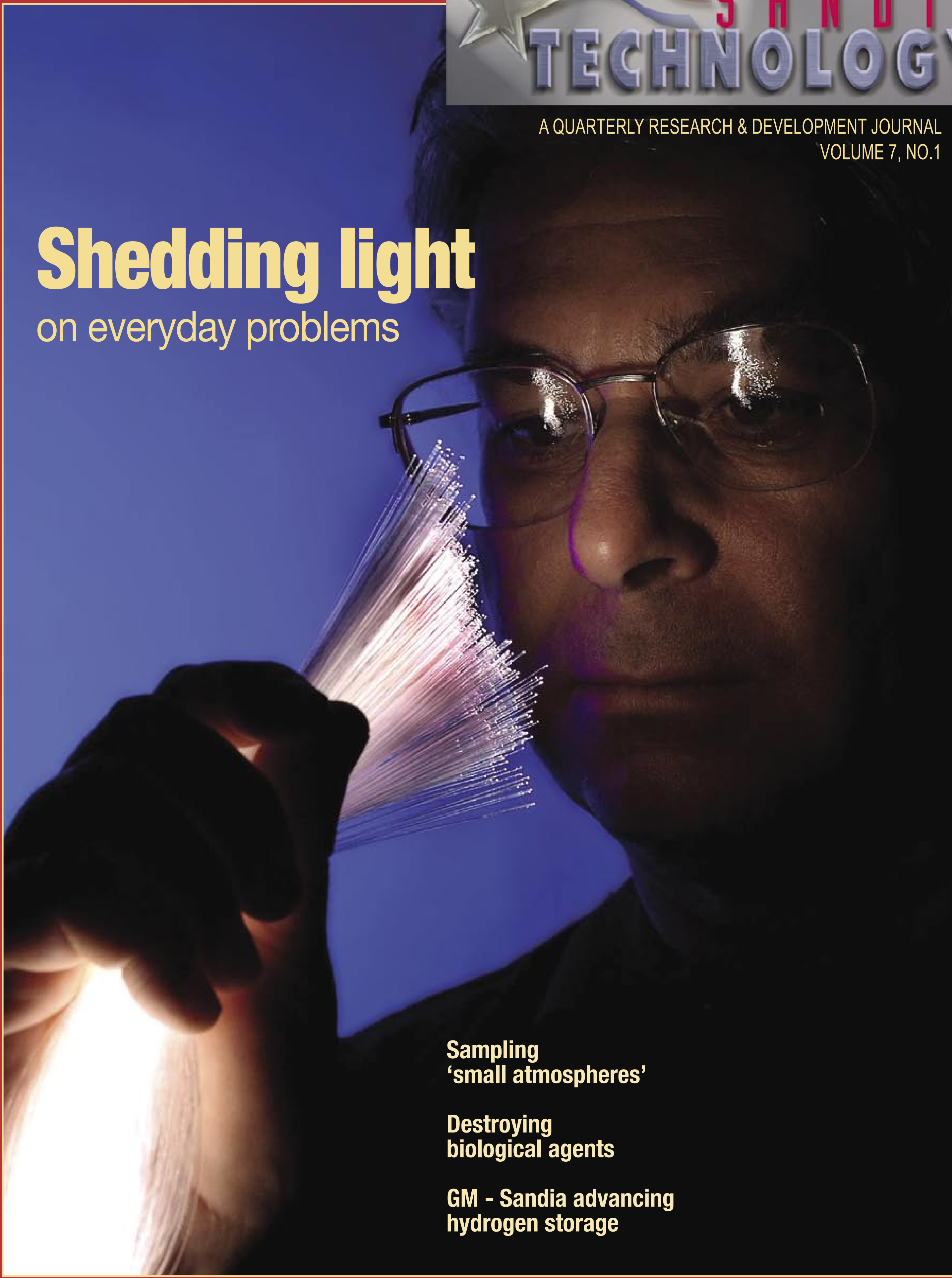
SPRING • 2005

# SANDIA TECHNOLOGY

A QUARTERLY RESEARCH & DEVELOPMENT JOURNAL
VOLUME 7, NO.1



## Shedding light
on everyday problems

**Sampling ‘small atmospheres’**

**Destroying biological agents**

**GM - Sandia advancing hydrogen storage**

## What is LDRD

Sandia's world-class science, technology, and engineering work define the Labs' value to the nation. These capabilities must remain on the cutting edge, because the security of the U.S. depends directly upon them. Sandia's Laboratory Directed Research and Development (LDRD) Program provides the flexibility to invest in long-term, high-risk, and potentially high-payoff research and development that stretch the Labs' science and technology capabilities.

LDRD supports Sandia's four primary strategic business objectives: nuclear weapons; nonproliferation and materials assessment; energy and infrastructure assurance; and military technologies and applications; as well as an emerging strategic objective in homeland security. LDRD also promotes creative and innovative research and development by funding projects that are discretionary, short term, and often high risk, attracting exceptional research talent from across many disciplines.

When the LDRD logo appears in this issue, it indicates that at some state in the history of the technology or program, LDRD funding played a critical role.

## On the Cover:

Sandia researcher Jonathan Weiss uses light fibers in clever ways to address everyday problems.
(Photo by Randy Montoya)

*Sandia Technology (ISSN: 1547-5190)* is a quarterly journal published by Sandia National Laboratories. Sandia is a multiprogram engineering and science laboratory operated by Sandia Corporation, a Lockheed Martin company, for the Department of Energy. With main facilities in Albuquerque, New Mexico, and Livermore, California, Sandia has broad-based research and development responsibilities for nuclear weapons, arms control, energy, the environment, economic competitiveness, and other areas of importance to the needs of the nation. The Laboratories' principal mission is to support national defense policies by ensuring that the nuclear weapon stockpile meets the highest standards of safety, reliability, security, use control, and military performance. For more information on Sandia, see our website at *http://www.sandia.gov*

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# FROM THE *Editor*

Dear Readers,

The Spring 2005 issue of *Sandia Technology* illustrates the Labs' bent toward the practical side of engineering.

Sandia's work with General Motors on hydride storage (page 2) complements the Department of Energy's 2003 Hydrogen Fuel Initiative. The GM-Sandia partnership will look at a specific storage technology for the hydrogen vehicle of the future.

Sandia engineer and innovator Jonathan Weiss has thought out how light, transmitted through tiny tubes, can play a role in everyday problems — like predicting when a car battery might fail (page 11).

Engineers in the Labs' geothermal research group are making down-hole instruments more resistant to temperature and pressure, to provide new insights on a number of geologic processes (page 14).

And, Sandia computer scientist Carl Diegert has been working closely with a consortium of artists, photographers, and communications experts on a digital photography breakthrough (page 9). The hope is to create a "you are there" visual experience with detail that can be measured in the gigapixel (billions of pixels) range.

While all of this work stems from research that supports Sandia's national security missions, some is linked more directly. Consider the work of Steve Thornberg and others on encasing microelectromechanical (MEM) devices (page 5) and for the U.S. Army on development of a system to safely neutralize biological weapons (page 7).

Finally, Sandia has a new leader. Tom Hunter, senior vice president for Defense Programs, was promoted to Labs' director on April 29 (page 20).

