New research: Metal-organic frameworks mop up radioactive gases from spent nuclear fuel

By Nancy Salem

Research by a team of Sandia chemists could impact worldwide efforts to produce clean, safe nuclear energy and reduce radioactive waste.

The Sandians used metal-organic frameworks (MOFs) to capture and remove volatile radioactive gas from spent nuclear fuel. "This is one of the first attempts to use a MOF [pronounced "MOF," not as initials] for iodine capture," says team lead Tina Nenoff (1114) of Sandia's Surface and Interface Sciences Department.

The discovery could be applied to nuclear fuel reprocessing as well as to cleanup from nuclear reactor accidents. A characteristic of nuclear energy is that used fuel can be reprocessed to recover fissile materials and provide fresh fuel for nuclear power plants. Countries such as France, Russia, and India are reprocessing spent fuel.

The process also reduces the volume of high-level wastes, a key concern of the Sandia researchers. "The goal is to find a methodology, to line things up so less waste is interred," Tina says.

Part of the challenge of reprocessing is to separate

(Continued on page 4)

SANDIA CHEMIST TINA NENOFF heads a team of researchers focused on removal of radioactive iodine from spent nuclear fuel. They identified a metal-organic framework that captures and holds the volatile gas, a discovery that could be used for nuclear fuel reprocessing and other applications.
(Photo by Randy Montoya)

Diversity Library offers inspiration, resources

By Sue Major Holmes

Diversity & Inclusion Organization (DIO) Senior Manager Esther Hernandez (0040) says there's a mission imperative for an inclusive environment: When people work where they are valued, they will be more engaged and therefore more productive.

She says Sandia has a phenomenal workforce, with people whose hearts are in the right place, but that often "we just don't know what we don't know." Individuals might not know "how to be inclusive, how to create an environment in which people can be the best they can be without having to leave part of themselves at the door," she says.

The Diversity & Inclusion Organization — which promotes lasting inclusion for everyone — wants to make members of the workforce more aware of its library of books, videos, and workshops.

The holdings are detailed at the Diversity website (http://diversity.sandia.gov), which had 29,000 hits between November 2010 and the end of September 2011, says Marie Brown (0040), diversity projects lead. Part of the website — the history of inclusion at Sandia, for example — doesn't change, but new information appears each month showcasing current activities, such as November's Diversity Cinema presentations commemorating American Indian Heritage Month and Veteran's Day.

An important point, say Esther and Marie, is that inclusiveness goes way beyond race and gender.

(Continued on page 4)

Nominate a colleague. See page 2

Sandia LabNews

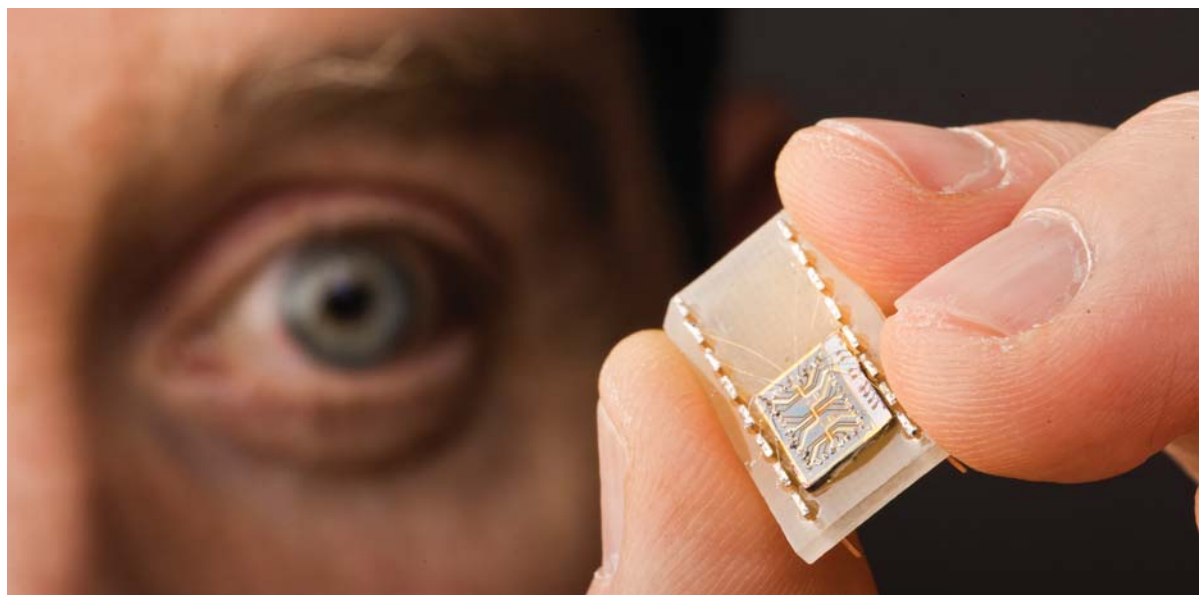
Vol. 63, No. 23 December 2 , 2011

Managed by Sandia Corporation for the National Nuclear Security Administration

Sandia National Laboratories

Twenty-five percent voltage increase observed in closely packed nanowires

Work has implications for devices and basic science

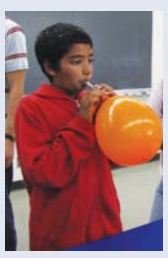


THE EYE OF MIKE LILLY observes two individually powered nanowires, embedded one above the other, in a few atomic layers of Sandia-grown crystal. The unique test device already has yielded new information about nanoworld electrical flows.
(Photo by Randy Montoya)

By Neal Singer

Suppose you believe — as many researchers do — that nanowires will be the electrical current-carriers of the future for certain types of solar arrays, batteries, telephones, and tiny portable computers. But perhaps you also suspect — as many researchers do — that strange and unpredictable effects may take place in the currents carried by these nanowires when placed in proximity to each other — the *sine qua non* for carrying out their business.

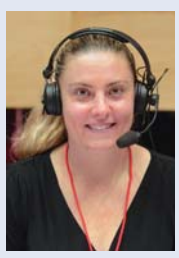
(Continued on page 5)



Science Night shines at Bay Area Science Festival

Sandia's popular school-based Family Science Night program found a new venue this year — the first-ever Bay Area Science Festival. Read all about it on **page 3**.

Inside . . .



Hoop dreams

Former Lady Lobo basketball standout and now-Sandian Nikki Lobato learned valuable life and career lesson through her participation in sports. Nikki now moonlights as the color commentator for Lady Lobos games on KNML. See **page 8.**

That's that

"When the moon is in the seventh house and Jupiter aligns with Mars . . ." Remember that? If you do, there are probably some very embarrassing photos of you in paisley bellbottoms lurking around out there, safely locked in chemicals on paper rather than in bits and bytes. Come to think of it, that's one of the downsides of the digital age. Back in the day, you could outlive and outgrow such sillinesses as bellbottoms, huaraches, Nehru jackets, and disco. Today, your past clings to you like a bad suit, almost literally. That ridiculous leisure suit you wore to your sister's wedding? If you were digitally captured wearing that today, it could become a serious impediment to your future job prospects. In *Julius Caesar*, Shakespeare (or whomever) observed that "The evil that men do lives after them; the good is oft interred with their bones." Maybe that was true in the 17th century; today, nothing is interred with your bones: good and bad, it's all out there.

