Research Review

Summer 2008

College of Engineering • University of Wisconsin-Madison

research advances • recent patents • new funding

research advances

Self-assembling polymer arrays improve data storage potential

Combining lithography techniques with novel self-assembling materials, a university-industry team has demonstrated a patterning technology that may revolutionize manufacturing processes for the microelectronics and data-storage industries. Read more.

Airless tire project may prove a lifesaver in military combat

In four-year, $18 million project with the U.S. Department of Defense and Madison startup Resilient Technologies, polymer engineers are helping to develop a non-pneumatic tire for heavy-grade military vehicles. Read more.

Making the connection for cell-signaling networks

Using a model intended to trace telephone networks for intelligence purposes, an engineer and a genetics researcher are studying how cells communicate. Read more.

Transportation researchers evaluate Madison Metro bus service

Information about passenger demographics, satisfaction and bus trips will help transit planners improve routes and attract riders. Read more.

About the banner image: Study solidi es science behind ecosystem restoration initiatives—An evaluation of a southwest Wisconsin watershed restoration project could apply to similar initiatives around the country. Read more.

research advances (continued)

Synchronized swimming: Groups of microorganisms make their own waves

An analysis of populations of up to 100,000 model bacteria indicates that the particular style in which bacteria "swim" leads to different large-scale fluid motions and mixing. Read more.

'Green' snowmobile wows Arctic researchers

An electric snowmobile built by student members of the Clean Snowmobile Team spent summer 2008 in Greenland, on loan to the National Science Foundation (NSF) to support environmentally sensitive climate research projects at the Greenland Environmental Observatory. Read more.

Addressing human challenges in space initiatives

Fusion technology expert and College of Engineering Associate Dean for Research Gerald Kulcinski chairs a committee that seeks to attract top-notch young people to NASA. Read more.

Preventing identity theft

Electrical and Computer Engineering Assistant Professor Stark Draper works with a novel type of data encryption that prevents hackers from accessing original biometrics data stored in a database or security program. Read more.

Collaboration leads to welding solutions

With Wisconsin-based company Friction Stir Link, UW-Madison mechanical engineers are improving friction stir welding, a method often used in shipbuilding to join materials without melting them. Read more.

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research advances (continued)

Cutting-edge robotics for human users

Mechanical Engineering Assistant Professor Michael Zinn develops complex robotic systems that provide an immersive experience: Not only do they receive and follow user commands, but they also provide constant feedback. Read more.

Altering the interaction between solid and liquid

Balancing basic and applied research, Mechanical Engineering Associate Professor Tom Krupenkin is using nanotechnology to make surfaces that alternately are hydrophobic and hydrophilic. Read more.

new funding




Young faculty draw more than $1.6 million in NSF awards

Four College of Engineering faculty received 2008 Faculty Early Career Development Awards from the National Science Foundation. Among the most prestigious honors for faculty members who are just beginning their academic careers, NSF CAREER awards are granted to creative projects that integrate research and education effectively. Electrical and Computer Engineering Assistant Professor Hongrui Jiang is developing a tunable compound "eye," Biomedical Engineering Assistant Professor William Murphy is studying stem cell differentiation in protein gradients, Mechanical Engineering Assistant Professor Krishnan Suresh is perfecting a method for modeling geometrically complex manufactured components, and Materials Science and Engineering Assistant Professor Izabela Szlufarska is developing biosensors that can identify specific individual molecules. Read more.

NSF, DOE fund development of decision-support problem-solving tools

The National Science Foundation and the U.S. Department of Energy have awarded more than $725,000 to Industrial and Systems Engineering Assistant Professor Jeffrey Linderoth for his project "Next-generation solvers for mixed-integer nonlinear programs: Structure, search and implementation." Linderoth and his team will study mixed-integer nonlinear programming (MINLP) optimization problems, which combine the difficulty of optimizing over discrete variable sets with the challenges of handling nonlinear functions. The group hopes to transform MINLP into an area in which researchers and practitioners can access robust tools and methods capable of solving a wide range of important commonly occurring decision support problems. Collaborators on the projects include Industrial and Systems Engineering Assistant Professor Jim Luedtke, Andrew Miller of the University of Bordeaux, and Sven Leyffer and Todd Munson of Argonne National Lab.

recent patents

Batch fabrication of high-aspect-ratio micromechanical probe tips

One of many types of scanned-proximity probe microscopes, the atomic-force microscope images a sample by lightly touching it with a probe tip attached to the end of an extremely flexible leaf spring cantilever. Current methods of manufacturing high-aspect-ratio probe tips are complex and expensive, and result in tips shorter than 30 microns.

Developed by Electrical and Computer Engineering and Biomedical Engineering Professor Daniel W. van der Weide and Yaqiang Wang, this invention provides a multistep batch process for manufacturing silicon probe tips with superior tip height and high aspect ratio for atomic force microscopy. Less expensive than current manufacturing methods, the new method allows for mass production of up to 400 tips on a single wafer and can produce tips taller than 30 microns. In addition, the tips can have an aspect ratio of height to width of seven or greater. Read more.

Zirconium-rich bulk metallic glass alloys

Bulk metallic glasses (BMGs) exhibit unique properties including high strength, excellent wear and corrosion resistance, high resistance to fractures, and outstanding castability. They are also inexpensive to prepare and fabricate, making them extremely attractive for use in many applications. One of the few commercially available metallic glasses contains toxic and costly beryllium. Developed by Wisconsin Distinguished Professor of Materials Science and Engineering Y. Austin Chang, and Hongbo Cao, Dong Ma, Ling Ding, Ker-chang Hsieh, this invention provides improved bulk metallic glass alloys that contain zirconium, aluminum, titanium, copper, and nickel, but do not require the addition of beryllium to provide high quality BMGs. Read more.

SISO model predictive controller

Currently, most single-input, single-output (SISO) systems use a proportional, integral, derivative (PID) controller. The PID controller is simple, fast and easily implemented on simple computing hardware; however, it is also difficult to tune, falls short in setpoint tracking accuracy and disturbance rejection, lacks robustness when the system and system model are mismatched, and has difficulty handling system constraints. Most large-scale processes with multiple-inputs, multiple-outputs (MIMO) systems use model-based control methods such as linear quadratic (LQ) control or model predictive control (MPC). Model-based control methods explicitly optimize the process, can handle complex multivariable processes, and account for constraints; however, they are slow, difficult to implement on simple computing hardware, and hard to tune.

Developed by Chemical and Biological Engineering Professor James B. Rawlings and Gabriele Pannoccia and Nabil Laachi, this invention provides a fast, easily tuned controller specifically tailored to SISO processes. The controller combines the best features of model-based control methods and PID controllers, and performs better than PID controllers on all SISO processes. This offset-free, constrained, linear quadratic (CLQ) controller has three modules: a state and disturbance estimator, a target calculation, and a constrained dynamic optimization. Each of the modules is implemented efficiently so that the overall CLQ algorithm has little computational cost and can be applied using simple hardware and software. Read more.