Argonne NATIONAL LABORATORY

Update

FALL 2007

The Community Newsletter of Argonne National Laboratory

Argonne helps improve air quality for 2008 Beijing Olympics

ELEANOR TAYLOR

TO IMPROVE the air quality of Beijing and ensure a healthy atmosphere for athletes and spectators at the 2008 Summer Olympics, Argonne has been working with leading institutions, including the U.S. Environmental Protection Agency, the University of Tennessee, Tsinghua University, Peking University and the Chinese Academy of Sciences.

The team has researched and modeled the local and regional contributors to Beijing's air quality, leading to a greater understanding of regional air quality management and development of new emission control strategies. The modeling study has been widely cited by Chinese policy makers, including the Beijing mayor, in requesting the government to implement unprecedented regional control programs to ensure that the air quality goals for 2008 will be met in Beijing.

This research was funded by the U.S. Environmental Protection Agency. The report, "Air quality during the 2008 Beijing Olympic Games," is available online.

"Air quality in Beijing in the summertime is dictated by meteorology and topography," said David Streets, a senior scientist in Argonne's Decision and Information Sciences Division.

"Typically, temperatures are high, humidity is high, wind speeds are low, and the surrounding hills restrict venting of pollution. Thus, regional pollutants and ozone build up over several days until dispersed by wind or removed by rain.

"Our modeling suggests that emission sources far from Beijing exert a significant influence on Beijing's air quality," Streets said. "Typical industrial, coal-burning cities within several hundred kilometers of Beijing add to the local pollution. In these areas, emission controls on stationary sources and vehicles are not as stringent as in Beijing, and emissions are high. Each province's contribution varies dramatically from day to day, depending on wind direction and other meteorological factors.

"The Olympic Games are of paramount importance to China," Streets said, "and great steps have already been taken to ensure success."

"The United States is diligently working with cities like Beijing to improve environmental controls and reduce emissions in the face of rapid economic development," said Steve Page, director of EPA's Office of Air Quality Planning and Standards. "Over the past several years, Beijing has implemented a number of measures to improve air quality, and China is now looking at regional approaches to meeting air quality standards similar to successful approaches used in the U.S. The air quality improvements from their actions will benefit everyone." ■

Photo of a Beijing scene before a 2005 rain storm, and the same scene after the storm.

www.anl.gov/Media_Center/News/2007/Beijing_report_final.pdf

New catalyst helps eliminate NOx from diesel exhaust

A catalyst developed by Argonne researchers could help diesel truck manufacturers eliminate harmful nitrogen-oxide emissions from diesel exhausts. The catalyst is shown here by researcher Christopher Marshall. The catalyst will be placed in the reactor at left which is then connected to the diesel engine pictured in the background with post-doctoral researcher Sundar Krishnan, left, and Argonne researcher Steve Ciatti. *Photo by George Joch.*

DONNA JONES PELKIE

A CATALYST developed by Argonne researchers could help diesel truck manufacturers eliminate harmful nitrogen-oxide emissions from diesel exhausts.

The technology — which has a patent pending — appears so promising that multiple large and small companies have expressed interest in licensing it and working with Argonne researchers to scale up the technology and bring it to market. Argonne researcher Christopher Marshall, one of the technology's developers, believes there could be a commercially available product within two to three years.

Nitrogen oxides — collectively called "NOx" — contribute to smog, acid rain and global warming. Yet they are among the most difficult pollutants to eliminate from diesel exhaust. For example, many technologies that reduce NOx result in increases in undesirable particulate emissions.

"For diesel engines, we envision

(See "Catalyst" on page 3)

Researchers develop technique for bacteria crowd control

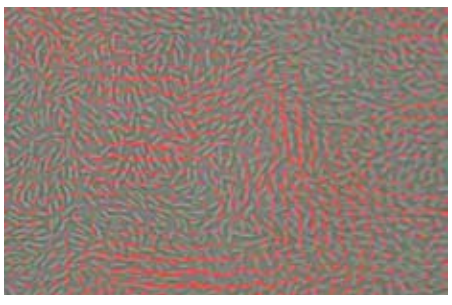
SYLVIA CARSON

A SURPRISING technique to concentrate, manipulate and separate a wide class of swimming bacteria has been identified through collaboration between researchers at Argonne, Illinois Institute of Technology, University of Arizona at Tucson and Cambridge University, U.K. This device could have enormous applications in biotechnology and biomedical engineering, including use in miniaturized medical diagnostic kits and bioanalysis.