By the way, I'm getting around to the point of that first sentence: It's from the hit musical *Hair*, which was a cultural phenomenon 40-something years ago. The words are from the song *The Age of Aquarius*, an astrologically significant epoch of peace and love. I don't know about that but I do know that every few years, Mars is in juxtaposition with Earth in just such a way that it's the perfect time to launch spacecraft to the Red Planet.

We're in one of those happy periods right now and the US has successfully launched an incredibly ambitious payload on an eight-month voyage to Barsoom (that's what author Edgar Rice Burroughs claimed was the Martians' own name for their planet). The Mars Science Laboratory, with its incredible Curiosity rover — the "Monster Truck of Mars," as it's been called — is NASA's boldest Mars mission yet. Its goals include characterization of the climate and geology, and — the Philosopher's Stone of planetary exploration — a determination of whether life ever arose on the planet. That's what we really want to know. Is anybody there?

As it happens, there's a significant New Mexico connection to the mission: A Sandia team was responsible for range safety issues during the launch sequence (necessary because the spacecraft carries a specialized nuclear power source); a laser instrument used to zap soil samples for spectroscopic tests was developed at Los Alamos National Laboratory; and a University of New Mexico team is deeply involved in the geology portions of the mission. Sandia, by the way, was singled out for praise by then-NASA Administrator Dan Goldin back in 1997 for its role in the development of the Mars Pathfinder airbag landing system.

If you want to see some brilliant, stunning, inspired engineering, I'd strongly recommend you track down the NASA animation that depicts the Curiosity rover landing on Mars, then rolling off into the Barsoomian hinterlands collecting and analyzing soil samples. (Here's one link: http://www-a.jpl.nasa.gov/video/index.cfm?id=979) The audacity of this mission will blow you away.

As adept as we have become over the years at spacefaring, we laymen mostly assume these missions will succeed just as a matter of course. NASA does have a pretty good track record, but success is no certainty. Earlier this month we got a stark reminder of that: A Russian spacecraft, taking advantage of that same Mars/Earth alignment, was launched into a parking orbit prior to firing the rocket engines that would send it on its way to Mars. Unfortunately, the Russian team lost contact with the craft, which was intended to collect a soil sample from Phobos and return it to Earth. Experts say the apparent mission failure points up some deep systemic problems in the Russian space industry. That may be true, but more to the point, the failure reminds us that 55 years into the age of space travel, this stuff still ain't easy and probably won't be for some time yet.

* * *

Do you say toe-may-toe or toe-mah-toe? And do you say twenty-twelve or two-thousand twelve for the year we're about to begin? So far, I've always used the "two-thousand" construction, as in two thousand-one (which was how Arthur C. Clark and Stanley Kubrick pronounced the title of their movie). I've heard people refer to twenty-oh-nine, twenty-ten and so on, but it hasn't sounded right to me. So far. I think, though, I'm getting okay with the construction. And inevitably, I think usage will universally be of the "twenty" style before long. The later we get into the century, the more awkward the "two-thousand" formulation sounds. And speaking of centuries, I'm finally beginning to internalize that when we speak of "the last century" we're talking about the 1900s, not the 1800s. Being accused of being "a man of the last century" in 2011 isn't quite as bad as being so accused in 1999. But being accused of being a 16th century Renaissance man? That's another thing altogether, and one I'd be OK with.

See you next time . . .

— Bill Murphy (505-845-0845, MS0165, wtmurph@sandia.gov)

Sandia's Heart of Diversity Award seeks nominees

Sandia wants to recognize employees who do something inclusive, respectful, and courageous on behalf of someone else in the workforce.

The Labs' Diversity & Inclusion Organization Heart of Diversity Award is meant to recognize individuals or teams who stood up for change to improve diversity and inclusion in the workplace.

Senior manager Esther Hernandez and diversity team lead Marie Brown (both 0040) and each division's Corporate Diversity Team (CDT) members will be handing out heart-shaped cards during department meetings, all-hands meetings, celebrations, and other gatherings to make people aware of the award and to solicit nominations.

A CDT subcommittee will review nominations and make the selections. The team recommends Heart of Diversity recipients receive their awards at a division or all-hands level meeting.

The actual award is a set of stone coasters in a wooden holder with the heart of diversity logo. Marie says the coasters displayed in an office can themselves become a way to further a conversation on diversity. *— Sue Major Holmes*

Arian Pregenzer wins prestigious APS award

Arian Pregenzer, a senior scientist in Nonproliferation and Cooperative Monitoring Center 6800, has been awarded the Joseph A. Burton Forum Award for her contributions to the success of Sandia's Cooperative Monitoring Center (CMC). The award is one of the most prestigious offered by the American Physical Society.

ARIAN PREGENZER

Arian's citation reads: "For her intellectual and managerial leadership in creating centers that allow international technical and policy experts to explore confidence-building measures and other arms control regimes."

The Joseph A. Burton Forum Award recognizes outstanding contributions to the public understanding or resolution of issues involving the interface of physics and society.

Upon being notified she had won the award, Arian stated in a message to her colleagues that "I want to acknowledge the role that many of you had — in particular Kent Biringer [(6821)], Mike Vannoni [(0216)], Ren Salerno [(6820)], Karl Horak[(6832)], Sharon Deland [(6831)], and Amir Mohagheghi [(6821)] — in making the CMC a success. There are many more who contribute to that success every day, and who have grown the original ideas into entirely new areas. So, this award really belongs to all of us."

Arian, who retires from the Labs this month, has been at Sandia for 28 years. As a senior scientist in the Global Security Program, her responsibilities have included initiating new programs in arms control and nonproliferation and developing strategies for nuclear security that intersect multiple laboratory missions.

In 2009-2010, Arian served as a visiting scholar at the Center for International Security and Cooperation at Stanford, where she initiated new research in applying the concepts of systems resilience to nuclear nonproliferation.

She is internationally recognized for her work to enable international technical collaboration to enhance security. In 1994 she led the establishment of Sandia's Cooperative Monitoring Center, which promotes dialogue between policy and technology experts.

Arian earned bachelor's degrees in physics, mathematics, and philosophy from the University of New Mexico. In 1983 she received a PhD in theoretical physics from the University of California at San Diego.

She is a member of the Council on Foreign Relations, the International Institute for Strategic Studies, and the American Association for the Advancement of Science.

The Burton Award will be presented to Arian at the APS April 2012 meeting in Atlanta, Ga.

Sandia LabNews

Sandia National Laboratories

http://www.sandia.gov/LabNews

Albuquerque, New Mexico 87185-0165
Livermore, California 94550-0969
Tonopah, Nevada • Nevada Test Site • Amarillo, Texas •
Carlsbad, New Mexico • Washington, D.C.

Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corp., for the US Department of Energy's National Nuclear Security Administration.

Bill Murphy, Editor **505/845-0845**
Randy Montoya, Photographer **505/844-5605**
Mike Janes, California site contact **925/294-2447**
Michael Lanigan, Production **505/844-2297**

Contributors: Michelle Fleming (Ads, Milepost photos, 844-4902), Neal Singer (845-7078), Iris Aboytes (844-2282), Patti Koning (925-294-4911), Stephanie Holinka (284-9227), Darrick Hurst (844-8009), Stephanie Hobby (844-0948), Heather Clark (844-3511), Sue Holmes (844-6362), Nancy Salem (844-2739), Jennifer Jennings Carr (284-7676), Tara Camacho-Lopez (284-8894), Jane Zingelman (845-0433), Jim Danneskiold, manager (844-0587)

Lab News fax **505/844-0645**
Classified ads **505/844-4902**

Published on alternate Fridays by Media Relations and Communications Dept. 3601, MS 0165

LOCKHEED MARTIN

Lab News Reader Service

The *Sandia Lab News* is distributed in-house to all Sandia employees and on-site contractors and mailed to all Sandia retirees. It is also mailed to individuals in industry, government, academia, nonprofit organizations, media, and private life who request it.

