Many Facets
Materials science transforms to meet societal needs
Advances in materials science and engineering are fundamental to solving many of today’s technological and societal challenges and are key to new developments in fields ranging from advanced energy systems to biotechnology.

A materials engineer myself, with interests in the joining of advanced aerospace materials, I have seen the transformation of this field both from the educational and research perspectives. Now I am proud to witness Ohio State’s increasing eminence in materials research, evidenced by national rankings from the National Science Foundation. Our materials engineering research expenditures, more than $28 million in fiscal year 2006, place us at third in the nation.

Materials science is pervasive across the College of Engineering, led by our outstanding Department of Materials Science and Engineering, which boasts major materials-focused interdisciplinary research centers; internationally recognized faculty, including several National Academy of Engineering members; and world-class research facilities.

On many different fronts, we’re doing work at the cutting edge of materials technology: biosensors, drug delivery devices and tissue engineering for health care; electronic materials for solar cells; and computational materials modeling to predict the properties of advanced aerospace materials for gas turbine engines.

Consider just one specific discovery, which holds promise to help our overwhelming energy concerns: A new thermoelectric material, invented by Ohio Eminent Scholar Joseph Heremans of the Department of Mechanical Engineering, will — with twice the efficiency of anything currently on the market — convert heat wasted through automobile engine exhaust into electricity. The same patent-pending technology could work in power generators and heat pumps. (Visit researchnews.osu.edu/archive/thermal.htm for more details.)

We have long been nationally recognized for our academic programs in metallurgy, ceramics and polymers, which for decades educated an outstanding workforce and created new technologies to support Ohio's traditional manufacturing industries. Over the past 20 years, materials-related research here has rapidly evolved and expanded into a highly interdisciplinary field involving colleges and departments across campus. Today, this far-reaching effort is led by the Institute for Materials Research, which creates and sustains a coordinated, state-of-the-art environment to foster collaborative research that addresses the needs of society.

Our Center for Affordable Nanoengineering of Polymeric Biomedical Devices is an excellent showcase of the interdisciplinary facet of materials science. An NSF Nanoscale Science and Engineering Center, CANPBD aims to revolutionize medical diagnosis and treatment by establishing nanoengineering techniques to design, synthesize and fabricate biomedical and therapeutic devices. Its researchers represent such diverse disciplines as engineering, chemistry, physics, philosophy, economics, medicine and entrepreneurship.

Beyond our own campus, we have formed strong collaborations with universities worldwide as well as with industry, business and government. For example, a long-standing, major strategic partnership between our Department of Materials Science and Engineering and scientists and engineers in the Materials Directorate at the Air Force Research Laboratory includes joint research, shared equipment and facilities, and faculty and staff exchanges.

Looking to the future, we are sustaining the materials field in general, giving students opportunities that are clearly distinctive: Facilities like the Titan scanning transmission electron microscope are available in only a handful of locations worldwide. And this summer, ASM International held its only nationwide Advanced Materials Camp for high school teachers here on our campus. All 25 attendees previously completed an ASM Materials Camp for Teachers and are introducing materials science into their own classrooms.

Read more about the foundation we’ve built in traditional materials science and about the ways we're transforming our research in this area to meet society’s needs throughout this edition of News in Engineering. And as always, feel free to contact me if you have ideas to share. My e-mail is baeslack.1@osu.edu.
Many Facets

Ohio State materials science and engineering researchers, recognized nationally and internationally for developments in the field, are finding new uses for traditional materials such as metals and ceramics and are developing new materials for emerging markets in energy, electronics and biotechnology.
From the Associate Dean for Research

Materials Research: Solutions for grand challenges

Earlier this year, the National Academies identified “Grand Challenges for Engineering in the 21st Century,” many of which are critical to sustaining our current way of life.

Of the 14 challenges, 10 depend on significant breakthroughs in materials research, either explicitly or implicitly:

- make solar energy economical
- provide energy from fusion
- develop carbon sequestration methods
- provide access to clean water
- restore and improve urban infrastructures
- manage the nitrogen cycle
- prevent nuclear terror
- enhance virtual reality
- engineer better medicines
- advance health informatics

Ohio State’s materials science and engineering experts can help solve many of these challenges. Our success in materials research funding is highlighted by federal research centers including the NSF Center for Affordable Nanoengineering of Polymeric Biomedical Devices and Industry/University Cooperative Research Centers: the Smart Vehicle Concepts Center, Center for Advanced Polymer and Composite Engineering, and Center for Precision Forming.

These entities are strengthened by major industry- and state-supported centers, such as the Wright Center for Multifunctional Polymer Nanomaterials and Devices, the Fontana Corrosion Center, and the Center for the Accelerated Maturation of Materials. Along with the University of Toledo, Ohio State is a founding member of the Wright Center for Photovoltaics Innovation and Commercialization, which alone represents $18.6 million in direct funding and includes 16 participating companies.

Ohio State’s Institute for Materials Research supports, leverages and coordinates these centers. These organizations and the efforts of individual faculty members contribute significantly to the university’s ranking of third in materials research funding, enabling us to make significant progress in a number of the Grand Challenges. A few examples:

**Make solar energy economical:** Yearly global power consumption exceeds 14 trillion watts. Solar is the only renewable entity capable of providing this amount of energy in a truly sustainable fashion, but using solar power to produce electricity costs far more than coal. Using bulk silicon, polycrystalline materials; third-generation photovoltaic techniques; and low-cost, second-generation thin film techniques in photovoltaics can bring down manufacturing costs. At Ohio State seven faculty research groups, plus several groups of senior research scientists, work on third-generation photovoltaics, with collective funding in excess of $3 million annually from competitive federal and industrial sources. Recently, our researchers’ work yielded the record performance for integrated III-V compound PV with silicon, and this is now being extended to the exploration of novel bandgap-engineered III-V cells on a variety of low-cost substrates.

**Provide access to clean water:** Ohio State researchers have pioneered the development of membranes using interfacial polymerization for water treatment. Compared to standard membranes using reverse osmosis, these membranes double the amount of fresh water produced from both seawater and brackish water. Recent advances have led to the development of supported liquid membranes with strip dispersion for the removal and recovery of heavy metals from wastewaters and on hydrogen purification membranes for application to fuel cells.

**Restore and improve urban infrastructures:** A national leader in the modeling, design and control of plug-in hybrid vehicles, our college is involved with American Electric Power’s gridSMART program, which involves intelligent charging, information management and battery management technology related to electric and plug-in hybrid vehicles.

**Develop carbon sequestration methods:** According the Department of Energy, Ohio State’s patented chemical looping technology is a leading technology for capturing CO₂ efficiently, simply and directly at the plant while simultaneously allowing for the production of clean energy.

The Ohio State University is one of a handful of institutions uniquely positioned to impact materials research and these corresponding challenges in a significant manner. Read more about the Grand Challenges for Engineering online at www.engineeringchallenges.org.
Thirty years ago, titanium was the new kid in the manufacturing neighborhood, rejected for its high cost and the unknowns of its performance.

Now, however, it has become a golden child among metals, preferred for its corrosion resistance, high strength and relative low density and weight. In fact, each of Boeing’s new 787 airliners, touted for a 20 percent reduction in fuel use, uses titanium alloys extensively, accounting for about 20 percent of the aircraft’s weight when empty. In addition to its burgeoning use in aerospace applications, titanium’s demand is on the rise in markets including offshore oil and gas production as well as automotive and architectural applications.

What brought titanium into favor? Materials science and engineering — an area of established yet broadening expertise and discovery at Ohio State.

“It’s absolutely a key structural material for low temperature parts of jet engines and the future of jet aircraft,” Jim Williams, Honda Chair and professor of materials science and engineering, says of titanium. Honored as a pioneer in aerospace alloys research and materials science policy and education by the National Academy of Engineering, Williams has spent three decades of research and industry work determining the fundamental characteristics of titanium, thus increasing industry’s confidence in its use the same way scientists did for steel years ago.

Ohio State materials science researchers such as Williams — recognized nationally and internationally for developments in the field — are finding new uses for traditional materials such as metals and ceramics and developing new materials for emerging markets in energy, electronics and biotechnology.
A Foundation of More than a Century

Matching Ohio’s needs at the time, the university’s strengths in metallurgy and ceramics, now materials science and engineering, started even before engineering became a college at Ohio State, in 1896.

Ohio State is now a world leader in understanding the role that composition and processing have on the performance of a wide range of high-performance structural materials and also in the fundamental knowledge of the corrosion behavior of structural alloys, including methods of corrosion loss prevention.

“We continue to invest in and be loyal to our traditional areas,” says Rudy Buchheit, professor and chair of the Department of Materials Science and Engineering, “given where we are in the Midwest and the importance of continued scientific pre-eminence in these areas for the economic enterprise of this country.”

The traditional areas of materials research also continue to provide support for industry, especially when bolstered by new technology.

One of the most recent advances comes as the Edison Welding Institute, in a project headed by senior engineer Karl Graff, collaborates with Ohio State and industry partners to increase the power of ultrasonic manufacturing in a new research project funded by $2.5 million from the Ohio Third Frontier Wright Projects Program.

Materials’ move to the 3-D

Hamish Fraser leads a team at the Center for the Accelerated Maturation of Materials in the development of new research tools for 3-D characterization and modeling of materials.

For three years, Fraser and colleagues at Ohio State and other universities including Carnegie Mellon University, Drexel University and the University of Pennsylvania have worked at the request of the Office of Naval Research to develop tools to predict the mechanical behavior of a range of titanium alloys. The challenge of the program is based on the fact that alloys such as Ti-6Al-4V can exhibit properties that vary quite significantly depending on the materials’ microstructure.

The researchers have demonstrated the feasibility and need for the integration of characterization methodologies and computational models. For direct 3-D characterization, researchers have developed methods and applied them to the RoboMet-3D (a robotic serial sectioning device for mesoscale features such as grains); the Dual-Beam Focused Ion Beam microscope (for microscale features such as particles); and scanning transmission electron microscope tomography (for nanometer features such as extremely refined precipitates).

