GUIDING LIGHT

Sandia researchers create 3-D metasurfaces using III-V semiconductors, opening a world of optical possibilities

By Neal Singer

Last night I saw upon the stair,
A little man who wasn't there,
He wasn't there again today
Oh, how I wish he'd go away.

— From the poem *Antigonish*, by William Hughes Mearns (1899)

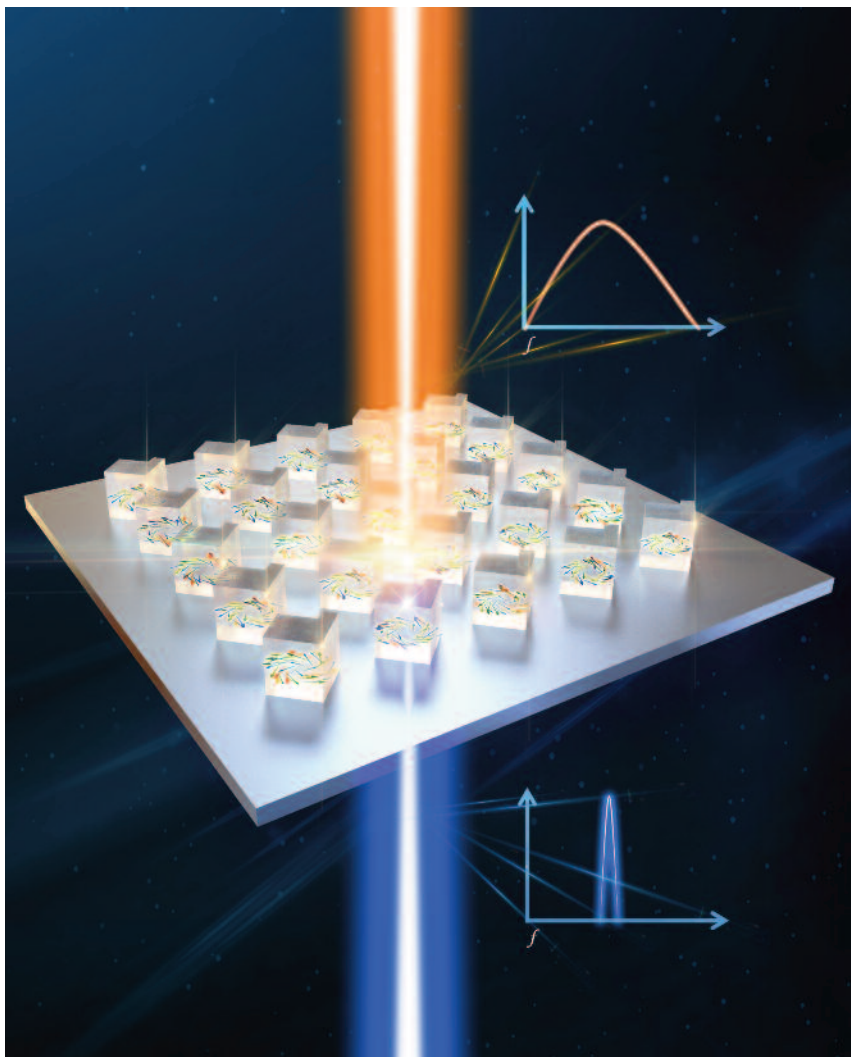
Like the little man upon the stair, metamaterials don't exist in nature, but unlike him, no one wants them to go away. Formed by nanostructures that act as "atoms," or unit cells, arranged on a substrate to alter light's path in ways no ordinary material can achieve, these surrogate substances can manipulate an incoming light beam's characteristics to enable more efficient versions of already known devices — optical filters, lasers, frequency converters, and beam steering devices, for example. They might create ultra-thin lenses and ultra-efficient cell phone antennas, bend light to keep satellites cooler, and make photovoltaics more efficient by enabling the absorption of more energy. They offer, in short, a world of possibilities.

"There is very little worldwide on all-dielectric metamaterials using III-V semiconductors. Our advantage is Sandia's vast access to III-V technology, be it growth or processing, so we can move pretty fast."

— Sandia researcher Igal Brener

One problem restraining extensive commercial use of this technology is limitations imposed by the materials composing them. Metal-based metamaterials are lossy at

(Continued on page 4)



THE BROKEN-SYMMETRY METASURFACE of cuboid resonators shows a spectrally broad incoming light wave (the graph on top shows a broad spectrum). After passing through the metasurface, the beam becomes spectrally narrow due to the sharp resonances of the broken symmetry metasurface. (The graph on the bottom shows a narrow spectrum.) The swirling pattern of arrows represents the electric field distribution of light trapped in the resonators.

