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Catalysts are not only materials that produce a change faster than otherwise possible, but catalysts can also be people. Argonne is fortunate to have people whose creativity and insights have fostered change. **Page 2**

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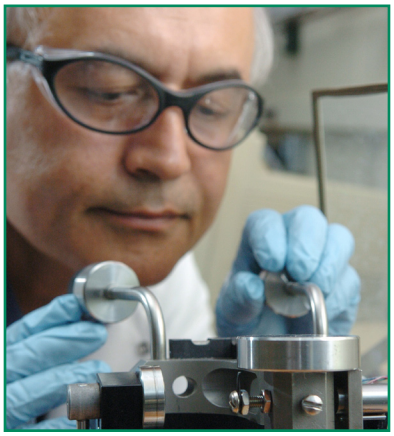

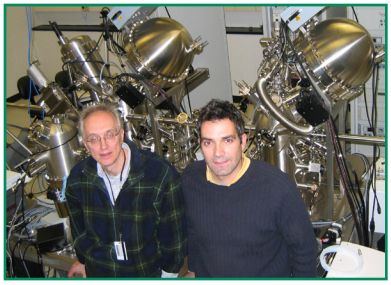

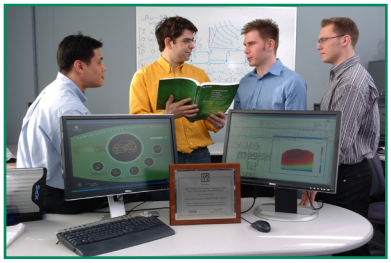

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Catalysts: Facilitators of Change

In the last issue of TransForum, Lee Slezak of the U.S. Department of Energy (DOE) discussed the importance of developing a diverse set of technology options that will enable consumers to select a clean, efficient vehicle that best meets their needs at the lowest possible cost. Our nation's transportation needs are complex, and as some of the stories in this issue of TransForum highlight, the solutions may be facilitated by catalysts.

We often think of catalysts as materials that produce a change faster than otherwise possible, but people can also be catalysts. Argonne's Transportation Technology Research & Development Center (TTRDC) is fortunate to have people whose creativity and insights have fostered change, and some in the process have developed catalytic materials. The catalytic materials highlighted in this issue include zeolites that can dramatically reduce NO_x from diesel engines and the discovery of new properties of nano-engineered platinum to improve the stability of cathodes in fuel cells.

But these discoveries as well as the hydrogen storage research, battery development, nano-lubricants, and vehicle system modeling also discussed in this issue are made possible by teams of very bright, dedicated scientists and engineers focused primarily on the U.S. Department of Energy goal of reducing our country's petroleum dependence. Whether the concern is the nation's energy security or climate change, we are constantly motivated with the knowledge that we are working on a major problem for the nation.

I encourage you to contact our principal investigators, if they are working on a problem that is important to you, your agency, or your business.

Larry R. Johnson

Larry Johnson, Director,
Transportation Technology R&D Center

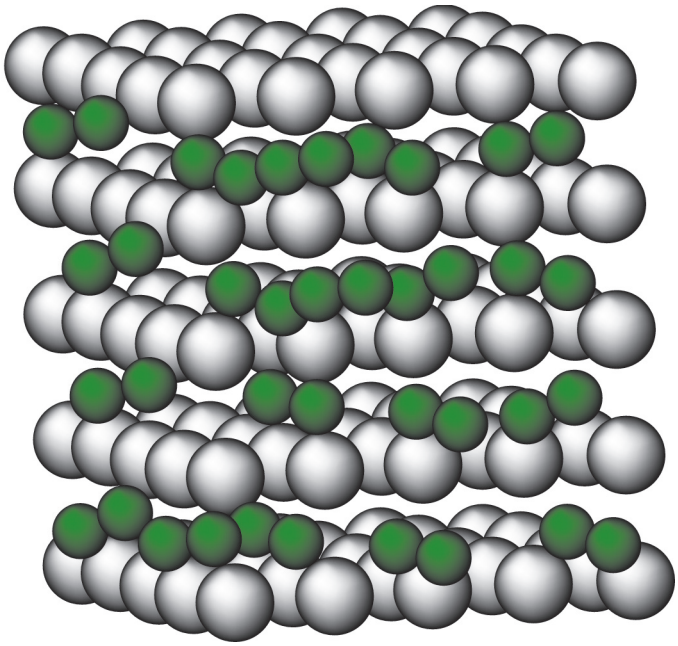
RESEARCH REVIEW

Argonne Receives $1.88 Million from DOE to Study Practical Onboard Hydrogen Storage

Solving one of the biggest problems in commercialization of fuel cell automobiles is the goal of a new $1.88 million research project addressing onboard hydrogen storage at Argonne National Laboratory.

To be practical, researchers say, the hydrogen storage system must be able to hold sufficient amounts of the fuel at outdoor temperatures 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 (DOE) will provide further improvements in storage capacity and an in-depth understanding of hydrogen-polymer interactions.



