LOS ALAMOS NATIONAL LABORATORY
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE
LOS ALAMOS

U.S. DEPARTMENT OF ENERGY
UNIVERSITY OF CALIFORNIA

# IN SEARCH OF INNOVATIVE SCIENCE

## R&D MAGAZINE HAILS SEVEN LOS ALAMOS TECHNOLOGIES AS WINNERS IN ANNUAL CONTEST

For more than 56 years, the name Los Alamos has been synonymous with world-class scientific research and development. While the Laboratory has been perceived, at different times and from various perspectives, as being either devoted to basic scientific research or as a wellspring of new technology development, the fact is it has always been both. Los Alamos scientists have contributed much to the academics of basic science, and the Laboratory's technologies are in use around the globe. Today, Los Alamos serves the nation as a research laboratory immersed in basic science, and yet, ever since the Laboratory was established in World War II to build the world's first atomic weapons, Los Alamos has developed devices that can, and often do, change the world.

# DATELINE: LOS ALAMOS

This special issue of *Dateline: Los Alamos* examines the blending of research and development that takes place at Los Alamos. The pages that follow describe the Laboratory's 1999 winners of *R&D Magazine*'s R&D 100 Awards along with the other entries placed into the competition by the Laboratory this year.

These entries are as diverse in nature as the Laboratory itself and together they represent the continuing legacy of Los Alamos National Laboratory as an institution devoted to advancing the frontiers of science and creating technologies that improve and enrich life on Earth.

Now in its 37th year, the R&D 100 Awards program is designed to recognize exceptional commercial promise in products, materials or processes developed by the international research and development community. Technical experts selected by the Illinois-based *R&D Magazine*, the award's sponsor, choose the 100 most significant, unique or promising technologies from all nominations received.

This year Los Alamos received seven R&D 100 Awards out of the 17 entries it submitted. This is the highest number of awards received by the Laboratory since 1990, and these latest winners give the Laboratory 63 awards won over the past 12 years. Los Alamos has received more R&D 100 Awards than any other national laboratory during the same period.

DATELINE LOS ALAMOS

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Laboratory Director John Browne applauded Los Alamos' continued strong showing in the R&D 100 Awards, noting that "Los Alamos is home to some of the best science and scientific minds in the world. Many of these award-winning technical and scientific innovations were born out of Los Alamos' goal to create science that truly serves society, and I think these recent awards embody that goal."

1999 produced the highest-ever ratio of awards to entries for the Laboratory. This success is perhaps due to the manner in which this year's entries were nominated and selected. In October 1998, Director Browne appointed a technical advisory committee to improve the process by which R&D 100 entries were selected from the many outstanding research projects at the Laboratory.

According to Sue Goff, a senior adviser to the Industrial Business Development Office director and the Laboratory's R&D 100 coordinator, "the advisory committee was charged with shaping the initial selection process to better represent the breadth and depth of the scientific programs at Los Alamos.

"Before this, some really great nominations came in on their own, but often only a select group of divisions or technical specialties were represented. We felt that some of the Lab's best technical work was not being represented in the competition and we have tried to change that by going out and finding more of the Laboratory's great technologies," said Goff.

The projects entered into this year's R&D 100 Awards program span a diverse range of scientific and technical areas — from innovative computing techniques to revolutionary engine technology and plasma physics.

Of the seven awards received by Los Alamos this year, five were developed in collaborations with private companies or other scientific institutions. Still, 60 percent of this year's entries were funded, at least in part, by the Laboratory-Directed Research and Development (LDRD) program with support that was essential to the award-winning technologies. (For more information on LDRD funding, see the August 1999 issue of *Dateline: Los Alamos.*)

Like similar programs at other national laboratories, the Los Alamos LDRD program employs 6 percent of the Laboratory's total operating

The award-winning PREDICT process was used to develop reliability characterizations of an automotive fuel rail assembly before the parts were built. A team led by Mary Meyer (left),

Jane Booker (center) and Tom Bement is comparing test results of the finished product to the predictions. Delphi Automotive Systems is using PREDICT as the basis of its design assurance program.

and capital equipment budget to make strategic investments in research and development projects that further emerging scientific opportunities and help the Laboratory fulfill its national security mission.

The benefits of LDRD funding to entries winning R&D 100 Awards are considerable. All seven R&D 100 Award winners this year receive $75,000 in LDRD funding to continue the research.

According to David Watkins of the Laboratory's LDRD program, "the R&D100 Awards are an important indicator of the value of the Laboratory's efforts in making good on its motto of 'science serving society.' I believe people who apply for these awards are serious about wanting to see their projects turned into commercial products.

"The R&D 100 Awards draw industrial attention to our technologies, but often some additional work will be needed to succeed in a technology transfer," Watkins said. "The additional LDRD funding can be critical in providing an R&D 100 Award winner the opportunity to further advance and potentially transfer a technology to industry.

"The $75,000 in LDRD support offered to winners demonstrates the Laboratory's commitment to those who make the effort to develop technology judged to be commercially significant," Watkins concluded.

One of this year's R&D 100 Award winners that benefited substantially from the advisory committee's effort was the PREDICT team. PREDICT — a set of formal, structured techniques for statistically estimating the performance of a product when little or no test data are available — was developed at Los Alamos by a group led by Mary Meyer, Jane Booker and Tom Bement of the Technology and Safety Assessment Division.

PREDICT was a joint R&D 100 entry between Los Alamos and Delphi Automotive Systems that was initially funded under the auspices of the Department of Energy's Enhanced Surveillance Program — a part of the Laboratory's Stockpile Stewardship Program — to develop a method for estimating the reliability of an aging nuclear weapon.

Advisory committee members brought the PREDICT process to the attention of the R&D 100 coordinators, a somewhat unusual connection that would likely be missed in the traditional call for nominations.

According to Meyer, "PREDICT is the product of a true multidisciplinary collaboration by a team made up of statisticians, engineers, chemists, physicists and even a cultural anthropologist. The collaborative efforts of the team are the key to PREDICT's success. This is significant since the collaboration reflects the integration of basic research with technological development."

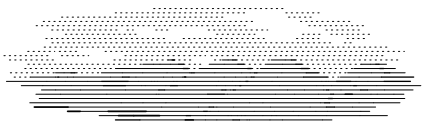
PREDICT's Bement agrees and notes that the successful use of the project at Delphi in the development of engine-management systems makes it something of a "bridge between the divide that traditionally lies between pure science and technology development."

Greg Swift (left), Scott Backhaus (center) and Chris Espinoza have developed an acoustic Stirling heat engine that efficiently converts heat to intense acoustic power in a simple device with no moving parts.

Other R&D 100 Award winners, like Greg Swift, also regard basic research and technology development as distinct, but certainly not incompatible, pursuits. Swift's field is condensed matter and thermal physics, but he has chosen to apply this specialized knowledge in some very practical ways.

Swift, a Laboratory Fellow who, along with Scott Backhaus and Chris Espinoza, developed the acoustic Stirling engine, has an impressive list of academic papers to his credit, but also holds nearly a dozen patents on advanced technologies. He is both a researcher and a developer.

"Really it's a matter of personal choice," said Swift. "Some researchers like basic science, others like the





applied side. Personally, I like to keep one foot in each camp. I enjoy basic research, but find great satisfaction in applying what I've learned. Occasionally that work turns into something with a good commercial application, like the acoustic Stirling engine."

Obviously, Swift's philosophy is a good one — this is his second R&D 100 Award in less than 10 years.

Since the R&D 100 Awards are most commonly given to products or materials, the PREDICT group was a bit surprised, but happy, to learn it had won. PREDICT was unique among this year's entries from the Laboratory because it is a method and a process, not a gadget or software.