Labs Director Jill Hruby ranked No. 2 on* Business Insider *list of most powerful women in US tech.

Story on page 4.

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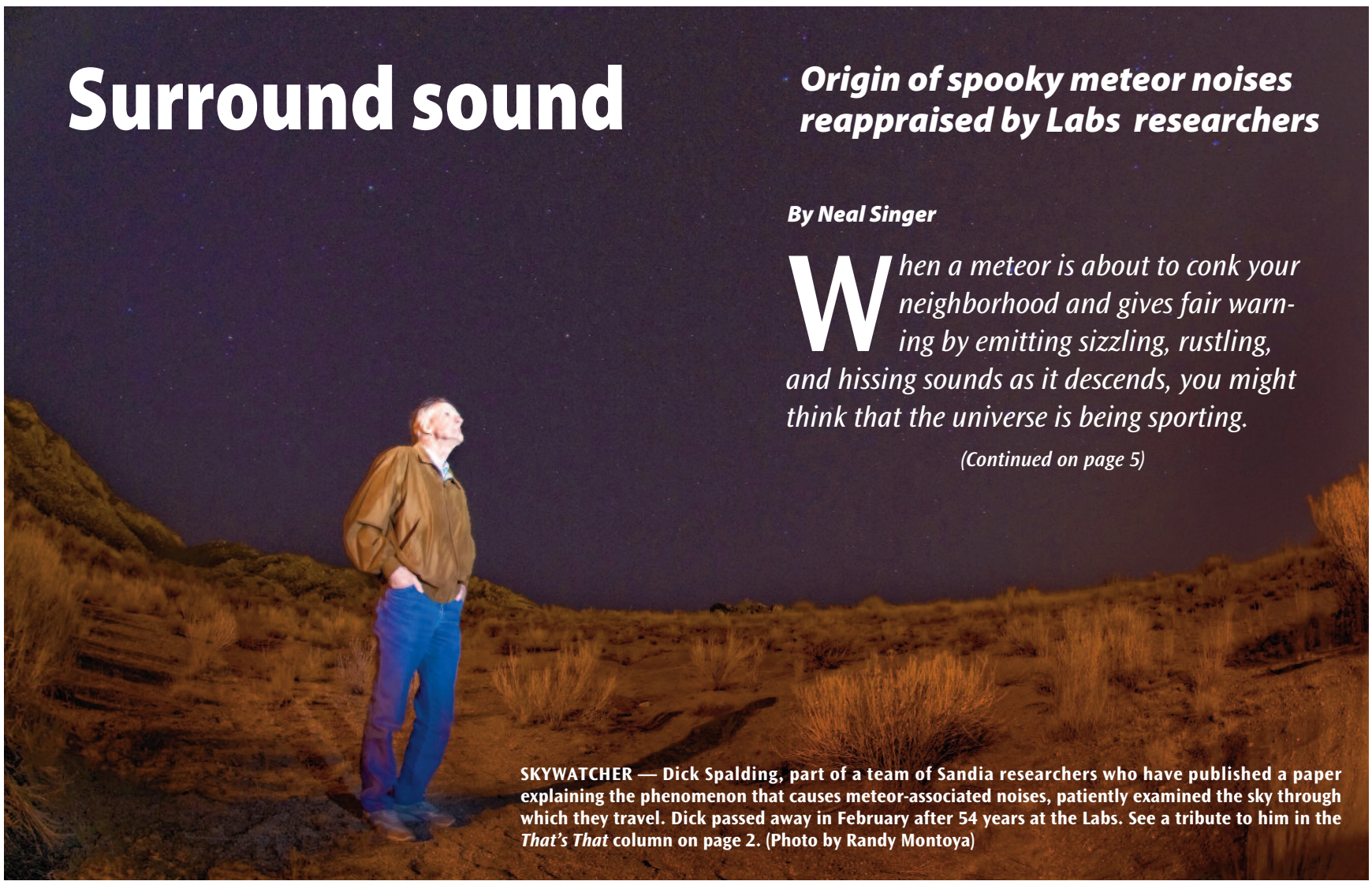
Surround sound

Origin of spooky meteor noises reappraised by Labs researchers

By Neal Singer

When a meteor is about to conk your neighborhood and gives fair warning by emitting sizzling, rustling, and hissing sounds as it descends, you might think that the universe is being sporting.