“Routine direct 3-D characterization and modeling,” says Pete Collins, CAMM associate director, “will become an integral part of many future research programs that cross disciplines and applications to address a wide range of materials problems.”

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For many properties and phase transformations, the phases that precipitate along the grain boundary are very important. In this particular case, the grain boundary allotriomorphic alpha phase in Ti-550 has been characterized and visualized using the 3-D slice and view capabilities of the Dual-Beam Focused Ion Beam/scanning electron microscope. Hamish Fraser and his team have used the 3-D modeling tools they developed to identify features that help improve the properties of a material as well as potential weak links, in this case estimating the tensile properties of Ti-6Al-4V to within 3 percent of its actual value and the fracture toughness to within 6 percent of its actual value.
ADMA Products Inc., U.S. Army Research Laboratory/Weapons Materials Research Directorate, Boeing Co., GE Aviation, Nanodynamics Inc. and Solidica Inc. in the development of a very high power ultrasonic additive manufacturing (UAM) system capable of creating advanced materials with embedded features including solid-state actuators, sensors and other complex functions. In June, Ohio’s Third Frontier Commission approved $2.5 million in Wright Project funds for the program. Leading Ohio State’s research efforts are Sudarsanam Suresh Babu, associate professor of industrial, welding and systems engineering, and Marcelo Dapino, associate professor of mechanical engineering.

“The UAM system is ideally suited for near-net shape manufacturing of complex, multifunctional components, as parts created through the UAM process require little or no finish machining,” says Dapino. “A distinguishing characteristic of UAM is that it is an ultrasonic solid-state welding process, meaning there is no melting of metals, thus avoiding the impact of high temperatures on material properties. This is of utmost importance in dealing with advanced materials as well as precision control of part shape.” Near-term targeted commercial markets are rapid prototyping/tooling needs, advanced military vehicle armor and multifunctional automotive and aerospace components.

With such long-term success in metallurgy and ceramics, the college’s faculty members often offer expertise for related industry and government projects.

For example, Williams in January chaired a 14-member international panel convened by the United Kingdom Engineering and Physical Sciences Council to assess the academic materials research program there.

In addition, Hamish Fraser, director of the Center for the Accelerated Maturation of Materials, Ohio Eminent Scholar and professor of materials science, has been a consultant in materials and structures for the U.S. Air Force and the Pentagon, the government

This backscattered electron image shows a secondary dwell fatigue crack in the titanium alloy Ti-6Al-2Sn-4Zr-2Mo. The location of the crack was determined using microfocus x-rays. A precision polisher was subsequently used to reveal the crack and its surrounding microstructure.

This Electron Back Scatter Diffraction scan was carried out on the first layer of the material after polishing down about 183 microns from the top-flat surface. Each grain is then color-coded to depict its orientation in relation to a particular direction on the EBSD map. The grains are colored with respect to the loading axis, which is vertical in this case. A red-colored grain means that it is hard to deform, whereas a green, blue or pink color means that it is easier to deform. In this figure, a large secondary crack is seen embedded in a soft region that is just below a hard region.

This image shows the EBSD scan of the surface, 59 microns below the first layer (248 microns below the flat surface) and a secondary crack that lies embedded in a hard region (red). The regions of nearly constant color share similar crystallographic orientation and are said to be microtextured. Several such serial sections were taken during this investigation, which is still ongoing, and the orientation of the material around a secondary crack was recorded at each section. This investigation has clearly demonstrated that the intersections of hard and soft microtextured regions are prone to dwell fatigue crack initiation. This study has also shown that cracks may be arrested at neighboring soft regions, as shown on the left side of this figure where the crack tip has blunted in the soft region.
Using nanotechnology for drug delivery

Viruses currently are the most efficient vehicles scientists can use for delivering genes directly to invading cells to treat diseases like cancer. They are not, however, easy to control, says L. James Lee, the Helen C. Kurtz Professor of chemical and biomolecular engineering.

So materials science engineers are stepping in, studying ways to mimic the viruses’ ability to enter cells efficiently while making them safe for the release of controlled amounts of medicine.

“We have to develop a new engineering concept and redesign the entire manufacturing process so traditional and new biomaterials can co-exist,” says Lee.

Lee is collaborating with researchers from Ohio State’s College of Pharmacy and James Cancer Hospital and Solove Research Institute to develop multifunctional nanoparticles that would act like a virus for leukemia and cancer treatment. Liposomes and some polymers would be used as the medicine carriers because of their biocompatibility and ability to incorporate drug molecules.

The team developed a patent-pending five-inlet, polymeric microfluidic device with microchannels to precisely control the flow and mixing process for producing polymer-based polyplex and liposome-based lipoplex nanoparticles that contain cancer-fighting oligonucleotides such as SiRNA and antisense oligonucleotide.

Processing and delivering the smaller, more uniform nanoparticles through the body by this new approach minimizes chances that medicine intended to get rid of cancer cells will damage healthy cells.

Now, Lee and his colleagues are developing a nanoscale-guided assembly method that functions better than the microfluidic devices.

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Improving materials in advanced electronics

Steven Ringel, professor and Neal A. Smith Endowed Chair in Electrical Engineering and director of Ohio State’s Institute for Materials Research, is leading one team of a seven-university effort to study high-power electronic device reliability.

High-power military and space-based electronics such as radar and military sensors, unlike consumer electronics, require long-term reliability — on the order of 30-40 years. This research, which will develop test methodologies and a model to predict how these devices may degrade in operation, is funded by a $6.5 million Office of Naval Research Multi-University Research Initiative.

Ringel’s team, including Ohio State Professors Jonathan Pelz in physics and Leonard Brillson in electrical and computer engineering, with faculty members from MIT, Vanderbilt, Carnegie Mellon and University of California-Santa Barbara, will examine gallium nitride semiconductors used in electronic devices.

“Since the materials properties of gallium nitride electronics are so unique (large bandgap energies, polarization and piezoelectric effects) compared to conventional electronics,” Ringel says, “there is a large knowledge gap to explain the mechanisms by which these devices degrade.”

The team’s effort focuses on developing and applying unique nanoscale characterization methods to identify material defects associated with or driving the degradation of devices and how the properties of these defects relate to external factors, such as electric fields, current and temperature. The Ohio State-led innovation of a method known as DLOS (deep level optical spectroscopy), developed by Ringel and his students, will be applied to achieve 3-D nanoscale defect characterization.

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of Western Australia and the British government. A Fellow of ASM International and the Institute of Materials, he also has lent his expertise to national laboratories such as Los Alamos and to industry leaders, including those at Pratt & Whitney Aircraft and General Electric Aircraft Engine Group, now GE Aviation.

And the Fontana Corrosion Center in the Department of Materials Science and Engineering received the 2008 Distinguished Organization Award from NACE International, originally known as the National Association of Corrosion Engineers, for 60 years of leadership and contribution to the corrosion community through education, research and professional development.

**Fulfilling the Needs of Ohio and Society**

Ohio State is leveraging its established success in materials research to expand exploration in the field, particularly in the areas of nanomaterials and nanobiotechnology, computational materials science and engineering, and electronic materials.

More than $50 million in funding from the National Science Foundation and the Ohio Department of Development currently supports nanomaterials and nanobiotechnology alone. In the past six years, computational research at the Center for the Accelerated Maturation of Materials has made approximately $18 million in research expenditures and brought in more than $22 million in funding from sources including the Air Force Research Lab, Office of Naval Research and industry. In the electronic materials focus, researchers have won prestigious NSF and Ohio Department of Development competitions for nearly $20 million.

The university’s Institute for Materials Research brings these materials experts together by providing coordination for researchers to incorporate science and engineering from the development of biobutanol as a biofuel.

Biobutanol is widely recognized as a better liquid fuel than ethanol but more difficult and expensive to produce using conventional fermentation technology.

Shang-Tian Yang, professor of chemical and biomolecular engineering, biomedical engineering and food science and technology, is working to address technical and commercial issues related to the development of biobutanol as a biofuel.

Supported by a $1 million grant from the Ohio Third Frontier Advanced Energy Program, Yang is developing engineered strains of a bacterium, Clostridia, for use in a novel two-step fermentation process to economically produce butanol as a biofuel. First, sugars (glucose, xylose, etc.) derived from starchy food processing wastes and lignocellulosic biomass will be converted into butyric acid by anaerobic fermentation by cells immobilized in Yang's patented fibrous bed bioreactor (0.5-liter column in photo, right). The butyric acid and additional sugars can then be converted into butanol efficiently in a second fermentation step using butanol-tolerant mutants to be developed in this project.

The new fermentation processes can double the butanol yield and concentration, thus reducing the product cost to an economically competitive level — less than $2 per gallon — for fuel application. Yang plans to construct a pilot plant model process to demonstrate whey permeate as the feedstock for butanol production and fine-tune his technology.

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Heather Powell, assistant professor of materials science and engineering and biomedical engineering, works with students to grow skin cells on collagen mesh electrospun scaffolding. Powell says human bioengineered skin can be used, for example, to help burn victims. The collagen mesh would be absorbed by the body, and the new cells would remain.
Heather Powell, assistant professor of materials science and engineering and biomedical engineering, and Jason Drexler, a master’s degree student in materials science and engineering, examine patterns of texture in a collagen sponge made by freeze drying in a lyophilizer. Powell develops materials for tissue engineering; the sponges could be used to grow cells used for tendon repair.

21st century — energy, environment, healthcare, clean and inexpensive water, homeland security, food, etc. — have one thing in common: materials,” Ringel says of the impetus behind such support of materials work. “In order for Ohio to continue to improve its competitive position and achieve a robust and growing economy, a major acceleration is required in the discovery and development of new materials that have performance capabilities far beyond those of traditional materials.”

There is a real need for materials that have integrated and complementary functionalities, materials with intrinsically “smart” capabilities, and materials from sources that are renewable, “green” and affordable, he says, pointing out that Ohio State research has made progress in all of those areas.

A Field of Change

These societal needs for solutions in energy and biotechnology are driving a transformation in materials science nationwide and bringing new opportunities for engineers. Engineers are collaborating with other researchers as never before — and giving Ohio State an edge, considering its breadth of engineering expertise and on-campus access to scientists in medicine, pharmacy, mathematics, physical sciences and other areas.