As the Statistical Science Group's hallways echoed with laughter and cheers upon receiving the news they had won, Sallie Keller-McNulty, the group leader for many members of the PREDICT team, noted this was "a real home run for statistical science — a discipline whose triumphs are generally celebrated much more modestly."

Booker agrees with Keller-McNulty, and added that "the Statistical Sciences Group has always served the Laboratory by providing solutions to problems in science and technology using statistical philosophy. We are often part of multidisciplinary teams on projects. PREDICT is a good example of what we do and it also happens to be a very successful one."

Not surprisingly, this R&D 100 Award was the first ever for the Statistical Sciences Group and TSA Division. With this success comes the distinct possibility that it may not be their last.

In the end, even the publicity associated with entering the R&D 100 Award contest can be advantageous to a project. CHEMIN, another of this year's winners, benefited significantly from the interactions and publicity associated with the R&D 100 Award competition.

The CHEMIN instrument was developed jointly with NASA in response to difficulties encountered in interpreting the chemical data sent by the Viking lander from the Martian surface. By gathering X-ray fluorescence chemical data simultaneously with X-ray diffraction data, CHEMIN could overcome the kind of analysis difficulties encountered by Viking and later by the Pathfinder missions.

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Los Alamos members of the award-winning CHEMIN team include David Bish (left), David Vaniman (center) and Steve Chipera. Publicity associated with the R&D Award competition brought CHEMIN to the attention of an X-ray optics company, which has offered free loan of a much-needed X-ray focusing system.

Despite CHEMIN's advantages over other technologies, the project team faced many hurdles in garnering the funding necessary to implement the latest technology. Recently, as a result of publicity associated with the R&D 100 Awards, the CHEMIN project received an offer from an X-ray optics company for the free loan of an X-ray focusing optic for experimentation with CHEMIN.

The team was in need of such a focusing system, but had been hindered by the high cost of such a device. Now, with this focusing optic on its way and the LDRD funding forthcoming, the future for CHEMIN is bright.

As you read the short descriptions of the Los Alamos technologies that follow, you might consider the fact that out of the 100 R&D Awards awarded by *R&D Magazine*, more than 30 went to the seven national laboratories that are part of the United States Department of Energy.

According to Secretary of Energy Bill Richardson, "the R&D 100 Awards are both a tribute to the impressive creativity of the scientists and engineers at our national labs and a recognition of the numerous practical contributions that Department of Energy research makes to our nation."

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# LICENSING THE LABORATORY'S INTELLECTUAL ASSETS

## IT BRINGS IN MORE THAN MONEY

The role of licensing Los Alamos-developed technologies and other intellectual assets goes far beyond receiving royalties for the institution and its inventors. It helps strengthen Los Alamos' core capabilities by increasing its ability to secure new or increased programmatic funding to perform its mission. Licensing also attracts, creates and enhances strategic alliances with major industrial partners and academic institutions, boosts economic development regionally and nationally, and helps keep U.S. industry competitive in today's global economy.

What does licensing have to do with the R&D 100 Awards program? Simply, it's that *R&D Magazine* gives these awards to those in the international research and development community whose products, materials or processes show exceptional commercial promise. It's no surprise, then, that four of the seven Los Alamos technologies that won R&D 100 Awards this year either are licensed to companies or currently are being sought by them for commercialization.

In addition, R&D 100 Award winner PREDICT directly resulted from work performed with Delphi Automotive Systems under a cooperative research and development agreement. PREDICT is a structured method for estimating the performance of a product when test data are scarce or unavailable. The company is expected to soon apply the technology commercially.

Rosemount Analytical Systems Inc., currently is negotiating with Los Alamos for the license rights to the Sulfur Resistant Oxymitter 4000™, a long-life, sulfur-resistant oxygen sensor for automatically controlling combustion processes in heavy-duty, industrial boilers found in power plants, refineries, cement kilns, and pulp and paper mills.

During the license negotiations, Rosemount entered into a CRADA with Los Alamos to determine the best approach for packaging the sensor, including beta testing to determine the sensor's longevity under real-world industrial applications. In fact, funds-in

CRADAs or funds-in agreements (also called work for others) increasingly result from strategic licenses that leverage intellectual property to attract and foster relationships with qualified companies.

Under both agreements, companies pay Los Alamos to conduct research and development. But with funds-in CRADAs, companies also collaborate with Los Alamos divisions and provide added technical expertise to help solve problems and complete their objectives. Such agreements typically include options for the company to license the intellectual property resulting from work performed under the agreement as part of Los Alamos' overall strategy.

Cryenco Sciences Inc. (recently acquired by Chart Industries Inc.) received licensing rights to the acoustic Stirling heat engine back in 1994 to liquefy natural gas. The engine creates acoustic energy in the form of sound waves and also can be used for acoustically powered refrigerators or to generate electricity. Like Rosemount Analytical, Cryenco's license agreement was accompanied by a CRADA for further product development.

Los Alamos currently is developing a licensing strategy for the Atmospheric-Pressure Plasma Jet, a device with many potential uses, including decontamination of areas tainted by chemical or biological weapons. Los Alamos Licensing Team Leader Jerome Garcia explains that a license strategy means using business and technical criteria to fairly select qualified companies that Los Alamos feels will best serve its mission and above-mentioned objectives. To date, four companies have expressed interest in the device, and Garcia expects that number to increase significantly.

Discussions also are under way with a company to license a unique puncture detecting barrier material technology that instantly detects punctures or other breaches of personal protective equipment and other items, such as gloves, bodysuits, biohazard suits and boots, hazardous waste or chemical drums, and radiation sources.

Garcia notes that the other three R&D 100 Award-winning technologies also may one day be licensed to the commercial or noncommercial sectors.

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# ACOUSTIC STIRLING HEAT ENGINE

Concerns over global warming and shrinking fossil fuel reserves have focused world attention on increasing the efficiency of power production. Heat engines, which convert heat energy into mechanical or electrical energy, produce about a terawatt — one trillion watts — of power worldwide. However, only the largest, most sophisticated and most expensive engines, such as the steam-driven turbines of electric utilities, attain high efficiencies. Efficient engines are needed to provide power on a smaller scale, at low capital and operating costs.

A hybrid acoustic Stirling heat engine invented at Los Alamos efficiently converts heat to intense acoustic power in a simple device that combines an efficiency comparable to that of the internal combustion engine with the high reliability and low manufacturing costs of engines with no moving parts.

The first experimental engine consists of a long, baseball-bat-shaped resonator with an oval “handle” on the lower end. By applying heat to the compressed helium contained within the system through a heat exchanger located on the “handle,” the engine creates acoustic energy in the form of sound waves. The power production process is environmentally friendly and up to 30 percent efficient while typical internal combustion engines are 25 to 40 percent efficient.

The idea behind the engine comes, in part, from the Stirling cycle where a confined volume of gas expands at high pressure and contracts at low pressure, thereby doing work on the surrounding environment. The expansion and contraction of the gas is driven by the absorption and rejection of heat at the engine's hot and cold heat exchangers.

The discovery of this principle by Robert Stirling in 19th century Scotland laid the groundwork for the conventional Stirling engine in which a fixed amount of helium is compressed in a cool chamber and then transferred to another chamber heated by an external burner. As

the gas expands it drives a piston that delivers energy. As it cools it returns to the cool chamber and the cycle begins again.

This new Los Alamos heat engine is an important technological advance for several reasons. First, sound waves can be harnessed powerfully and efficiently. Sound waves are usually thought of as small, coupled oscillations of pressure and displacement.

The hybrid acoustic Stirling heat engine combines low-tech hardware and an elegant engineering design in a no-moving-parts engine that produces acoustic power from heat with a 30 percent efficiency. Shown here is the helium-filled acoustic network loop. The heat exchangers and regenerator are housed within the large-diameter insulated segment. The resonator extends off to the right.