*Will Keener*
*Editor*

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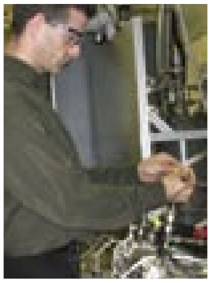

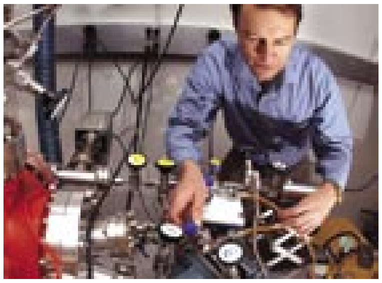

# GM - Sandia advancing hydrogen storage

*The GM-Sandia project is part of a concerted effort to store enough hydrogen for a fuel-cell vehicle to equal the driving range from a tank of gas — a key to customer acceptance. Two current methods of storage — liquid and compressed gas — do not provide the needed range and running time for fuel-cell vehicles.*

Recharging and release of the hydrogen from metal hydrides require heat, which can reduce overall fuel economy. Sandia engineer Terry Johnson sets up a test apparatus. (Photo by Bud Pelletier)

General Motors Corp. and Sandia National Laboratories have launched a partnership to design and test an advanced method for storing hydrogen based on materials called metal hydrides.

Metal hydrides — formed when metal alloys are combined with hydrogen — can absorb and store hydrogen within their structures. When subjected to heat, the hydrides release their hydrogen. In a fuel-cell system, the hydrogen can then be combined with oxygen to produce electricity.

GM and Sandia have embarked on a 4-year, $10-million program to develop and test tanks that store hydrogen in a complex hydride, called sodium alanate. The work is aimed at developing a solid-state hydrogen storage tank that would store more hydrogen onboard a fuel-cell vehicle than current conventional hydrogen storage methods. Researchers also hope to create a tank design that could be adaptable to any type of solid-state hydrogen storage.

"Hydrides have shown significant early promise to one day increase the range of fuel-cell vehicles," says Jim Spearot, director, GM Advanced Hydrogen Storage Program. "We know a lot of research still needs to be done, both on the types of hydrides we use, as well as the tanks we store them in. We think our work on projects like this with Sandia will get us another step closer to our goal."

## Challenging requirements

"We are designing a hydrogen storage system with challenging thermal management requirements and limits on volume and weight," says Sandia manager Chris Moen. "Our researchers are excited to ap-

GM and Sandia researchers will also be testing various tank shapes to see which are the most promising.

ply their unique, science-based design and analysis capabilities to engineer a viable solution."

"This is the kind of public private research partnership that will help us realize the President's vision, communicated in his 2003 State of the Union Address, that 'the first car driven by a child born today can be powered by hydrogen, and pollution-free,'" said outgoing DOE Secretary Spencer Abraham. "Over the long term, clean, efficient hydrogen fuel technologies like this will help make our nation far less reliant on foreign sources of energy."

The 2003 Hydrogen Fuel Initiative directs $1.2 billion over five years to accelerate hydrogen research. Sandia's research activities in hydrogen storage support the Initiative's long-term vision for commercially viable hydrogen-powered vehicles.

The GM-Sandia project, privately funded and separate from the President's initiative, will be conducted in two phases. First, the program will study engineering designs for a sodium alanate storage tank. Researchers will analyze these designs using thermal and mechanical modeling; develop controls systems for hydrogen transfer and storage; and develop designs for external heat management. GM and

Sandia engineer Mark Zimmerman integrates a hydride bed with temperature monitoring sensors to study recharging and discharging of hydrogen. (Photo by Bud Pelletier)

Sandia researchers will also be testing various tank shapes to see which are the most promising.

## Rigorous safety testing

Next, researchers will subject promising tank designs to rigorous safety testing and ultimately fabricate pre-prototype sodium alanate hydrogen storage tanks, based on knowledge gained from the first phase of the project.

A possible scenario for filling up with a solid-state storage solution such as sodium alanate could look like this: The alanate would come pre-loaded in the tank, where it would remain, giving up its hydrogen, and becoming a mixture of sodium hydride and aluminum. The customer could fill up using gaseous hydrogen. During filling, the mixture of aluminum and sodium hydride would absorb the hydrogen and turn it back into alanate, which would be ready to yield hydrogen when needed by the fuel cell. Once the tank is filled, the hydrogen would be stored at low pressure.

While it has shown good potential, hydride-based hydrogen storage also has some hurdles to clear. One current drawback is that most complex metal hydrides, such as sodium alanate, still operate at too high a temperature, which causes an inefficiency that forces some of the hydrogen to be used up in order to release the remaining hydrogen. Another challenge is reducing the time it takes to reabsorb hydrogen. It currently takes at least 30 minutes to recharge.

## Independent work

In separate, independent projects outside of this collaboration, both GM and Sandia are working to identify alloys that will store greater amounts of hydrogen that can be released at lower temperatures. Reducing filling and recharging times is another key area of research.

The research conducted through the GM-Sandia partnership is independent from that of Sandia's participation in the Metal Hydride Center of Excellence. The Center of Excellence, to be funded in Fiscal Year 2005 through a DOE "Grand Challenge," aims to develop a new class of materials capable of storing hydrogen safely and economically. (See *Sandia Technology* Vol. 6 No. 2.)

General Motors Corp., the world's largest vehicle manufacturer, employs about 325,000 people globally. GM has manufacturing operations in 32 countries and its vehicles are sold in 192 countries. More information on GM and its products can be found on the company's corporate website at www.gm.com.

*In separate, independent projects outside of this collaboration, both GM and Sandia are working to identify alloys that will store greater amounts of hydrogen that can be released at lower temperatures.*

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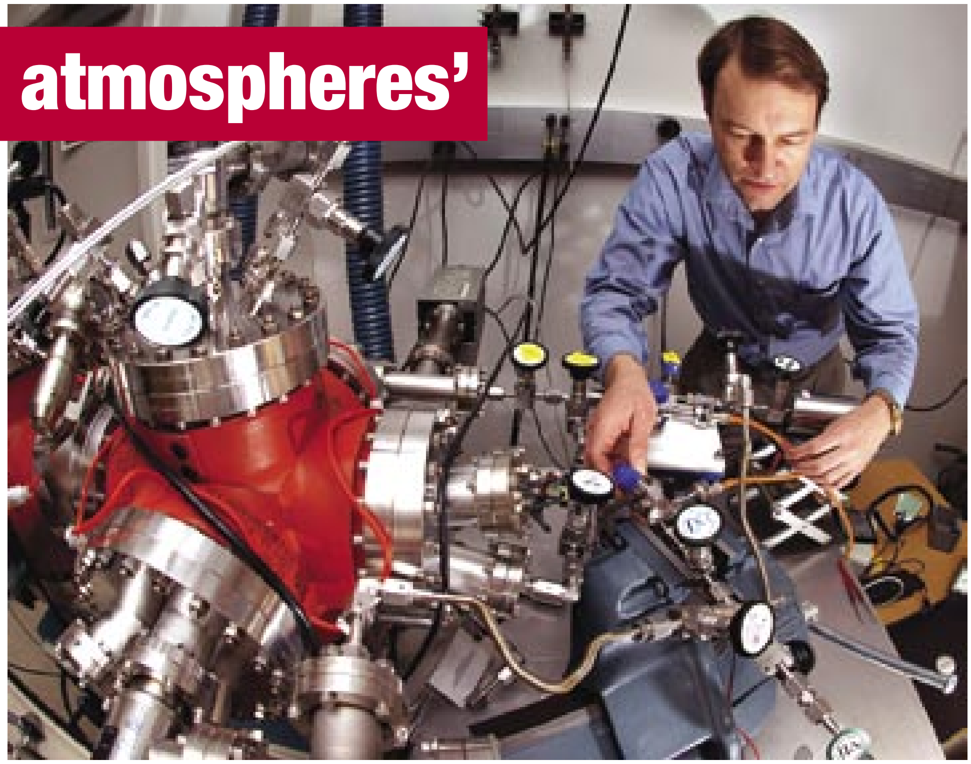
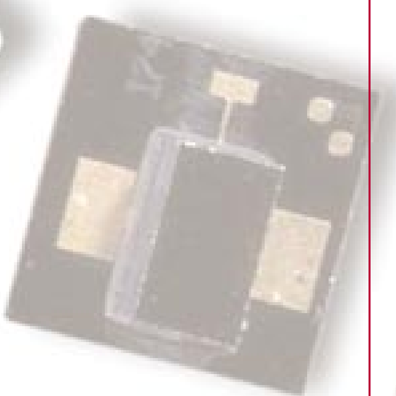
# Sampling ‘small atmospheres’