The technique is based on the transmission of tiny electric current in a thin film sample cell containing a colony of bacteria. The current produces electrolysis that changes the local pH level in the vicinity of the electrodes. The bacteria, uncomfortable with the changes in pH, swim away from the electrodes and ultimately congregate in the middle of the experimental cell. Concentrated bacteria form self-organized swirls and jets resembling vortices in vigorously stirred fluid.

The method, which is suitable for flagellated bacteria such as E. coli, Bacillus subtilis, among many others, relies on the ability of bacteria to swim toward areas of optimal pH level. The bacteria live in an environment of a specific pH level, so that an increase or decrease of pH stimulates the bacteria to avoid areas of non-comfortable pH and swim in the direction of pH gradient. The researchers used an electric current to create a controlled deviation of the pH levels from the bulk values. Since only living bacteria respond to the pH stimulation, using this method can separate living and dead cells or bacteria with different motility.

The device, with the capability to change the thickness of a film from one millimeter to one micron (with five-percent accuracy) and



Bacteria swimming in a thin film.

control the position of electrodes, is intended to separate and concentrate small quantities of living and dead microorganisms in confined spaces. It can be used for the purposes of express bioanalysis, diagnostics and identification of small bacterial samples, and to separate sick and live cells. A patent for the device is currently pending.

"Using this method, our research

(See "Bacteria" on page 2)

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Atomic layer deposition fuels future solutions to nation's energy challenges

JENNIFER DEANGELIS

More efficient and less costly solar cells, solid-state lighting and industrial catalysts are potential applications of atomic layer deposition (ALD), a technique that Argonne researchers are working to perfect. Other potential applications are improved superconductors and separation membranes.

ALD is a thin-film growth technique that offers the unique capability to coat complex, three-dimensional objects with precisely fitted layers. The scientists expose an object to a sequence of reactive gas pulses to apply a film coating over the object's surface. The chemical reactions between the gases and the surface naturally terminate after the completion of a "monolayer" exactly one molecule thick. ALD can deposit a variety of materials, including oxides, nitrides, sulfides and metals.

What makes ALD more effective and flexible than traditional methods, such as evaporation, for producing thin-film coatings is its ability to coat every nook and cranny of a complex object.

Scientists use this procedure to fabricate nanostructured catalytic membranes, or NCMs. These structures enable catalytic reactions that, for example, convert inexpensive feedstocks into valuable products and synthesize hydrocarbon fuels. Argonne has filed for a patent on NCMs.

"We are focusing our attention now on measuring the properties of the catalysts and synthesizing other catalytically relevant materials inside the NCMs," said Jeffrey Elam, a research chemist in Argonne's Energy Systems Division.

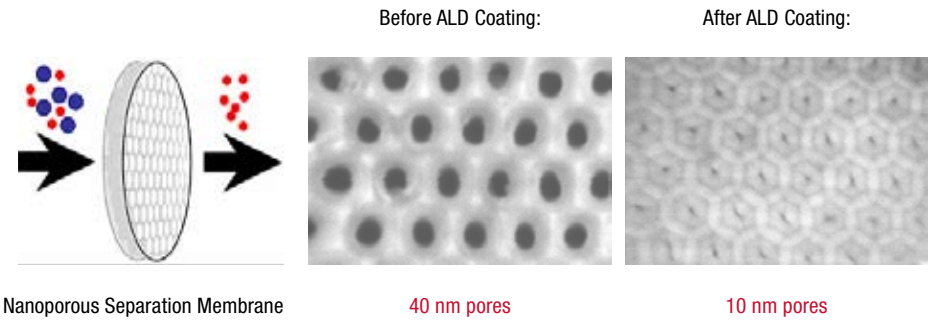
Elam, along with Michael Pellin of Argonne's Materials Science Division, has been working with NCMs to carry out chemical reactions to produce materials that help the nation sustain itself in a more cost-effective and efficient manner.