Ringel champions such collaboration as director of the Institute for Materials Research and benefits from it in his own electronic materials discoveries on the forefront of photovoltaics.

“Energy materials and the processing of those materials into real devices requires expertise in areas all the way from atomic-scale synthesis and materials chemistry to system design, with researchers working in a symbiotic fashion,” says Ringel. “Photovoltaics requires an understanding of the physics and chemistry of electronic materials at all length scales and their interaction with the solar energy resource in order to engineer an efficient energy conversion device. So you see, you can’t do one without the other.”

L. James Lee, the Helen C. Kurtz Professor of chemical and biomolecular engineering, also finds success in his field of biotechnology through interdisciplinary opportunities at Ohio State. His $12.9 million NSF National Science and Engineering Center, the Center for Affordable Nanoengineering of Polymeric Biomedical Devices, applies materials science combined with pharmaceutical and medical expertise to create devices related to health care: biosensors for fast detection of cancers and HIV, drug delivery devices to target specific sites in the body, and tissue engineering. He also directs the NSF Center for Advanced Polymer and Composite Engineering.

“The single most important reason Ohio State can play an important role in materials science is because it is one of the largest universities in the United States with one of the most comprehensive education programs,” says Lee. “Materials science is really interdisciplinary, and we have all this infrastructure, expertise and people on the same campus that make it easier to collaborate.”

A microcosm showing how Ohio State can influence the materials field through its expertise and collaboration, Ringel says, is the IMR Center for Photovoltaics Innovation and Commercialization, where researchers from chemistry, physics, electrical engineering and mechanical engineering work together.

“Faculty from the College of Engineering get to see and hear about problems from what might have otherwise appeared to be completely unrelated fields — but those fields need engineers to solve those problems,” Ringel says. “We now have a vitally important playground where talented students and new faculty have opportunities to define their careers earlier. It’s incumbent upon engineering to continue to evolve itself.”

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At Nanotech West, electrical engineers bump elbows with biomolecular engineers and scientists who grow cells and manipulate DNA — an exciting premise for the professionals using the facility. With a wide array of microscopy, tools and cleanrooms, Nanotech West offers a single location for myriad researchers to collaborate.

“That’s really what’s novel about this place, because you’ve got a working cleanroom upstairs and you’ve got this active bioactivity downstairs and you have a lot of people that use both,” says Nanotech West Director Bob Davis.

Besides the large number of graduate students who use the laboratory, there are also several startup companies that utilize Nanotech West instruments and capabilities, where the open-information environment helps the fledgling businesses. These startups also have access to professional scientific labs rather than improvised spaces.

“It’s really enabling to us,” says Tom Zupancic, chief scientific officer of Applied Biomolecular Technologies Inc., a startup company at Nanotech West. “When I’ve been involved with startups, other places got a space that converted into a lab. It’s nice here because it’s different.”
The two major parts of Nanotech West are a bio-hybrid lab and a cleanroom, which hosts numerous types of fabrication activities, such as lithography, pattern transfer and materials etching. In the bio-hybrid lab, work consists of active tissue and cell cultures, protein analysis and DNA manipulation.

This year the capabilities of the research building have been used by 20 companies, from small startups to established businesses working on micro- and nanofabrication with an emphasis on materials research.

“Our end goal is to support Ohio State research and the local economic research and development activities in the state of Ohio,” Davis says.

Some of the major programs at Nanotech West:

- The Center for Affordable Nanoengineering of Polymeric Biomedical Devices, which is an NSF Nanotechnology Science and Engineering Center program.
- The Center for Multifunctional Polymer Nanomaterials and Devices, a Wright Center for Innovation, which seeks new commercialization pathways for new polymers and polymeric devices, from structural polymers like those on the body of cars and airplanes to biology. CMPND alone encompasses about 60 companies in the state of Ohio, Davis says.
- The Photovoltaics Innovation and Commercialization Center, another Wright Center, which conducts research, development and commercialization activities in advanced photovoltaic (solar cell) materials. PVIC supports the creation of employment opportunities for Ohio’s workforce by reducing commercialization barriers facing Ohio companies in the photovoltaic sector. "PVIC investments, just like the CMPND investments, are going to impact and help a wide variety of programs that are completely outside of photovoltaics," Davis explains.
- The Institute for Materials Research is an umbrella organization that coordinates and supports materials research at Ohio State.

Tom Knox is a College of Engineering student communications assistant.

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Controlling Cells: Interdisciplinary center sets out to engineer biological solutions

Abundant experimental evidence exists to show that cells in contact with engineered materials respond to biological systems and synthetic materials, and designing that interface to control biological functions, are virtually unexplored,” says Professor Michael Paulaitis, an Ohio Eminent Scholar in chemical and biomolecular engineering. “The challenge is to augment engineering design methods that have been built based on well-established basic science and engineering principles to accommodate biological systems, where the design rules are incompletely understood.”

This challenge is being met by faculty in the Center for Cell Engineering, a multidisciplinary research enterprise created to develop cutting-edge technologies for fabricating new materials capable of directing specific cell responses on molecular-to-nanometer-to-micron length scales. The center brings together faculty who have a wide range of expertise in materials research, computational biophysics, multi-scale modeling and systems biology to develop engineering models, advanced characterization techniques and assembly processes that will ultimately lead to novel biomaterials with chemical, mechanical and topological features on length scales relevant to cellular organization and tissue function.

Paulaitis and Associate Professor John Lannutti, materials science and engineering, direct the Center for Cell Engineering, which has expanded to include several recently recruited engineering faculty members. Materials-related research directed by these new center members is funded by the NSF and NIH:

- **Lannutti** creates 3-D models that mimic cell combinations found in the early stages of cancer metastasis by applying femtosecond laser machining to construct bioactive electrospun scaffolds that can reproduce biochemical signaling between cells. Other center researchers:

- **Keith Gooch**, biomedical engineering, leads a team of colleagues in developing multi-scale models that integrate macroscopic descriptions of tissue growth and remodeling in response to mechanical stimuli with molecular and cellular descriptions of the underlying mechanisms.

- **Jianjun Guan**, materials science and engineering, is engineering novel, thermosensitive hydrogels that can be injected as stem cell/hydrogel constructs at room temperature but have mechanical properties similar to human heart muscle at physiological temperature.

- **Andre Palmer**, chemical and biomolecular engineering, is developing novel oxygen carriers for use as blood substitutes by encapsulating polymerized hemoglobin in mechanically strengthened, actin-containing biomaterials and designing that interface to accommodate biological systems and synthetic materials, and designing that interface to control biological functions, are virtually unexplored,” says Professor Michael Paulaitis, an Ohio Eminent Scholar in chemical and biomolecular engineering. “The challenge is to augment engineering design methods that have been built based on well-established basic science and engineering principles to accommodate biological systems, where the design rules are incompletely understood.”

- **Heather Powell**, materials science and engineering, fabricates protein-based materials to generate 3-D models of human skin. Her ultimate goal is to create a skin replacement with the same mechanical and biological properties as native human skin.

- **Jessica Winter**, chemical and biomolecular engineering, develops materials consisting of artificial tissues combined with magnetic nanomanipulators to elucidate the role of mechanical forces in cell migration in wound healing, cancer metastasis and nerve regeneration.

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A basic physics rule provides the foundation for Derek Hansford's research to find new ways to treat the most common brain tumor in adults.

Glioblastoma Multiforme tumors are the most common and most malignant of brain cancer tumors. Even with optimal care, the life expectancy of patients with this type of cancer is approximately one year.

A primary challenge in treating this cancer is the fact that these tumor cells not only grow quickly, but they also move rapidly through the brain.

"The problem is we don't know the mechanics of them, so we can't address keeping them from moving around," says Hansford, associate professor of biomedical engineering.

So Hansford, collaborating with neurological surgery assistant professor Atom Sarkar, related his research to Newton's "work = force x distance" formula and developed tiny force sensors to measure the cells' mechanics.

"If we can get these cells to move along a pattern and have sensors along that path, we can measure the force they use," he says.

In the next step, Hansford is studying moving cells. A linear array force sensor, with probes near a continuous path to guide the moving cells, is designed to be too thin for the cancer cell to move along the path without spreading out onto the probes. The forces exerted onto the probes can be measured using the same optical microscopy method Hansford uses for the circular array sensor probes.

A potential application of Hansford's cell force sensor is evaluating the effects of drugs, toxins and other chemicals on cell mechanics.

"We can expose the cell to chemicals to determine what causes the cell skeleton to degrade, which then stops the movement of it," he says.

Hansford's ultimate goal: a device similar to "an instrumented Petri dish," he says, "where you could have a huge collection of cells and get useful information from all of them."

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A Boost for Business:
Using autonomic cloud computing and autonomy to deliver services

An Ohio State collaborative is finding ways computer science and technology can increase the quality, efficiency and value of business services. The Collaborative for Enterprise Transformation and Innovation (CETI) is working with the Georgia Institute of Technology to find such “services computing” solutions with $100,000 of equipment support from IBM and a $50,000 NSF Industry/University Collaborative Research Center management grant.

Services computing solutions will assist a lion’s share of the U.S. economy, as workers in service-providing industries are the primary users of information technology, reports the National Academy of Engineering. And those workers — in fields such as utilities, finance, retail and professional and business services — make up 76 percent of this country’s workforce, according to the U.S. Bureau of Labor Statistics. Outsourcing, mergers and unexpected disruptions make business processes highly dynamic and the underlying IT increasingly complex.

“Streamlining these service operations with information technology is key to today’s private and public institutions that must adapt to changes more rapidly,” says Rajiv Ramnath, who co-directs CETI with Jay Ramanathan.

Such technology developments will require “cloud computing,” which allows businesses to operate more efficiently by using data and applications that exist on a “cloud” on the Web rather than on local machines or servers at those businesses, and “autonomic computing,” which enables computer systems to regulate themselves in much the same way the autonomic nervous system regulates and protects the human body.

High-performance blade servers provided to Ohio State and Georgia Tech by IBM will provide infrastructure for the researchers to build an example cloud with autonomic features.