Sandia National Laboratories researcher Steve Thornberg arranges picopuffs of gases from crushed MEMS devices to be sampled by his group’s unique analytic device. (Photo by Randy Montoya)

*Just as astronomers want to understand the atmospheres of planets and moons, so engineers want atmospheric knowledge of worlds they create that are the size of pinheads, their “skies” capped by tiny glass bubbles.*



Should the tiny silicon parts we are now creating — microcircuits, microgears, and micropower drivers — exist in a vacuum? In nitrogen? In air as we know it? More importantly, whatever atmosphere is intended, how long will it stay that way? Is the protective barrier hermetic or will its atmosphere change over time, potentially leading to the early death of the device? Will water vapor seep in, its sticky molecules causing unpredictable behavior? What, in short, can we say about how long this little world and its inhabitants will survive and function?

The most advanced sampling procedure known — requiring only picoliters (trillionths of a liter) of gas to evaluate the contents of these small atmospheres — is now in place at Sandia. The method was recently revealed at the SPIE Photonics Meeting in San Jose, California.

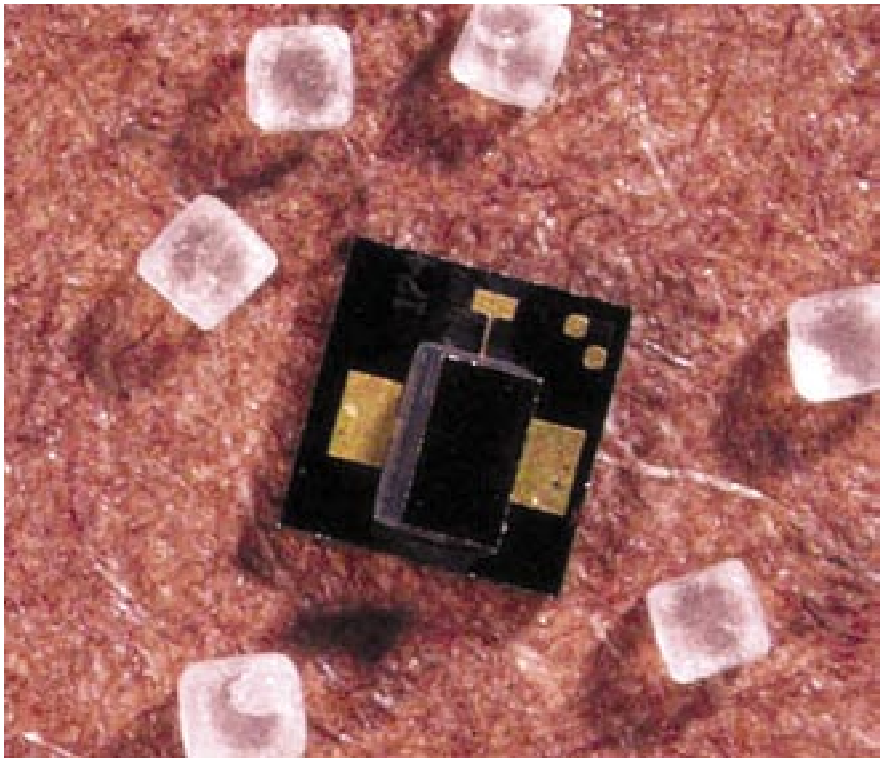
“I know of no one, anywhere else, who can do this kind of testing,” says Sandia innovator Steve Thornberg.

John Maciel, chief operating officer of Radant MEMS, a three-year-old start-up company in Stow, Massachussetts, is under contract with DARPA to develop high-reliability microelectromechanical, or MEMS, switches for microwave devices and phased array antennas. He also sees markets for the switches in cell phones.

For long-term reliability, small-atmosphere stability is a must. “We can’t go to a commercial house to get this work done,” he says. “We can’t find the capability anywhere else but Sandia.”

The Sandia method — funded by the Laboratory Directed Research and Development ( LDRD ) program, and presented for consideration to Sandia’s patent office — involves a small commercial valve that comes down like a trash compactor and crushes a tiny device, releasing its gases — currently, about 30 nanoliters — into a custom-built intake manifold.

Because Thornberg’s test mechanism requires only picoliters, his sensitive device can recheck its own measurements — using bursts of gas delivered in a series of puffs — dozens of times from the same crushed device in a 20-minute time span.



A MEMS test unit sits under the black box that contains its atmosphere. The gold plates beside it are wiring sites. Next to the device, for size comparisons, are grains of table salt.

*Maintaining the integrity of the internal atmosphere of a hermetic device is essential for long-term component reliability.*

The method thus provides statistically significant atmospheric measurements at any given moment in a component's life. (Current industry tests can achieve at best a single reading from the release of nanoliters of gas. A single, statistically unverified result may contain significant error.)

By waiting a longer period of time — weeks, or even months — other microdevices from the same batch can be crushed and analyzed to see what changes occurred in their atmosphere over time.

Currently, the system is able to measure gasses emerging in pressures ranging from one atmosphere to .0001 torr. (One atmosphere is 760 torr.) The group hopes soon to decrease its lower sensitivity limit to .000001 torr — in effect, measuring the quality of vacuums.

Says Sandia researcher Danelle Tanner, who describes herself as "a reliability-and-aging mechanism physicist" working on a silicon re-entry switch, "We want 100 percent nitrogen [atmosphere] in our device. Steve's group gave us a really good idea of what species other than nitrogen were present in the package."

## Integrity essential

"Maintaining the integrity of the internal atmosphere of a hermetic device is essential for long-term component reliability," says Thornberg. "It is within this environment that all internal materials age." Success of his group's new investigatory technique lies in the details of the test mechanism.

- A precisely machined sample holder holds the MEMS package to be crushed within the sampler valve.
- Because tested devices come in many sizes, height adjustments to the crushing mechanisms are needed for each sample.
- The problem of debris from the smashed part interfering with gases that must pass through tiny tubes was solved by sintering a filter into a central gasket.
- Perhaps most important, manifold volumes were minimized to maximize pressures when MEMS-released gases expand, reducing the amount of gas needed for an analyzable puff.

Still ahead is success in measuring very small amounts of moisture, which stick to manifold walls without making it to the detector. To overcome this problem, the Sandia group is working with Savannah River National Laboratory to incorporate that lab's optical moisture measurement techniques that measure based on wavelength shifts.

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# Destroying biological agents

The Explosive Destruction System (EDS) can be transported to sites where materiel may not be safe to store or transport.

*From the beginning, Sandia researchers who created the U.S. Army's Explosive Destruction System suspected the system could, in addition to snuffing out chemical warfare material, treat and destroy biohazards such as those containing anthrax.*

A recently released study by Sandia confirms its Explosive Destruction System's (EDS) effectiveness against biological agents, bio-contaminated containers, and improvised biological devices.