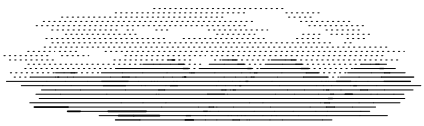
However, temperature oscillations accompany the pressure and displacement oscillations, and in tremendously intense sound waves, the heat transfer accompanying the temperature oscillations produces intense acoustic power, which can be readily converted to more useful forms of power.

Second, producing and harnessing such intense sound waves efficiently is an elegant engineering process. Although the design for the acoustic Stirling heat engine is based on complex laws of thermodynamics and acoustics — a field of engineering the researchers hope will come to be known as thermoacoustics — the hardware is simple enough to assemble at home.

This is engineering at its best, according to the researchers: a high-tech design resulting in low-tech hardware made of environmentally harmless materials. The engine comprises merely ductwork and conventional heat exchangers, things that have been around for years.

Yet only now have scientists come to understand acoustics well enough to put them together to form an efficient heat engine with no moving parts. Simply apply heat, and the sound wave springs to life, growing in intensity and power as the heat is increased.

Third, the enormous fossil-fuel-based energy industry, spanning everything from transportation to residential heating, faces mounting challenges in the coming decades as concern for combustion-triggered global warming grows and as oil production declines. These challenges





may result in doubling the cost of fossil fuel and most other energy resources. Anticipation of such challenges already is driving industrial partners to begin implementing Los Alamos' heat engine in applications with enormous economic impact.

One of these areas is natural-gas liquefaction. Natural gas currently provides a quarter of the United States' energy supply, and domestic gas reserves will outlast oil reserves by many decades at current levels of consumption. Large natural-gas liquefaction plants and cryogenic storage tanks exist throughout the world.

Typically, however, such liquefaction plants are too expensive, too large and require too much maintenance to be used in recovery of "associated gas," a byproduct of oil production. Each year, megatons of associated gas are flared at remote and offshore oil wells, not only wasting valuable fossil fuel but also contributing to global warming.

Los Alamos currently is working with an industrial partner, Cryenco of Denver, to couple the Lab's acoustic Stirling heat engine to pulse-tube refrigerators to liquefy natural gas. The aim is to design a compact liquefier that would have a capacity of 30,000 gallons per day and be relatively small — about the height of a grain silo.

Residential cogeneration — the practice of generating electricity while producing necessary heat — also is an important application of the acoustic Stirling heat engine. If some electricity were produced in every home as a byproduct of combustion-powered home or hot-water heating, both residential electric bills and power-plant consumption of fossil fuels would be reduced.

In cogeneration, the heat of combustion of natural gas at high temperatures is used to produce electricity. All "waste" heat from this process is used to heat the home or hot water, so no heat is really wasted. Cogeneration has long appeared attractive, but its commercial viability has awaited the invention of a low-cost heat engine, with a lifetime and reliability comparable to those of residential furnaces and hot-water heaters and small enough to fit inside or on top of these appliances.

Another application for the new heat engine is for combustion-powered air separation. Air is now separated into its principal components (nitrogen, oxygen and argon) at a few large cryogenic distillation plants.

These industrial gases are trucked long distances, as compressed gas or cryogenic liquid, to their ultimate users throughout the health-care, food-processing, steel and welding industries. Local air-separation plants employing Los Alamos' heat engine and pulse-tube refrigerators and powered by natural-gas combustion would reduce the transportation costs for these gases.

In the future, researchers say the acoustic Stirling heat engine could be combined with other technologies to provide solar generation of electricity, generation of electricity from waste heat from industrial processes, heat-driven pumping of gases in the transcontinental pipeline, heat-driven refrigeration and heat pumping in home heating and air conditioning systems, and truck refrigeration powered by truck exhaust heat.

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## ATMOSPHERIC-PRESSURE PLASMA JET

A technology originally developed for the semiconductor industry to clean silicon wafers without using solvents has widespread applications, including decontaminating, cleaning, etching, coating and sterilizing.

The Atmospheric-Pressure Plasma Jet — or APPJ — uses electrically charged gas to create a spray that cleans, coats or decontaminates. The award-winning technology was developed by Los Alamos; the University of California, Los Angeles; Beta Squared Inc. of Allen, Texas; and DuPont Nylon of Chattanooga, Tenn.

In a plasma jet, a pressurized feedstock gas, usually helium mixed with small amounts of oxygen, flows between electrodes to generate an electrical field that pulls off certain electrons to create an ionized gas, or plasma. When the plasma is forced out a nozzle and strikes a dirty or

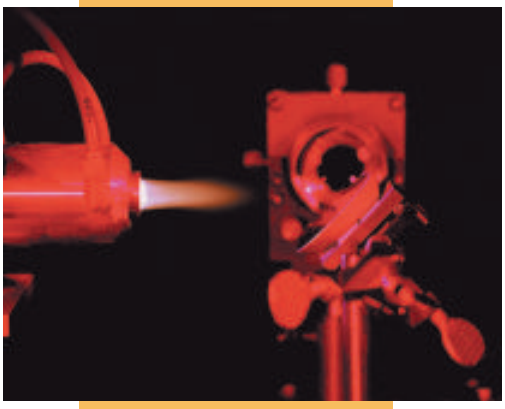
contaminated surface, it destroys or "burns" the contaminants at a very low temperature.

The plasma jet can convert a vast range of organic residues or toxins into water vapor, carbon dioxide and other nontoxic gases in a minute or less. And unlike other atmospheric-pressure plasma sources, whose high temperatures limit their use, the plasma jet's gas stream is cool enough to treat paper without scorching it.

Until now such plasma treatments could take place only in a vacuum, but the plasma jet can spray surfaces in the open air, somewhat like a fire extinguisher.

Researchers currently are operating the APPJ technology on a small scale, but it could be tuned for high-power applications to decontaminate large areas such as ships and airfields. It also can be used at much lower power for use on delicate electronics.

The Army is testing the plasma jet for decontaminating equipment, vehicles and areas exposed to chemical or biological warfare agents. With adaptation, the plasma jet may someday be used on humans. It also has potential for decontaminating objects containing radioactive materials



The Atmospheric-Pressure Plasma Jet uses electrically charged gas to create a spray that cleans, coats or decontaminates. This is the "round jet" version, which produces a steam about 1 centimeter in diameter. Researchers also have built an "immersion plasma" jet that cleans draw rolls in the nylon industry as well as a "flat jet" version that can be adapted for large-scale applications.

DuPont is evaluating the technology for use in cleaning the steel draw rolls used to produce nylon, which become coated with residue and must be cleaned every two to three weeks. DuPont and Los Alamos have concluded that the plasma jet could clean the draw rolls in place on the production line, which would eliminate having to remove them, dunk them in chemical baths and reinstall them.

Another industrial application includes using the plasma jet to deposit silicon dioxide films onto plastics and other materials, in effect lining them with thin layers of glass. This could improve the taste and shelf life of foods and beverages stored in plastic containers.

The plasma jet also can sterilize surfaces. In a hospital it could be used to destroy bacteria or viruses. And it has the potential to replace or complement the autoclave in sterilizing surgical or dental instruments. In the food industry the plasma jet can sterilize utensils and food-processing equipment, thus reducing the risks posed by *E. coli*, salmonella and other pathogens.

Researchers also have used the plasma jet to take paint off brick, showing its potential for removing graffiti.

There are no foreseeable limits to the size, shape or composition of an object that the plasma jet can treat. A work piece can be as large and complex as an aircraft carrier or as small as a silicon wafer. By changing the composition of the feed gas, the gas-flow rate and the jet's design, size and power level, the APPJ can easily be adapted to specific applications.

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## CHEMIN: A MINIATURIZED X-RAY DIFFRACTION AND X-RAY FLUORESCENCE INSTRUMENT

In nature, roughly 100 elements exist and can combine to form at least 3,800 minerals. Chemical analysis identifies the elements in a material but usually cannot reveal how the atoms and molecules bind together. For example, diamonds and graphite are identical chemically, but their crystalline structure differs.