“IBM has had a long-standing relationship with both Georgia Tech and Ohio State, and this infrastructure is intended to drive deeper and more significant research collaboration to solve real-world challenges,” says Matthew Ellis, vice president of IBM Autonomic Computing.

As a program affiliated with Georgia Tech’s IUCRC, CETI will work on the application side of technology. Ohio State researchers will analyze, model and simulate these complex systems of businesses; build cyber-infrastructures that can electronically deliver the businesses’ services; and create integrated environments to develop and deploy software for these cyber-infrastructures and support and manage them.

“Current tools to develop software for these systems are like using just a spade to build a city,” Ramnath says. “We need an environment to develop the software for these complex systems, deploy that software without interfering with business operations, and monitor and manage these systems to ensure that they are performing at the necessary operational level.”

In one project, for example, Nationwide Insurance has asked CETI to collaborate with the company on its data center optimization efforts. Nationwide’s data centers, Ramnath explains, are focused on the conservation of power, which is critical to both the longevity of the data center as well as the prudent management of expenses. Could machines not in use intelligently shut down? Could multiple machines share power or run on one machine instead?

“Through this project we hope to extend the life of our data centers with considerable savings in ongoing costs, as well as multiple millions of dollars in savings due to being able to delay the construction of a new data center,” says Scott Miggo, Nationwide vice president of technology engineering.

“All of these experiences will feed into our teaching,” Ramnath says of the research. “We use the actual results from these projects in our classes to make computer science real and relevant to our students.”

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Bringing in the Reinforcements: Innovations in concrete infrastructure design

When he was an undergraduate student studying civil engineering, a major earthquake struck the city of Erzincan in Halil Sezen’s native country of Turkey. Less than two years later, while he was applying for master’s degree programs, the 1994 Northridge quake shook California.

Those events sparked Sezen’s interest in earthquake engineering, the focus of his master’s degree studies at Cornell University and doctorate work at the University of California, Berkeley. Now an Ohio State assistant professor of civil and environmental engineering and geodetic science, Sezen mentors students who are studying earthquake-resistant structures, while his own research has expanded to overall concrete infrastructure.

“In our field, earthquakes are still the most critical factor for the design of structures,” Sezen says. “For example, even here in Ohio, the recent retrofit design of Ohio State’s main library was done to resist earthquakes. Also, it has been widely accepted that earthquake-resistant structures perform much better when subjected to natural and man-made hazards such as hurricanes or explosions.”

Working with former graduate student Mohammad Shamsai, now a structural engineer for River Consulting in Columbus, Sezen has developed a new prefabricated steel cage reinforcement system for concrete columns.

Their patent-pending system, which could be used in new construction such as buildings and bridges or in retrofits of existing structures, involves perforating steel tubes or plates using laser, punching, casting or other methods. A solid, removable form is then placed around the resulting “cage” before pouring concrete inside the formwork. The concrete flows through the openings in the cage, providing a solid mixture of concrete around the steel.

The resulting prefabricated cage system acts similarly to a steel rebar cage and works compositely with the surrounding concrete to resist applied loads. The system is made off-premises of construction sites and then placed inside the formwork, eliminating the time-consuming and costly labor associated with cutting, bending and tying steel bars in traditional rebar construction.

In addition to reducing construction time, labor and associated costs, the prefabricated cage system has better corrosion and fire resistances than methods where the steel is exposed, such as in concrete-filled steel tubes. Ohio State has filed three U.S. patent applications related to Sezen and Shamsai’s work.

Master’s degree student Matt Fisher is studying the prefabricated steel cage system for his thesis.

“I’m comparing the traditional rebar with the reinforced cage system in terms of how they perform in beam column joints,” says Fisher, who is an engineer with URS in Cleveland. “It has been tested under compression, but there are questions as to how you would frame into the prefabricated cage system column and how the beam and column would interact with each other.”

The system has shown success in laboratory testing; Sezen is seeking funding for full-scale testing.

Now, Sezen is investigating the use of fiber-reinforced polymers in wraps for concrete and steel or as reinforcement inside concrete columns or beams.

“We are comparing how these systems are performing compared to our steel cage,” Sezen says, “and also compared to traditional systems, like steel tubes and rebar.”

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A team of engineering professors is developing nonlinear 3-D modeling and characterization to design and manufacture 3-D multi-functional materials, devices and structures in a way that is not possible today.

The team’s multidisciplinary collaboration has resulted in a systematic method to synthesize “smart” materials tailored to optimize a desired behavior, combining fundamental, nanoscale physics with mesoscale continuum mechanics principles. They are now using this method to examine new alloys that could be used in more efficient fuel injectors.

Smart materials, which change their shape and properties in response to external stimuli such as thermal, mechanical, electrical, magnetic or optical signals, are often used to make solid-state sensors and actuators that, when integrated within a structure and connected to a control system, create a smart system that can adapt to its environment.

In some cases, the smart material is the structure. For example, new magnetostrictive iron-gallium (Galfenol) alloys have been found to be machinable and capable of supporting compressive loads. With these properties, Galfenol can function as both a structural member and electromagnetic sender/receiver, enabling, for instance, submarine hulls that provide structural integrity and also vibrate under magnetic field control to generate and detect sonar signals.

Although most smart materials exhibit 3-D responses, current design of smart systems is generally 1-D.

“Some smart materials can actuate and sense in all three directions, but they are only being used in one direction,” says Stephen Bechtel, professor of mechanical engineering, who works on the project with Marcelo Dapino, associate professor of mechanical engineering, and Michael Mills, professor of materials science and engineering. The research is supported by the Institute for Materials Research.

A car suspension, Dapino explains, can illustrate the 3-D concept.

“A car suspension has multiple elements to perform different functions. Each of them is typically 1-D in the sense that they apply a force or create a displacement in a single direction,” he says. “With our new materials we could make a suspension system with fewer links, as few as only one, each of which performs multiple functions in multiple directions.”

The research will greatly reduce time-consuming trial-and-error combinatorial testing of materials and will remove the constraints of small signal and 1-D operation imposed by such testing.

Working with Joseph Heremans, Ohio Eminent Scholar and professor of mechanical engineering and physics, the team wants to determine the feasibility of using Galfenol as an actuator material for driving fuel injectors.

As the automotive industry strives to improve fuel economy and emissions, the requirements for fuel injectors are increasingly stringent, with the current system of several short injection pulses per engine cycle requiring very precise and very repeatable timing. The industry has started to move to smart materials to meet these challenges.

“Galfenol could fundamentally change the manner in which fuel injectors are made,” says Dapino. “The enhanced control of the injection schedule made possible by Galfenol, along with this alloy’s steel-like mechanical properties, promise fuel injectors capable of delivering enhanced performance, improved fuel efficiency and reduced emissions concurrently with robust operation and high reliability.”

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A 3-D smart system is represented by four domains: electrical, electromagnetic, thermoelastic and mechanical. The system operates as an actuator, from left to right, or as a sensor, from right to left.
Design and Definition: Challenging modernism’s limitations

By Moni Wood

Combining the use of traditional materials and modern methods, Stephen Turk, associate professor of architecture at the Knowlton School of Architecture, creates unique pieces that challenge the definition of function and design.

“The design is experimental in trying to blur the distinction of the components and challenge the traditional ideas, such as what a table is and what a table can offer you,” says Turk.

His concept was inspired by his interest in woodworking as well as from his study of tomography — a method of producing a three-dimensional image of a series of sections of a solid object. Although he uses traditional methods to assemble and finish the pieces, Turk favors modern animation software as a tool to design and produce them.

“Animation software allows me the freedom to create variations in the model in much more complex ways,” explains Turk.

“I teach the graduate level computer graphics course for architects,” Turk adds, “which includes fabrication methods and computer animation software. I often use the computer files from which my furniture pieces are produced as examples during class.”

Using the computer program 3D Studio Max, Turk experiments with design configurations, finding novel ways for enhancing certain aspects of the piece, such as unusual yet sturdy leg placements. He can also use the application to “visualize” the interior of the piece, enabling him to enhance certain aspects, such as the wood grain, and make the material be part of the aesthetic.

Although Turk creates his furniture pieces with customary plywood, he brings a new awareness to his use of this material by seeking ecologically sound and renewable resources.

“It didn’t start out as an ecological endeavor,” says Turk. “However, since I became more aware of environmental conditions, I now seek out wood from environmentally friendly resources such as wood from forests with good stewardship.”

Turk’s method of construction is also one of several used by students in their class projects. The particular equipment that Ohio State’s architecture section has — a computer-controlled router — is particularly suited to this method and the use of plywood.

Turk’s design research also led him to study the conditions of the human body and how our bodies react to objects, materials and our environment.

“In creating furniture, it was a natural progression to think of the architectural problem of the relationship of our bodies to the world around us,” he explains. “The conditions of the body and its reaction to objects and materials became an important part in the design.”

By his use of modern computer animation, Turk can change the design to fit the exact wants or needs of an individual. Similar to the traditional tailor who cuts custom designs for clothing, Turk can create a chair “tailored” for an individual or a table that meets a particular need without sacrificing aesthetic appeal.

All of these design aspects combined into a single project make it difficult to define Turk’s creations.

“It want to challenge the idea that something has to fit into one definition — art, function, design — and to see if we can overcome limitations that might be viewed in modernism,” he says. “It continues the study for larger architectural problems.”

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Stephen Turk combines traditional materials, such as plywood, with modern computer design in his pieces, such as this half-size model of a table in his Wave Table Project. His furniture combines function and design, for example, through the single surface construction, which allows for the blending of functional and aesthetic effects producing both the useable surface and the tables’ ornamentation.
Nuclear Waste Storage and Disposal: Corrosion experts explore safe options

Ohio State researchers are among scientists nationwide who are determining ways to safely store and then dispose of civilian and defense nuclear waste from across the nation in a proposed repository in Nevada.

For more than two decades, the U.S. Department of Energy has headed an extensive scientific effort to analyze whether Yucca Mountain, Nev., is a safe site for a deep underground facility, called a repository, to safely isolate highly radioactive nuclear waste for at least 10,000 years.