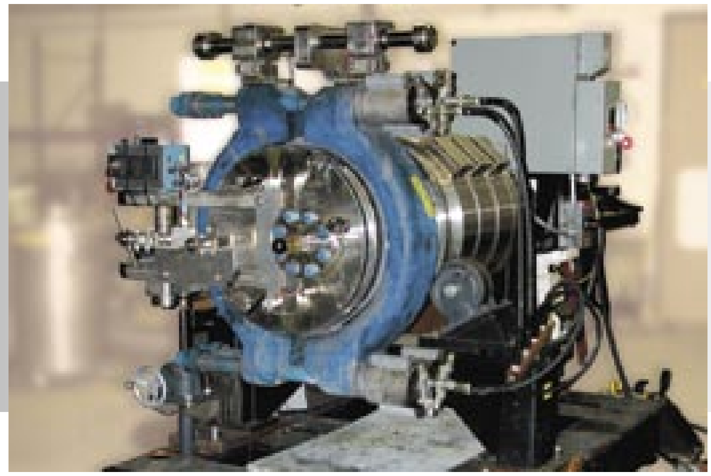
Such a system could give homeland security personnel a tool for safely neutralizing a dormant terrorist device, or it could be used by the military to remove a land mine or canister shell without having to set off an open-air explosion.

Sandia researchers used $60,000 in Laboratory-Directed Research and Development (LDRD) funds over the past year to demonstrate the capability. This augments the system's already established capability to destroy explosively configured munitions containing chemical agents.

"There's high value in extending the EDS's successful track record into other areas — and bio came to mind right away," said Mary Clare Stoddard, the manager overseeing the research at Sandia's Livermore, California, site. With this project, called BioEDS, Sandia's goal was to confirm that the already-robust technology could be adapted to destroy a bioagent. "That means that should the need arise, a solution stands ready," said Stoddard.

First delivered to the Army in 1998 and under the sponsorship of the Army, the EDS is a proven, transportable system that has safely neutralized and discarded recovered chemical warfare material in an environmentally sound manner. It was originally conceived for use with World War I and World War II vintage chemical warfare materials.

In 2000, the EDS was first called to action when it was selected to destroy six sarin-filled nerve agent bomblets found in



The EDS containment vessel is resistant to corrosion, allowing it to treat a wide variety of munitions. Recent tests showed its efficacy in treating simulated bio agents in addition to chemical agents.

*The system, now patented by the Army, married existing technologies in a novel way so that munitions could be destroyed in a self-contained fashion without having to be transported.*

a pile of scrap metal at Rocky Mountain Arsenal near Denver, Colorado. In 2001, EDS safely destroyed an additional four sarin bomblets at the same site, while the following year it destroyed a 4.2-inch mortar shell containing phosgene, found in a farmer's field near Gadsen, Alabama. The surrounding land was previously used as a World War II Army training base.

The system weighs up to 55,000 pounds and mounts on an open flatbed trailer, making it easily transportable for rapid response to emergency recovery sites. The system operates by first explosively opening the casing and deactivating explosives, then neutralizing harmful agents. Components of the system include:

- A rotating vessel that contains the blast, vapor, and fragments generated during the munition treatment process and serves as the container for the chemical neutralizing process,
- A system of linear and conical charges to open the munition,
- A chemical storage and feed system that supplies reagents and water to the containment vessel, and
- A waste handling system for draining and storing the treated effluent.

During evaluation, Sandia performed tests with anthrax simulants, such as *Bacillus thuringiensis* and *Bacillus stearothermophilus.* The test system was operated in steam autoclave, gas fumigation, and liquid decontamination modes of operation. Each of the three treatment processes used during testing resulted in complete neutralization of the bacterial spores based on no bacterial growth in post-treatment incubations.

Sandia has worked with the Army to build five EDS units, which were originally expected to treat one to two munitions annually (generally aging, unstable recovered munitions). The system's usefulness and proven effectiveness has expanded demand for its services, resulting in the safe treatment of 228 items to date. More use is envisioned for sites such as Pine Bluff Arsenal, in Arkansas, where the EDS was deemed to offer the quickest, safest, and most affordable way to dispose of 1,200 non-stockpile munitions.

Sandia's original design was based on examination of a number of alternative approaches. The system, now patented by the Army, married existing technologies in a novel way so that munitions could be destroyed in a self-contained fashion without having to be transported. EDS offered an alternative to the previously used method of open burn/open detonation.

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# Displaying gigapixel-sized images

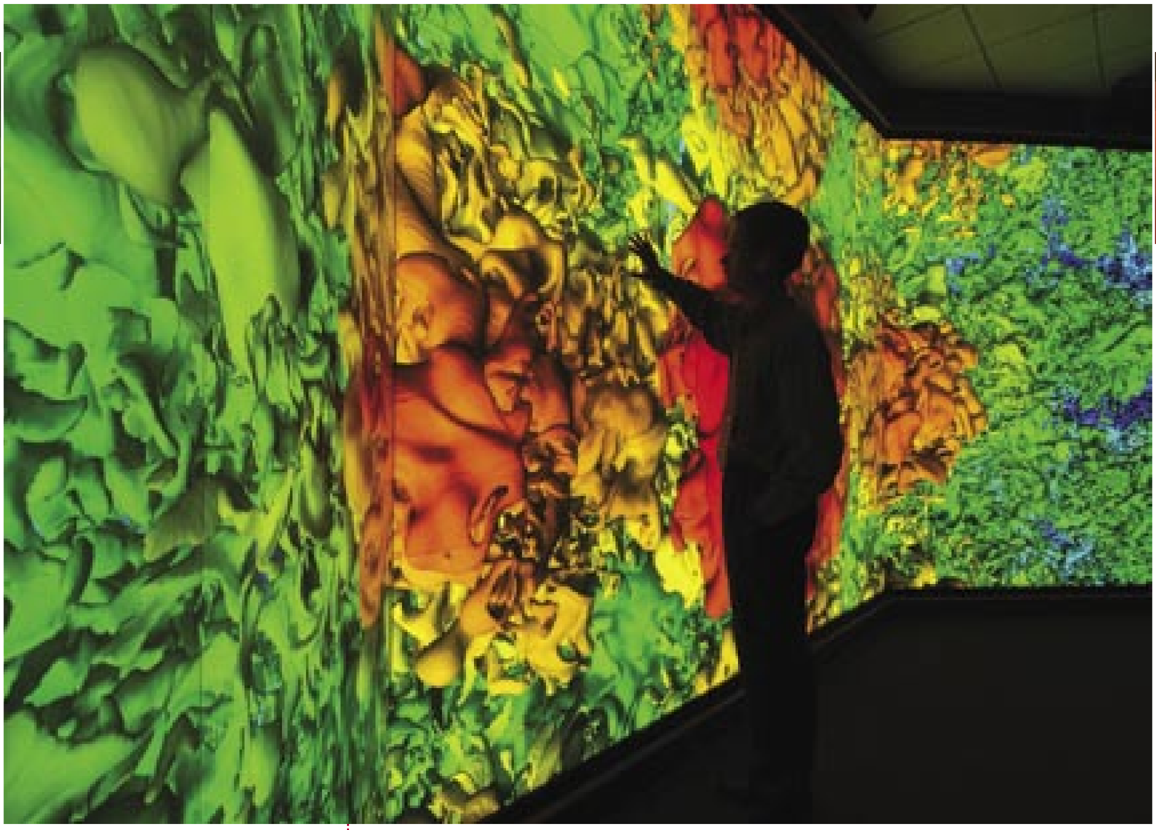
*Call it the oil paint of the 21st century. To develop it, the first Big Picture Summit was organized last December by artist-photographer Clifford Ross and co-hosted by Sandia National Laboratories and the Interactive Telecommunications Program at New York University's Tisch School of the Arts.*

Artist-photographer Clifford Ross uses his invention, the R1 camera system, capable of gigapixel single-shot images, to shoot sweeping yet highly detailed landscape photographs.
(Photo courtesy of Clifford Ross)

Photographer Clifford Ross says his goal in bringing together top imaging experts from leading scientific institutions last December was to create a "you are there" photographic experience for those who have not personally witnessed the sublime beauty of natural scenes, such as Mt. Sopris in Colorado.