Hydrogen molecules (green spheres) are adsorbed inside of layered polymeric storage material.

"The successful outcome of the project will lead to a low-cost, high-capacity hydrogen storage material that can be mass-produced within the existing industrial infrastructure," said Di-Jia Liu, the Argonne scientist who is leading the research project. Hydrogen is regarded as a future clean fuel replacement for gasoline. However, current hydrogen storage technology, as a high-pressure compressed gas or as a liquid at very low temperatures, does not adequately meet all the requirements for the automotive application. A suitable hydrogen adsorbent will work at low pressures with enhanced capacity, Liu said. The polymer materials under investigation by the Argonne-University of Chicago team have the potential to adsorb hydrogen without breaking its bond, a process called "physisorption." Preliminary tests of the material have demonstrated "encouraging hydrogen storage capacity, reversibility, and stability," he said.

The research effort includes Argonne chemists Liu, Martha Finck and postdoctoral researcher Junbing Yang of the Chemical Engineering Division, theorist Peter Zapol of the Materials Science Division, physicist Peter Chupas of the Advanced Photon Source, and Professor Luping Yu's research group at the University of Chicago. "This project brings together experts from different disciplines, ranging from basic sciences to applied technology. Our hope is that through such close interaction, we will be able to develop the best possible materials with the support of fundamental understanding of hydrogen storage chemistry."

Funding for the preliminary research came from DOE's Office of Science under a Laboratory-Directed Research and Development Project. The new four-year grant from DOE's Office of Energy Efficiency and Renewable Energy-Hydrogen, Fuel Cells & Infrastructure Technology Program will allow this Argonne-University of Chicago research team to significantly expand its scope of study and continue technology development.

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A New Nanolubrication Technology May Solve Problems Caused by Low-Sulfur Diesel Fuels and Oils

As often happens when you try to solve one problem — in science, society, etc. — you end up creating another. When the U.S. Environmental Protection Agency (EPA) mandated steep reductions in the amount of sulfur allowed in diesel fuels and lubricating oils, it took a big step in the much-publicized effort to significantly reduce particulate emissions from diesel-fueled vehicles. (The allowable sulfur content in fuels decreased from more than 3,000 ppm over the years to less than 15 ppm today.)

In lubricating oils, the amount of sulfur- and phosphorous-bearing additives and all the heavy elements are also under increasing scrutiny and demand to be drastically reduced or replaced by environmentally benign alternatives. Besides contributing to particulate emissions, these additives poison and/or adversely affect the performance of aftertreatment devices in diesel engines. In particular, sulfur combines with moisture in engine combustion chambers, forming acids that can lead to corrosion and severe wear problems.

So reducing sulfur and other additives in fuels and lubricants is a good thing, right? Yes and no. Trucking fleets throughout the nation reported fuel component failures after switching to low-sulfur diesel fuels. Turns out that removing the sulfur reduces the lubricating capacity of the diesel fuel, accelerating wear in fuel system components. Reduction of sulfur and phosphorous in lubricating oils has also been shown to result in higher friction and wear in engines.

To address these issues, Argonne may have a solution, with a recently patented nanoscale lubrication technology — U.S. Patent No. 6,783,561: Method to Improve Lubricity of Low Sulfur Diesel and Gasoline Fuels, and U.S. Patent Applied for No. US2005/0009712: Methods to Improve Lubricity of Fuels and Lubricants. Specifically, Argonne's boron-based additives are environmentally safe, inexpensive, and have an unusual capacity to enhance the antifriction and antiwear properties of sliding surfaces in diesel- and gasoline-powered engines. Fig. 1 shows its ability to restore the lubricity of sulfur-free (Fischer-Tropsch) diesel fuel, even at concentrations down to 250 ppm.

Who Can Benefit from Using Boron-Based Lubricants?

Complaints related to low-sulfur diesel fuels without lubricating additives include premature fuel system component wear or failure, unstable engine speed, plugging of injector/injection nozzles, seal failures, hard starting, decreased power, and engine

smoke. Reduction of sulfur and phosphorous-bearing additives in engine oils has also resulted in increased friction and wear in critical engine parts and components. These outcomes are bad news for trucking companies and engine and truck manufacturers. In addition, there are claims that, because sulfur is an antioxidant, fuel quality could degrade faster without it — posing potential problems for the makers and distributors of diesel fuel. Whether all of these problems can actually be blamed on low-sulfur diesel is debatable, but a lubricant additive that could economically solve them without causing separation or other harmful refining effects would be a welcome answer.

This boric acid "rose" shows the intricately layered microscopic structure of the compound.

What Do They Do?

