Argonne wins four R&D 100 Awards

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Advances in technology ranging from help for victims of Parkinson's disease and epilepsy to more efficient combustion in industrial furnaces are likely with award-winning research at the U.S. Department of Energy's Argonne National Laboratory and its partners.
Argonne's research accomplishments have won four of the prestigious R&D 100 Awards, given to the world's top 100 scientific and technological innovations. This is the second year in a row that Argonne has won four R&D 100 Awards.

This year's awards bring Argonne's total to 90 of the awards since R&D magazine began presenting them in 1964.

Argonne director Bob Rosner congratulated the winners, saying, "I am thrilled that Argonne staff members have won four more of these prestigious awards. Winning such awards attests to the high quality of research at Argonne and to the caliber of our staff."

"These awards demonstrate that DOE scientists and researchers are hard at work developing the technologies of the future," said Secretary of Energy Samuel W. Bodman. "In the past, breakthroughs like these have played an important role in both our economic and national security."

This year's winners from Argonne are:

-- A self-contained battery-powered microstimulator, developed jointly with Advanced Bionics Corp., Alfred Mann Foundation, Quallion LLC, and the Organosilicon Research Center at the University of Wisconsin.

-- MPICH2, software that enables scientists to write parallel programs that run efficiently on all major computer systems, from parallel processors to laptops.

-- Multilayer lens wafers for X-ray lenses, providing the ability to focus hard X-rays well below 100 nanometers with high efficiency.

-- High-temperature potentiometric oxygen sensor, developed jointly with Ohio State University.

Microstimulator

Argonne was involved in developing battery chemistry and materials for the microstimulator pictured above. The lithium-ion battery is the smallest cylindrical, rechargeable battery ever made.

 The *bion* microstimulator, trademarked and manufactured by Advanced Bionics Corporation, is a miniature, self-contained, rechargeable implantable neurostimulator. It is designed to treat a wide variety of diseases, including incontinence, chronic headaches, peripheral pain, angina, and epilepsy.

An estimated 50 million Americans suffer from debilitating conditions

that may benefit from treatment with microstimulators. The bion implant represents a new generation of implantable technologies, designed to be placed in the body near affected muscles or nerves through minimally invasive surgery. The microstimulator is designed to stimulate viable nerves and muscles to prevent muscles from deteriorating and to help restore nerve and muscle function.

The fully integrated device measures 27.5 millimeters by 3.2 millimeters and weighs less than one gram, making it a fraction of the size of conventional implantable neurostimulation devices. Developing a microstimulator this size that would also be safe and effective required presented enormous engineering challenges to the team.

Argonne's researchers on the project, Khalil Amine, Bookeun Oh, Ilias Belharouak, Qingzheng Wang and Donald Vissers, were primarily involved in tackling the problem of developing battery chemistry and materials.

The key to the battery's success is an advanced lithium-ion chemistry that provides a calendar life significantly greater than commercially available lithium batteries. Previous batteries for medical microelectronics are large, have short lives and typically are not rechargeable.

Silicon polymers were first studied by researchers at the University of Wisconsin. For the past few years, Argonne and the university, working with Quallion, have developed a new class of polymer electrolytes, made largely of silicon-oxygen chains, that exhibit extraordinary conductivity and safety properties.

Other developers are Jeff Greiner, Curt Hafner, Kelly McClure, Matt Haller, Todd Whitehurt, Carla Mann and Alfred Mann of Advanced Bionics; Joe Schulman, Dan Dell and John Gord of Alfred Mann

Foundation; Hisashi Tsukamoto of Quallion LLC; and Robert West of the Organosilicon Research Center at the University of Wisconsin.

MPICH2

MPICH2 is a high-performance, portable implementation of community standards for the message-passing model of parallel computation. Parallel computation requires many computers to work together on large-scale problems by quickly distributing the mathematical workload. The new software's layered architecture permits computer vendors and researchers to customize its lower layers for particular proprietary networks while using its portable upper layers to provide compliance with computer community standards and state-of-the-art computational algorithms.

The software, developed at Argonne by William Gropp, Ewing Lusk, Robert Ross, Rajeev Thakur and Brian Toonen, enables application developers to run the same code on a wide variety of platforms, from laptops and workstations, through clusters of computers that can be assembled from off-the-shelf components, to the largest and fastest parallel computers in the world. Applications include materials science, combustion simulation, astrophysics, climate modeling and bioinformatics.

MPICH2 is the first freely available open-source implementation of the MPI-2 international message-passing standard, and both users and vendors have been quick to adopt it. Companies such as Pratt and Whitney are using MPICH2 to design aircraft engines, and the software is also widely used in scientific applications. A new epilepsy modeling program from a neuroscience group at the University of Chicago was one of the first applications to take advantage of the new remote memory access functionality in MPI-2.