Materials science and engineering Professor Gerald S. Frankel and Professor and department Chair Rudy Buchheit, who are director and co-director, respectively, of Ohio State’s Fontana Corrosion Center, are studying the behavior of very corrosion-resistant alloys currently selected in the design to fabricate the waste canisters. They also are investigating localized corrosion, such as crevice and pitting, under highly aggressive conditions to support the analysis of the Yucca Mountain site.

Nuclear waste is currently stored in temporary facilities in more than 120 locations in 39 states, according to the Department of Energy. The civilian waste, spent nuclear fuel, is stored at nuclear power plants. The defense waste, highly radioactive material associated with weapons production, is stored in underground tanks and in other forms at government facilities.

“There are specifications for the tank chemistry, and we are studying the susceptibility of the steel to corrosion in these environments and how the specifications can be improved for safety and cost savings,” Frankel says.

For the potential disposal at Yucca Mountain, Frankel and Buchheit are examining the breakdown of the alloys as they are exposed to thin electrolyte layers resulting from the dust, particulates and moisture from the surrounding rock and humidity; the use of the Scanning Kelvin Probe for studying corrosion under the electrolyte layers; and the effects of various anions in the electrolyte layers on the corrosion processes.

The Department of Energy is funding Frankel and Buchheit’s studies through a major multi-university effort, coordinated at Case Western Reserve University with researchers from 10 universities and several national laboratories, that began in 2004.

This June the Department of Energy submitted a license application to the U.S. Nuclear Regulatory Commission seeking authorization to construct the repository at Yucca Mountain, a remote ridge on federally controlled land in the Mojave Desert. The U.S. Congress and President Bush approved the site in 2002. The goal is to begin depositing the waste at the site by March 2017.

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Stimulating Ohio’s Economy: Walter develops new fuel cells with local business

By Tom Knox

Mark Walter is helping Ohio power its energy industry. Walter, associate professor of mechanical engineering, works with NexTech Materials Ltd., a central Ohio business that uses science and engineering to conceive, develop and commercialize energy and environmental products. Earlier this year, NexTech received a $1 million grant for a solid oxide fuel cell manufacturing project from the Ohio Third Frontier Fuel Cell Program, which aims to accelerate the advanced energy industry in Ohio.

A portion of the grant will be used by Walter, in collaboration with NexTech, to develop fuel cells to be incorporated into 100-kilowatt-plus power generation systems for commercial and residential applications.

“Using fuel cells for these applications has some real advantages: It’s clean power, it’s far more efficient than combustion, and because the cells run very hot, you can use some of the waste energy for heating or hybridization with turbines,” Walter says.

Another positive aspect to the 100-kilowatt fuel cell system is its efficiency within distributed power systems.

“The average American home needs about one kilowatt of power for peak demand, so this new fuel cell could currently power about 100 houses,” explains Walter.

Society needs to become more aware of how wasteful it is with energy and take simple steps to reduce consumption, Walter says. Energy conservation together with other innovations would make it possible to power large neighborhoods with 200 or more houses by a single 100-kilowatt fuel cell system.

“The efficiencies of scale associated with newer apartment complexes in Asia could provide a niche market for the 100-kilowatt-plus fuel cell system and provide power for larger numbers of families,” says Walter.

To meet the needs of megawatt-scale distributed power generation, multiple fuel cell stacks can be combined and integrated into a power generation system. As system power output increases, it is necessary to increase the power output per stack module to reduce the number of modules in the system. This leads to a need for larger and more powerful fuel cells (500 watts/cell, compared to the current 100 watts/cell).

Most fuel cells are made at about 20 by 40 centimeters, but the goal now is to make them about four times bigger, a feat that has never been done before with scalable manufacturing technologies, Walter says.

“It’s not clear whether the materials are strong enough to withstand stresses in these much larger components, and so our contribution is to investigate ways of strengthening the material and components, first by modeling how much strength is needed and then coming up with different ways to strengthen the structure,” Walter says.

Afterward, NexTech will manufacture the fuel cells here in Ohio. Such investment is a goal of the Third Frontier Project, created in 2002 as the state’s largest-ever commitment to expanding Ohio’s high-tech research capabilities with the hope of promoting innovation and company development.

“Development of these power systems will allow NexTech’s commercial partners to design cost-effective and efficient solutions for distributed generation of power,” says NexTech’s CEO, Bill Dawson. “NexTech will establish critical, world-class manufacturing capability right here in Ohio.”

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While predictive modeling is revolutionizing materials design, Ohio State researchers are finding even more solutions by adding experts in characterization and experimentation to the equation.

“We have an integrated team, with researchers who do modeling from the nanometer to the meter scale and researchers who do characterization and experiments at the same length scales for validating those models,” says Hamish Fraser, director of the Center for the Accelerated Maturation of Materials, Ohio Eminent Scholar and professor of materials science.

In the past six years, this team has made approximately $18 million in research expenditures and brought in more than $22 million in funding from sources including the Air Force Research Lab, Office of Naval Research and industry.

Materials modelers have a tall order: Aircraft designers, for example, used to take 10 years to find an improvement for a jet engine — at a cost of more than $30 million. Now, they can do that same process in 36 months for significantly less money.

“Our aim is to do materials modeling in concert with designers,” Fraser says, pointing out that designers’ choice of materials often relies on their comfort level with existing materials. “We need the benefit of exploring new materials while reducing the risk when they are used during subsequent phases of design.”

That’s where the predictive modeling comes in, reducing the time needed for experimentation. Ohio State’s integrated team streamlines the process: Characterization experts determine the mechanisms behind certain materials’ properties, modelers use those results to predict materials’ behavior in specific uses, and then the characterization and experimentation experts validate those predictions at scale.

These three-dimensional computer simulations show predictions of microstructural evolution in a nickel-based superalloy for jet engine applications. In the diagrams, (a) is the starting microstructure in a new turbine blade and (b) and (c) are the microstructures after nine hours of continuous operation at $1300K$ ($1027$ degrees C) under $152$ MPa tensile and compressive stress, respectively. These quantitative simulation predictions provide valuable data for the assessment of the creep behavior and lifetime of turbine blades that are a key component determining the safety, performance and fuel efficiency of a turbine engine. The simulation predictions were made by Ning Zhou, a doctoral student in Yunsi Wang’s group in materials science and engineering. The simulation method used is the phase field method, and the calculations were carried out at the Ohio Supercomputer Center on campus.
“Our ability to predict the behavior of materials at different length scales has dramatically increased, and now we’re trying to get this integrated with characterization and experimentation. In the next three to four years, I expect very significant advances,” Fraser says. “The wave is there. We’re on the wave — we’re not still paddling around looking for it.”

CAMM researchers already have perfected the ability to predict the strengths of certain alloys for industry without extensive experimentation and to predict how the microstructure of materials will change as a result of heat and stress. Now, they’re working to improve materials used in nuclear and solar energy, predict the behavior of new alloys used in thermal protection systems of hypersonic vehicles, and find a new alloy for prosthetic implants.

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Battery Boost: 
Examining the life of lithium-ion power

For years, lithium-ion batteries have been ideal for devices such as mobile phones and laptop computers thanks to their high-energy density, fast charging time, low toxicity, lack of memory effect and minimum maintenance.

In those uses, the batteries often outlived the devices, which undergo rapid development cycles.

As technology changed, the lithium-ion batteries showed promise for more durable goods, like automobiles, where they are subject to much harsher environmental and electrical duty cycles.

The catch: Evidence that these batteries can meet the requirements established by U.S. Council for Automotive Research’s Advanced Battery Consortium, which expects batteries to last for 15 years in hybrid electric vehicles and 10 years in electric vehicles, is still incomplete. Much research is directed at assessing and extending the life of these batteries.

“The goal is to be able to accelerate the pace of the development of batteries that would be capable of satisfying harsh requirements in the automotive world,” says Giorgio Rizzoni, professor of mechanical engineering and director of the Center for Automotive Research at Ohio State. To examine the batteries from the systems level to the nanoscale, Rizzoni is partnering with mechanical engineering colleagues Bharat Bhushan, Howard D. Winbigler Professor and Ohio Eminent Scholar; Yann Guenezennec, professor; and Shrikant Nagpure, a doctoral student, and with Suresh Babu, associate professor, industrial, welding and systems engineering.

On the system level performance of the cell, the team will age lithium-ion cells under representative automotive electrical and thermal cycles in the battery aging facility at CAR. At specific intervals, they’ll use non-intrusive electro-thermal battery identification and electrochemical impedance spectroscopy to see how the batteries measure up to the aging protocols of the Advanced Battery Consortium. Then they will disassemble the aged batteries to look at their micro- and nano-characteristics to determine how the aging changed the surface of the cathodes and anodes on the batteries. They’ll also identify the chemical compositions of deposits on the cathodes and anodes. The researchers will correlate the two facets of the work to relate internal damage mechanisms at the nanoscale with fading of electrical characteristics after harsh usage.

“We need to determine what changes in materials property, topology and composition cause the battery to age,” says Rizzoni. “By understanding that process, we can understand how to design a better battery.”

CAR’s industrial consortium and a $45,000 Interdisciplinary Materials Research Grant from the university’s Institute for Materials Research are providing seed money for the research. Babu, Bhushan and Rizzoni will be joined on the research team by Gerald Frankel and Rudy Buchheit of the Fontana Corrosion Center and by three faculty members in chemistry.

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At the Center for Automotive Research, (from left) Shrikant Nagpure, a mechanical engineering doctoral student; Kristin Bergner, a Rensselaer Polytechnic Institute mechanical engineering student on an internship at CAR; and John Neal, a research assistant, change lithium-ion batteries in a fixture with temperature-controlled Peltier junctions to age the batteries. After testing, Nagpure will open the batteries (image at left) and examine the cathodes in a controlled environment to see the material degradation at the micro- and nanoscale.
Stopping Loss:
Gear Lab studies transmission power

By Emily Burkhart

As fuel prices skyrocket and environmental concerns prevail, the advancements made in the College of Engineering’s Gear Dynamics and Gear Noise Research Laboratory become more imperative.

Researchers at the laboratory work to model power losses and improve efficiencies of gear systems and transmissions.