Several years ago, Argonne scientists discovered that boric acid, used as a lubricant, is one of the most slippery solids in existence. Earlier tests showed that thin films or bulk powders of boric acid can provide friction coefficients as low as 0.02 to 0.05 — one-fourth to one-sixth the value of other, more expensive

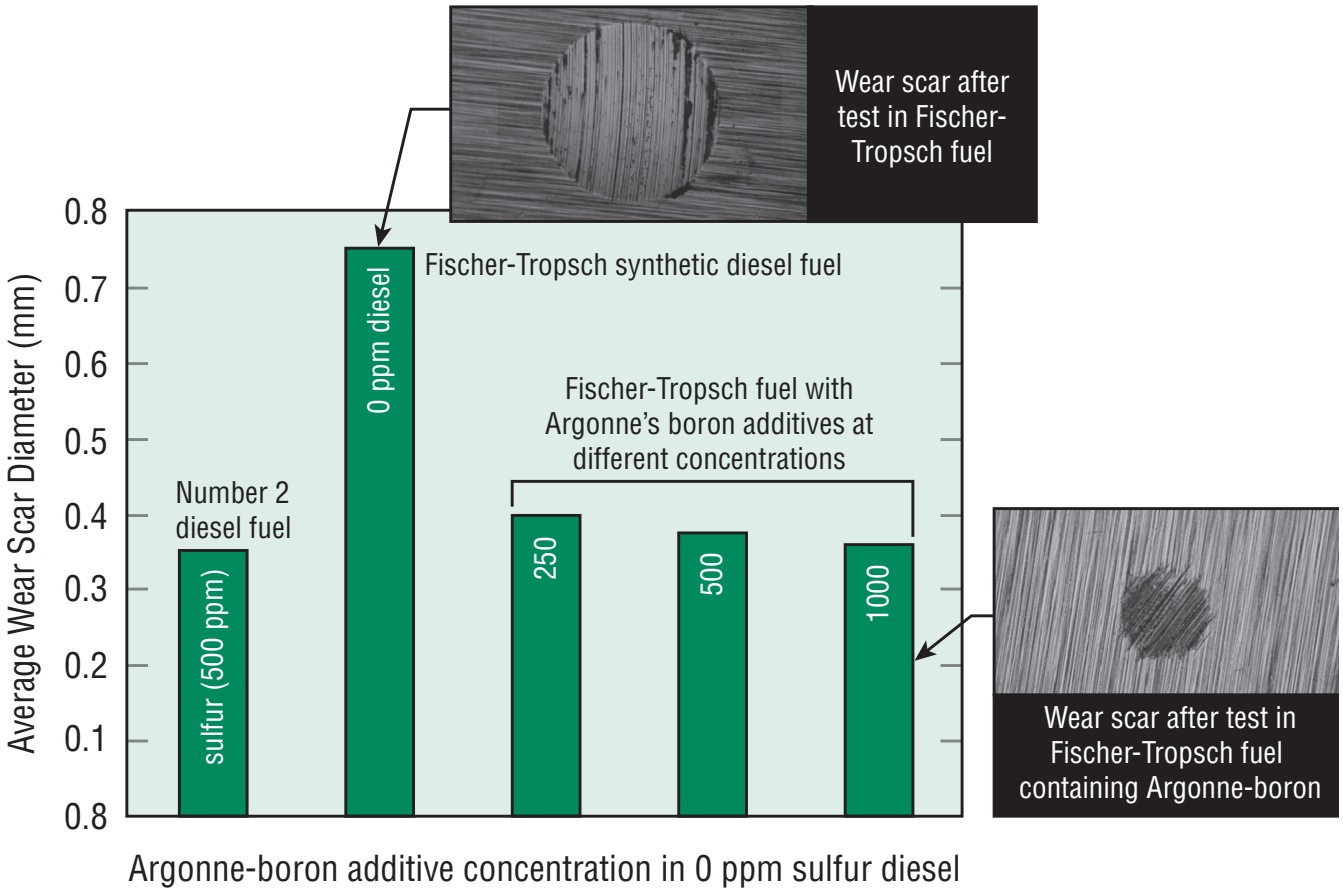
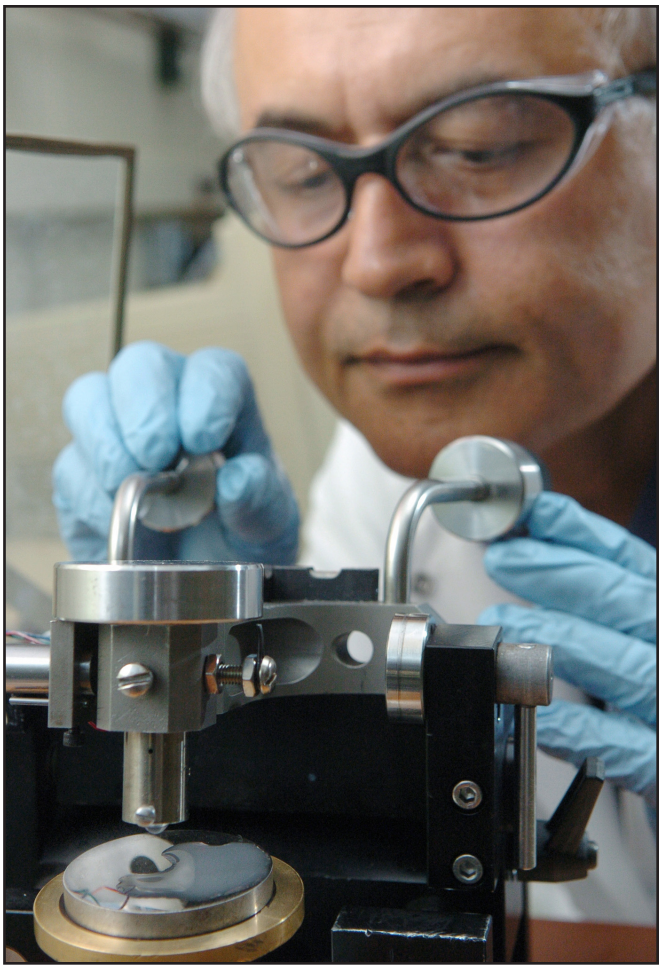