Crystalline structure can be crucial for determining the properties of a mineral (a naturally formed crystal) or synthetic crystal. Moreover, knowing which minerals are present in a sample can illuminate its history: how the elements first came together to form minerals and whether those minerals were subsequently altered through sedimentation, metamorphism or weathering.

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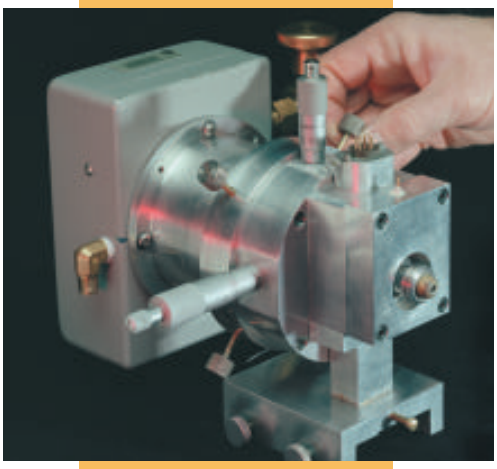
Los Alamos has developed a new instrument in collaboration with NASA Ames Research Center, Mountain View, Calif., and the Jet Propulsion Laboratory in Pasadena, Calif., that identifies the elements and minerals or synthetic crystals in powders and fine-grained samples. CHEMIN, so named because it identifies both the CHEmistry and MINeralogy of a sample, gathers high-resolution data with an instrument so small it can fit in your hands.

CHEMIN is the first instrument optimized for gathering both X-ray diffraction and X-ray fluorescence data. Less than a milligram of sample material is placed in the path of a low-intensity X-ray beam and the resulting photons are recorded on a detector the size of a postage stamp. The sample's chemistry and crystalline makeup can be quickly determined from the data.



CHEMIN represents a breakthrough, both in its small size, simplicity and ease of use, and in its analytical capability, with capabilities that approach those of large X-ray diffraction and X-ray fluorescence instruments found in laboratories. CHEMIN enables the elemental and crystalline constituents of a small sample (usually less than 1 milligram) to be determined quickly, whether sampling from a cement kiln, assaying ore for mining or surveying the damage after a dangerous chemical spill.

Identifying the elements and crystalline constituents of tiny samples is particularly useful when material is costly, rare or difficult to fabricate. Because of its size, CHEMIN can be used inside a glovebox or shielded container to determine the nature of contaminated material. In industrial settings, CHEMIN has applications ranging from sampling the feedstock in processes for which mineral content is crucial to the integrity of the product, such as steel and cement production, to assaying powdered rock for mineral content at mining sites.

At the heart of CHEMIN is a postage-stamp-size charge-coupled device (CCD) that records both the X-ray fluorescence spectrum and the pattern of diffracted X-rays from a sample held in the path of an X-ray beam. The fluorescence spectrum characterizes the chemistry of the sample and the X-ray diffraction pattern reveals the crystalline makeup.

Because each element has a characteristic X-ray fluorescence spectrum, interpretation of the chemistry is straightforward. To identify the crystalline composition of a sample, the observed diffraction patterns are compared with a large database of diffraction patterns from known minerals and synthetic crystals.

These data fit onto a CD-ROM that a laptop computer can accommodate, and standard commercial software searches through the database to determine which minerals or synthetic crystals are present.

CHEMIN may someday find uses out of this world. Researchers are working to further miniaturize the instrument so that it can be sent on a space probe. Although not in existence today, the flight-ready version of CHEMIN will be the size of a soda can, consume only 2 watts of power and weigh less than 1 kilogram.

More information on CHEMIN can be found at the following address on the World Wide Web: http://www-geo.lanl.gov/chemin/chemin.html.

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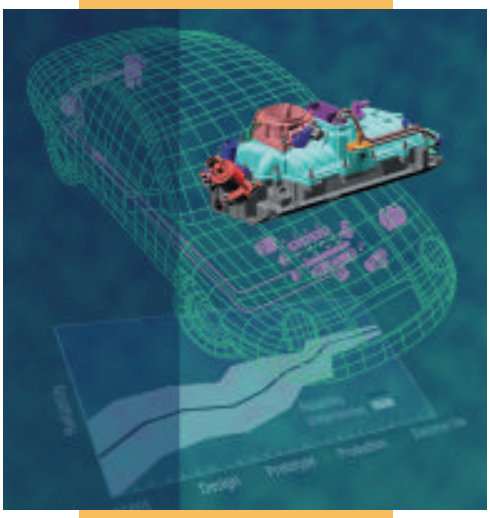
## PREDICT — A NEW APPROACH TO PRODUCT DEVELOPMENT

Industry gauges a new product's reliability by testing prototypes or large numbers of the products themselves. In short, performance is evaluated only after development is well advanced or complete. So, when problems arise, they may require expensive manufacturing changes or even more expensive product recalls. The award-winning technology PREDICT is a method of statistically estimating the performance of a product when test data are scarce or unavailable.

PREDICT, short for Performance and Reliability Evaluation with Diverse Information Combination and Tracking, is a set of formal techniques developed at Los Alamos. Work began on PREDICT several years ago in the weapons program to estimate the reliability of aging nuclear weapon systems.

PREDICT minimizes or prevents costly surprises by forecasting reliability while the product is still a concept. It also can forecast the future performance of existing systems that cannot be tested but which must be guaranteed to perform as required when they are needed.

PREDICT accomplishes this three ways: by documenting and exploiting the expert knowledge of a product's designers, engineers and scientists; by folding uncertainties about the product's expected performance into its calculations; and by statistically combining expert knowledge and uncertainty with a wide variety of existing "hard" data.



Delphi Automotive Systems is using PREDICT to develop engine-management systems, represented here by the colored objects inside the wire-frame car and by the three-dimensional image of an integrated air/fuel module.

Hard data include information such as performance results of similar products, test data from components of the product in question and output from computer models of the product. As a "product" itself, PREDICT consists of customized training, a reference book and sample tools (worksheets, statistical/mathematical formulas and computer codes) that users are taught to adapt to their particular situation.

PREDICT's ability to estimate performance already has been proven. Delphi Automotive Systems, which develops engine-management and other systems, is using PREDICT as the basis of its design assurance program — known as the Design for Reliability program. PREDICT has been applied to four automotive systems and the results have led Delphi to evaluate this approach for its new Customer Solutions Center.

At Los Alamos, the Enhanced Surveillance Program is using PREDICT to estimate the reliability of aging nuclear weapons, which cannot be

tested but whose reliability must be certified to the president. Specific applications are in weapons engineering, detonators and nuclear packages. For Los Alamos and the Department of Energy, which has ultimate responsibility for maintaining the U.S. nuclear weapons stockpile, PREDICT provides a formal, quantitative and updateable process for stockpile-management decisions.

PREDICT also can be used for other one-of-a-kind systems that must be guaranteed reliable and for which specific test data are sparse or nonexistent. Examples include aircraft, ships, conventional weapons, power plants, space missions, space vehicles, oil platforms, computers, telecommunication equipment, semiconductors and robotic systems.

PREDICT's greatest strength — the integration of expert knowledge with statistics, thus allowing customization to specific user needs — makes it a valuable tool for all design or engineering communities. Users establish a core of expertise and perpetuate PREDICT as a permanent shift in company culture. Because of that shift, PREDICT would conceivably revolutionize the way products are developed and analyzed. It could be as significant a change for industry as was the assembly line.