One of the Argonne researchers' goals has been to improve the effectiveness of the catalyst in Fischer-Tropsch synthesis. The Fischer-Tropsch process takes syngas, a mixture of carbon monoxide and hydrogen, and converts it into hydrocarbon fuels. Syngas can come from a variety of materials, including natural gas, coal or biomass.

Recently, Argonne researchers also have begun to apply ALD technology to solid-state lighting, which uses light-emitting diodes, or LEDs. Unlike incandescent light bulbs, LEDs consume little electric power and do not burn out or overheat. They are illuminated by the movement of electrons in a semiconductor and are considered the most efficient light source in existence. LEDs can be found in many electronic devices, from digital displays to traffic lights. This research is funded by the U.S. Department of Energy to develop by 2025 advanced solid-state lighting technologies that, compared to conventional lighting technologies, are much more energy efficient, longer lasting and cost-competitive.

In cooperation with Northwestern University, Argonne researchers are also fabricating highly efficient solar cells for converting sunlight into electricity. The researchers aim to eventually commercialize these novel and efficient solar cells. Because no pure, costly silicon is involved in the fabrication process — as it generally is with conventional solar cells — the researchers hope to produce electricity at a much lower cost. ■

Scientists at Argonne have started work that could provide clean, renewable fuels for transportation using a variety of feedstocks. Here, chemist Jeffrey Elam (ES), front, holds a prototype membrane that is ready to be evaluated in a catalytic testing reactor operated by chemical engineer Donald Cronauer (CMT).



These images illustrate how a combination of anodized aluminum oxide and atomic layer deposition provides precisely controlled, ultra-uniform porous support for new and well defined catalysts.

Innovation

For more information on these and many other research developments, see the Argonne Web site at *www.anl.gov*.

PRACTICAL ON-BOARD HYDROGEN STORAGE IS GOAL OF NEW ARGONNE RESEARCH PROJECT

Solving one of the biggest problems in commercialization of fuel-cell-powered automobiles is the goal of a new $1.88 million research project on on-board hydrogen storage.

To be practical, researchers say, the hydrogen storage system must be able to hold enough of the fuel for a driving range of 300 miles before refilling; no current technology meets this goal within the constraints of allowable weight and volume for passenger cars.

The Argonne research will investigate nanostructured polymeric materials as hydrogen storage adsorbents. Developed through an earlier collaboration between Argonne and The University of Chicago, the new polymer adsorbent material has shown great promise in preliminary tests. The new project, funded by the U.S. Department of Energy, will seek further improvements in storage capacity and an in-depth understanding of hydrogen-polymer interactions.

TECHNIQUE WILL OPEN NEW VISTAS IN MICROSCOPY

Argonne Researchers Gary Wiederrecht and Stephen Gray, along with colleagues John Rogers at the University of Illinois and Renaud Bachelot at the University of Technology at Troyes have demonstrated a way to resolve infinitesimally small areas in highly scattering environments and break through one of the most important barriers in optical microscopy.

Earlier advances in optical microscopy were limited by what was perceived to be a rigid boundary: When attempting to resolve an area smaller than approximately 250 nanometers, or about half the wavelength of visible light, physicists were frustrated by the tendency of a sample to diffract, or scramble, the incident light.

Instead of shining using one laser beam on the sample, Wiederrecht and his team used a second beam to eliminate much of the unwanted scattering and diffraction that distorted the images obtained with the one-beam technique.

ARGONNE, NORTHWESTERN SEEK ANSER TO SOLAR ENERGY CHALLENGES

Helping the world meet increasing energy needs through solar energy will be the goal of a new research center established by Argonne and Northwestern University.

The Argonne-Northwestern Solar Energy Research Center, or ANSER Center, will combine and expand the research interests of both institutions to address the grand scientific challenges posed by the need for economically viable solar energy use.

"Global energy needs will double by 2050 and triple by 2100," said Michael R. Wasielewski, Northwestern chemistry professor and director of the new center. "An increase in the use of solar energy is essential for meeting this need in an environmentally responsible manner."