Figure 1. Fuel lubricity performance of a boron-based additive in sulfur-free (Fischer-Tropsch) diesel fuel. For comparison, the fuel lubricity performance of 500 ppm-sulfur containing number 2 diesel fuel is also provided. These tests were run in a ball-on-three disk fuel-lubricity test machine.

solid and liquid lubricants. Recently, patented nanoboric acid powders and liquid media additives containing special boron compounds proved to work even better. Specifically, when used as solid dispersion or liquid media additives in lubricating mineral and synthetic base oils, they were able to reduce friction by 50% to 90% (depending on the concentration) under a wide range of boundary-lubricated sliding conditions. These novel additives were also able to enhance the lubricity of sulfur-free and ultra-low sulfur diesel fuels. They reduced wear-scar diameters by as much as 50% in high-frequency reciprocating and ball-on-three disk fuel lubricity tests; see Fig. 1 for a typical result. The ball-on-three disk is a fuel lubricity test machine, in which a rotating ceramic ball is pressed against three flat disks at an angle. The ball and disks are submerged in liquid fuel; the average size of wear scar diameter that forms on disk surfaces is recorded as an indicator of that fuel's lubricity. The smaller the diameter, the higher the lubricity.

The unusual lubricating mechanism of boric acid in these oils and fuels is controlled by its very special chemical structure and its ability to form a strongly bonded protective boundary film on rubbing surfaces. The compound is crystallized in layers in which the atoms are tightly bonded to each other. The layers themselves are weakly bonded; when stressed, they shear and slide over one another easily, so friction is low. The strong bonding between the layers prevents direct contact between sliding parts, minimizing wear. The boron-based fuel and oil additives developed by Argonne take advantage of this special structure to provide enhanced lubrication in diesel fuels and lubricating engine oils.

The frosting on the sands of Boron, California, wasn't caused by a snowstorm – rather, it consists of spontaneously forming boron deposits. The natural abundance of boric acid makes it a temptingly cheap and environmentally friendly lubricant.



Argonne researcher Ali Erdemir performs a friction test on a metal disc coated with a solution of motor oil with nano-boric acid particles.

Although discussions are underway with several companies, the innovative technology is available for licensing through Argonne's Office of Technology Transfer.

This work was funded internally by Laboratory-Directed Research and Development funds.

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Argonne-developed Cerium-Oxide Catalyst Helps Eliminate NO_x from Diesel Exhaust

Researchers in Argonne's Chemical Engineering Division have developed a catalyst that could help diesel truck manufacturers eliminate harmful nitrogen-oxide (NO_x) emissions from diesel exhausts. The technology appears so promising that several 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 that the technology could be available commercially within two to three years.

Argonne post-doctoral associate Sundar Krishnan (left), and researchers Steve Ciatti (center) and Chris Marshall (foreground, right) working with the equipment that will be used to engine-test the Cu-ZSM-5 catalyst. Marshall is holding a beaker of the catalyst material.

"For diesel engines, we envision manufacturers placing ceramic catalytic reactors in the exhaust pipes, where they will convert NO_x emissions into nitrogen," said Marshall. Nitrogen, or N_2, is a harmless gas that makes up 79 percent of the Earth's atmosphere. NO_x emissions are well-known contributors to smog, acid rain, and global warming, yet they are among the most difficult pollutants to eliminate from diesel exhaust, and many technologies that reduce NO_x cause increases in undesirable particulate emissions.

"Our most promising catalyst for diesel engines is a cerium-oxide catalyst," Marshall said. "It 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. Those working previously with Cu-ZSM-5 and similar catalysts, he said, found that they performed poorly at removing NO_x 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.

Using Argonne's Advanced Photon Source to analyze the structure and performance of various catalysts, Marshall's group 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% of NO_x emissions."

Argonne's new catalyst also avoids the problems associated with ammonia, which competing catalysts use as the reductant. The Argonne catalyst uses the diesel fuel that is already on board, thus requiring no additional fuel tanks.