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## REAL-TIME, PUNCTURE-DETECTING, SELF-HEALING MATERIALS

Working around hazardous materials could be a lot less dangerous if workers knew immediately when their gloves were punctured. Radiation protection workers who work in gloveboxes routinely inspect their lead-lined gloves for holes using both visual and radiological evaluations, but physical punctures and pinholes that develop during glove use are still the primary means of worker exposure. Workers

must monitor their hands after each use of the gloves to prevent contamination from spreading. However, contamination is usually discovered only well after the exposure has occurred.

A puncture in a glovebox glove made from INSTALARM material sets off an alarm, displayed here as a small red light with a battery power source. The two gooey, conducting layers within the five-layer material also are self-healing.

Methods to test the integrity of gloves used in the health-care industry often depend on an electronic device and fluid immersion to detect a hole. These tests are cumbersome, time-consuming and require that work stop while the glove is tested. Other alarm systems function only when the glove is pierced by an electrically conductive substance.

A new material developed specifically for glovebox gloves at Los Alamos not only signals an immediate puncture, it also heals itself. INSTALARM Materials, created by Los Alamos, will work for all punctures, whether conducting (such as a scalpel or other metal object) or nonconducting (such as wood splinters or glass shards), and in any configuration, whether a glove, bootie, full body suit, hazardous-waste storage container or disposal bag.

North Hand Protection of Charleston, N.C, was instrumental in making prototype gloves based on Los Alamos' patented technology.

The material could save lives by instantly warning of punctures, thereby minimizing workers' exposures to chemicals, biohazards and radioactive contamination. The material also will save time by eliminating the need for time-consuming glove-testing procedures.

The layered construction allows items made of INSTALARM Materials to trigger an alarm when two “gooey” conductive layers, sandwiched within the material, are brought into contact with one another by any piercing object. The flexible nature of the conducting layers ensures electrical contact if the breach occurs throughout the four outermost layers, allowing them to signal a breach before the final protective layer closest to the wearer has been punctured.

DATELINE: LOS ALAMOS

The completion of the electric circuit provides a signal that can be used to sound an alarm, turn on a warning light or otherwise alert the users that a breach has occurred. This simple electric circuit also could be tied to the computer network for instant notification to safety personnel.

The original design of the gooey layers used polyvinyl alcohol, sodium chloride (table salt) and glycerine as a plasticizer, while later developments used carbon-filled butyl rubber. These conductive inner layers both trigger alarms and self-heal; the sticky goo flows into and seals pinholes and other small punctures.

Applications for INSTALARM Materials are numerous. The materials can be fashioned into personnel protection equipment such as gloves, garments, booties, biohazard suits and masks; storage containers for chemicals, biohazards and radionuclides; disposal bags; natural gas lines and oil pipelines; and environmental containment, such as membranes for hazardous-waste sites and landfills and petroleum-storage areas.

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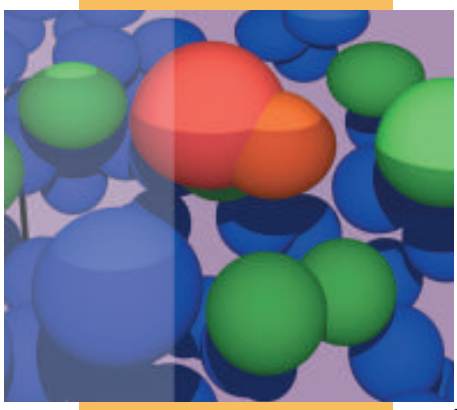
# REED-MD: A COMPUTER CODE FOR PREDICTING DOPANT DENSITY PROFILES IN SEMICONDUCTOR WAFERS

Modern microelectronic devices are made from semiconductors whose electrical properties have been modified by doping, a process that buries certain types of ions within the semiconductors. Optimizing device performance requires controlling the dopant concentration by adjusting the depth of the implanted ions — the dopant density profile.

To make a transistor, for example, a designer specifies the dopant density profiles required for each of the transistor's semiconductor

elements. Experiments are then run in which the implant parameters are varied until the desired profiles are obtained.

Industry's mainstay for measuring profiles is done with costly and slow experiments involving a multimillion-dollar instrument called a secondary ion mass spectrometer (SIMS) or by predicting the profiles with computer codes that rely heavily on existing SIMS data. It can take nearly a year to obtain an incomplete set of profiles, a long time in a competitive industry that doubles the density of transistors on a chip every 18 months.



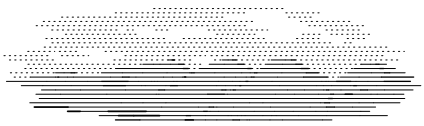
Semiconductors such as silicon are "doped" by implanting ions in them, which is part of making microelectronic devices such as transistors. REED-MD simulates ion implantation as shown here. An incident ion (red) strikes an amorphous silicon surface and interacts strongly enough with a silicon atom (orange) to form a short-lived "quasi-molecule." The ion interacts weakly with several other silicon atoms (green) but not with the blue silicon atoms. The final positions of the implanted ions give their concentration with depth, which is the dopant density profile.

The semiconductor industry is at a crossroads. To build faster microelectronic devices, it needs data that are difficult to obtain by SIMS. Los Alamos has developed a complementary technology: a computer code called REED-MD, which simulates ion implantation; it accurately and efficiently predicts dopant density profiles in ion-implanted semiconductor wafers.

REED stands for rare-event-enhanced domain following, which refers to two of the code's special features. Rare-event enhancement is a statistical method that ensures high accuracy in the detail of the dopant density profile, where ions that contribute to the dopant density profile are rare. Domain following is a technique that reduces the number of atoms REED-MD must track.

The MD stands for molecular dynamics, referring to the fact that the code follows the trajectories of particles such as molecules or, in this case, ions and atoms, by numerically solving their equations of motion.

The code runs on personal computers and can produce in one day a single profile whose quality rivals or exceeds that possible with SIMS measurements when calibration data already exist. But REED-MD's real power is in obtaining profiles when calibration data do not exist. In this





case, REED-MD can obtain a complete set of profiles in a few weeks, instead of the year it takes to get an incomplete set with SIMS data. Using faster PCs or several PCs in parallel can reduce this time accordingly.

Since its first release in 1998, REED-MD has been used by research groups at Motorola, Intel and IBM. In fact, for Motorola, the code has become a key component in the company's work on designing advanced transistors.

Researchers have focused on using REED-MD to solve the needs of the U.S. semiconductor industry, but with minor changes, the code also could be used to study radiation damage in semiconductors. Damage can occur in semiconductor devices in electronic equipment exposed to radiation from a nuclear burst or a nuclear power plant or to the radiation experienced by satellites and other space vehicles.

The code also could provide dopant density profiles for materials other than semiconductors, such as materials used to construct walls of fission or fusion reactors, as well as to study how ion implantation modifies surfaces to improve the hardness, corrosion resistance and optical properties of treated surfaces.

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## THE SULFUR-RESISTANT OXYMITTER 4000™

Fossil fuels are used in 90 percent of the world's industrial and power-generating boilers. This does not come without a negative environmental impact. In 1995, the world's coal consumption was roughly 3.2 trillion metric tons, releasing 12 billion metric tons of the greenhouse gas carbon dioxide and copious amounts of air pollution and acid-rain-causing substances into the environment.

However, the amount of fossil fuel burned can at least be minimized with combustion control, which requires placing an oxygen sensor in a

boiler exhaust stream to measure the oxygen content. By precisely controlling the air-to-fuel ratio in a boiler system, combustion control optimizes the amount of fossil fuel burned. This process also minimizes the amount of pollution released while reducing fossil-fuel waste. Unfortunately, sulfur oxide, a byproduct of burning fossil fuel, destroys the oxygen sensors.

The Sulfur Resistant Oxymitter 4000™ has been proven to last 40 times longer than traditional oxygen sensors in high-sulfur, high-temperature environments like those found in paper mills, power utility stations, refineries, petroleum plants and cement kilns.