Retirees (only):

To notify of changes in address, contact Benefits Dept. 3332, Customer Service, at 505-844-4237, or Mail Stop 1021, Sandia National Laboratories, Albuquerque, NM 87185-1021.

Others:

To receive the *Lab News* or to change the address (except retirees), contact Michelle Fleming, Media Relations and Communications Dept. 3651, 505-844-4902, email meflemi@sandia.gov, or Mail Stop 0165, Sandia National Laboratories, Albuquerque, NM 87185-0165.

Employees:

To address concerns regarding delivery of the *Lab News* to your facility, call Mail Services Team 10268-4, at 844-3796. At Sandia/California contact the Mail Room at 925-294-2427.

Web users:

The *Lab News* is on the external web at www.sandia.gov/LabNews. *Lab News Interactive*, accessible on the internal web, is at: www-irn.sandia.gov/newscenter/interactive.

Family Science Night a big hit at Bay Area Science Festival

By Patti Koning

Each year, Family Science Night (FSN) brings the excitement of scientific discovery to thousands of children and their families at weekly events at schools in the Livermore area. At the Bay Area Science Festival, held Oct. 29 –Nov. 6, FSN reached many more families.

Led by the University of California, San Francisco (UCSF), the first-ever Bay Area Science Festival was designed to showcase the region's catalytic role in scientific progress and provide innovative opportunities to build community around science, technology, and engineering. The weeklong event, which included star parties at Bay Area observatories, guided hikes on regional trails, and "wonder dialogues" with scientific leaders, was deemed a smashing success by coordinators and participants alike.

The festival kicked off Oct. 29 at Cal State East Bay's Discovery Day. Jennifer Halstrom, Mike Janes, and Patti Koning (all 8529) represented Sandia along with retiree volunteers Joel Lipkin and Leo Mara and FSN coordinators Leslie Swift and Karen Abelar. A steady stream of parents and children came through the Sandia room, where they worked on signature FSN activities like the hoopster, straw flute, optical illusion, spinning balloon, and wonderwhirler. The infrared camera proved to be a huge hit — who wouldn't want a heat map picture of themselves to bring home?

"I think Sandia brought something unique to the Bay Area Science Festival," says Mike. "Family Science Night is all about hands-on activities that teach basic scientific concepts in a fun and engaging way while bringing together parents and their children." In some cases, the parents were more involved in the activities than their children.

Sandia also participated in the closing day of the festival, another Discovery Day held at AT&T Park in San Francisco. More than 21,000 people of all ages came to the park and visited activities and booths run by more than 170 exhibitors representing a "who's who" of the Bay Area scientific community — NASA, Stanford University, the US Geological Survey, the Search for Extraterrestrial Intelligence, Chabot Space Center, the Exploratorium, Lawrence Livermore National Laboratory, and, of course, Sandia.

RETIREE VOLUNTEER Leo Mara shares a moment of science fun with kids at the Bay Area Science Festival.

Located near home plate, the Sandia FSN booth stayed busy all day with the wonderwhirler, optical illusion, and crowd favorite glue goo.

"It was pretty exciting to be a part of this event from the beginning," says Mike. "We didn't know what to expect — but I'm not sure we could have envisioned the level of enthusiasm and sheer numbers of people we saw. Hopefully the Bay Area Science Festival will become an annual event and an ongoing tradition for Sandia."

Dan Segalman named to Air Force Scientific Advisory Board

Dan Segalman (8259) has been selected to serve on the Air Force Scientific Advisory Board (SAB) for a four-year term that began in October. The SAB, organized under the Federal Advisory Committee Act, provides a link between the Air Force and the nation's scientific community.

DAN SEGALMAN

The SAB promotes the exchange of the latest scientific and technical information that may enhance the accomplishment of the Air Force mission.

As a board member, some of Dan's duties will include regular reviews of the Air Force Research Laboratories, including the Air Force Office of Scientific Research, where he did a two-year Intergovernmental Personnel Assignment in 2000-2001. The SAB also conducts numerous studies for the secretary of the Air Force and the chief of staff of the Air Force.

"I'm pleased to be appointed to the board because I feel it's important for Sandia to be connected to other government agencies," Dan says. "It's also an opportunity for me to fulfill our mission of providing excellent service in the national interest."

Dan has been with Sandia since 1986 and is working in the Multi-Physics Modeling and Simulation Department, which he joined in 2010 after a one-year appointment to NNSA to support the Advanced Simulation and Computing Program. From 2006 to 2009, Dan served as vice president for Technical Communities of the American Society of Mechanical Engineering.

Dan is in good company with his appointment; other Sandians who have served on the SAB are former Div. 8000 VP Mim John, former Executive VP Joan Woodard (retired), Deputy Labs Director and Executive VP for National Security Programs Jerry McDowell (2), and former VP of advanced concepts Gerry Yonas.

—Patti Koning

Sandia CaliforniaNews

REP. ZOE LOFGREN, D-CALIF., who represents the 16th congressional district (including much of San Jose and Silicon Valley), visited Sandia/California on Nov. 9. She received an overview of Sandia from Div. 8000 VP Rick Stulen, an update on the Livermore Valley Open Campus from Andy McIlroy (8310), and a tour of the HCCI Engine Laboratory at the Combustion Research Facility with John Dec and Bob Carling (both 8300). (HCCI stands for homogenous-charge compression ignition.) Len Napolitano (8100) provided an overview of Sandia's cybersecurity work.
Lofgren serves on the House Judiciary Committee and the House Science, Space and Technology Committee. Among other issues discussed during her visit, she solicited a formal technical assessment from Len on two pieces of Internet legislation under consideration by Congress. (Photo by Dino Vournas)