(Continued on page 5)



SKYWATCHER — Dick Spalding, part of a team of Sandia researchers who have published a paper explaining the phenomenon that causes meteor-associated noises, patiently examined the sky through which they travel. Dick passed away in February after 54 years at the Labs. See a tribute to him in the *That's That* column on page 2. (Photo by Randy Montoya)

STOCKPILE STEWARDSHIP
PAGES 6-7.

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SUPER PLANTS NEED SUPER ROOTS
PAGE 9.

That's that

Dick Spalding died in February after 54 years of service to the Laboratories and the nation. He was a unique thinker, a brilliant, kind, and gentle man. He always seemed to me to have a twinkle in his eye, like he'd just thought of something wonderful that hadn't yet occurred to anyone else. And he probably had!

I had the pleasure of interviewing Dick several times, going back to the late 1990s, for *Lab News* stories. I would like to think we became friends. Not that we hung out after work, but from time to time, I'd invite Dick over to my office or vice versa to just talk about things he'd been thinking about lately.

And his thinking was certainly original. Being out of step with majority opinion in the science community was really characteristic of Dick. Trained as an electrical engineer, he spent most of his career working in Sandia's nuclear detonation detection programs. The value of his contribution to the Labs and the nation in that role can't be overstated. His commitment to improving our understanding of the world around us, of the cosmos, was total.

As a senior NASA official who worked with Dick said upon learning of his death, "He was a great man as well as an insightful scientist and a hero to us all, albeit largely unsung. It is nice to see this latest paper come out [see story on page 1] and know that he was active to the end in uncovering the mysteries of nature."

Dick's lifelong quest to understand the underlying reality of things led him far afield from mainstream science. In a story about Dick that I wrote in 2009, he noted that in the course of his work he was seeing atmospheric behaviors for which he could find no good explanation. "Looking into these dilemmas got me to thinking that, hey, science doesn't know everything about some of these phenomena." He made it his business to try to figure them out.

A few months before he passed away, Dick was in the process of organizing a series of luncheon meetings with a few like-minded Sandians — or maybe more accurately, Sandians like me who were just fascinated by hearing Dick's ideas. Dick asked me to serve as a sort of historian, keeping track of the course of the discussions, which were sure to raise some original, out-of-the-box concepts. I was very happy to be involved, if just for the sheer exuberance of listening to Dick explain things his way.

In anticipation of those lunchtime gatherings, Dick put together a list of some of the things he wanted to address over the next few months. "In thinking about subjects that might be the focus of our luncheon get-togethers," he wrote in an email almost exactly a year ago, "I pulled together the following list: Atmospheric Electricity Revisited • 1978 Bell Island and Similar Events • Ball Lightning • Tommie Gold • Fossil Fuels, Global Warming, and Earth Expansion • The Jumbo-Jet Syndrome • Earthquake Prediction • Hurricane Mitigation • UFOs — The Spalding Viewpoint • Cattle Mutilations • Woolly Mammoth Graveyards • Arctic Muck • Falls of Material — Fish, Frogs, Ice, etc. • Meteor Electrophonic Sounds."

Those luncheons never happened. Dick's health took a turn for the worse and he never really recovered. The world's a poorer place that we didn't document those conversations that might have been.

As you can glean from a consideration of the list above, Dick's was a wide-ranging intellect. But don't get the wrong idea, what with UFOs, cattle mutilations, and what-not — Dick was no crackpot. He was a scientist and engineer right down to his marrow. He didn't look to alien beings or giant conspiracies to explain what he wanted to understand. He was deeply interested in finding rational explanations for some of the unexplained phenomena people have seen and reported for millennia.

For me, Dick embodied the best of what it is to be a Sandian: endlessly curious, enthusiastic about his work, and committed to serving the nation. He stayed at the Labs far longer than most for a very simple reason: "I like what I'm doing better than anything I can see out there," he told me when he reached his 50th year here.

When I think of Dick now, I'm reminded of the words from the song "I Believe in You": "You have the cool, clear eyes of a seeker of wisdom and truth/Yet there's that upturned chin and the grin of impetuous youth."

That was Dick, all right, right to the end: forever young.

See you next time.