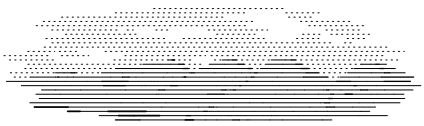
To solve the problem, a Los Alamos team led by principal investigator Fernando Garzon and researchers from Rosemount Analytical Inc. of Orrville, Ohio, has developed the world's first sulfur-resistant oxygen sensor for automatic combustion control. The Sulfur-Resistant Oxymitter 4000™ combines Los Alamos' patented ceramic-electrode-based zirconia oxygen cell with Rosemount's brazing and packaging techniques.

The sensor can withstand the high-sulfur, high-temperature environments found in heavy duty boilers at power utility stations, refineries, pulp and paper mills and cement kilns.

The Oxymitter 4000™ was tested in one of the harshest environments known in the industrial manufacturing business: a sulfur-recovery boiler at a paper pulp processing factor in Canada. The sensor has been operating continuously since August 1997 and shows no signs of deterioration. A traditional sensor in the same setting had to have its platinum-zirconia cell replaced every 12 days.

Until now, combustion control was a luxury that many industrial manufacturers couldn't afford because of maintenance expenses, downtime and staffing needs. These extra costs involved easily outweighed the cost savings in reduced fuel consumption. In the end, many boilers simply run without combustion control.

Because the unique ceramic-metal oxide-electrode in the sensor is so hardy, it will save industrial manufacturers and electric utilities money. If reliable, low-cost combustion control using the Oxymitter 4000™ is more affordable and attainable, more industries will be likely to use it,





resulting in less waste of precious, nonrenewable fossil fuel and less environmental pollution.

The Oxymitter 4000™ is ideal for applications such as sulfur-recovery boilers in pulp and paper mills; power utility stations, refineries, petroleum plants and cement kilns burning high-sulfur coal or heavy fuel oil; process heaters and furnaces that use waste gases containing large amounts of sulfur; and spent-acid furnaces.

While the sensor can last 40 times longer than standard sensors in heavy-duty boilers, it will last much longer in light-duty boilers and applications that use fossil fuels containing relatively low concentrations of sulfur, such as natural gas and light crude oil. Light-duty boilers (generally less than 1,000 horsepower) are commonplace in small business manufacturing, schools and universities, hospitals, municipal utilities, cogeneration facilities and municipal waste incinerators.

With simple modifications, the Oxymitter 4000™'s unique cell technology will have an impact on the automotive oxygen sensor industry, which currently is a multibillion-dollar-a-year industry. Current standards by the federal Environmental Protection Agency require that emissions systems in new autos and light trucks be warranted to function without failure for 100,000 miles. This includes the catalytic converter, exhaust tubing, muffler and the oxygen sensor, which currently is made of platinum-zirconia.

The potential impact for the automotive market is significant, considering every single auto and light truck sold in the United States and Europe requires at least one oxygen sensor.

For commercial product information, contact Rosemount Analytical Inc. by writing to Rosemount Analytical Inc., Customer Support Center, 1201 North Main Street, Orrville, OH 44667; by calling 1-800-433-6076 or 1-330-682-9010; or at the following address on the World Wide Web: http://www.frco.com/proanalytic/news/Sulfer.html.

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## ARIES: ADVANCED RECOVERY AND INTEGRATED EXTRACTION SYSTEM

The airlock and part of the conveyor that integrate the ARIES modules.

The nuclear age has made plutonium a valuable commodity. Although the Cold War's end brought agreements from the superpowers to reduce the number of nuclear weapons, many fledgling powers still want to build such arsenals. Nuclear weapons slated for dismantlement pose a tempting and vulnerable source of plutonium for rogue nations and terrorists.

One of the United States' most important goals is to dismantle excess nuclear weapons and store the plutonium safely and securely. A critical part of this effort is removing the plutonium from the weapon. Unfortunately, the method initially proposed to do it, acid-leach recovery, would generate mixed waste, which is both hazardous and radioactive.

A first-of-its-kind system deployed at Los Alamos and developed by scientists from Los Alamos and Lawrence Livermore national laboratories removes plutonium from the core of a weapon in a dry process and converts it to either unclassified plutonium metal or plutonium oxide, which can be used as fuel in light-water reactors.

The Advanced Recovery and Integrated Extraction System — or ARIES — is an integrated set of modules operated by Los Alamos for the demonstration of technologies in support of the Office of Fissile Materials Disposition Program for Pit Disassembly and Conversion. ARIES disassembles and separates the weapons components and uses waste-free techniques to destroy the weapon's classified shape and geometry.

Once the plutonium has been converted, ARIES packages the product into sealed containers and decontaminates the containers so they can be safely removed from the glovebox environment. The final step uses nondestructive assay techniques to quantify and qualify the sealed container's contents, making it readily available for storage and inspection by the international community.

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DATELINE: LOS ALAMOS

## BONE-SHAPED SHORT-FIBER COMPOSITES

Short-fiber composites are in demand because they are compatible with standard manufacturing processes, such as powder metallurgy, casting and molding, and thus are cost effective. However, for decades, scientists and engineers have been unable to solve a problem intrinsic to straight short-fiber composites: how to achieve effective load transfer between a straight fiber and its surrounding matrix without making the composite brittle.

Los Alamos researchers have solved this dilemma by taking a different approach. Rather than trying to increase interface strength, they have redesigned the fibers, adding enlarged round ends to them.

Bone-shaped fibers bridge cracks without breaking, while the enlarged, round ends prevent them from slipping out of the matrix.

The enlarged ends anchor the fibers in a matrix, enabling them to help carry the load. Because their shape keeps them from slipping out of the matrix, the bone-shaped fibers can bridge a crack without breaking. This bridging effect of the fibers gives the bone-shaped composites resistance to crack propagation and prevents catastrophic failure in structures.

The high strength and toughness of the composites, coupled with their low fabrication cost, make them suitable used for many applications, including concrete infrastructures such as roads, bridges, buildings and sidewalks. The composites also can be used in the manufacture of motor vehicle parts such as connecting rods, cylinder blocks, pistons, transmissions and fenders; aircraft flooring, helicopter blades and landing gear; armor for police cars, tanks and ships; and numerous other industrial structural applications.

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## FLASH 3-D COMPUTED TOMOGRAPHY

Computed tomography images the interior of an object by electronically detecting the variation in X-ray transmissions through a section of the object at different angles and using this information in a digital computer to reconstruct the X-ray absorption of the object at points representing the cross section.

Two-dimensional computed tomography data can be used for a variety of applications in nondestructive testing, materials science and reverse engineering, in which the integrity of individual components is verified in completed systems. However, many additional applications in the nuclear, electronics and aircraft industries demand practical three-dimensional imaging.

The Flash 3-D Computed Tomography system is capable of producing high-resolution three-dimensional images up to 100 times faster than other technologies. Generating images such as this rock core requires only 10 to 30 minutes.

Los Alamos and a local company, HYTEC Inc., have developed Flash 3-D Computed Tomography — a practical, affordable system that combines high-speed, low-cost personal computers, lower-cost memory, improved three-dimensional imaging software, and large-area, flat-panel, thin-film-transistor image plates.

Because Flash 3-D CT is much less expensive, up to 100 times faster and much easier to use than other systems, many previously excluded applications now are feasible, including full three-dimensional nondestructive evaluations in the nuclear, electronics and aircraft industries. For instance, Flash has been used for inspection and verification of component assemblies, circuit boards, and model and serial numbers in enclosed assemblies and samples for hazardous waste storage.

Other applications include allowing researchers to view small test animals with resolution comparable to that obtained with conventional medical scanners. In addition, the system can be used to detect materials defects and flaws in oil field pipes before their insertion into a borehole. The technology also may have applications in the medical field for three-dimensional reconstructions of human anatomy.