Researchers at the ANSER Center will come from both Argonne and Northwestern, and will examine new economical ways to use sunlight to produce clean fuels, such as hydrogen, from water and to produce electricity directly from low-cost photovoltaic and thermoelectric systems.

NEW '1/F NOISE' DISCOVERY PROMISES TO IMPROVE SEMICONDUCTOR-BASED SENSORS

More sensitive sensors and detectors based on semiconductor electronics could result from new findings by researchers from the United States, Norway and Russia.

Their research has yielded a decisive step in identifying the origin of the universal "one-over-f" (1/f) noise phenomenon; "f" stands for "frequency."

"One-over-f noise appears almost everywhere, from electronic devices and fatigue in materials to traffic on roads, the distribution of stars in galaxies and DNA sequences," said Valerii Vinokour (MSD). "Finding the common origin of one-over-f noise in its many forms is one of the grand challenges of materials physics. Our theory establishes the origin and lower limit to one-over-f noise in semiconductor electronics, helping to optimize detectors for commercial application."

In nanomaterials, such as the tiny circuits in semiconductor electronics, the noise generated by the random motion of a single electron can be devastating, since there are so few electrons in the system.

Bacteria

(Continued from page 1)

succeeded in dramatically increasing the concentration of microorganisms in tiny fluid drops and films. Unlike traditional centrifuging techniques, the new approach allows selective concentration of healthy cells," said Andrey Sokolov, Ph.D. student from Illinois Institute of Technology and contributor to the research.

In addition to the development of the device used in the experiment, research findings uncovered the explanation for the long-standing fundamental questions on the properties of collective and organized motion in the systems of interacting self-moving objects. Besides swimming bacteria, other examples include bird flocks, fish schools, motor proteins in living cells, and even swarms of communicating nano-robots.

"We have presented experimental studies of collective bacterial swimming in thin fluid films where the dynamics are essentially two-dimensional and the concentration can be adjusted continuously," explained Argonne's Igor Aronson. "Our results provide strong evidence for the pure hydrodynamic origin of collective swimming, rather than chemotactic mechanisms of pattern formation when microorganisms just follow gradients of a certain chemical, such as nutrient, oxygen, or other."

Detailed results of these findings have been published in Physical Review E and in Physical Review Letters.

Funding for this research was provided by the U.S. Department of Energy's Office of Basic Energy Science.

Details of the instrument and animations are available online. ■

www.anl.gov/Media_Center/News/2007/news070416.html

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Argonne among leaders in safety in lab system

SINCE 2001, an aggressive employee safety program has placed Argonne National Laboratory among the leaders for safety in the U.S. Department of Energy's laboratory system.

From 2001 to 2007, safety at Argonne has improved impressively. One Occupational Safety and Health Administration (OSHA) safety measure is improved by a factor of 4.6, another improved by a factor of 16:

- Argonne's OSHA total recordable incident rate fell from 3.1 to 0.62, and
- The Days Away, Restricted, or Transfer (DART) rate fell from 1.6 to 0.1.

This total recordable incident rate measures the annual number of recordable incidents an organization experiences per 100 employees. The DART rate measures the number of incidents per 100 employees that results in lost or restricted work days or job transfer due to work-related injuries or illness.