— Bill Murphy (MS 1468, 505-845-0845, wtmurph@sandia.gov)

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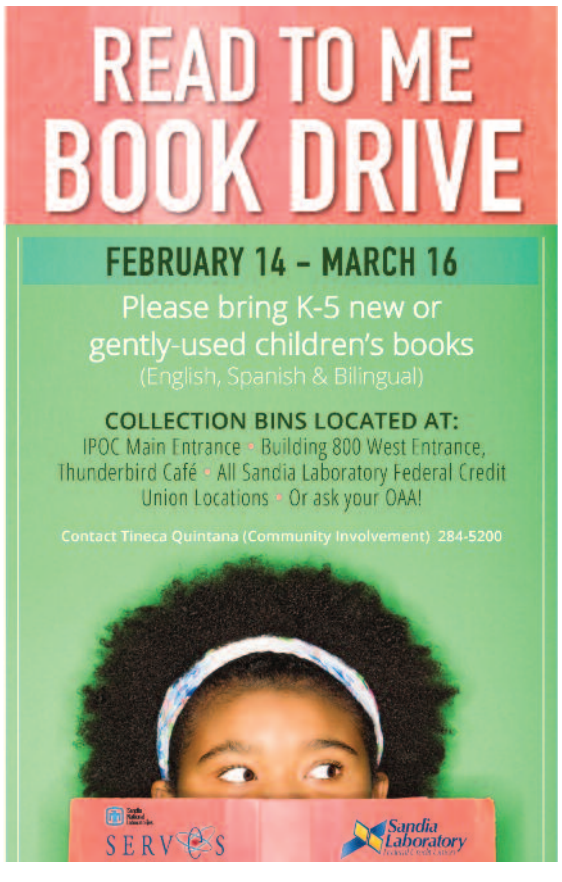


Employee death

Colleagues say goodbye to a fiercely loyal friend

MICHAEL R. TAYLOR, 65, who had 34 years of experience at Sandia, passed away Feb. 15 after a short illness. Mike started at Sandia in 1982 as a technologist, completed college and became a Principal Member of Technical Staff for Dept. 2137. According to his manager, Brent Blankenship, from day one when Mike hired on, he made his mark on the Nuclear Weapon mission.

"Mike was best known as a straight talker and someone you would go to when things got tough," Brent says. "He ran toward problems rather than away from them."


MICHAEL R. TAYLOR

Mike was known as a team player who never let the group down. He didn't look for kudos and didn't seek the spotlight; instead, he was the guy taking whatever time it took crunching the numbers or running the tests to solve a problem.

His colleagues say Mike's efforts resolved numerous issues across the stockpile during his long career. During the W76-1 Life Extention Program, for example, he was instrumental in resolving several challenging issues in roles varying from lead electrical engineer to weapon system lead.

Answering the call

"In those days," Brent says, "our team and myself were struggling. In typical fashion, he answered the call and joined the team.

"I had the privilege to share an office with Mike for several years. His demeanor and example taught me patience and dogmatic perseverance in tackling hard technical challenges. When those Friday 4:30 p.m. phone calls came in during early production about a problem in the field, we would listen to the issue, hang-up, crack a joke, or just laugh out loud on how much trouble we were in and then go about fixing it."

Brent recalls that when he needed a leader to help on the W88 Alt a few years later, Mike answered the call again. Unfortunately his illness changed the plan. But even then — even up until his final days in the hospital — Mike was offering advice and interest.

"He would have given anything to get back into the office to help," Brent says. "It is hard to find that dedication. As the word is getting out about Mike's passing, I am still getting calls of condolences from LANL, Pantex, and Kansas City."

Mike's recent safety assessment duties included closely reviewing and assessing several challenges with the stockpile across multiple systems. His manager in that effort, Darren Hoke, says, "I had the pleasure of working closely with Mike from January 2011 to October 2016 in my role as his manager in Independent Nuclear Safety Assessment and I am proud to have also called him my friend. Technically, Mike was our go-to electrical engineer and he demonstrated a deep understanding of all the stockpile weapons, from production, to operation, to disassembly."

Mike never hesitated to share his vast knowledge with anyone in a non-threatening and patient manner, Darren says, noting, "He was a willing mentor to many people at Sandia, including me."

Mike's colleagues remember him as a straightforward guy; you always knew where you stood with him, they say, adding that he was not afraid to let you know what was on his mind. Outside of work, Mike was fiercely loyal and a good friend.

"Mike could portray an image of sternness, and I sometimes heard folks refer to him as 'Scary Mike,' but once you got to know him it was far from reality," Darren says. "I can recall several times laughing so hard with Mike about something or other that it brought tears to our eyes."

Mike was the embodiment of the Sandia value of "service to the nation." Brent says. "To borrow a quote from Ronald Reagan, 'Most people go through their life not knowing if they made a difference . . . Mike Taylor does not have that problem.'"

Another tribute to Mike and his Sandia family, Brent notes, was the number of colleagues at the Labs who helped with Mike's care every day for the last several months. "Sandia lost one of our own, and it hurts," Brent says. "Godspeed and rest in peace Mike 'Megaton' Taylor."