Spent fuel

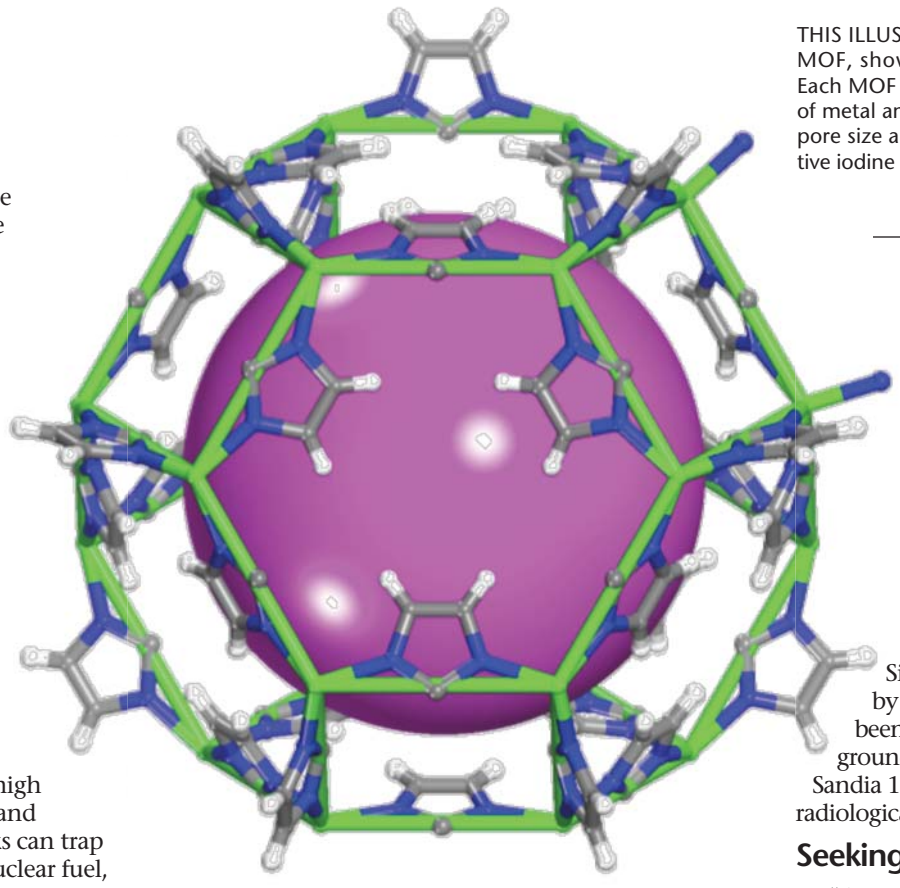
(Continued from page 1)

and isolate components that are not burnable fuel but are radioactive. Tina took knowledge from her early Sandia research into materials for cleanup of nuclear waste from the Cold War and applied it to gas separations for nuclear fuel reprocessing.

The Sandia researchers are part of the Off-Gas Sigma Team, which is led by Oak Ridge National Laboratory and studies waste form capture of volatile gases associated with nuclear fuel reprocessing. Tina's team is focused on removing iodine, whose isotopes have a half-life of 16 million years, from spent fuel. Other volatile gases of interest include krypton, tritium, and carbon, and are being looked at by other members of the Off-Gas Sigma Team — Pacific Northwest, Argonne, and Idaho national laboratories.

The Sandians studied known materials, including silver-loaded zeolite, a crystalline, porous mineral with regular pore openings, high surface area, and high mechanical, thermal, and chemical stability. Various zeolite frameworks can trap and remove iodine from a stream of spent nuclear fuel, but need added silver to work well. "Silver attracts iodine to form silver iodide," Tina says. "The zeolite holds the silver in its pores and then reacts with iodine to trap silver iodide."

But silver is expensive and there are environmental issues, so the team set out to engineer materials that would work like zeolites but have higher capacity for the gas molecules, and not need silver. They explored why and how zeolite absorbs iodine, and used the critical components discovered to find the best MOF, in this case named ZIF-8.



THIS ILLUSTRATION OF A METAL-ORGANIC FRAMEWORK, or MOF, shows the metal center bound to organic molecules. Each MOF has a specific framework determined by the choice of metal and organic. Sandia chemists identified a MOF whose pore size and high surface area can separate and trap radioactive iodine molecules from a stream of spent nuclear fuel.

"We studied materials that are known, like the zeolite mordenite, and made new materials," Tina says. "We investigated the structural properties on how they work and translated that into new and improved materials."

MOFs are crystalline, porous materials in which a metal center is bound to organic molecules by mild self-assembly chemical synthesis. The choice of metal and organic result in a very specific final framework.

'Making the hole round'

The trick was to find a MOF highly selective for iodine. The Sandians took the best elements of zeolite Mordenite — its pores, high surface area, stability, and chemical absorption — and identified a MOF that can separate one molecule, in this case iodine, from a stream of molecules. The MOF and pore-trapped iodine gas can then be incorporated into a glass waste form for use in long-term storage.

"We've shown that MOFs have the capacity to capture and, more importantly, retain many times more iodine than current materials technologies," says team member Karena Chapman of Argonne National Laboratory. She added that the iodine can also be trapped by pressure treating the MOF to change the dimensions of its entry/exit apertures. "This process could be compared to putting a square peg through a square hole then making the hole round," Chapman says.

The Sandia team also fabricated MOFs, made of commercially available products, into durable pellets. The as-made MOF is a white powder with a tendency to blow around. The pellets provide a stable form to use without loss of surface area, Tina says.

Sandia has filed for a patent on the pellet technology, which could have commercial applications. "We figured out a binderless process to make industrially relevant pellets," Tina says.

The project began six years ago and the Sigma Team was formalized in 2009. It is funded by the DOE Office of Nuclear Energy. Tina has been involved from the beginning, tapping a background in nuclear weapons cleanup. She has been at Sandia 18 years and previously worked on removal of radiological ions from liquid tanks.

Seeking capture and removal solutions.

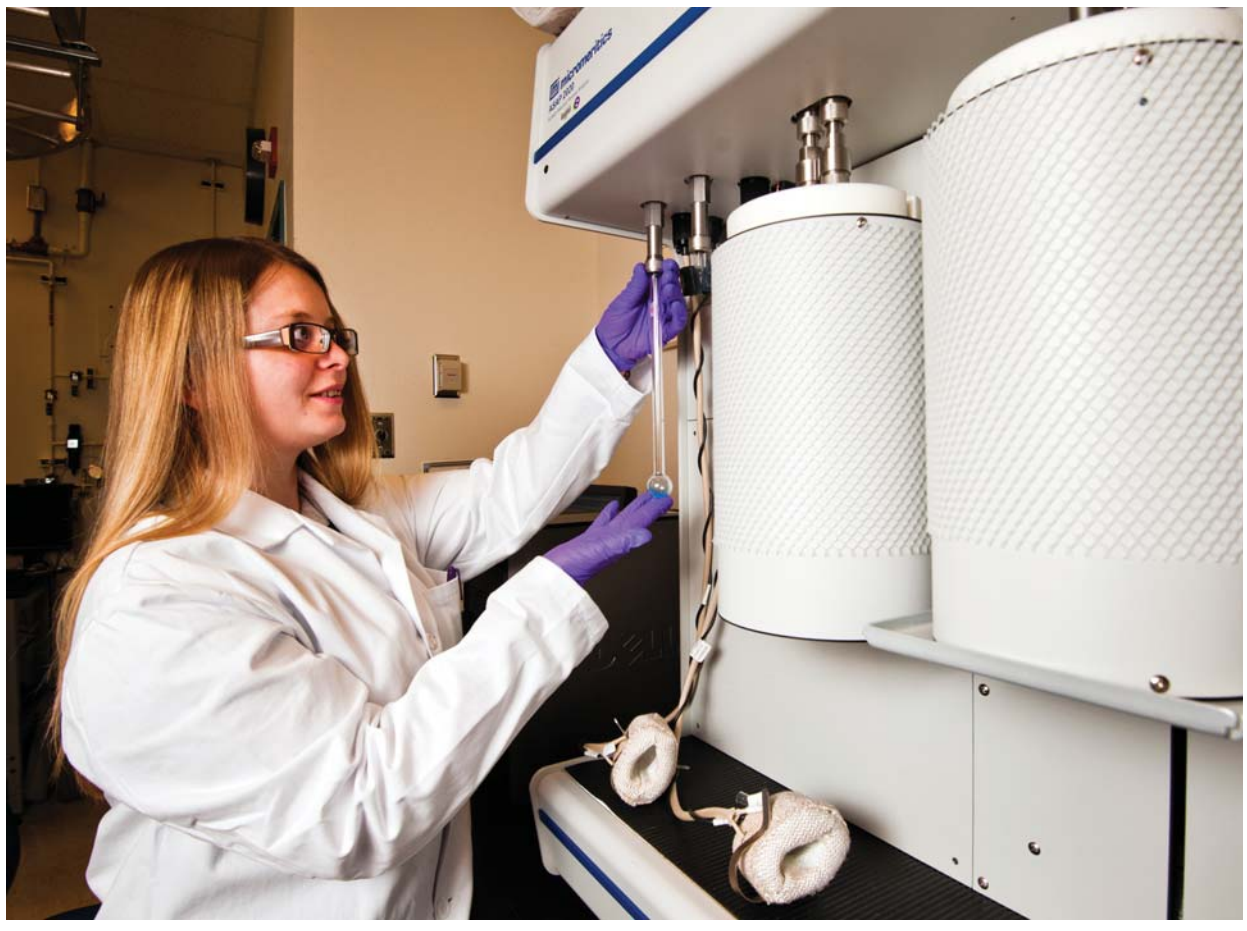
"Over the years, through my career, I've gone back to working on materials associated with separations and waste forms for radiological elements," she says.