"In the early 15th century, the impulse to render flesh more realistically drove the artist Jan van Eyck to invent oil paint," says Ross. "The same sort of impulse is driving me, except that I'm trying to capture a mountain. Pixels are simply 21st century oil paint."

Scientists have different but complementary goals. Computational scientists at Sandia believe a display system of the magnitude proposed by Ross will enhance the ability of many researchers to visualize and gain insight from massively complex data sets that can be understood only through



The photographic camera and display system sought by artists and scientists at the Big Picture Summit would have 16 times the data display capability of this Sandia National Laboratories display, which scientists use to visualize complex supercomputer-generated physics simulations. (Photo by Randy Montoya)

*The project could have major implications for all industries that rely on precise imaging, including environmental science, space exploration, telecommunications, and homeland security.*

human intuition, ranging from supercomputer-generated physics simulations to high-resolution satellite imagery.

"We have a lot in common with an artist like Clifford Ross and his quest to make extremely detailed images that evoke a powerful emotional response," says Carl Diegert, Sandia computational scientist.

## Gaining insight

"We want to understand from an intuitive standpoint what it is that enables viewers to gain insight — for example, a visual metaphor that makes a human viewer comfortable and thus better able to interact with an image. Computer science alone is not likely to invent a means for scientists to intuitively comprehend highly complex problems."

"My own goal is to fill the eye with so much information that it overflows and reaches the human heart," says Ross. "Art is emotional, but the path is technical, and virtually all the scientists involved in this effort know more about the technical aspects of imaging than I do."

Ross' newly patented R1 camera system, which broke through the gigapixel barrier, has achieved some of the highest resolution single-shot images ever created. (Efforts by other photographers have digitally melded many smaller images taken over a period of time into single sweeping, gigapixel-sized landscape images.)

To create the camera, Ross, who was schooled at Yale as an abstract painter and later sculpted and painted in classic forms, made use of his business skills, his interest in things technical, and his art background.

*The project has two parts. The first is to design and build a new camera, expanding on concepts embodied in the R1, that can capture a gigapixel of digital information at a speed of 1/15th of a second or faster.*

The Ross images, on 9-by-18-inch negatives slowly processed by hand and digitally scanned, contain 100 times more data than the average professional digital camera. In his Mt. Sopris series, taken near Carbondale, Colorado, the images reveal shingles on a barn some 4,000 feet from the camera in sharp focus. So, too, is a tree on a ridge four miles away.

The 15 professionals invited by Ross to participate in the Big Picture Summit included renowned artists, scientists and engineers from government agencies, and digital imagery experts from the entertainment and film industries.

The project could have major implications for all industries that rely on precise imaging, including environmental science, space exploration, telecommunications, and homeland security, says Diegert.

The project's first goal is to design and build a new camera, expanding on concepts embodied in the R1, capturing a gigapixel of digital information at a speed of 1/15th of a second or faster.

The second goal is to create the display system, which Ross likens to building an "electronic Sistine ceiling," with 16 times greater data display capabilities than the advanced system currently in use at Sandia. The display would provide an overall view of images at a very large scale while allowing viewers to perceive extremely fine detail.

## Promising start

"This extraordinary convergence of talent is a promising start," said renowned digital innovator Red Burns, creator and chair of the Interactive Telecommunications Program at the Tisch School of the Arts. "The group is skilled in virtually all the necessary elements of hardware and software design for a high-resolution imaging project of great ambition. Individually, the participants are some of the keenest minds in the field. Collectively, with an unyielding artist in our midst and the right support, there is a chance to create a real breakthrough."

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More information on R1 System:
www.cliffordross.com



Ross at work on his patented R1 camera. (Photo courtesy Clifford Ross)

# Shedding light on everyday problems

Sandia researcher Jonathan Weiss uses light fibers in clever ways to test car batteries, determine landfill leakage, and help separate oil from water. (Photo by Randy Montoya)

*Car battery failing? Hazardous material leaching? Oil level dropping? Sandia optical innovator Jonathan Weiss uses soda-straw-like tubes to solve widespread sensing problems.*

There you are, tapping your fingers on the cold steering wheel as your windows ice over from your breath. How could you have known your car battery was that low?

Sending weak beams of light through inexpensive glass or plastic tubes that resemble soda straws, Sandia researcher Jonathan Weiss has inexpensively solved industrial and everyday problems starting with telling when your automobile battery will be too weak to start the car. Other sensors can detect the movement of hazardous chemicals in landfills.

Similar sensors also could tell oil field operators when to stop pumping oil from their tanks before the pumps pick up water that often accompanies oil from the ground.

The oil/water interface sensor is the subject of a pending Sandia patent application and a research agreement with Custom Electronics, an electronics company in upstate New York. The company is partnering with Sandia to develop a prototype device from the current bench-top demonstration.

The car battery solution awaits a visionary entrepreneur to put this cheap, safe, patented solution in the hands of the public. In an invited talk at a meeting of the American Soil Society last fall in Seattle, Weiss presented his patented device for detecting the movement of hazardous wastes in landfills.

## The dead battery

A turkey-baster-like device inserted into a popped-open port has been the traditional way for a driver to test the amount of acid in a car battery (and possibly splash sulfuric acid on his or her fingertips). Weiss's simple invention requires no direct human intervention under the hood.

His procedure: factory-inject sulfuric acid or even, possibly, sugared water into a clear glass tube smaller than a soda straw and immerse the tube in the battery's acid. Glass is inert in acid and should have ample longevity, he says.

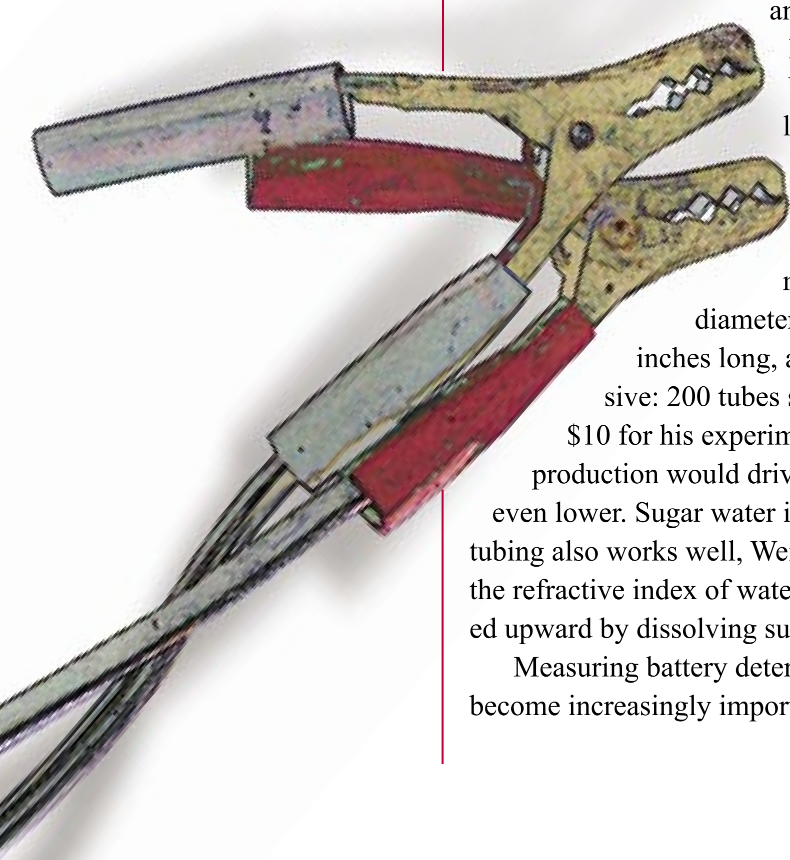
*A simple solid-state light detector — a photodiode — at the tube's near end registers more light as the battery deteriorates. The detector could easily be wired to activate a dashboard alarm light.*

Next, send light through the tube and measure the amount that returns. (The light is generated by hardy, inexpensive diodes [LEDs] already mass-produced for traffic signals, house night lights, bike tail lights, and instrument control panels.) The amount of light that stays in the tube (as reflected by a tiny piece of metal placed at the tube's far end) depends on the refractive index of the surrounding solution.