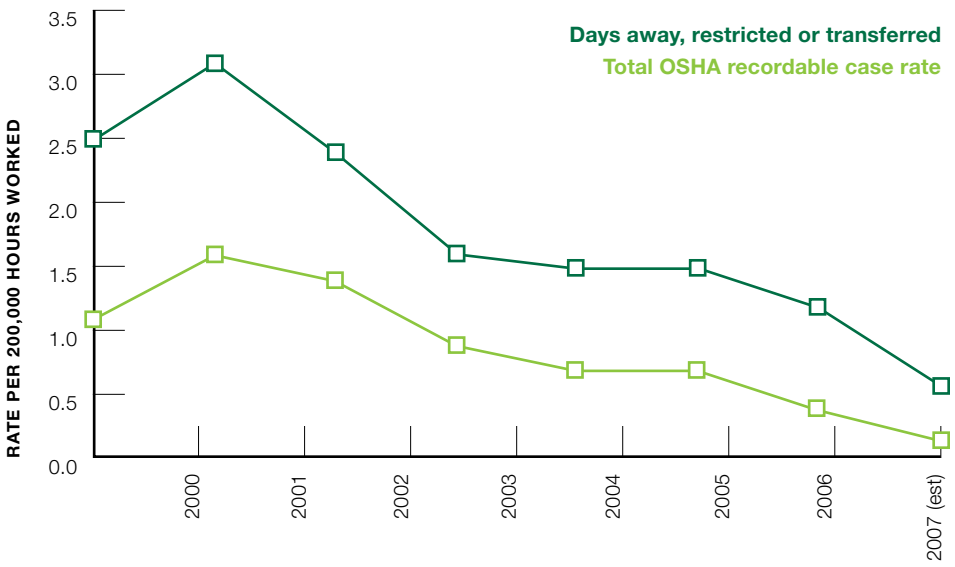
It gets better: "In April," said Bob McCook, who oversees Argonne's safety programs, "the laboratory achieved a safety milestone of more than 3 million consecutive work hours — the equivalent of about six months — without an employee injury that resulted in days away from work."

McCook, Director of Argonne's Office of Environment, Safety, and Health/Quality Assurance Oversight, credits the steady improvement to the involvement of senior Argonne management. "A sound safety culture," he said, "always comes from employees genuinely believing that management truly cares about safety. Many places might develop programs and processes to show that management is engaged in safety, but here, management really is engaged. It's not a separate process."

McCook meets weekly with Argonne Director Robert Rosner's Safety Council to discuss environment-, safety-, and health-related issues. In addition to Rosner and McCook, the Director's Safety Council includes the two senior-most members of Argonne's Directorate, the four associate laboratory directors who guide Argonne's research programs, the director of Argonne's Medical Department and a representative from the University of Chicago.

In addition, safety is always the first agenda item at weekly meetings of the Management Council, which comprises Argonne's highest level directors of research and operations.

The UChicago Argonne, LLC, Board of Governors for Argonne is also deeply involved in overseeing safety at Argonne. The board's Environment, Safety and Health Committee receives face-to-face reports quarterly from senior Argonne management and closely guides the laboratory's safety policies and programs. The committee members are safety leaders from major companies, universities, and research organizations around the nation. ■



'MODERN MARVELS' TAPS ARGONNE'S BATTERY EXPERTS

A film crew from the Discovery Channel's "Modern Marvels" program recently visited Argonne for an upcoming show focusing on batteries. They visited the Battery Test Facility and the Center for Transportation Research and interviewed several of Argonne's battery experts, including Ira Bloom, shown here, Jim Miller, John Basco, Andy Jansen, Ted Bohn, Mike Duoba, Glenn Keller, and Neeraj Shidore. The show's air date has not been determined.

Catalyst

(Continued from page 1)

manufacturers placing ceramic catalytic reactors in the exhaust pipes, where they will convert NOx emissions into nitrogen," said Marshall. Nitrogen, or N2, is a harmless gas that makes up more than 80 percent of the Earth's atmosphere.

"Our most promising catalyst for diesel engines," Marshall said, "is Cu-ZSM-5 with an external coating of cerium oxide." Cu-ZSM-5 is a zeolite with copper ions attached within its micropore structure. Zeolites are common catalysts in the petroleum industry.

Those working previously with Cu-ZSM-5 and similar catalysts, he said, found that they performed poorly at removing NOx from diesel exhaust. They require temperatures higher than normal diesel exhaust temperatures and don't work well in the presence of water vapor, which is almost always found in engine exhausts.

With the help of the Advanced Photon Source at Argonne to analyze the structure and performance of various catalysts, Marshall's group at Argonne developed an additive that allows Cu-ZSM-5 and similar catalysts to overcome these difficulties.

"Our new cerium-oxide additive," Marshall said, "is the breakthrough that makes it work. When it's combined with Cu-ZSM-5, the resulting catalyst works at normal exhaust temperatures and is actually more effective with water vapor than without it. With a lean fuel-air mixture, it removes as much as 95 to 100 percent of NOx emissions."