"Another type of technology is ammonia-selective catalytic reduction, using a material called urea as the ammonia source," Marshall said. "Ammonia is toxic, and unless all of it is converted during the process, whatever remains could be released to the atmosphere. While some European diesel manufacturers are taking the urea approach, U.S. diesel manufacturers are looking for alternatives." Since a system using the new catalyst would not require an onboard urea storage tank and uses the onboard diesel fuel as the reductive material, the new catalyst is considered safer and more energy-efficient.

Another alternative for U.S. manufacturers is the use of NO_x traps. These are platinum-based systems that work well if they don't come into contact with sulfur, which is present in most commercial diesel fuel. Since the Argonne-developed catalyst contains no platinum, it is less prone to the negative effects of fuel-borne sulfur.

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, biodiesel, and JP8, which is a jet fuel preferred by the military. The next step is to subject the catalyst to engine testing, which will occur soon at Argonne's Diesel Engine Test Facility. Marshall expects these tests will show that, in addition to its other advantages, the Argonne catalyst has a greater life expectancy than other catalysts currently on the market.

Marshall and his colleagues are also working with the Chemical Engineering Division's fuel cell research group. 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-Freedom CAR and Vehicle Technologies Program. The catalyst was developed for chemical plant emissions under a joint research agreement with BP. Research plans call for expanded work aimed at both diesel and natural gas engines and coal-fired power plants.

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Catalyst Breakthrough Boosts Hydrogen Fuel Cells

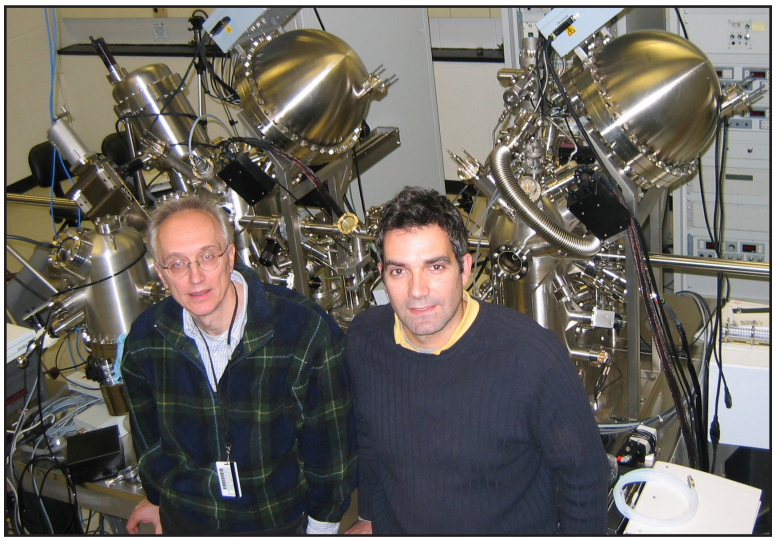
Our nation's dependence on foreign sources for transportation fuels threatens our economic and national security — but how do we overcome our dependence on petroleum products for transportation? A hydrogen economy based on fuel cells is one strategy. A key challenge in developing a hydrogen economy is reducing the amount of expensive platinum catalyst needed to operate fuel cells efficiently.

To overcome that challenge, Argonne researchers have discovered new information about the behavior of nano-engineered platinum surfaces that may bring polymer electrolyte membrane fuel cells for hydrogen-powered vehicles another step closer to full development.

Argonne researchers Nenad Markovic and Vojislav Stamenkovic — in collaboration with colleagues Philip Ross and Bongjin Mun at Lawrence Berkeley National Laboratory, Christopher Lucas from the University of Liverpool, and Guofeng Wang from the University of South Carolina — have recently discovered that a nanosegregated platinum-nickel alloy surface has unique catalytic properties. Their discovery opens up important new directions for the development of active and stable practical cathode catalysts in fuel cells. The findings were published in the January 2007 issue of the journal *Science*.

According to Stamenkovic, "This discovery sets a new bar for catalytic activity in fuel cells and makes it feasible to meet U.S. Department of Energy (DOE) targets for platinum-specific power densities without a loss in cell voltage. We have identified a cathode surface that is capable of achieving and even exceeding the target for catalytic activity, with improved stability for the cathodic reaction in fuel cells."

Stamenkovic further explained, "Although the platinum-nickel alloy itself is well-known, we were able to control and tune key parameters, which enabled us to make this discovery. Our study demonstrates the potential of new analytical tools for characterizing nanoscale surfaces in order to fine tune their properties in a desired direction."



Argonne researchers Nenad Markovic and Vojislav Stamenkovic with the new three-chamber ultra-high vacuum system used in their electrocatalysis work.

George Crabtree, director of Argonne's Materials Science Division, emphasized the path-breaking importance of the research: "It is not only world-class basic science, it is a major advance for energy research."

The research was funded by DOE's Office of Basic Energy Sciences, Office of Energy Efficiency and Renewable Energy-Hydrogen, Fuels Cells & Infrastructure Technology Program, and by General Motors.

