as freezing and drying are sometimes used, often in conjunction with a protectant agent that helps blood survive the stress of freezing or drying. However, protectant agents can be costly and may need to be removed before the blood can be used for medical purposes. Developed by Chemical and Biological Engineering Professor Juan J. De Pablo, student Ying Nie and Associate Professor Sean P. Palecek, the invention provides an improved protectant mixture for preserving blood platelets. The mixture includes the platelets, at least one polyhydroxy compound, such as trehalose, and phosphate ions. It may also include human serum albumin. The mixture can be used with a variety of preservation processes, including freezing and drying, to provide a stable, preserved composition of platelets. Less expensive than current protectant agents, the mixture also could preserve a wide range of other biological materials, including enzymes, vaccines, tissues, viruses, whole blood, cells, semen, nucleic acids, and foodstuffs. Read more.

Method of forming a microstructure by using maskless lithography

Developed by Biomedical Engineering Professor David J. Beebe, this invention provides a maskless lithography method for fabricating microfluidic channels and systems. Maskless lithography is cheaper and simpler than current fabrication methods, such as micro-molding, that require a final bonding step to attach a top cover to enclose the channel on all sides. To create a device using the method of this invention, a first layer is laid down in relation to a base layer, creating a construction cavity between them. The construction cavity is filled with a polymerizable material and a desired mask pattern is drawn on a computer. Using the mask as a guide, the computer uses mirrors to direct a polymerizing agent, such as UV light, toward the regions of the device that will be polymerized. Parts of the device not subjected to the polymerizing agent (including the inside of the channels) are not polymerized. Flushing the non-polymerized material from the construction cavity leaves the desired channel network.

patents continued, next page

new funding

Addiction researchers receive $2 million to form national center

The Network for the Improvement of Addiction Treatment (NIATx), led by Industrial and Systems Engineering Research Professor David Gustafson, has received a $2 million grant from the Robert Wood Johnson Foundation (RWJF) to create a national center for quality in addiction treatment. NIATx works with addiction treatment providers to improve treatment access and retention and optimize resources through several programs, including the RWJF program "Paths to Recovery," the Center for Substance Abuse Treatment program "Strengthening Treatment Access and Retention" and a number of independent addiction treatment organizations. The award will enable NIATx to integrate all of its addiction research into one nationally recognized center.

Three nuclear energy research initiatives funded

Competing in an overall field of 79 proposals, UW-Madison research teams received three of 10 Department of Energy University-Nuclear Energy Research Initiative (U-NERI) grants, which support innovative research in advanced nuclear technologies. The three-year grants total approximately $1.73 million. Engineering Physics Professors Michael Corradini and Gerald Kulcinski, Assistant Professor Todd Allen, Research Professor Kumar Sridharan and Associate Scientist Mark Anderson, and Materials Science and Engineering Assistant Professors Izabela Szlufarska and Dane Morgan will conduct multiscale modeling and experimental projects to study fission product transport in TRISO-coated particle fuels, oxidation and surface modification treatments of candidate materials for very high temperature reactor pressure vessel applications, and materials corrosion and heat transfer issues in the use of liquid salts as media for process heat transfer from very high temperature reactors.

$1.35M EPA grants fund climate change studies

The Environmental Protection Agency has awarded two grants totaling $1.35 million to researchers in the Environmental Chemistry and Technology Program. In one project, Civil and Environmental Engineering Associate Professor Jamie Schauer, Associate Scientist Martin Shafer, Assistant Professor Tracey Holloway (also of the Gaylord Nelson Institute of Environmental Studies), and researchers at the University of New Hampshire will study the impact of climate change on atmospheric cycling of mercury. In the second grant, Schauer will collaborate with colleagues at the University of California at Davis to study changes in motor vehicle emissions associated with future climate change scenarios and the effect of these changes on urban air pollution.

$1.1M will improve mid-IR semiconductor lasers

The Defense Advanced Research Projects Agency (DARPA) has awarded a $1.1 million grant to Electrical and Computer Engineering Professors Dan Botez and Luke Mawst and Assistant Professor Irena Knezevic, and Chemical and Biological Engineering Professors Thomas Kuech and Paul Nealey. The team will develop and perform research on quantum-box semiconductor lasers emitting the mid-infrared (mid-IR) with 25 times higher electrical-to-optical power conversion efficiency than conventional mid-IR lasers. This work will develop the first practical mid-IR lasers for a vast array of applications ranging from defense to medical diagnostics. The team members' broad expertise includes nanophotonics, nanopatterning, nanofabrication, crystal growth and nano-device modeling. The project will benefit from technologies developed in the Reed Center for Photonics and the NSF-funded Nanoscale Science and Engineering Center (NSEC).

(more) recent patents

Method of forming a microstructure by using maskless lithography (continued)

Additional layers may be placed on top of the first layer to create additional construction cavities between them. The additional construction cavities are filled with material, a portion of which is polymerized to define additional channels in the microstructure. Read more.

Elastographic imaging of soft tissue *in vivo*

Elastography is a new ultrasound imaging technique that detects and images the local stiffness properties of tissues during compression. Three-dimensional elastography provides a way to visualize cancerous tumors, track changes in tumor size over the course of therapy, and monitor the treated margins of a tumor during radio frequency (RF) ablation. In the last case, large differences in stiffness between the ablated tumor and surrounding normal tissues allow elastographic imaging of the ablated region size, volume and position. Accurately computing these parameters may determine the success or failure of the RF ablation procedure.

Despite its promise, 3-D elastography rarely has been used to image tissues and organs inside the body due to their tendency to slip laterally when compressed from the outside. Biomedical Engineering and Medical Physics Associate Professor Tomy Varghese; Biomedical Engineering, Human Oncology, Medical Physics and Radiology Professor James A. Zagzebski, former research assistant Udomchai Techavipoo and former student Quan Chen discovered that by using an RF ablation probe to internally compress tissue, they can generate 3-D elastographic images of the liver *in vivo*. Thus, this technique provides a simple and effective way of monitoring the RF ablation of soft tissue inside the body, without the lateral slippage caused by external compression. Elastography may be performed either during RF ablation or after the procedure is complete. Read more.

System for calculating the spatial-temporal effects of environmental conditions on animals

Current changes in global climate, land use and other human activities, such as increased pesticide use, can have a negative impact on animal well-being. Developed by Zoology and Molecular and Environmental Toxicology Professor Warren P. Porter and Mechanical Engineering Professor Emeritus John W. Mitchell, this invention provides an accurate method to predict and thereby diminish or even prevent these negative effects. The invention uses an integrated set of models to incorporate all the conditions needed to accurately predict how animals (both ectotherms and endotherms) will react to changes in their surroundings. The software package contains three subsections: a microclimate model, a model for warm-blooded animals with fur or feathers, and a model for cold-blooded animals, including insects and reptiles. Input for the models is taken from the animal's temperature-dependent behaviors, morphology and physiology. The software has been successfully used in a number of cases—one of which caused the Environmental Protection Agency to cancel registration of a particular pesticide in Florida. Read more.

about Research Review

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