The Sigma Team is seeking capture and removal solutions for all the volatile gases involved in reprocessing. Sandia's iodine and MOFs research was featured in two recent articles in the *Journal of the American Chemical Society* authored by Tina and team members Dorina Sava (1114), Mark Rodriguez (1822), Jeffery Greathouse (6915), Paul Crozier (1426), Terry Garino (1816), David Rademacher (1114), Ben Cipiti (6223), Haiqing Liu (1114), Greg Halder, Peter Chupas, and Chapman. Chupas, Halder, and Chapman are from Argonne.

"The most important thing we did was introduce a new class of materials to nuclear waste remediation," says Dorina, postdoctoral appointee on the project. She joined the team 18 months ago from the University of South Florida, where she did graduate work on such materials.

Tina says a third paper was published this year in *Industrial & Engineering Chemistry Research* that shows the incorporation of MOFs with iodine in a one-step process, low-temperature glass waste form. "We have a volatile off-gas capture using a MOF and we have a durable waste form," Tina says.

She and her colleagues are continuing their research into new and optimized MOFs for enhanced volatile gas separation and capture. "We are looking at a broad range of materials and learning from them to make new materials," Tina says.



DORINA SAVA (1114) is the postdoctoral appointee in a group of Sandia chemists who are part of a multilab team seeking capture and removal solutions for volatile gasses involved in nuclear fuel reprocessing. The Sandians zeroed in on removal of radioactive iodine. (Photo by Randy Montoya)

Diversity library

(Continued from page 1)

The library's holdings reflect that. Videos and books fall into such categories as culture, elderly caregiving, diversity, civil rights, leadership, gay/lesbian/transgender, communication, racial equality, management and professional development, disabilities, sex/gender, veterans, women, harassment, team building, generational, religion, and self-improvement.

The online checkout process is similar to getting a movie from Netflix. Borrowers click on the title, then the "edit item" button. They then type in their Sandia email, work number, and due date (two weeks for videos and a month for books) and change the item's availability from "yes" to "no." That notifies the Diversity Office, which sends the item via interoffice mail. The borrower views or reads it, then returns it in the same packaging using an included label. If something is already checked out, people can add their name to a waiting list. Any member of the workforce can visit the library in Bldg. 802, Rm. 2333, to check out resources.

The library also offers one- to three-hour workshops on diversity topics. Although the DIO staff can and do present them, the material is set up as a "workshop-in-a-box" that can be checked out by staff or managers. The kits have PowerPoint slides, guides on how to give the presentation, talking points, guidance on how to respond to certain comments or questions, and oftentimes DVDs and handouts for participants.

Workshop subjects are varied and include respect in the workplace, the impact of micro-inequities and micro-messages, generational differences, and how men and women can communicate better when working together.

Esther says building a culture of lasting inclusion will require self-awareness, respect, and a trusting environment.

Marie illustrates that message by recounting a story told by the final speaker at a diversity conference she attended in Washington, D.C. Erik Weihenmayer, who calls himself a blind adventurer, put his faith in his sighted partner during a climbing trip when they had to jump together off a 40-foot cliff into a river and swim about 50 feet to the other side to continue on their way.

"We need that level of trust, of camaraderie," Marie says.

Nanowires

(Continued from page 1)

So you'd want to measure the possible changes in voltage of one wire as caused by another, to determine how significant the current boost or drag, so you can allow for it in designing your device. But you have a problem. The best test method available involves putting a charged piece of material called a gate between two nanowires on a single shelf. The gate, flooded with electrons, acts as a barrier: It maintains the integrity, in effect, of the wires on either side of it by repelling any electrons attempting to escape across it. But the smallest wire separation allowed by the gate is 80 nanometers. A much smaller gap is necessary for verisimilitude with expected future devices.

Simple but brilliant test design

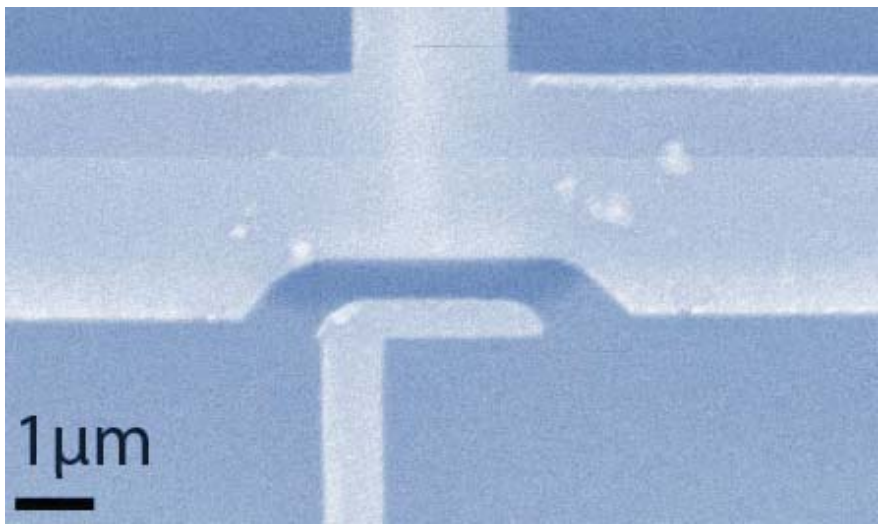
Now consider instead this simple but brilliant test design: What lead researcher Mike Lilly (1132) and coworkers at McGill University envisioned was to put the nanowires one above the other, rather than side by side, by separating them with a few atomic layers of very purely grown crystal. The result? Nanowires separated vertically by only 15 nanometers. And because each wire sits on its own independent platform, each can be independently fed and controlled by electrical inputs varied by the researchers.

"In the long run, our test device will allow us to probe how 1-D conductors are different from 2-D and 3-D conductors." **— Researcher Mike Lilly**

The researchers found, as reported online at DOI: 10.1038/NNANO.2011.182, and in the upcoming December 2011 *Nature Nanotechnology*, highly significant effects: Positive voltage boosts could be as high as 25 percent on the second wire.

The work required the crystal-growing expertise of John Reno (1132), the fabrication and measurement skills of McGill doctoral student Dominique Laroche, and elements of previous work by Jerry Simmons (1120).