Marshall says the Argonne catalyst has been tested and performed well with a number of diesel and diesel-type fuels, including standard diesel, synthetic diesel, bio-diesel and JP8, which is a jet fuel preferred by the military. The next step is to subject the catalyst to engine testing. This will take place soon at Argonne's Diesel Engine Test Facility.

Marshall and his colleagues are also working with the Fuel Cell Research Group in Argonne's Chemical Engineering Division. Using a reformer developed by this group could provide better fuel for the catalyst, said Marshall. "Our catalyst already works well, but it would work even better with the smaller hydrocarbons produced by a reformer. Collaborations like this and access to Argonne's unique facilities allow us to work together on projects in a way that couldn't be done anywhere else."

Initial research on the cerium-oxide catalyst was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. The catalyst was developed for chemical plant emissions under a joint research agreement with BP. ■

Students turn 362 Auditorium into cosmic-ray observatory

JARED SAGOFF

High-energy physics, teamwork and good old-fashioned stick-to-it-iveness supplanted reading, writing and arithmetic as the course of study for a crew of local high school students who engaged in a week-long study of cosmic rays at Argonne in June.

Eleven students from six area high schools — Glenbrook North, Glenbrook South, Ida Crown Jewish Academy, Chicagoland Jewish, Alan Shepard and Plainfield-Central Campus — participated in QuarkNet, a particle physics outreach program based out of Fermi National Accelerator Laboratory that attempts to link mentors at universities and national labs throughout the country with high school students who have limited physics backgrounds.

"The idea was to have our students do some of their own unique research and to share that on the Web with students and teachers at other schools," said Carol Baker, curriculum director for Community High School District 218. "Having the kids here means that they're learning how do to science from the ground up, and building a network of students who will all know each other and work together."

During the week of June 22, the students appropriated the stage of the Building 362 Auditorium to assemble scintillators, photomultiplier tubes and GPS devices into cosmic-ray detectors. Cosmic rays penetrated the auditorium and hit the scintillators; photomultiplier tubes converted the resulting flashes of light into an electronic pulse that in turn was sent to a computer. The students then performed either a flux study, which measured the rays over time, or a shower study, which looked for bursts of rays that can pepper many different locations almost simultaneously.

Ilan Cohn and Carol Baker, at left, take cosmic-ray data in the Building 362 Auditorium. Students from several local high schools engaged in a week-long study of cosmic rays at Argonne in June.

Aaron Weinberg, a junior at Chicagoland Jewish Academy, concurred with Baker's assessment. "This is real science," he said. "Kids are doing the research, and kids are collecting the data that scientists go and use to further science, which I think is appealing to every student. It's a dream." ■

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FUEL CELL SPRINT

Chicago area middle school students raced hydrogen-fueled model cars at the 17th annual model car competition at Chicago's Museum of Science and Industry. The competition is part of the Chicago Regional Science Bowl sponsored by the U.S. Department of Energy, Argonne, CNH Corporation and the Chicago Section of the Society of Automotive Engineers. Each team started with a standardized kit that includes an electrical motor powered by a fuel cell; the rest of the car design and components are limited only by their imaginations. The car competition inspires students to use applied skills to meet technical challenges comparable to those faced by scientists and engineers.

Honors

WORLD-RENOWNED PHYSICIST JOINS ARGONNE TO LEAD PROPOSAL FOR EXOTIC BEAM FACILITY

Henning

World-renowned physicist Walter F. Henning is joining the scientific staff at Argonne to head up Argonne's efforts to build a proposed exotic beam facility for nuclear physics research, which will revolutionize our understanding of nuclei, the core of matter and the fuel of stars. Henning is presently professor of physics at the University of Frankfurt and director of GSI Darmstadt, Germany's premier nuclear physics research facility. He is a Fellow of the American Physical Society and the winner of the 2004 Hessian Order of Merit.