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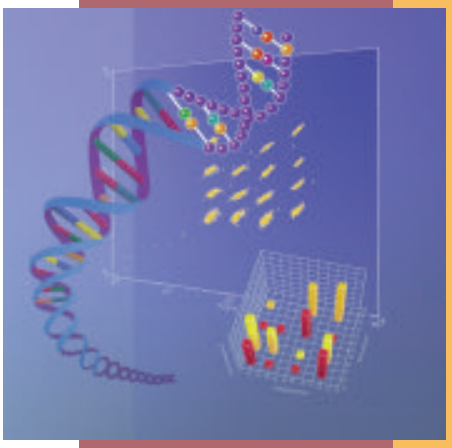
DATELINE: LOS ALAMOS

## HIGH-THROUGHPUT GENOTYPING FOR MEDICAL DIAGNOSIS AND GENE DISCOVERY



Biomedical research in the genomic era will increasingly focus on the genetic-level variation among individuals. This will require more sensitive and higher throughput methods of genomic analysis.

The genetic differences among individuals are important to understanding human health and disease. As the sequencing of the human genome approaches completion, attention is being focused on how to use this information to identify genes associated with diseases, to develop new drugs to treat diseases and to better design therapies for individual patients. Development of these applications will require analysis of individual genetic variations.

Los Alamos has developed a technique for high-throughput — rapid, large-scale — analysis of individual sites in deoxyribonucleic acid — DNA — using fluorescently labeled microspheres and flow cytometry. The technique combines the parallel analysis of many individual sites in a single sample of DNA with rapid analysis to enable large-scale genotyping of many thousands of samples with less time and cost than other methods. The technique determines the identity of nucleotide bases at specific sites in DNA. Dozens or even hundreds of individual sites in a single sample can be analyzed in less than one minute.

Since many human diseases can be traced to genetic defects, the technology should see wide use in disease diagnostics. For example, many cancers are strongly associated with specific genetic mutations. Other diseases, including cystic fibrosis, are associated with a set of mutations. The new assay system is well suited for screening multiple mutations in a single sample.

The technology also has agricultural applications, such as identifying mutations to enhance insect and disease resistance in livestock and crops. It also can be used to detect and identify specific pathogens based on their unique DNA sequences. This will be a useful tool for food safety and medical diagnostics. Another application is in forensics for DNA fingerprinting in criminal cases.

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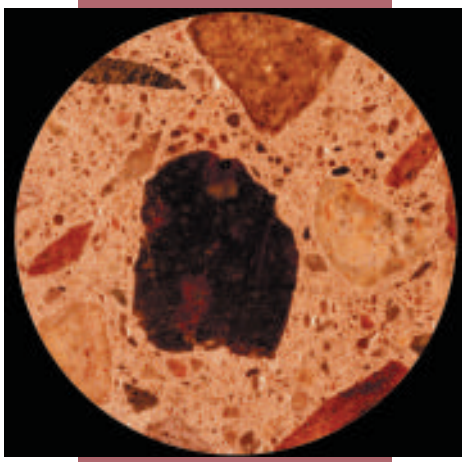
DATELINE: LOS ALAMOS

## NONLINEAR RESONANT ULTRASONIC INSPECTION

A new method of acoustical nondestructive testing can detect flaws, small cracks and other damage in a myriad of materials and objects, from rock cores and cement to bridges and building materials to aircraft components and nuclear reactors.

The technology, called nonlinear resonant ultrasonic inspection, was developed by Los Alamos and Dynamic Resonance Systems Inc. of Powell, Wyo. It works by measuring both the linear and nonlinear acoustic resonances of a solid object. A comparison of these curves tells if the object is damaged or not.

Small objects can be measured in a few seconds; field measurements of large structures such as bridge pillars take less than two minutes. Not only is the technique fast and easy to interpret, it also offers the most sensitive acoustical measurement of damage in existence today — 10 to 100 times greater than before.



Concrete cores like this one are being tested to find damage using the nonlinear resonant ultrasonic inspection technique.

The inspection technique originally was developed to study the behavior of rock and other earth materials. This has led to increased understanding of the damage that occurs during earthquakes, which in turn will lead to better design and construction of earthquake-resistant buildings.

The technology is being used in the automotive industry to investigate damage in plastic and metal components. The oil industry is using it to study the physical state of rock core to diagnose well-bore collapse.

Other applications include studying damage in concrete that occurs during freeze/thaw cycles; inspecting bridges and other transportation infrastructure; and checking for damage in nuclear reactor containment walls.

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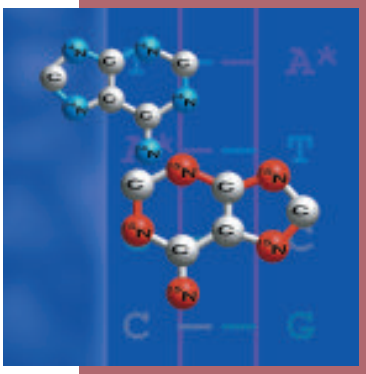
DATELINE: LOS ALAMOS

## APPLICATIONS OF STABLE-ISOTOPE-ASSISTED MASS SPECTROMETRY



Replacing the $^{14}N$ in this nucleotide with $^{15}N$ shifts its mass, creating a characteristic tag that enables researchers to track the number of times this type of nucleotide occurs in a target DNA sequence. The use of nucleotides labeled with different combinations of stable isotopes creates mass shifts that permit the entire nucleotide composition to be determined.

The coming of age of molecular genetics is marked by massive gene-sequencing efforts. As researchers unravel the vast amounts of information stored in the hundred quadrillion nucleotides in the human genome, faster and more cost-effective analysis and error-checking techniques are needed to keep up with the onslaught of new information. Meanwhile, clinical diagnostics require rapid, large-scale genetic screening.

Accurate DNA sequence validation has become very important for correctly interpreting genomic data. The substitution of even a single nucleotide may affect an individual's susceptibility to a particular disease, a pathogen's virulence or the productivity of an agricultural crop. In the past, verifying the sequence of nucleotides that make up a gene and comparing sequence variations have been time-consuming and expensive, often requiring that the same samples be sequenced repeatedly to ensure the accuracy of the results.

Los Alamos researchers have developed a technique for verifying sequencing data and detecting genetic variations that is fast, accurate, inexpensive and easily automated and bypasses the need for radioactive or fluorescent labels, both of which require careful handling and disposal. The simple technique combines the ease and efficiency of stable-isotope labeling with the speed of mass spectrometric analysis. It also offers researchers detailed molecular information from minute quantities of materials.

The technique, stable-isotope-assisted mass spectrometry, determines the nucleotide composition of a DNA fragment by amplifying a DNA sequence using stable-isotope-labeled nucleotides and comparing the fragments. The difference in masses, the mass shift, reflects the nucleotide composition of the fragment. By comparing the results with a related, already sequenced gene fragment, researchers can validate the sequencing data or flag anomalies, which can suggest errors or genetic variations.

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## PCMCIA MICROCONTROLLER CARD AND AN OPEN-ARCHITECTURE, MINIATURE CARD CRATE

The PCMCIA card and card crate can be used in infrasound data loggers, which can unobtrusively survey large areas and operate unattended for up to 16 days.

The popularity of laptop computers and the ever-increasing developments in the commercial digital market have accelerated the use of smaller and lower-powered digital modules — particularly standardized, removable, multifunctional PC cards (known as PCMCIA cards). To date, however, these cards have served as individual, single-purpose modules that are interfaced with laptop or other full-function computers.

Los Alamos and the Boeing Co. of Titusville, Fla., have developed a microcontroller card that replaces the need to use a laptop or desktop computer to control PC cards. The controller card and its card crate, which holds up to five commercially available PC cards, has all the elements of a central processing unit: program memory, buffer memory and input/output versatility.