"There are all sorts of people working on nanowires," says Mike. "They've been doing it for 20 years. At first, you study such wires individually or all together, but eventually you want a systematic way of studying the integration of nanowires into nanocircuitry. That's what's happening now. It's important to know how one-dimensional (1-D) wires interact with each other rather than regular wires.



NANOWIRE TEST DEVICE — The suitcase-like handle are the two nanowires, one above the other. The darkest areas are gallium arsenide crystal. The two lighter areas in the shape of "plus" signs are gold gates at the top and bottom of the device. (Scanning electron microscope image)

A 1-D wire is not the common thick-waisted household (3-D) wire, which allows current to move across, vertically, and forward, nor is it your smaller flattened micron-sized wires (2-D) in typical electronic devices that allow electrons to move forward and across but not up and down. In 1-D wires, the electrons can only move in one direction: forward, like prisoners coming to lunch, one behind the other.

Though the gallium-arsenide structures used by Mike are fragile, nanowires in general have very practical characteristics — they may crack less than their bigger cousins, they're cheaper to produce, and offer better electronic control. But it's as a problem in basic science that their characteristics fascinate Lilly.

The Coulomb drag effect

"In the long run, our test device will allow us to probe how 1-D conductors are different from 2-D and 3-D conductors," says Mike. "They are expected to be very different, but there are relatively few experimental techniques that have been used to study the 1-D ground state."

One reason for the difference is the Coulomb force, responsible for what is termed the Coulomb drag effect regardless whether the force hastens or retards currents. Operating between wires, the force is inversely proportional to the square of the distance; that is, in ordinary microelectronics, the force is practically unnoticeable, but at nanodistances, the force is large enough that electrons in one wire can "feel" the individual electrons moving in another placed nearby.

The drag means that the first wire needs more energy because the Coulomb force creates, in effect, increased resistance. "The amount is very small," says Mike, "and we can't measure it. What we can measure is the voltage of the other wire."

There are no straightforward answers as to why the Coulomb force creates negative or positive drag, but it does.

What's known, Mike says, is that "enough electrons get knocked along that they provide positive source at one wire end, negative at the other. A voltage then builds up in the opposite direction to keep electrons in place."

The so-called Fermi sea — a 3-D concept used to predict the average energy of electrons in metal — should totally break down in 1-D wires, which instead should form a Luttinger liquid, says Mike. A Luttinger liquid is a theoretical model describing the interactions of electrons in a 1-D conductor. To better understand the Luttinger liquid is Mike's underlying reason for the experiment.

Having an interest on many levels proved useful because making the test device "took us a very long time," says Mike. "It's not impossible to do in other labs, but Sandia has crystal-growing capabilities, a microfabrication facility, and support for fundamental research from DOE's office of Basic Energy Sciences (BES). Their core program is interested in new science and new discoveries, like the work we're doing in trying to understand the fundamental ideas behind what is going on when you're working with very small systems."

Device fabrication was conducted under a user project at the Center for Integrated Nanotechnologies, a DOE Office of Science national user facility jointly run by Sandia and Los Alamos national laboratories. The device design and measurement were completed under the DOE Office of Science BES/Division of Materials Science and Engineering research program.

Carbon-storage to rival oil and gas industry in size, Schlumberger VP predicts

John Tombari leads fourth discussion in Sandia's Climate Security program

By Neal Singer

Some may still be debating — if not global warming itself — then who or what's causing it, and whether its consequences be good or bad. But industrial giant Schlumberger (Schlum-ber-JHAY) simply plans on making money on one aspect of it: capturing excess carbon in the atmosphere and storing it.

John Tombari, president of Schlumberger Carbon Services, told an audience of 41 at Sandia's CNSAC auditorium (and 20 more from the University of Texas – Austin who attended via teleconferencing) that he foresaw the rise of a carbon storage industry that would rival the size of the oil and gas industry.

The talk on the company's proposed carbon capture techniques and possible storage locations was presented as part of Sandia's Climate Security Program. The talks, hosted by program director Rob Leland (1400), was the fourth in a series of lectures to explore possible dangers and opportunities of a change in climate.

Facilities would accept carbon by injection

Storage facilities of 100 square miles — "circles with a radius of 5 miles," Tombari later said dismissively, "not very big" — would one day dot the United States. Most numerous near industrial centers, power plants, and associated gas facilities, they would accept carbon by injection for 30 years and then be closed and handed over to an undetermined entity for long-term stewardship.

He estimated the cost of capturing and compressing carbon into a dense liquid at $30 to $70 a ton, transportation at $1 to $10 a ton by pipelines or ships, and then storage in mainly saline geological formations, either on land or offshore, at $5 to $15 a ton. Approximately 100 million tons would be stored, making carbon capture and storage a $10 billion business opportunity.

"CO_2 [carbon dioxide, the major form of atmospheric carbon] can be used as a thinner for oil recovery. Then it will stay in the earth, but that handles only 10 to 30 percent of the problem," Tombari said. "For the rest, we need saline formations where oil and gas didn't trap themselves, filled with salt water too high in concentration to be utilized as a water source." There are many of these, he said.

However, a considerable number of possible locations might not make the cut. "We're looking for rock in the earth with capacity, injectivity, and stability," he said.

Big grains are desirable for good storage. Their porosity and permeability are factors that can be measured. The ideal site, he said, would be at depths greater than 3,000 feet for containment and to keep the gas in its compressed phase. A confining layer of small grains above it is the ideal.

Lack of awareness an obstacle

"A 41 percent reduction [of airborne excess carbon] by 2030 from 2005 levels is technically feasible using a full range of portfolios," he said. These would include increased efficiencies in current power generation, as well as increased use of a panoply of non-carbon-emitting energy production sources such as wind, photovoltaics, and nuclear.

Getting carbon capture programs started is a problem because the general lack of awareness makes it difficult to involve the public in accepting carbon storage sites in, so to speak, their backyards. "Every site has different risks," Tombari said. "It's not like building the same generator after generator."

Technically, he said, the process would be very expensive to move forward "without a price on carbon, without incentive funding, without a sense of urgency to defuse NIMBY [not in my backyard], and a national and international regulatory framework."

Things would pick up, he said, once there was an agreement on the value to monetize carbon.

"The US has 27 percent of the world's coal reserves, so it's to US interests to actively pursue and improve methods of carbon capture," he said.

In the question period, Rob asked, "If carbon will be monetized, as you believe, can you make a prediction as to when that will happen, and what we will see preliminarily?"

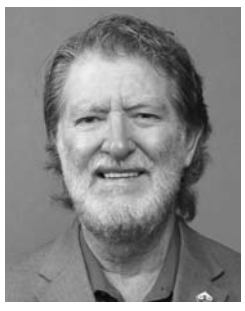
"You sound like my boss," said Tombari.

He estimated a beginning between 5 and 10 years. "You'd better start in 2018 if you want to put carbon in the ground by 2025."