The Department of Energy has proposed to build an exotic beam facility for the next generation of nuclear physics research, and Argonne is one of the sites competing for that facility. A recent National Academy of Sciences report stressed the scientific opportunities that exist with exotic beams. This new facility would provide physicists with energetic, high-quality beams of literally thousands of isotopes of elements in the periodic table, including a great many that have never before been observed on earth.

"This facility is an important project with great potential for discovery," Henning said. "Argonne provides for synergies and unique technical expertise from other programs and from its technical infrastructure. And, last but not least, the existing nuclear accelerator at Argonne provides for an effective base to realize science use of the rare isotopes produced from the very beginning. I believe that these conditions provide an excellent basis for a successful Argonne proposal."

JAYDEEP BARDHAN RECEIVES HOWES SCHOLAR AWARD IN COMPUTATIONAL SCIENCE

Santra

Argonne's Jaydeep Bardhan (MCS) has been named a Frederick A. Howes Scholar in Computational Science for 2007. The award was established to honor the late Frederick Anthony Howes, who managed the applied Mathematical Science Program in the U.S. Department of Energy during the 1990s and oversaw the DOE Computational Science Graduate Fellowship (CSGF) program. Only CSGF fellows are eligible for this prestigious award, and only one or two are named each year.

Bardhan was a CSGF fellow from 2002 to 2006 and spent a summer at Argonne in 2003 under that program. He received his Ph.D. in electrical engineering and computer science from the Massachusetts Institute of Technology in 2006. He is currently a Wilkinson Fellow at Argonne.

Bardhan's research focuses on biomolecular modeling, an emerging area that demands expertise in engineering, numerical methods, biology and high-performance computing. Among his accomplishments are the development of a novel technique for analyzing the interactions between protein molecules and the formulation of new approaches for determining optimal molecular targets for drug design.

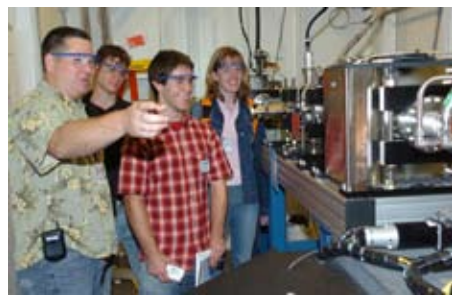
Bardhan was one of two former CSGF fellows presented with the Howes Scholar award at the 2007 CSGF Annual Fellows' Conference in Washington, D.C., June 19-21.

ARGONNE SCIENTIST WINS FIRST-EVER YOUNG SCIENTIST PRIZE FOR ATOMIC, MOLECULAR AND OPTICAL PHYSICS

Bardhan

Robin Santra has been selected as the winner of the first 2007 International Union of Pure and Applied Physics (IUPAP) Young Scientist Prize for Atomic, Molecular and Optical Physics. Santra is an assistant physicist in Argonne's Chemistry Division. He has collaborated on the discovery of a hole-orbital alignment in atomic ions generated in the focus of a strong laser field. He has also contributed to 12 scientific papers and been published in Physical Review Letters on five different occasions. Most recently, his theoretical work has uncovered electromagnetically induced transparency for X-rays, suggesting a simple switch to produce ultra-fast X-rays. He is currently investigating other ways of influencing X-ray absorption with strong lasers and is also interested in nonlinear X-ray science with free electron lasers.

Notre Dame students tour CNM



A GROUP of 20 students in the National Science Foundation's Research Experiences for Undergraduates (REU) program at Notre Dame University were recently treated to an extensive tour of Argonne's Center for Nanoscale Materials. The day's events included a two-hour in-depth nanofabrication experience in the cleanroom facility under the enthusiastic guidance of staff scientist Leo Ocola (CNM). Scientific program overviews were given by Seth Darling (CNM) on self-assembly and scanning probe microscopy, and by Dave Gosztola (CNM) on nanophotonics; postdoc Ligang Zhang (CHM) described her nanobio interface research project. Finally, Robert Winarski and Martin Holt of the CNM's X-ray Microscopy group explained the X-ray nanoprobe beamline, located at Sector 26 of the Advanced Photon Source, including a tour of their experimental and optical hutches. The students' visit was led by Marya Lieberman and Kristy DiVittorio of Notre Dame. ■