The Gear Lab research is primarily sponsored by the automotive, aerospace, heavy truck and off-highway vehicle industries and performed in state-of-the-art experimental facilities at Scott Laboratory in the Department of Mechanical Engineering.

One project, supported by General Motors Europe, is the development and validation of a manual transmission power loss model.

“Our efficiency model of manual transmissions allows us to evaluate new designs for their efficiency outcome,” says Ahmet Kahraman, director of the Gear Lab. “It also identifies the parameters that are critical to power losses. One parameter, for example, is the roughness of the contacting gear surfaces, so we are determining how much roughness corresponds to how much power loss.”

“The software developed in this project has proven to be instrumental to current and future transmission development and points once more to the leading position of Ohio State in the international gear and transmission community,” says Georg Bednarek, program manager and global chief engineer of automatic transmissions at GM Powertrain Europe. (Until this summer he was chief of manual transmissions.)

Also at the Gear Lab, GM sponsors a major helical gear efficiency project that is going into its fourth phase. Aarthy Vaidyanathan, a graduate student in mechanical engineering, conducts precise helical gear efficiency experiments for validating predictive models developed based on tribological aspects of gear contacts.

“In gearboxes, even if you can decrease power loss and increase efficiency by half a percentage point, that makes for a significant improvement in terms of fuel use,” says Vaidyanathan. “These efficiency improvements that are compounded in a transmission have the potential to improve fuel economy of a vehicle significantly.”

General Motors also sponsors theoretical and experimental investigations of planetary gear power losses in automatic transmissions and automotive rear axles.

“In addition to exposure to learning fundamental science issues associated with power transmissions and gearing, our students gain hands-on experience in practical aspects of research, thanks to our sponsors,” says Kahraman. “These students go on to start their professional lives at some very reputable companies in the field.”

The Gear Lab’s researchers investigate aspects of power transmission and gearing including design, noise and vibration, lubrication and wear, fatigue and efficiency. The lab is funded by a consortium of more than 50 industrial and government partners, such as GM, Ford, Honda, Mazda, Caterpillar, John Deere, Eaton, Gleason Works, Harley-Davidson, Sikorsky Aircraft, Honeywell, Rolls-Royce, Xerox, NASA and the National Renewable Energy Laboratory. It also conducts research projects in the form of individual grants.

Kahraman points out that making changes in transmissions for efficiency also affects factors including noise, mechanical lifespan and durability, size and cost.

“Our real challenge is to find solutions that will not influence other factors in the drive train adversely,” he says. “The goal is to bring efficiency into the design process of transmissions, making it a requirement at the very beginning.”

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Gear Lab supervisor Sam Shon, left, and mechanical engineering graduate student Timothy Szweda work on the transmission dynamometer with the manual transmission efficiency set-up. Pictured in the foreground is its manual six-speed transmission.
Fake Diamonds Help Jet Engines Take the Heat

By Pam Frost Gorder

Ohio State University engineers are developing a technology to coat jet engine turbine blades with zirconium dioxide — commonly called zirconia, the stuff of synthetic diamonds — to combat high-temperature corrosion.

The zirconia chemically converts sand and other corrosive particles that build up on the blade at high temperatures into a new, protective outer coating.

Ultimately, the technology could enable manufacturers to use new kinds of heat-resistant materials in engine blades so engines can run hotter and more efficiently, says Nitin Padture, professor of materials science and engineering, who developed the technology.

Jet engines operate at more than 2,000 degrees Fahrenheit, and blades in the most advanced engines are coated with a thin layer of temperature-resistant, thermally insulating ceramic to protect the metal blades. The thermal-barrier coating is designed like an accordion to expand and contract with the metal.

The problem: When sand hits the hot engine blade it melts — and becomes glass. The hot glass chews into the ceramic coating. But the real damage happens after the engine cools and the glass solidifies into an inflexible glaze on top of the ceramic. When the engine heats up again and the metal blades expand, the ceramic coating can’t expand because the glaze has locked it in place. The ceramic breaks off, shortening the life of the engine blades.

In research funded by the Office of Naval Research and Naval Air Systems Command, Padture and his colleagues developed a process by which the new coating forces the glass to absorb chemicals that will convert it into a harmless — and even helpful — ceramic. The key, Padture says, is that the coating contains aluminum and titanium atoms hidden inside zirconia crystals. When the glass consumes the zirconia, it also consumes the aluminum and titanium, eventually changes from a molten material into a stable crystal and stops eating the ceramic.

“The glass literally becomes a new ceramic coating on top of the old one. Then, when new glass comes in, the same thing will happen again,” Padture says.

The University of Connecticut, where Padture was a professor before joining Ohio State, has applied for a patent on the technique that he devised for embedding the aluminum and titanium into the zirconia. He’s partnering with Inframat Corp., a nanotechnology company in Connecticut, to further develop the technology. Padture stressed that the technology is in its infancy. He has yet to apply the coatings to complex shapes, and cost is a barrier as well: The process is energy-consuming.

But if that cost came down and the technology matured, the payoff could be engines that burn fuel more efficiently and create less pollution. Manufacturers would be able to use more sophisticated ceramics that boost the heat resistance of engines. Eventually, the technology could go beyond aircraft and power-generator turbines and extend to automobiles as well, Padture says.

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On the left, conventional ceramic coating destroyed by molten glass. On the right, ceramic coating designed to resist molten glass (which is in a thin layer on top). The field of view of both images is about half a millimeter.

IMAGES COURTESY OF AYSEGUL AYGUN AND NITIN PADTURE
High School Teachers Learn New Approaches to Teaching Science at Materials Camp

Students of Debbie Goodwin, a teacher at Chillicothe High School in Missouri, come to her class saying they can’t wait to arrive to begin that day’s projects.

“They will stay after school and sometimes come on the weekends — for no extra credit,” she says. “They come because they enjoy it.”

Goodwin is referring to the materials science classes she has been teaching for more than 10 years, with help from ASM International, which trains high school science teachers to take the science of materials into their classrooms and laboratories.

This summer, high school science teachers from across the nation arrived at Ohio State for the first ASM Advanced Materials Camp for Teachers. The Advanced Materials Camp provided classroom lesson plans and laboratory protocols as well as teacher lab training, all free of charge to the participating teachers.

Elizabeth Eddy, a science teacher at Westerville South High School in Ohio, has attended the camp three times and last year taught her first materials science course at her school. She makes use of recent media reports to show her students how materials science relates to new technology.

“The kids are learning stuff that is ‘right now, today,’” she says, “and they feel like they are looking into the future sometimes.”

ASM, the Materials Information Society, is leading a national effort to enlist the next generation of scientists and engineers by training high school teachers to introduce materials science courses into high school classrooms, to encourage more students to prepare for careers in the STEM fields and to build awareness of the exciting opportunities in these areas.

Ohio State’s Advanced Materials Camp was the only professional development workshop of the 22 camps held throughout North America that focused on more advanced materials science training. All of the 25 teachers attending the Ohio State camp had previously attended an ASM Materials Camp for Teachers and plan to introduce materials science into their own classrooms.

The Ohio State advanced camp provided more in-depth training and new instruction methods and laboratory experiences for the teachers to take back not only to their own classrooms but to their fellow teachers as well. Teachers attending the Ohio State camp came from 11 different states.

Materials science includes elements of applied physics and chemistry, two courses often taught in high schools. By training teachers to take the study of physics and chemistry farther by introducing materials science labs and experiments into their classrooms, ASM hopes that more students will choose materials science and engineering for their careers.

“What’s the future? It could be bleak if there is nobody ready to step in. It’s fun to do this stuff,” says Schwartz, a retired director of the Air Force Office of Scientific Research, referring to the materials science camp activities. “You pour things into other things and magic happens. The kids get into it, and they have fun, and that keeps them coming back.”
Global Attraction

International materials science experts collaborate at Ohio State

Scientists from Boeing, Australia, China, U.S. national labs and other locations around the world travel to laboratories at Ohio State’s College of Engineering to conduct their materials science research.

Take for example Yau Yau Tse, a research scientist from the United Kingdom’s University of Birmingham, who has been visiting Ohio State’s Center for the Accelerated Maturation of Materials to investigate solute distributions in multilayers of thin film, an electronic functional material. While Tse uses the Titan, a scanning transmission electron microscope, on campus at Ohio State, Ian Jones, a University of Birmingham professor, observes real-time from the U.K. at his own Department of Metallurgy and Materials in the School of Engineering.

Like the Titan, most of the equipment at the Campus...
Electron Optics Facility can be operated remotely to assist researchers like Tse and Jones. Such remote operation of the microscope facilities is an extremely attractive and cost-effective way to perform collaborative research and provides a unique advantage to CAMM, CEOF and Ohio State in terms of developing and nurturing international partnerships.

“It was absolutely invaluable for our research programs for me to be able to spend a few days at CAMM, watching the aberration corrected microscope being used and talking with the researchers,” Jones says. “Now we are in a position where we can usefully access this world-leading equipment remotely, via the Web.”

Expertise at College of Engineering materials facilities is recognized by peers and industry representatives worldwide. Boeing, for example, is relying on CAMM to find a very high-strength yet damage-tolerant titanium alloy, as well as a second titanium alloy that is extremely lightweight yet maintains the tensile and toughness properties of alloys currently in use.

Materials scientists also work through the College of Engineering’s Semiconductor Epitaxy and Analysis Laboratory, SEAL, which houses state-of-the-art, centralized molecular beam epitaxy (MBE) facilities to synthesize a wide range of electronic materials and nanostructures.

“The continuous collaborations with industry colleagues using SEAL facilities have a great two-way benefit,” says Steven Ringel, professor and Neal A. Smith Endowed Chair in electrical engineering and director of Ohio State’s Institute for Materials Research, who founded SEAL in 1994 as the first MBE facility at an Ohio university. "For example, we are currently working with a small Ohio-based startup company, NewCyte Inc., which relies on SEAL capabilities to synthesize its advanced solar cell technology that utilizes nanostructured compound semiconductors. The fact that NewCyte’s technology is being developed in part in conjunction with our Wright Center for Photovoltaics Innovation and Commercialization means students working in SEAL become quite attractive for NewCyte and similar companies. There is a win-win cycle, because we provide technical pathways to products as well as students who can lead that process in the future.”