Recent Retirees

New Mexico *photos by Michelle Fleming*

Ronald Halbgewachs
44 5623



John Anthes
37 5944

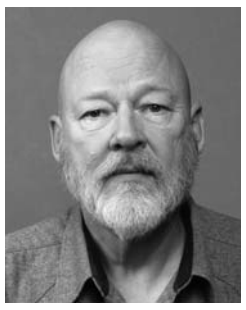
Jose M. Montoya
37 2132

John McBrayer
34 5358

Brenda Langkopf
31 6234

Ron Greene
34 5416

Bruce Gunckel
33 9538



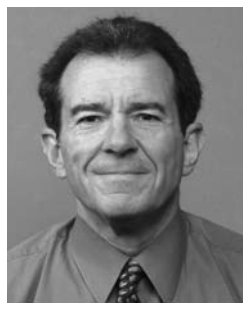
Mike Senglaub
33 5447

Reggie Tibbetts
33 4232

James Knapp
32 1111

Marlene Vigil
32 3333

Ramon Pacheco
31 2112



Joe Schofield
31 9535

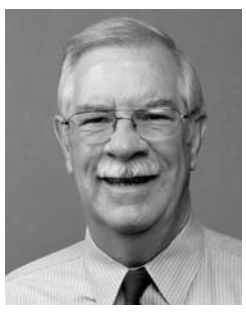
Tom Ashwill
30 6121

Thom Fischer
30 5760

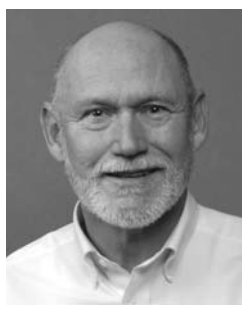
Lou Malizia
30 2548

Tom Salazar
28 10644

Dan Williams
27 4826



Robert Richards
26 753

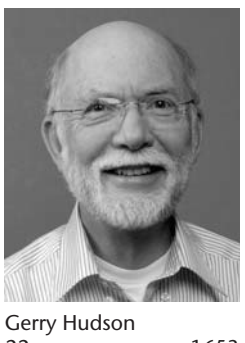


Donald Bridgers
24 4135

Mary Adams
23 97

Sylvia Thomas
23 10628

Camille Gibson
22 10243

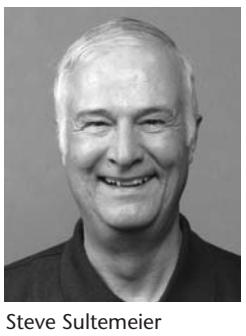


Gerry Hudson
22 1653

Ronald Schiller
22 9543

Steven Grieco
21 421

Sandra Wagner
20 10614

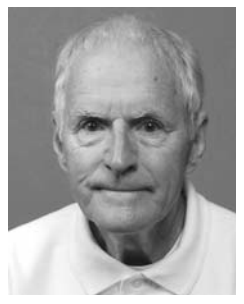


Steve Sultemeier
17 4032

Linda Hillis
13 20

Mileposts

New Mexico *photos by Michelle Fleming*



Richard Spalding
50 5730

Steve Kuehn
35 5965

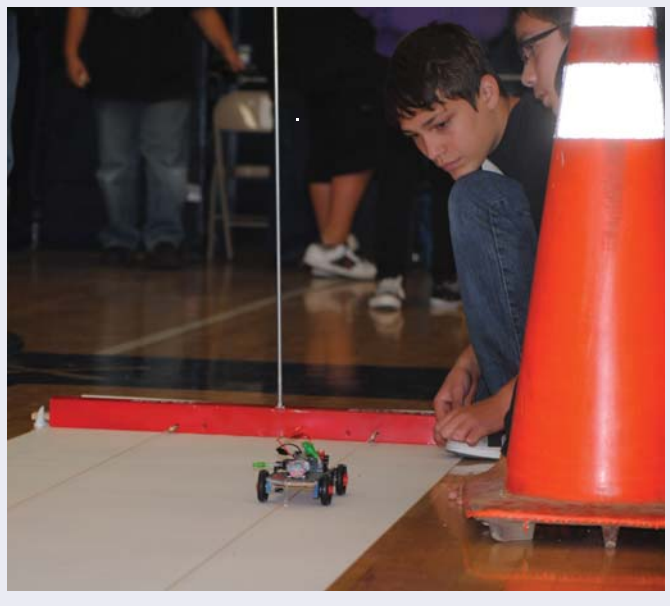
Donna Filip
25 10666

Samantha Flores
20 4249

Carol Eubanks
20 2996

Sandia sponsors N.M. Hydrogen Fuels Challenge

By Iris Aboytes



Sandia was one of the sponsors of Albuquerque Public Schools' sixth annual New Mexico Hydrogen Fuels challenge, held recently at Highland High School. Fifty middle schools teams — 300 students from 29 middle schools from around the state including Carlsbad, Espanola, Las Cruces, and Gallup — participated.

In addition to racing their built-from-scratch hydrogen-powered cars, the students were required to write a short essay on alternative fuel. That was followed by an oral presentation.

The project-based learning event restricts students to using a provided hydrogen fuel cell and electric motor.

First place went to Madison Middle School from Albuquerque. Ernie Pyle, also from Albuquerque, took second place. Third place went to P.R. Leyba Middle School from Carlsbad.

"This was one of the most diverse group of students," says project leader Cheryl Garcia (3652). "It is awesome watching them as they try their best. Each one was a winner in my book."

Food, Fun, Family and Friends

Retiree BJ Jones publishes cookbook

By Iris Aboytes

She did it. Retiree BJ Jones' cookbook, *Food, Fun, Family and Friends,* has just been published and is available on Lulu.com. To hear BJ tell it, she started writing it back in Christmas 1985. "I received my first journal and began recording our parties," says BJ.

The cookbook is based on BJ's own tested recipes in entertaining.

As a child, BJ says, some of her favorite programs were *Julia Child* and *The Galloping Gourmet*. As the oldest of three daughters, her working mother, Joanne, was happy to let her experiment in the kitchen, and experiment she did.

The Danish side of her family celebrated many family events with wonderful Danish food, so BJ appreciated good food from a very early age. One of her grandmothers was head of a rural school district cafeteria program. "When I was 14, I helped my grandmother cook for the YMCA camp," says BJ. "In high school, I catered family dinner parties and was written up in our local newspaper, *The Fresno Bee* (Fresno, Calif.).

YUM, YUM — Irresistible aromas invite a hungry guest as BJ stirs the pot.