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Argonne and PSAT: Making the Connection

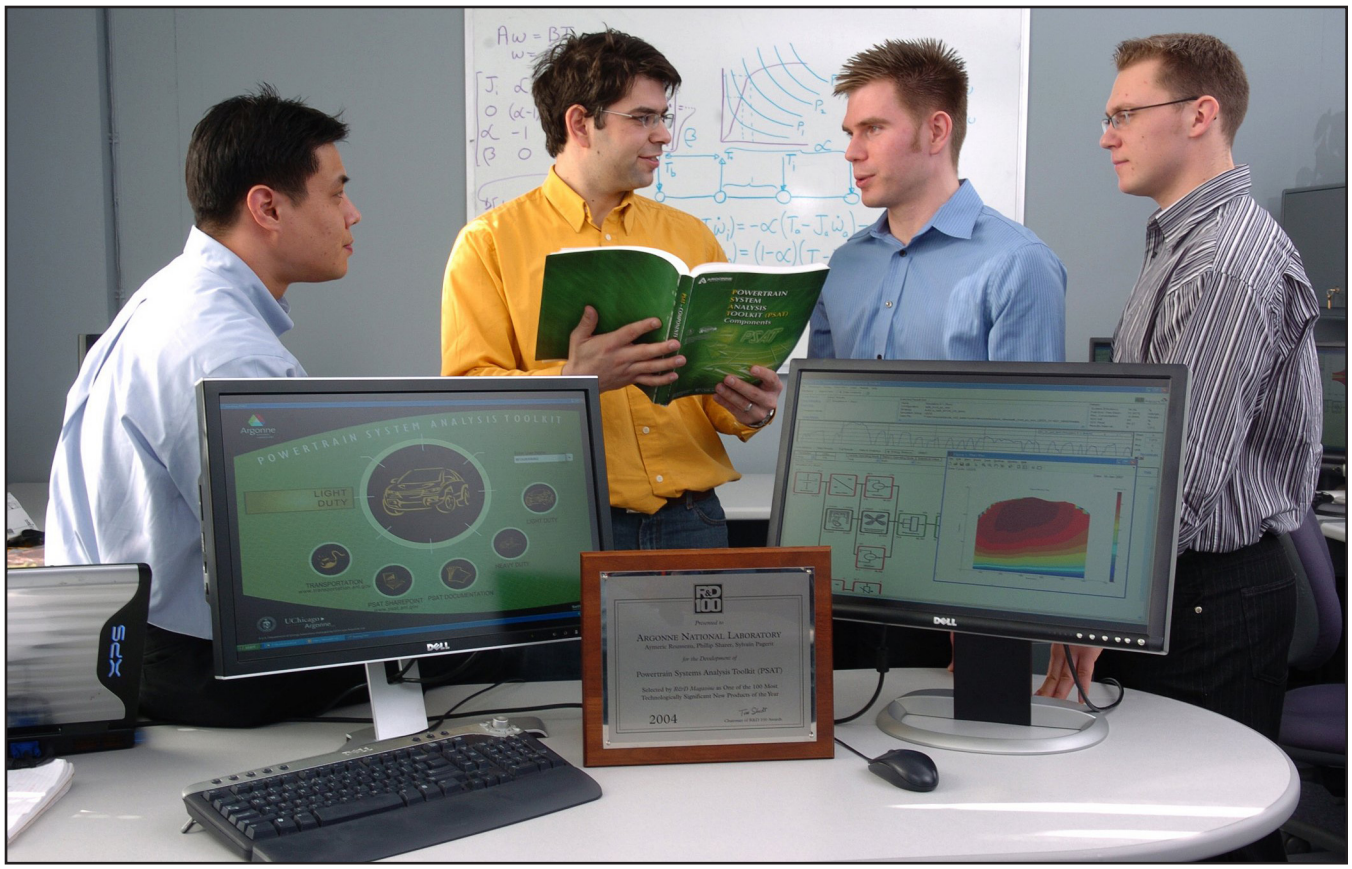
Each year, the Federal Laboratory Consortium (FLC), which comprises more than 600 federal laboratories and research centers, recognizes federal laboratory employees who have "worked industriously with others to move a vision from the laboratory to the marketplace, so that others may benefit." This year, Argonne's FLC Award for Excellence in Technology Transfer winner is the Powertrain System Analysis Toolkit (PSAT), developed by Aymeric Rousseau, Phillip Sharer, and Sylvain Pagerit of Argonne's Energy Systems Division, supported by Lee Slezak of the U.S. Department of Energy's (DOE's) FreedomCAR and Vehicle Technologies Program.

Because teamwork is at the heart of technology development and transfer, the theme for this year's FLC Technology Transfer Award competition was "Making the Connection." The story of PSAT's successful development and transfer to industry is filled with examples of the efforts of its developers to make those crucial connections: with their original industry partners, with DOE, and — finally — with PSAT users.

The project began in 1995 with a request from the Partnership for a New Generation of Vehicles (PNGV) (Ford, General Motors, DaimlerChrysler, and DOE) for a model to optimize hybrid-electric vehicles (HEVs). The automakers wanted a model that all the partners could use to work on collaborative projects. That tool was the forerunner of PSAT.