If the refractive indices are identical, light would just as soon escape from the sides of the tube as stay within it. That is the case when the tube is filled with sulfuric acid at maximum charge. The refractive index is at first the same as that of the battery acid surrounding it. But over time, the battery's acid weakens and becomes more like water. The lower refractive index attracts less light from the tube. The exchange rate, in a manner of speaking, is worsening, and light remaining in the tube increases.

A simple solid-state light detector — a photodiode — at the tube's near end registers more light, therefore, as the battery deteriorates. The detector could easily be wired to activate a dashboard alarm light.

While the glass of the tubing does have an effect on light leakage, says Weiss, "the liquid core and liquid cladding are dominant." The tube is a millimeter in diameter, two to three inches long, and inexpensive: 200 tubes set Weiss back $10 for his experiments. Mass production would drive costs down even lower. Sugar water inserted in glass tubing also works well, Weiss says, because the refractive index of water can be adjusted upward by dissolving sugar in it.



Measuring battery deterioration will become increasingly important as more hybrid electric/gas vehicles, with their high reliance on batteries, take to the highways, he says. Another possible use for the device is for cheap, continual monitoring of battery banks, used for back-up power to keep home telephones working when wall-current electricity fails due to an outage.

## Oil and water

Imagine you're in the oil business and you've pumped oil and water (just the way it increasingly comes out of the ground) into a holding tank. You want to retrieve only the oil floating atop the water so you can transport the least possible weight from the oil field to a refinery. How do you know — accurately, safely, and simply — when to stop pumping?

This widespread problem is often solved currently by the most primitive means: An employee opens a hatch and drops a stick into the liquid, possibly inhaling its fumes as pumping is in progress. With trivial hook-ups and a bit of engineering logic, Weiss shows — at least in laboratory demonstrations — that the answer to this problem can be quickly determined.

Weiss's recipe: Take two five-foot-long optical fibers made of plastic. Mount them vertically in a tank that holds water with oil on top. Send light down one fiber, and then detect light carried back up by the second fiber. The strength of the detector's signal depends on the height of the oil/water interface. If the tank is all water, the signal is very strong, and the pumping machine is instructed to stop pumping fluid; there is no oil left.

"The device is immune to electromagnetic interference and will not create sparks in a potentially explosive environment," says Weiss. The possibility of sludge building up on the device, muting the light, as the large tanks are filled and depleted is a potential reliability problem that might be overcome

*Sandia's new Mission Centric Venturing program is intended to expedite interactions with industry. The program offers Sandia researchers the alternative of marketing their ideas commercially while remaining at Sandia.*

by "potting" the fibers in a clear plastic that repels hydrocarbons, says Weiss.

The transfer of this technology to a private company is the maiden effort of Sandia's new Mission Centric Venturing program, intended to expedite interactions with industry. The program offers Sandia researchers the alternative of marketing their ideas commercially while remaining at Sandia.

## Landfill detection device

When people are interested in the behavior of a landfill that contains chemicals that may leach into ground-water, the problem comes up: How can an observer tell what the chemicals in a landfill are doing?

For leaching to occur, liquid must be present. Weiss's solution: Arrange two fiber optic cables like snakes, one above the other, in the landfill. Shine a light through the fibers. Because the temperatures of the fibers change the amount of light scattered by them, the emissions can be used to indicate the temperature at any point along the fiber. That temperature is determined in part by how much water is in the surrounding soil. Thus, fluid flowing down through the landfill would produce a clear signal from the wetted, cooled fiber that could help experts track or remediate fluid movement.

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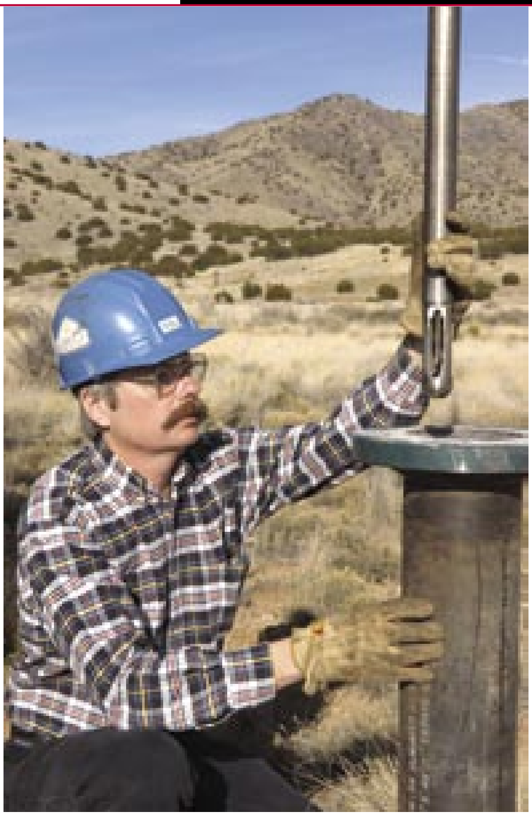
# Tough geo-tools aid earthquake research



Sandia National Laboratories geothermal researcher Joe Henfling fields one of Sandia's high-temperature downhole tools.

*Geothermal researchers at Sandia have developed sensors that can be placed in hotter and higher-pressure underground environments than previous instruments, a capability that is allowing geologists worldwide to make more precise measurements of subterranean conditions before and after large earthquakes occur.*

Geo-researchers on several key project now under way or in planning hope that new sensors being developed at Sandia will provide geologists with a better understanding of earthquake-related phenomena and possibly provide more sensitive measurements of warning signs for large earthquakes such as the devastating 9.0 magnitude earthquake near Sumatra on Dec. 26.

Lab engineers Joe Henfling and Randy Normann with technologist David Chavira are building a series of increasingly resilient and sensitive instruments that are being used by the U.S. Geological Survey (USGS) and other research groups to study a number of earthquake-related phenomena.

Sandia engineers, who have worked for decades with geothermal resources experts around the U.S., have gained a reputation for building reliable instruments that can operate in the high-temperature and high-pressure environments of a geothermal reservoir, explains Normann. Sandia-designed instruments continue to push the envelope to provide scientists with better data, he says.

Using Quartzdyne quartz pressure and temperature sensors with a relative resolution of less than 0.005 psi and .01 degree C makes the instruments extremely accurate, Normann says. "We can monitor extremely small temperature and pressure changes in deep reservoirs," he says.