“Materials science work at Ohio State can integrate academia and industry to perform world-class research and develop technologies that are eventually captured in products,” says CAMM director Hamish Fraser. “We end up creating wealth because we provide technical pathways to products as well as industry to perform world-class research and develop students who can lead that process in the future."

Materials science work at Ohio State can integrate academia and industry to perform world-class research and develop technologies that are eventually captured in products, says CAMM director Hamish Fraser. “We end up creating wealth and jobs and providing an enhanced educational process for our students.”

Materials facilities in the College of Engineering include:

**Campus Electron Optics Facility:**
- The Titan, a 12-foot tall, 2-ton scanning transmission electron microscope, helps researchers investigate the elemental distributions that occur over a very few atomic distances and can significantly impact the behavior of materials. The Titan features a corrector for aberrations generally associated with such microscopes; a monochromator that reduces the amount of energy spread in the electron beam used in imaging; and a spectrometer that reads information contained in electrons that passed through the imaged sample.
- Another state-of-the-art analytical transmission electron microscope, the Tecnai, which provides detailed information regarding the structure and composition of materials microstructures at the atomic and nanoscales.
- Two dual-beam focused ion beam/scanning electron microscopes (Nova and Helios), which provide for rapid site-specific transmission electron microscope sample preparation as well as three-dimensional characterization of materials microstructures.
- Three scanning electron microscopes (Sirion, Quanta, ESEM) that provide for analytical analyses of materials microstructures at the micrometer scale, including information regarding composition and crystal orientation.

**SEAL – Semiconductor Epitaxy and Analysis Laboratory:**
- Three MBE growth chambers interconnected with a surface and chemical analytical characterization chamber (x-ray photoelectron and Auger spectroscopies) that uniquely enables in-situ exploration of surfaces, interfaces and heterostructures grown in any of the MBE chambers. SEAL supports projects ranging from advanced photovoltaics and next-generation, high-speed electronics to the basic science of new materials and nanostructures, based on materials systems that include compounds such as gallium arsenide, indium phosphide and gallium nitride to next-generation spintronic materials.
- A custom, high-resolution, triple axis x-ray diffraction instrument capable of performing non-destructive measurements of structural properties with less than 0.0001 Angstrom of spatial resolution in various ambient environments and possessing integrated photoluminescence mapping.
- A state-of-the-art variable field and temperature Hall Effect system with quantitative mobility spectrum analysis capabilities that enables parallel characterization of nanometer-thick sheets of electrons as well as bulk carrier transport that are vital for advanced device development.
- A wide range of support tools for the MBE growth efforts. In addition, the Oxide MBE Laboratory, a state-of-the-art molecular beam epitaxy facility to grow ferroelectric and ferromagnetic oxides with atomic layer precision, is an interdisciplinary lab supported by Ohio State’s Colleges of Engineering and Mathematics and Physical Sciences and the Institute for Materials Research. It is designed to create a new class of materials for the next generation of electronics technology. And at Nanotech West, Ohio State’s main user facility for micro- and nanotechnology activity, various academic and industry users conduct research, development and commercialization work. (See story, pages 10-11.)

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Calculating Speed: Research improves computer communications

By Moni Wood

Dhabaleswar K. Panda sees the need for speed — on the information superhighway, that is. Panda and his computer science research team developed a software system that helps advance high-performance computing.

High-performance systems are used for solving all types of advanced computing problems in areas including the sciences, engineering, medicine and finance. Over the years, large-scale mainframe computers have been replaced with clusters of servers networked together.

"With cluster computing, the computers solve a larger problem in parallel by dividing the workload," explains Panda, professor of computer science and engineering. "However, this requires the computers to communicate in a parallel manner while sending large amounts of information to each other. This creates a need for a high-performance, scalable communication and synchronization protocol."

Panda and his team met that need by developing a software system named MVAPICH, which stands for MPI for InfiniBand on VAPI Layer.

MPI, or Message Passing Interface, is the standard programming model for writing and executing parallel programs in high-performance systems and clusters. InfiniBand, a new open standard networking technology that allows a plethora of features to deliver high-performance communication, created a need to take advantage of these features at the MPI library layer to deliver high-performance, scalable communication to parallel applications using the MPI library for InfiniBand-based clusters.

Using MVAPICH for high-performance computing applications on InfiniBand-based clusters enables the parallel applications to take advantage of all features (including low latency, high bandwidth and fault tolerance capabilities) of the underlying InfiniBand network. Overall, it reduces parallel communication time and provides the best speedup and scalability for parallel applications on a cluster.

"What started as a research prototype in 2001 is now a production quality software," says Panda.

The software is used by more than 715 organizations worldwide, including national and international supercomputer centers as well as industries and universities. It has been used to drive some of the world's top supercomputers, such as the 62,976-core cluster (recently ranked No. 4 in the world) at the Texas Advanced Computer Center.

Panda developed MVAPICH and its new version, MVAPICH2, as open source programs available for free download from his university Web site.

"By having the software as open source," he says, "organizations that have highly advanced systems allow students to remotely 'use' the most powerful and complex computers in the world to test their theories and new designs."

Panda, an IEEE Fellow, and his team have gained recognition for their research, including funding from NSF, the U.S. Department of Energy, and major industries such as Intel, Sun Microsystems and Cisco.

"People all over the world," Panda says, "use our code, benefit from it and know that this research was conducted at Ohio State by Ohio State students and faculty."

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Computer science and engineering students of D.K. Panda (second from right) include (from left) doctoral students Sundeep Narravula and Gregory J. Marsh and master’s degree students Hari Subramoni and Jaidev Sridhar.

Jo McculTy
Exploring Bulk Metallic Glasses

By Tom Knox

Toward the end of Kathy Flores’ master’s degree research at Stanford University, she learned of bulk metallic glass — a new material in the realm of materials science and engineering that has since become a major focus of her career.

Now Flores is among a small but growing group of researchers across the United States studying these high-strength alloys.

Eleven years after that class, Flores, an Ohio State associate professor of materials science and engineering, is still researching bulk metallic glasses and how they can be applied to the real world.

As an undergraduate, Flores received a bachelor’s degree in mechanical engineering, but the intricacies of design tilted her area of interest.

“I realized while co-oping that in order to design engineering structures, materials played a really vital role in the process, so I got really interested in designing things at the material level rather than the system level,” she says.

A lightweight, silver material, bulk metallic glass — contrary to its name — does not look like window glass. It does, however, have a random atomic arrangement like window glass, making it different from conventional metals. If one were to zoom in and look at the atoms of a normal metal such as aluminum, the atoms would all be neatly arranged in a crystalline structure. The much more random atomic arrangement of metallic glass changes how the material behaves.

One change is how the material responds to a load. Flores demonstrated this difference by first dropping a steel ball on an aluminum slab, then dropping it on a metallic glass slab. When dropped on the aluminum, the ball bounces for a short time then quickly loses energy, because the structure of aluminum has crystalline defects, which are weak spots that show up in the form of dents where the ball hits. When the ball is dropped on the metallic glass, there is very little indentation and the ball bounces much higher and for a longer duration.

“There’s no inherent weak spot, so when the ball is dropped, it doesn’t absorb the energy and doesn’t permanently deform,” Flores explains. Thus, metallic glass has high resilience and elasticity.

Bulk metallic glasses were first applied to the real world in the form of golf clubs, where the improved springiness in the club head increases the distance the ball travels. The materials are still in their infancy, however, and Flores has expanded her research from the mechanical behavior of bulk metallic glasses to novel ways of processing them. She sees a future with many products using bulk metallic glasses, such as small springs, hinges and cutting tools like scalpels. With her research, she hopes to take stable glasses and use them in a smaller way, such as tiny camera gears.

Right now, there are only a handful of researchers working in her primary area of interest. This work is challenging because the atomic structure that controls behavior is so different from traditional crystalline metals, so none of the old, well-understood rules apply.

In the future, Flores plans to research structural materials for nuclear applications and biomaterials from a structural standpoint.

Clearly, Flores has a lot on her plate, but she is hungry to find out more in the world of materials science.

“There’s always more to do,” she says. “It’s all about pushing the boundaries of what phenomenon you can achieve with a given material.”

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Shroff Named Eminent Scholar

Ness B. Shroff has been named Ohio Eminent Scholar in Computer Networking and Communication Research in the College of Engineering, where he is a chaired professor of electrical and computer engineering and of computer science and engineering.

Shroff was previously a professor of electrical and computer engineering at Purdue University, where as director of the Center for Wireless Systems and Applications, he was involved in a number of initiatives involving the applications of wireless systems for entertainment, transportation, food safety and the environment and education.

His research interests span the areas of wireless and wireline communication networks, particularly in fundamental problems in the design, performance, pricing and security of these networks.

Shroff received his doctoral degree in electrical engineering from Columbia University in New York.

NSF Honors Two Rising Faculty Members

Two College of Engineering professors were among young researchers honored this year by the NSF with its Faculty Early Career Development (CAREER) award.

Rebecca Dupaix, assistant professor of mechanical engineering, received $400,000 for her project, “Integrated Approach to Modeling, Simulation and Design for Manufacture of Micro-hot Embossing Using a Polymer Glass Transition Modeling Framework.” She aims to help engineers understand how the properties of polymers change during the critical few seconds when these materials change from a soft, rubbery state to a more rigid “glassy” state while stamping takes place.

Yusu Wang, assistant professor of computer science and engineering, will use her $420,000 award toward her project, “Geometric and Topological Methods in Shape Analysis, with Applications in Molecular Biology.” She develops new methods to accurately manipulate biological molecules on computers, using tools from both computer science and mathematics.

Gustafson Named Education Innovation Center Director

Robert J. Gustafson has been named director of the Engineering Education Innovation Center and to the Honda Professorship for Engineering Education.

In his new role, Gustafson, the college’s associate dean for undergraduate education and student services, will oversee the Engineering Education Innovation Center, which serves as a hub for programs to enrich the student experience and strengthen the academic credentials of the college’s undergraduate students.