In 1999, working closely with the PNGV partners, Rousseau and his team at Argonne took over the project, rewriting the entire code, adding a graphical user interface, and allowing users to compare test data with simulation data. The three automakers agreed to release a nonproprietary version of the software about three years ago; this version was a direct antecedent of the version of PSAT that is distributed today. Soon after the nonproprietary version of PSAT was introduced, DOE conducted an assessment to see which software would best serve as the primary vehicle simulation tool to support its FreedomCAR and Vehicle Technologies Program and the 21st Century Truck Partnership. PSAT was selected as a result of this thorough independent assessment, which evaluated candidates from the U.S. Government and the private sector.

The main strategy in developing PSAT was to make the software as flexible and user-friendly as possible. So the development team strengthened PSAT's analytical capabilities, increased the number of powertrain configurations that PSAT could simulate



Members of the Powertrain System Analysis Toolkit development and support team confer.

(currently more than 400), and improved the model to ensure effortless integration of virtually any proprietary models, controls, and driving cycles — making PSAT truly unique. These efforts help explain why, just two years after being made available for licensing, PSAT has become one of the most widely distributed and executed software licenses at Argonne to date. The model is available on the Argonne Software Shop web site with a downloadable video demonstration that offers an extensive review of PSAT capabilities.

Since then, the Argonne team has worked hard to make PSAT accessible to new users through journal articles, presentations, conference papers, and the extraordinary degree of technical support offered to current users. The PSAT development team is in constant contact with users, who often request new features for new types of studies. When the new features will benefit users generally, they are incorporated in subsequent releases of the software.

These achievements and the continued growth in new licensed users are also testament to the benefits of the national laboratory system. Industry researchers are often under tremendous pressure to obtain analytical results as quickly as possible with the software tools at hand; little time can be budgeted to make the software they use more flexible, reusable, or user-friendly. Because it is based at a national laboratory, the Argonne team is able to focus on these developmental efforts and respond quickly to user requests.

A recent Cooperative Research and Development Agreement (CRADA) between Argonne and General Motors is aimed at developing an enhanced version of PSAT to serve as the basis for the development of an industry standard for vehicle and component modeling. Successful completion of this project would put PSAT at the center of a revolution in advanced vehicle design by permitting models to be developed through a common language and a common means of exchanging technology.

In the long term, the PSAT developers hope that their software will help foster the development of advanced vehicle technologies (such as HEVs, plug-in HEVs, and fuel cell and hydrogen-fueled vehicles) and contribute to eventual petroleum independence for transportation sectors worldwide.

PSAT was funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy-FreedomCAR and Vehicle Technologies Program.

More About PSAT

Because of time and cost constraints, automotive designers cannot build and test each of the many possible powertrain configurations for advanced vehicles. Thus, developing advanced vehicle technologies such as HEVs requires accurate, flexible simulation tools. PSAT is a state-of-the-art flexible and reusable simulation package designed to facilitate advanced vehicle (e.g., hybrid, plug-in hybrid, fuel cell) development. PSAT's architecture is "forward-looking," meaning that component interactions are "real-world," allowing powertrain designers to develop realistic control strategies and assess component behaviors in a system environment by using models that are closer to reality. The model allows automotive and truck manufacturers and their suppliers to quickly select the advanced technologies that will best meet their needs — helping them bring their advanced vehicles to market as quickly and cost-effectively as possible. PSAT received an R&D 100 Award in 2004; the awards recognize the 100 best newly available products and technologies around the world. The model is also used by 17 collegiate engineering teams to select their powertrains and develop control strategies as part of the multi-year Challenge X competition, a student engineering vehicle competition sponsored by DOE and General Motors. PSAT is currently used by more than 300 researchers worldwide in more than 65 companies and universities.

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PSAT is available on the Software Shop web site at
http://www.anl.gov/techtransfer/Software_Shop/PSAT_NP/PSAT_NP.html)

Nanoexa, Decktron Collaborating with Argonne on Commercialization of Next-Generation Batteries

Nanoexa, a leading nanotechnology-based clean energy company, and Decktron, a lithium battery and display company, jointly announced an agreement to develop and transfer into commercial use new lithium battery technology originally developed at the U.S. Department of Energy's (DOE's) Argonne National Laboratory.

The goal of this agreement is to commercialize next-generation rechargeable lithium battery technologies from Argonne's Battery Technology Department. Together, the organizations will introduce into the marketplace batteries with increased power output, storage capacity, safety, and lifetime that will be used in high-rate applications such as hybrid electric vehicles, power tools, and radio-controlled devices.

"The recent news about laptop battery safety has exposed the limitations of current rechargeable battery technologies. One of the primary goals of Argonne's battery technology is to dramatically improve lithium battery safety," said Michael Pak, CEO of Nanoexa. "Argonne's R&D expertise in developing lithium battery materials as well as its deep relationships with the world's automotive makers will create a powerful opportunity for our company. We look forward to expanding our strategic relationship with Argonne even further."