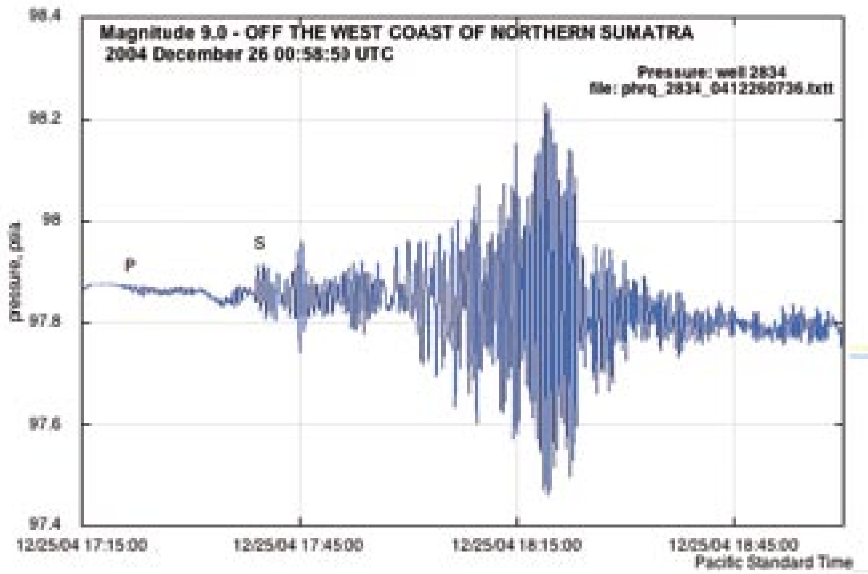
## Increased sensitivity

Sandia began working with the USGS two years ago on a program to monitor geothermal wells, which contain water in the pore spaces between grains in the hot rock. Using pressure and temperature tools to analyze earthquake data shows potential because reservoirs can sometimes be five to 10 miles long, creating a much larger area of sensitivity to the waves generated by quakes than the relatively small area used by seismic detectors.

"We also have the potential to put tools much deeper in hotter zones below the reservoir where the rock is over 200 degrees C," says Normann. California's Long Valley is one of several places where distant earthquakes are registered through a phenomenon called remotely triggered seismicity, says Evelyn Roeloffs, a Vancouver, Washington-based USGS geophysicist.

Large earthquakes, sometimes far away, create waves that cause bursts of micro-earthquakes in the area. Some persist for days after other seismic activity has returned to normal.

"We have a history of monitoring in Long Valley," she says. "In the past, we couldn't record the pressures frequently enough to determine if there was any




Seismic waves from the disastrous tsunami-producing Dec. 26 earthquake off the west coast of Sumatra were recorded using Sandia-designed instruments in a geothermal reservoir in Long Valley, California.

*Basically, scientists understand that the friction between two moving rock faces causes them to stick and build up pressure until it overcomes the friction, moving the rock and creating an earthquake.*

response to seismic activity. Now we are recording temperatures and pressures once every 2.5 seconds. We want to see if we can get better timing of the pressure changes in the rock relative to the seismic activity and if there are temperature changes."

Sometimes pressures in the fluids in the reservoirs increase after earthquakes and movements in the rocks can be measured. "If we could put tools in deeper and hoter wells, we could get better information," Roeloffs says.

## Drilling deeper

At New Mexico Tech in Socorro, geophysicist Harold Tobin is also discussing a deeper and hotter regime for the placement of Sandia's geothermal tools.

"We are still in the planning stages, but in about a year and a half we are going to start a big drilling project to bore into a tectonic feature similar to the one where the Sumatra earthquake occurred," says the associate professor. The site is off the coast of Japan in the Nankai Trough Seismogenic Zone.

The target is six kilometers (3.6 miles) beneath the ocean's floor in water two kilometers (1.2 miles) deep, in a subduction zone where some of the largest earthquakes on the planet have been generated. In 1944 and again in 1946 the quakes generated significant tidal waves, or tsunamis, as well.

"We are looking to place instruments in the fault zone to better understand the precursors of earthquakes and to learn about the physics of these zones in terms of storing stress and releasing it as the plates slip and displace," he says. "We will need instruments that can withstand temperatures of 150º to 180º C, which are well up in the range where normal electronics don't work."

Basically, scientists understand that the friction between two moving rock faces causes them to stick and build up pressure until it overcomes the friction, moving the rock and creating an earthquake.

"There's a theory that the pore fluid pressure in the rocks affects this dynamic," Tobin says. High water pressure may push faces apart, allowing slippage of the rock faces. "When earthquakes happen may be governed by fluid pressure, which is why the instruments down hole are so important," he says.

## Going barefoot

The secret to Sandia's success in designing robust high-temperature tools is in part a material called Silicon-on-Insulator (SOI), which isolates the transistors from one another and greatly reduces thermally generated current leaks that occur on normal silicon-designed components, says Normann.

With silicon-based electronics, the resistance of the silicon material breaks down as heat increases and it begins to act increasingly like a conductor of electricity. The SOI reduces the frequency of breakdowns by a factor of 100, he says. Engineers have also worked on a phenomenon called metal migration at silicon-metal junctions by thickening the wires there, reducing the current, and ultimately prolonging the life of the junctions.

"These types of components were originally developed for aircraft and other high-reliability applications," Normann says. In fact Sandia is working with the Air Force on similar extreme environmental electronics technology. The ultimate goal is something called "going barefoot," says Normann, a term that means building components so rugged that they will not need any heat shielding to protect them.

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# NEWSNOTES

## New Mexico institutions sign bundling agreement

Seven New Mexico research institutions have joined together to sign the Inter-Institutional Agreement, a contract that allows bundling of patents for economic development.

The institutions include Sandia, Los Alamos National Laboratory (LANL), Science and Technology Corporation (STC) at the University of New Mexico, New Mexico State University, New Mexico Institute of Mining and Technology, The MIND Institute, and the National Center for Genome Resources. The agreement is also designed for other research organizations to become signatories.

The point of the agreement is to provide rapid response and flexibility so that when commercialization opportunities arise, these institutions can quickly capitalize on each opportunity rather than spending time negotiating contracts. This will be accomplished by allowing each institution to identify specific patents that are appropriate for this agreement and are available for licensing.

Selected patents can then be included in a bundle of patents, along with those from other institutions, and licensed to interested companies. The licensing will be handled by one institution, as identified by the institutions with patents in the specific patent bundle.

"The flexibility and capability of this agreement give it great power and the potential to create both economic benefits for the region and technological advances that will strengthen the U.S.," says Paul Smith, the Sandia licensing executive who negotiated the agreement. "This agreement will help strengthen the Technology Research Collaborative (TRC) now forming in New Mexico."

Formed in May 2003, the TRC's mission is to collaborate on the acceleration of new technology businesses and expansions to benefit the research programs of TRC members, entrepreneurs, industry, investors, and New Mexico. "This agreement will be used as a tool by TRC members to foster the growth of high-tech industries within New Mexico," says Allen Morris, LANL licensing executive.

"The agreement will allow a company to easily access patents from a number of New Mexico research organizations and have one party represent these institutions in the transaction," says Lisa Kuuttila, CEO and president of STC. "This reduces the barriers considerably." STC is a nonprofit corporation owned by the University of New Mexico.

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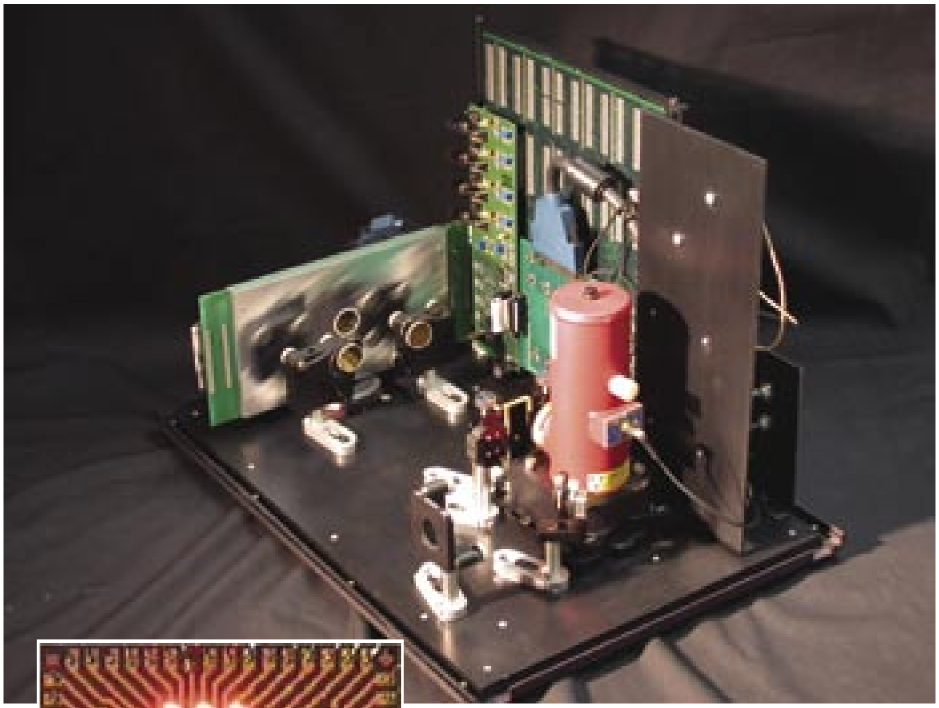
# Online database for Sandia intellectual property