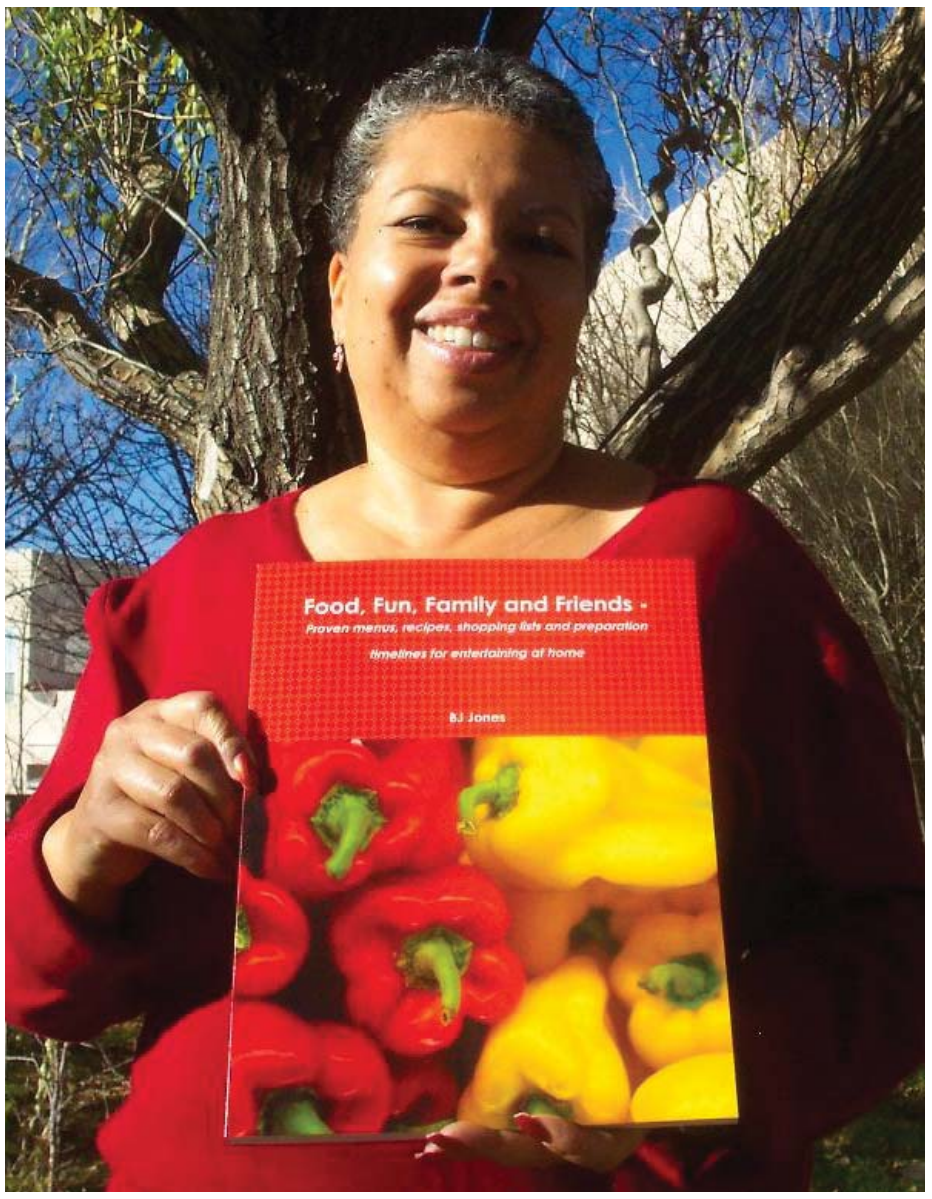
In 1983 BJ married Orlando Lucero and moved to his native New Mexico. BJ began her career in Human Resources management at Sandia in 1984, but continued to cook, entertain and collect recipes. "I decided to type our favorite recipes and have them bound as homemade cookbooks to give out as Christmas presents to family in friends," says BJ. "Thus began our annual tradition. I constantly try new recipes and my family rates them. Those that receive excellent ratings are part of our annual private cookbook.

"When you cook and entertain a lot, there are bound to be some unwelcome surprises. In fact, the first party I put in the book was Christmas 1985 when my family from California came to visit us in our new home in Albuquerque. New home, new appliances — what could go wrong? Well, the refrigerator door got stuck and would not open. I had to get the stuffing and crown pork roast into the oven. The guys wrestled the door open and the stuffing tumbled out all over the floor. I was horrified because we were raised to be neat and clean, not to scrape our dinner off the floor! As with so many mishaps in life, this incident has proven to be a great family story and memory."

In 1996 Orlando surprised BJ and submitted her name for a contest celebrating the 75th anniversary of Betty Crocker. She was selected as one of 75 women across the US and Canada to be included in the updated 1996 image of Betty Crocker. The contest celebrated women who love to cook and nourish others as a part of their busy lives.

When BJ retired from Sandia, she channeled her creative energies into making her wish to publish a cookbook a reality. She hopes the book inspires others to take up the heart-centered practice of entertaining at home.

"Orlando and I are privileged to be involved in various volunteer opportunities in our community," says BJ. "I believe it is important that we take the time to nurture not only our bodies but also our souls. Having people join us for the fellowship of a meal is the best example of real social networking. Sometimes we donate a dinner at our home as a fundraiser for an organization. It allows me to have fun planning and creating a party while raising money for a great cause."



COOKING AND BOOKING — BJ Jones proudly displays her labor of love, the cookbook she vowed to write when she retired. (Photos courtesy of BJ Jones)

To find out more about BJ's book go to lulu.com/spotlight/bjjones. It is currently available in Albuquerque exclusively at ScoJo's Gift and Cards, Paseo del Norte at Wyoming.

"I think my cookbook is for someone who would appreciate having the pre-planning for entertaining done. That will enable them to concentrate on the fun of the event," says BJ. "I know people are busy. We are all multitasking and juggling these days, but it means so much to friends, family, and acquaintances when you take time and invite them to your home for a meal."

"I hope you enjoy it as much as I enjoyed creating it."

Participating in sports teaches the value of teamwork

Sandian Nikki Lobato learned her lessons well as member of Lady Lobos basketball squad

By Iris Aboytes

"That's my mama," says 4-year-old Ryan Lobato, pointing to the radio. His mom is Sandian Nikki Lobato. Nikki does the color commentary for the University of New Mexico (UNM) Lady Lobo basketball games on 610 KNML, the Sports Animal.

From 1997 to 2001 Nikki, then Nikki Heckroth, was the point guard for the Lady Lobos. She was the team captain for two years and was Academic All-Mountain West Conference the final three seasons. She had a school-record 200 assists in the 2000/2001 school season.

NIKKI LOBATO

"You can bet that if I had another year of eligibility, I would gladly join the Lobos for another season."

Nikki earned an accounting degree from UNM and came to Sandia in 2004. She began her career in the area of Safeguards and Security, where Sandia supported her in earning a master's degree in accounting. Nikki is now in Org. 10666, where she provides business partnering with Center 6600, Critical Asset Protection & Security. She is the business financial lead in two program areas that include the Nuclear Counterterrorism Incident Response (NCTIR) Program in the Nuclear Weapons (NW) SMU and the Critical Asset Protection Program in the International Homeland and Nuclear Security (IHNS) SMU.

In 2007, Nikki was approached about being the color commentator with Joe Behrend, the sportscaster. The adrenalin still pumping from her days as a Lobo, she accepted.

"The Pit is one of the most exciting venues to play a collegiate basketball game," says Nikki. "It is ranked seventh the country in attendance for women's basketball. That speaks volumes for the atmosphere the Pit provides. I was lucky to be part of such an amazing basketball environment. I was excited to be in that venue again.

"You can bet that if I had another year of eligibility, I would gladly join the Lobos for another season," says Nikki.

Being a color commentator is a good way to stay close to basketball without the day-to-day practices, says Nikki. "I was fortunate to be coached by [retired UNM coach] Don Flanagan. Not only was he a good coach, but he taught us a positive approach to visualizing success."

She would have loved to play overseas. "In retrospect, I was ready to stop playing," says Nikki, "but I love to travel and would have loved to play in New Zealand or Australia. I have visited and enjoyed New Zealand as a tourist."

When March Madness comes along, you can count on her family — Ryan, her husband, Jason (10508), and her 2-year-old daughter Payton — to be in Las Vegas.

"Growing up in the sports arena is a very healthy environment," says Nikki. "It teaches us winning and losing lessons, plus it teaches us all the value of teamwork."

Nikki loves working at Sandia. "Sandia is a big community with people leading several different careers," she says. "Sandia affords you a good work/life balance."

So next time you attend a Lobo game or listen to the radio, remember you're hearing someone from our community. Nikki is an accountant who just happened to be a top Lady Lobo.