“If you could look out 10 years from now and see what contributions the center has made to engineering undergraduate education at Ohio State,” Gustafson says, “I hope it’s that we have a really improved education system because we’ve been innovative in how we teach and scholarly in what we teach and that we’ve contributed to the body of knowledge about innovative teaching and learning.”

Gustafson, former professor and chair of the Department of Food, Agricultural and Biological Engineering at Ohio State, earned a doctorate in agricultural engineering from Michigan State University.

He is well-known for his research in electrical power applications in food and agriculture and for his textbook, “Fundamentals of Electricity for Agriculture.”

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Carrying the Green Torch

By Tom Knox

“Green” is a theme rife with citizens’ concerns nationwide, and Ohio State engineering students are helping to guide environmentally friendly methods with a variety of completed and ongoing projects:

Solar Decathlon
A student/faculty team is participating in a U.S. Department of Energy-sponsored competition to design, build and operate the most engaging, energy-efficient, solar-powered home. The prestigious Solar Decathlon competition challenges university-led teams to develop a solar-powered home that meets various requirements in architecture, engineering, livability, comfort and power generation. The competition will culminate in fall 2009, when each team will transport its solar home to the National Mall in Washington, D.C., for display and final judging. (solardecathlon.osu.edu)

Buckeye Bullet 2
The student team for the Buckeye Bullet 2, a hydrogen fuel cell powered streamliner racer that has traveled faster than any other similar vehicle on record, plans a return to the World Finals at Bonneville Salt Flats this fall for more test runs. Last fall, the Buckeye Bullet 2 set an international record for a hydrogen fuel cell powered vehicle with a speed of 132.129 mph, certified by worldwide motor sports governing body Federation Internationale de l’Automobile. This summer the Bullet sped to 297 mph on the Flats. The racer, powered by recycled fuel cell stacks donated by Ballard Power Systems, has been designed and built by engineering students with the assistance of Ballard, Ford Motor Co. and Roush Performance. (www.buckeyebullet2.com)

Challenge X/EcoCAR
A team of engineering students took third place in Challenge X, a series of competitions held by the U.S. DOE to improve automotive technology in engine efficiency and emissions. Only 17 teams were selected to participate in the four-year competition, which involved the re-engineering of a Chevy Equinox to minimize energy consumption, emissions and greenhouse gases while maintaining or exceeding the vehicle’s function and performance.

The DOE has named Ohio State as one of 16 universities selected to participate in the next competition, called EcoCAR: The NeXt Challenge, in which students must re-engineer a 2009 Saturn Vue to achieve improved fuel economy and reduced emissions while retaining the vehicle’s performance and consumer appeal. (www.osuchallengex.com)

Pod
Engineering and architecture students designed and built the Pod, a sustainable and energy-efficient, 125-square-foot living unit for one or two people. Students working on the project first researched “green” technology, energy efficiency and sustainability and then spent winter and spring quarters designing and building the home as part of their senior honors distinction and capstone projects.

The Pod served as a prototype model for the larger 800-square-foot house the Solar Decathlon team is building for fall 2009. The team hopes to feature the Pod as an educational exhibit for children at the Center of Science and Industry (COSI) in Columbus in April 2009. (engineering.osu.edu/news/archive/2008/080527.php)
Accomplishments

A pollution sensor invented by Ohio State researchers Prabir Dutta, chair, Department of Chemistry; Sheikh Akbar, professor, materials science and engineering; and former graduate students Nicholas Szabo and Juin Chan Yang has received a 2007 R&D 100 Award from R&D Magazine.

Patrick Fox, professor, civil and environmental engineering and geodetic science, received the International Geosynthetics Society Award for his research contributions on the static and dynamic shear strength of geosynthetic clay liners.

Gerald Frankel, professor, materials science and engineering, received the U.S. Department of Defense’s Strategic Environmental Research and Development Program Weapons Systems and Platforms Project of the Year Award for his work, “Development of Chrome-Free Welding Consumables for Stainless Steels.”

James Gregory, assistant professor, aerospace engineering, and Ji-Cheng (J.-C.) Zhao, associate professor of materials science and engineering, have been selected among 82 of the nation’s brightest young engineers to take part in the National Academy of Engineering's 14th annual U.S. Frontiers of Engineering symposium.

Brian K. Hajek, senior research engineer and associate chair, nuclear engineering, received the 2008 Arthur Holly Compton Award from the American Nuclear Society.

W.S. Winston Ho, professor, chemical and biomolecular engineering and materials science and engineering, won the 2007 Clarence G. Gerhold Award from the Separations Division of the American Institute of Chemical Engineers.

L. James Lee, professor, chemical and biomolecular engineering, received the Council for Chemical Research’s 2008 Malcolm E. Pruitt Award and the Society of Plastics Engineers’ 2008 Plastics Engineering/Technology (Fred O. Conley) Award.

Rongxing (Ron) Li, professor, civil and environmental engineering and geodetic science, is one of 24 scientists selected by NASA as a participating scientist for a new moon exploration mission, Lunar Reconnaissance Orbiter.

Ming-Tsan (Mike) Liu, professor, computer science and engineering, received a Special Presidential Award from the IEEE Computer Society.


Andre Palmer, associate professor, chemical and biomolecular engineering, has been named the 2008 Lloyd N. Ferguson Young Scientist Recipient by the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers.

Robert Parker, professor, mechanical engineering, and a research team at Ford Motor Co. received a Chief Engineer Award at the Ford Powertrain Technology Innovation Awards.

William Rich, professor emeritus, mechanical engineering, received the American Institute of Aeronautics and Astronautics 2008 Plasmadynamics and Lasers Award.


DeLiang (Leon) Wang, professor, computer science and engineering, has been named president of the International Neural Network Society and received the society’s 2008 Helmholtz Award.

T.H. Wu, professor emeritus, civil and environmental engineering and geodetic science, received the 2008 Ralph B. Peck Award from the American Society of Civil Engineers Geo-Institute.

Steve Yurkovitch, professor, electrical and computer engineering and mechanical engineering, is the recipient of the 2008 John R. Ragazzini Award in Control Education from the American Automatic Control Council.

Fellows

Dennis Burnside, faculty emeritus, electrical and computer engineering, Antenna Measurement Techniques Association

Dorota Grejner-Brzezinska, professor, civil and environmental engineering and geodetic science, International Association of Geodesy

Somnath Ghosh, professor, mechanical engineering and materials science and engineering, American Association for the Advancement of Science and U.S. Association for Computational Mechanics

Joel Johnson, professor, electrical and computer engineering, IEEE

Robert Lee, chair and professor, electrical and computer engineering, IEEE

William Marras, professor of industrial, welding and systems engineering; physical medicine and rehabilitation; and orthopaedic surgery, International Ergonomics Association

D.K. Panda, professor, computer science and engineering, IEEE

Robert Parker, professor, mechanical engineering, American Society of Mechanical Engineers

Leon Peters, faculty emeritus, electrical and computer engineering, Antenna Measurement Techniques Association

Rama K. Yedavalli, professor, aerospace engineering, American Society of Mechanical Engineers
Seeing the Light

Design studios give architecture students insight into materials and building concepts

By Joan Slattery Wall

Architecture students transformed the Knowlton School of Architecture into an experiment of light with their studio sequences this spring.

Teams of second-year students produced installations dealing with the effects of light within particular sites of Knowlton Hall. They investigated precedents in architecture and related arts, produced designs and developed proposals through drawings and model and material studies before they built the projects.

“Within the larger trajectory of a student’s education, the project underscores the difficult negotiation between design intentions, the development of those intentions in the studio, and their final realization in the built world,” says Michael Cadwell, architecture professor and chair of undergraduate studies.

Susan Melsop, a Columbus architect and Knowlton adjunct instructor, says a team in her studio used origami to illustrate the structural aspects of paper through tight and loose folds (see center photo at right).

“Instead of thinking about form or function, they thought about which material is going to do something for us,” says Melsop, ARCH ’87. “We’re trying to get them to recognize the importance of materials sciences because of that growing area.”

“The idea of origami was driven through the simplicity of using paper, a material we interact with every day, and pushing it to new limits,” says Katie Welsch, a member of the origami team, adding that the project gave students their first opportunity to build a design at full scale.

“Folding so many origami pieces sounded impossible,” says teammate Liberty Longalong. “However, it was truly rewarding to see a physical manifestation of 8,000 little pieces assembled — no matter how much sleep was lost.”

Another installation, “Exterior Invasion,” (see photo on back cover) was built in the shape of the Knowlton School of Architecture’s façade.

“We started with the basic idea of bringing outside materials inside,” Young Joon Chung says.

The students noted that working together as a team provided just as many lessons as the design and construction process.

“The ideas and opinions that each of us brought to the table influenced the design process for the better,” says Seifert. “Each of us seemed to recognize different correlations and properties that many times we tend to overlook when we are intimately invested in a project.”

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[Top] Chris Randolph, Corinne Knight, Scott McLemore, Tim Kaskewsky and Tim Bauer formed this sculpture, “Bad Hair Day,” by folding paper into points and stapling them onto a wooden frame. Behind the sculpture, red and blue lights shined through the paper to create purple and pink hues.

[Center] The origami team’s installation, “Struct(p)ure,” was so named as a play on the words “structure” and “pure,” referring to the purity of material, color and construction, says team member Chris Seifert. “This purity is further enhanced by the ornamental and seductive nature of the installation’s structure, which is inherent to the material,” he says.

[Bottom] For “Light Trajectories,” Aidan Quinn, Mark Olson, Chris Bowers and Michael Perez used paper tubes of different sizes to model the pedestrian traffic in Knowlton Hall and provide a range of vantage points, sometimes revealing and sometimes concealing views.
Sophomore architecture students created this sculpture, “Exterior Invasion,” using Styrofoam bricks, toothpicks and glue. They painted one end of each brick bright pink and made use of shadow and reflection so the pink appeared on neighboring bricks. The sculpture was built in the shape of the Knowlton School of Architecture’s facade, and the foam bricks simulated light shining through tree leaves. The team members were Young Joon Chung, Jeyun Do, Jonathan King and Lauren Luffy. Read more about the installations on page 33.