"As part of the FreedomCAR Partnership between DOE and U.S. automobile manufacturers, we at Argonne have been conducting research and development to help industrial battery developers lower cost and increase the lifetime and inherent safety of high-power lithium batteries," said Gary Henriksen, Manager of Argonne's Battery Technology Department. "These new Argonne-developed technologies could help lithium-ion batteries enter the automotive market. Also, we believe that some of these technologies could lead to improved (longer life and inherently safer) batteries for consumer electronic applications. We look forward to working with Nanoexa and Decktron to demonstrate our technologies in commercial cells and batteries."

Next-generation rechargeable lithium batteries with increased power output, storage capacity, safety, and lifetime will be used in high-rate applications such as plug-in hybrid electric vehicles.

Lithium batteries are the most popular rechargeable battery for consumer electronics such as mobile phones, digital cameras, camcorders, and laptop computers. As a result of their success in these applications, lithium batteries are now used in other applications such as electric vehicles, hybrid electric vehicles, power tools, and specialty battery applications that typically rely upon less-efficient NiCD (nickel cadmium) or NiMH (nickel metal hydride) technologies. Lithium batteries are 20% to 50% lighter than either NiCD or NiMH and can provide greater energy and power per unit of volume and weight.

Analysts predict that by 2010, automakers will annually sell more than three million hybrid cars around the world, generating battery sales of over $3 billion. Lithium batteries already represent a global market of $6 billion, growing at 10% to 15% per year.

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FASTRAX

Danilo J. Santini has been appointed Member Emeritus of the National Research Council's Transportation Research Board (TRB) Committee on Alternative Transportation Fuels (ADC80). TRB established the emeritus membership category to recognize the significant and long-term contributions of individuals who have provided outstanding service through participation in its standing committees. Dr. Santini served as chair of the TRB's Alternative Fuels Committee from 1996 to 2002.

Mike Thackeray and Chris Johnson's work on increasing the capacity and stability of rechargeable lithium-ion batteries through a new family of cathode materials was featured in the May 14, 2007, issue of *Chemical & Engineering News*. The technology is based on a new material for the positive electrode made of a unique nano-crystalline, layered-composite structure. Details of the new developments were presented at the 211th Meeting of The Electrochemical Society on May 8, 2007.

Steve Ciatti has been elected to the Executive Committee of the Internal Combustion Engine Division of the American Society of Mechanical Engineers. Ciatti will serve a six-year term.

Ali Erdemir, Osman Erylimaz, and George Fenske's near-frictionless coating (NFC) technology has been licensed to CemeCon, Inc. CemeCon designed a new line of coating systems around the NFC technology to cut the cost of applying diamond-like coatings.

Glenn Keller and Ted Bohn, along with Argonne's prototype plug-in hybrid electric vehicle (based on a stock Saturn Vue Greenline sport utility vehicle), played a major role in a recent press conference held by 10th District U.S. Rep. Mark Kirk to announce his six-point plan for reducing gasoline prices. One of his points is the development and commercialization of advanced vehicle technologies such as those that the Department of Energy is supporting. Argonne was asked to provide an advanced vehicle technology not available to consumers today. Keller and Bohn accompanied the vehicle (see image, page 10) and addressed questions from the press.

Michael Wang's article, "Lifecycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types," published in *Environmental Research Letters,* vol. 2, p. 024001 (2007), was downloaded 500 times in the first 22 days after it was published. Across all journals published by the Institute of Physics (this journal's publisher), just three percent of articles published this year have been accessed over 500 times. The article can be viewed at http://stacks.iop.org/1748-9326/2/i=2/a=024001.

Doug Longman, Pat McPartlin, David Bell, and Matt Lagessie received an Argonne Pacesetter Award for over a decade of sustained, high-quality research on one of Argonne's largest and longest fully industry-funded Work-for-Others contract. The team has worked on the locomotive engine performance and emissions research for Electro-Motive Diesels Inc., (formerly Electro-Motive Division of General Motors Corporation) since February 1996. Former U.S. Secretary of Energy Bill Richardson praised the effort as "an excellent model for outstanding industry-national laboratory collaboration."

PUTTING ARGONNE'S RESOURCES TO WORK FOR YOU

Industrial technology development is an important way for the national laboratories to transfer the benefits of publicly funded research to industry to help strengthen the nation's technology base. The stories highlighted in this issue of TransForum represent some of the ways Argonne works with the transportation industry to improve processes, create products and markets, and lead the way to cost-effective transportation solutions, which in turn lead to a healthier economic future.

By working with Argonne through various types of cost-sharing arrangements, companies can jump-start their efforts to develop the next generation of transportation technologies without shouldering the often prohibitive cost of initial R&D alone. Argonne has participated in dozens of these partnerships and has even been involved in helping to launch start-up companies based on the products and technologies developed here.

If working with world-class scientists and engineers, having access to state-of-the-art user facilities and resources, and leveraging your company's own capabilities sound like good business opportunities to you, please contact our Office of Technology Transfer and see how we can put our resources to work for you.

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