In addition to the team listed above, significant contributors to the project include David Ashton at Argonne, Ralph Butler at Middle Tennessee State University, and Anthony Chan at the University of Chicago.

Multilayer lens wafers for X-ray lenses

Argonne is home to the Advanced Photon Source, which produces the most brilliant X-rays in the Western Hemisphere. Only two other machines in the entire world are comparable, and they are located in Japan and in France. The brilliant X-rays help researchers find infinite detail in a range of materials.

The new Argonne-developed multilayer lens wafers for X-ray lenses are in use at the Advanced Photon Source to help focus the X-rays at the nanometer scale, which is even more precisely than before. Researchers Chian Liu, Raymond Conley and Albert Macrander, all part of the Advanced Photon Source Experimental Facilities Division optics fabrication and metrology group.

The focusing lens, called a linear Fresnel lens, is made up of 728 individual layers grown on a one-inch diameter silicon substrate. The lens – just like the lens of a camera – allows precise focusing of the light. However, unlike a camera, the lens focusing the X-ray beam can do so to a spot less than 100 nanometers in diameter. In recent testing, the lens was found to be successful at less than 30 nanometers and is expected to do so at less than 10 nanometers. For comparison, the period at the end of this sentence is approximately one million nanometers in diameter.

Using the lens, researchers will be able to visualize three-dimensional electronic circuit boards to find circuit errors, or map impurities in biological or environmental samples at the nanometer scale. They can

also analyze samples inside high-pressure or high-temperature cells.

Other examples of uses of the new lens include development of smaller, better-performing and more reliable computers and telecommunications equipment; reduction of electromigration in interconnects in electronic devices; detection of flaws or strains in materials for storage, machining or aviation; production of lighter, sturdier, safer transportation vehicles through advanced materials with tailored properties; imaging cell division and tumor growth, providing a new mechanism for the early detection of cancer; and faster, more sensitive detection of hazards in local and global environments.

Oxygen sensor
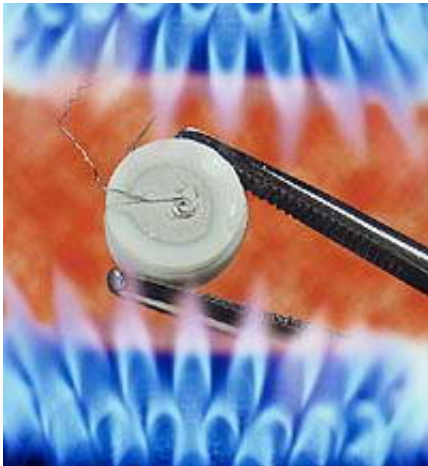
Researchers at Argonne and at Ohio State have developed a compact sensor to monitor combustion processes in coal-fire power plants, petrochemical plants, blast furnaces, glass processing equipment, and even inside internal combustion engines. The high-temperature

potentiometer oxygen sensor can withstand the heat inside the combustion chambers, allowing monitoring at the source in real time.

Image: This inexpensive, compact oxygen sensor developed by Ohio State University and Argonne monitors combustion processes ranging from internal combustion engines to coal-fired power plants. Argonne researchers provided the unique deformation bonding method for producing the sensor's gas-tight seal.

Developers include Jules Routbort and Dileep Singh, both of Argonne's Energy Technology Division.

The new sensor is the first that does not require an external supply of reference air. Instead, the sensor is enabled by an internal reference air chamber, sealed by a unique deformation bonding method that joins the protective ceramic housing components together without altering the ceramic's oxygen conductivity. By eliminating the need for costly and bulky high-temperature external plumbing for reference air, this novel sensor provides unsurpassed oxygen-sensing accuracy for a cost that is approximately one-twentieth that of conventional oxygen sensors.

The information provided by the sensor is important to manufacturers, because it helps them be more energy-efficient and economical in their operations by achieving energy savings by optimizing the air-to-fuel ratio and the fuel oil viscosity. While various sensors have been available, industry has never before had a truly inexpensive means of accurately monitoring its boiler efficiencies to achieve the highest possible energy savings.

The new oxygen sensor overcomes the limitation of conventional oxygen sensors by having the capability to withstand temperatures up to 1600 degrees C and by allowing the engineering of small sensors – smaller than a dime – since no external air source or plumbing is required. The

ceramic housing components of the sensor are joined without intermediate bonding materials through a unique deformation bonding method developed by the researchers. And the low cost of the sensor – about $200 – allows the use of multiple sensors, making it practical and affordable to monitor the combustion of oxygen and other materials throughout the combustion process.

The oxygen sensor development was sponsored by DOE's Office of FreedomCar and Vehicles Technology.

Source: Argonne National Laboratory