The PC microcontroller card (PCM Card) and crate will be used in a new generation of data loggers for making sensitive measurements. The technology originally was developed for infrasound monitoring — a method for detecting clandestine nuclear explosions — for the Comprehensive Test Ban Treaty.

Because data loggers can operate unattended for up to 16 days on a single battery, they are ideal for unattended field measurements of acoustic, chemical-biological, radionuclide and other sensitive environmental changes.

The technology also could be used to study elephant communication in Africa (elephants are thought to communicate in the infrasound band, out of the range of the human ear) or to monitor demilitarized zones, such as the one between South and North Korea, to determine if tunnels are being dug.

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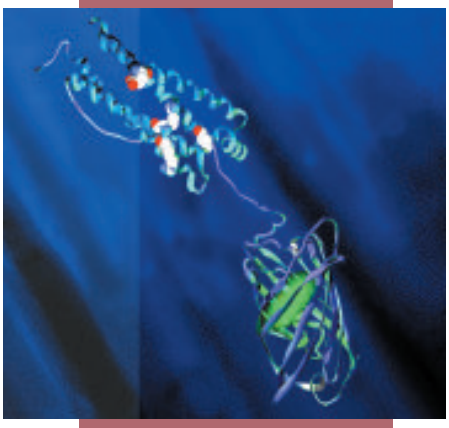
DATELINE: LOS ALAMOS

## RAPID ASSAY OF PROTEIN FOLDING

Proteins carry out the cell's work, acting as catalysts and controllers for numerous chemical reactions and helping to give organs and tissues their shape. Studies of a protein molecule's intricately folded, three-dimensional structure are important for medical research, drug development, chemical industrial processes and basic research because a protein's structure determines its function.

To learn about structure, researchers often examine crystals grown from dissolved protein. This soluble protein is essential for research, but is difficult to obtain because many of the proteins misfold and become insoluble and useless. To overcome this problem, Los Alamos researchers have developed a quick and easy way to differentiate soluble from insoluble proteins and convert insoluble proteins to soluble ones.



Rapid assay of protein folding links a test protein (X, top left) to the green fluorescent protein (GFP, lower right). If X folds properly during synthesis, the GFP also folds properly. It will then fluoresce under an ultraviolet or blue light. In this way, GFP's fluorescent capabilities serve as an indicator of X's folding and solubility.

This new technology, called rapid assay of protein folding, uses the folding of a green fluorescent protein to monitor the folding and solubility of a test protein. It does this by linking the two proteins in a hybrid molecule with the characteristics of both. When the hybrid is synthesized in a host cell or cell-free extract, the green fluorescent protein achieves its fluorescent capability only if proper folding has taken place.

In the future, the folding assay may be used to develop drugs for currently incurable diseases, like Alzheimer's and Huntington's, both of which are associated with protein misfolding. The technology also can speed up the evolution of proteins so they can be adapted to new functions. This is of particular interest to industry, which uses proteins to assist chemical processes.

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## SPECTRA: SMALL, PHASED, EIGHT-CHANNEL TRANSMIT/RECEIVE ANALYZER

By tapping a bell with a hammer and analyzing the quality of the resulting tone, we can learn a lot about the condition of the bell, whether it is soundly constructed or contains flaws. A mechanical system, such as a container under stress, may respond to the appropriate stimuli and alert an investigator to a crack or a broken part.

A SPECTRA circuit board. Input leads are attached from the eight transmitting ports on the left to the part and output leads are attached from the part to the eight receiving ports at the front of the board.

Network analyzers extract this type of information about an object or a system by sending a signal through an object and then inspecting the response to those signals. Los Alamos has developed a small, low-cost, low-power vector network analyzer called SPECTRA for probing electrical, mechanical and other types of systems and components.

SPECTRA uses programmable integrated circuits to produce very pure input signals. Its eight programmable and receiving channels make it possible to obtain 64 combinations of signals to measure numerous characteristics. In addition, the software is engineered for easy control and adjustment, and the data are displayed in easy-to-read format.

SPECTRA originally was developed and has been successfully tested for the ultrasonic inspection of nuclear weapons components. However, its ruggedness, portability, low cost and eight-channel flexibility make it applicable to many industrial uses.

It will be valuable to the automobile, aerodynamics and construction industries where it can be used to determine whether cracks have formed in systems stressed by temperature or pressure, such as bridges, and bolts and other connectors in aircraft or autos.

In addition, SPECTRA can detect the state and level of contents in sealed containers filled with hazardous materials, as well as whether the contents are solid or liquid. It also can be used to measure the frequency response of electrical networks, analyze the transfer function of passive or active devices such as filters, inspect control systems such as those on the head of a disk drive and measure the performance of amplifiers.

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DATELINE: LOS ALAMOS

## VIRTUAL PINHOLE MICROSCOPE

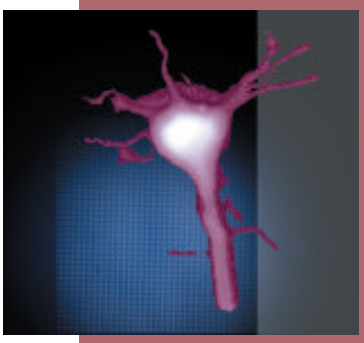
Microscopic images of cells provide important information about cell structure and function. Clear, three-dimensional images of microscopic specimens produced by confocal microscopes give scientists a better understanding of what happens within and between living cells.

A conventional confocal microscope focuses light onto a single point in the specimen. This light is refocused onto a pinhole aperture in the image plane of the microscope, which rejects out-of-focus light. This imaging system results in high-resolution images, with minimal contributions from above and below the focal plane in the specimen.

Existing confocal imaging systems are expensive, difficult to use and slow. The Virtual Pinhole Microscope, developed jointly by Los Alamos and Vay Tek Inc. of Fairfield, Iowa, is an inexpensive hardware and software system that can be integrated or retrofitted with conventional optical microscopes to provide true confocal imaging capabilities.

The system consists of an illumination subsystem, a solid-state image sensor and a "virtual pinhole" — a synthetic aperture implemented in software. A microlens array moves back and forth, illuminating the specimen with a grid of points. A series of images is collected with the video camera. Image-processing software takes this series of images and applies the synthetic aperture to create a composite image. Each composite image is an optical "slice" through the specimen. For three-dimensional imaging, a series of images is acquired at varying depths through the specimen.

A nerve cell reconstructed from a series of Virtual Pinhole Microscope confocal images.



The Virtual Pinhole Microscope has applications in many fields requiring quantitative three-dimensional microscopic imaging, including physiology, biochemistry, biophysics and cell biology; clinical applications and research such as *in vitro* fertilization, cloning, gene therapy and human tissue exams without biopsy; material science, geology, metallurgy and other fields that study the microstructure of natural and manufactured materials; forensic science and diagnostics; and quality-control applications for microcircuit/micromachine manufacturing.

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DATELINE: LOS ALAMOS

## BRIEFLY ...

THE CIVILIAN AND INDUSTRIAL TECHNOLOGY PROGRAM OFFICE AT LOS ALAMOS HAS SPLIT INTO AN ENERGY PROGRAMS OFFICE AND AN INDUSTRIAL BUSINESS DEVELOPMENT OFFICE. Charryl Berger will be the program manager for the Energy Programs Office. Richard Mah will head the Industrial Business Development Office on an acting basis. A search will begin to seek a permanent director for the Industrial Business Development Office. The Energy Programs office will focus one of the Lab's most important new technology initiatives, carbon management, and give renewed emphasis to growth areas such as fossil and nuclear energy, transportation, energy efficiency, renewable energy and the process industries. The reformulated Industrial Business Development Office will allow the Lab to make better use of its intellectual property, particularly for regional business development. CONTACT: INDUSTRIAL BUSINESS DEVELOPMENT OFFICE: (505) 665-9090.



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