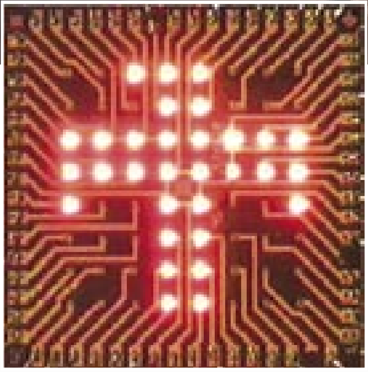
A new online database created to highlight opportunities to license Sandia's intellectual property is now available to the general public. The purpose of Sandia's Intellectual Property Available for Licensing, or iPAL™, database is to show Labs technologies that may not be fully utilized in the commercial marketplace and to help companies move promising technologies toward commercialization.

"iPAL highlights some of the interesting Sandia technologies that many people outside the Labs often have never heard of," says Licensing and Intellectual Property Manager Kevin McMahon.

"The database gives the public an opportunity to see if these technologies would be valuable in the commercial world," adds iPAL developer Kelly Cowan, a graduate student intern studying management of technology. The web-based system allows customers to search through Sandia intellectual property that is available for licensing and get in touch with the appropriate people at Sandia to negotiate a license. Sandia then works with interested companies to execute a mutually beneficial commercial licensing agreement.

iPAL provides a mechanism to see if anyone is interested in a particular technology, and if Sandia does not get any interest after a period of time, a decision could be made to drop a technology from the Labs' portfolio. Large businesses regularly save millions of dollars by actively reviewing their intellectual property portfolios and deciding which technologies to keep or drop.





VCSEL arrays (left) and Sandia's Polychromator (above) are among the many Sandia technologies available for licensing via the iPAL database.

"This is important because with the rapid pace of change in technology, intellectual property developed at the Labs only a few years ago can rapidly become obsolete, or at least may no longer be the optimum way of accomplishing its original purpose," says McMahon.

iPAL™
INTELLECTUAL PROPERTY AVAILABLE FOR LICENSING

iPAL can be found at http://ipal.sandia.gov

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# NEWS NOTES

Sandia President C. Paul Robinson (left) signs a memorandum of understanding between the Labs and the University of Texas System with Chancellor Mark G. Yudof (right). U.S. Sens. Pete Domenici and Kay Baily Hutchison (both standing) witnessed the signing in Washington, D.C., this spring.

## Sandia, University of Texas System unveil agreement

*The agreement calls for a newly designated UT System position on the Sandia Board of Directors to organize and lead technical reviews of Sandia's science and technology programs.*

Sandia National Laboratories and the multi-campus University of Texas System have announced an expanded relationship, unanimously approved by the university's Board of Regents and Sandia.

The agreement calls for:

- UT System to develop and implement an independent peer review process for Sandia's science, technology, and engineering programs;
- Joint development and implementation of "strategic program areas that enhance" Sandia's broad missions in national security; and for
- UT System to complement Sandia's currently available educational opportunities by their uniquely qualified professors providing courses on specialized topics relevant to Sandia's missions.

"As a national laboratory, Sandia has been working for many years to establish and maintain strategic partnerships with outstanding national institutions in academia, industry, and the government," says C. Paul Robinson, Sandia president and Laboratories director. "This action strengthens one such strategic relationship, which was created several years ago between the University of Texas System, including its medical research institutions, Lockheed Martin Corporation, and Sandia.

"This agreement represents a tremendous opportunity to advance the strong, existing relationship between our System and one of the country's premier national laboratories," says Mark G. Yudof, chancellor of the UT System. "This is a great opportunity for our faculty, our students, and our researchers to be involved more directly in the unclassified, cutting-edge science and research being conducted by Sandia National Labs."

The agreement calls for a newly designated UT System position on the Sandia Board of Directors to organize and lead technical reviews of Sandia's science and technology programs. As part of this activity, UT System will open an office at Sandia's Albuquerque, New Mexico, headquarters by Oct. 1.

The two institutions also will undertake joint technical research projects and collaborations that take advantage of their complementary competencies in the areas of simulation engineering, high-energy density physics, sustainable energy security for the nation's transportation infrastructure, and in health security.

"This will allow Sandia to further develop its people and enhance its technical abilities to better meet the national challenges we face," Robinson adds.

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# Tom Hunter named new Labs' Director

*"Sandia has a unique heritage and capabilities, working to maintain the nuclear weapons stockpile while improving the nation's homeland defenses and anticipating future national security challenges. I have great confidence that...Sandia will continue to be a laboratory that provides exceptional service in the national interest."*

*Tom Hunter*
*Director, Sandia National Laboratories*

The Sandia Corporation Board of Directors named Dr. Thomas O. Hunter President of Sandia Corporation and Director of Sandia National Laboratories effective April 29. Hunter most recently served as Sandia's senior vice president for Defense Programs, with oversight of the labs nuclear weapons programs.

He replaces Dr. C. Paul Robinson, who has served as President and Labs Director since August 1995. Robinson is assisting Lockheed Martin Corporation, which currently manages Sandia, in preparing its bid to the Department of Energy for the management and operating contract for Los Alamos National Laboratory.

Dr. Joan Woodard replaces Tom Hunter as head of Sandia's Nuclear Weapons Program. She also remains as Sandia's Executive Vice President and Deputy Director during the transition.

"We are thrilled Tom Hunter has agreed to accept the position of director of Sandia National Laboratories," said Michael F. Camardo, Sandia Corporation Board Chairman and executive vice president of Lockheed Martin Information and Technology Services. "Tom is a man of great intelligence and extremely high integrity. He has a deep and thorough understanding of the national security needs of the nation, the complex missions of the laboratory, and he cares about the people who work at Sandia."

Camardo also praised Paul Robinson for demonstrating great vision during his 10-year tenure as Sandia's director. "Paul kept Sandia on a steady course toward excellence, ethical behavior, and a better quality of life for its employees and the local community. This record reflects well upon Paul and the leadership team he put together to manage Sandia," he said.

Hunter, who earned a Ph.D. in nuclear engineering from the University of Wisconsin, has held a variety of positions since coming to Sandia in 1967. In his most recent post, he led the laboratories' Defense Programs, which encompasses about 60 percent of Sandia's $2.2 billion annual budget. From October 1995 to March 1999, he served as vice president of Sandia's California site and leader of Sandia's nonproliferation programs.

Hunter said the core mission of Sandia will continue to be maintaining the nation's nuclear weapons stockpile. As a premier national security laboratory, Sandia will also continue to develop technology solutions for the challenging problems that threaten peace and freedom at home and abroad.

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*Hydrides have shown significant early promise to one day increase the range of fuel-cell vehicles. We know a lot of research still needs to be done.... We think our work on projects like this with Sandia will get us another step closer to our goal."*

Jim Spearot
Director, GM Advanced Hydrogen Storage Program

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

SAND-2005-2424P

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