A memorial service to celebrate Mike's life and honor his memory will be held at The National Museum of Nuclear Science and History March 16, 4-7 p.m.

Sweating the small stuff

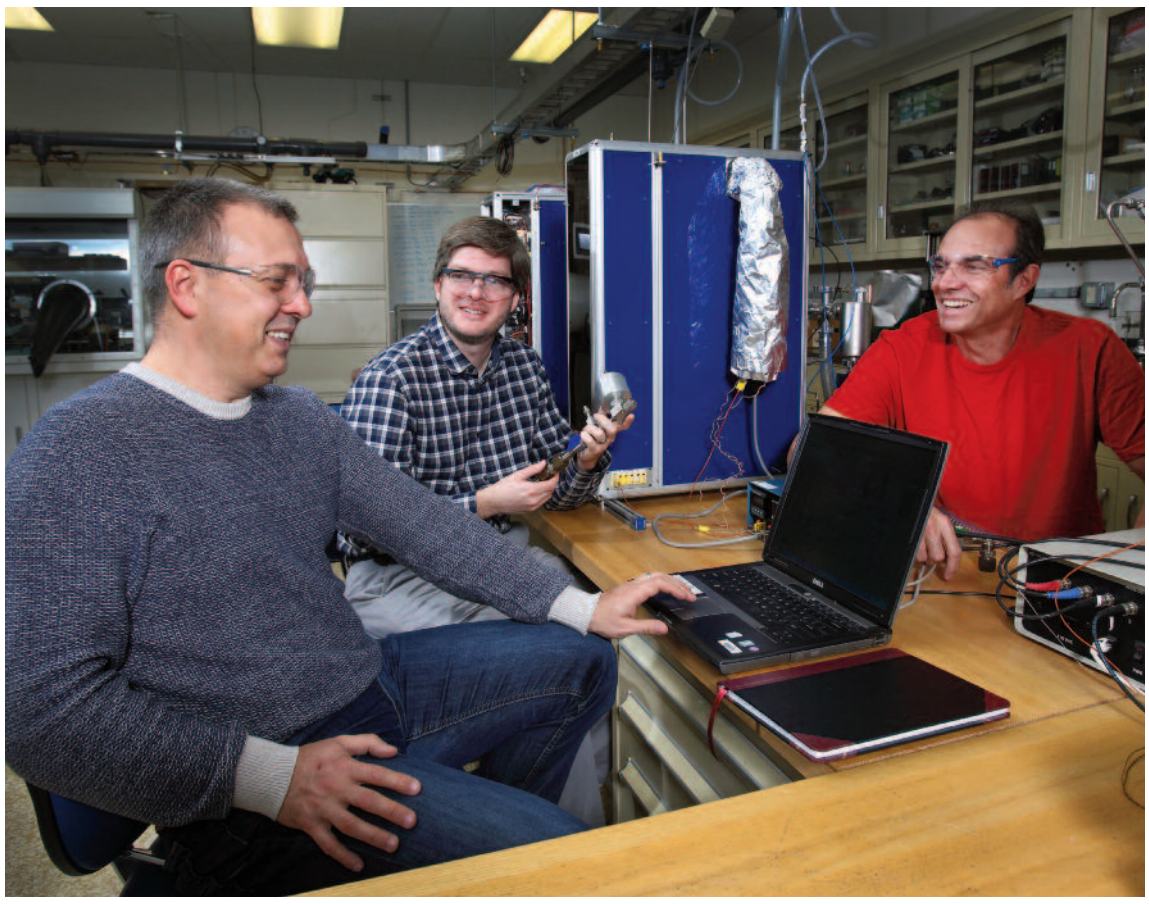
Sandia researchers use confined nanoparticles to improve hydrogen storage materials performance

By Michael Padilla

Sometimes, you have to go small to win big. That is the approach a multi-lab, interdisciplinary team took in using nanoparticles and a novel nanoconfinement system to develop a method to change hydrogen storage properties.

This discovery could enable the creation of high-capacity hydrogen storage materials capable of quick refueling, improving the performance of emerging hydrogen fuel cell electric vehicles. Sandia, Lawrence Livermore National Laboratory (LLNL), the National Institute of Standards and Technology, and Mahidol University in Bangkok, Thailand, collaborated on the research, published Feb. 8 in the journal *Advanced Materials Interfaces*.

The work was funded by DOE's Fuel Cell Technologies Office and Boeing.



SANDIA CHEMIST VITALIE STAVILA, left, talks to Lawrence Livermore National Laboratory computational scientist Brandon Wood, center, and Sandia chemist Lennie Klebanoff. (Photo by Dino Vournas)

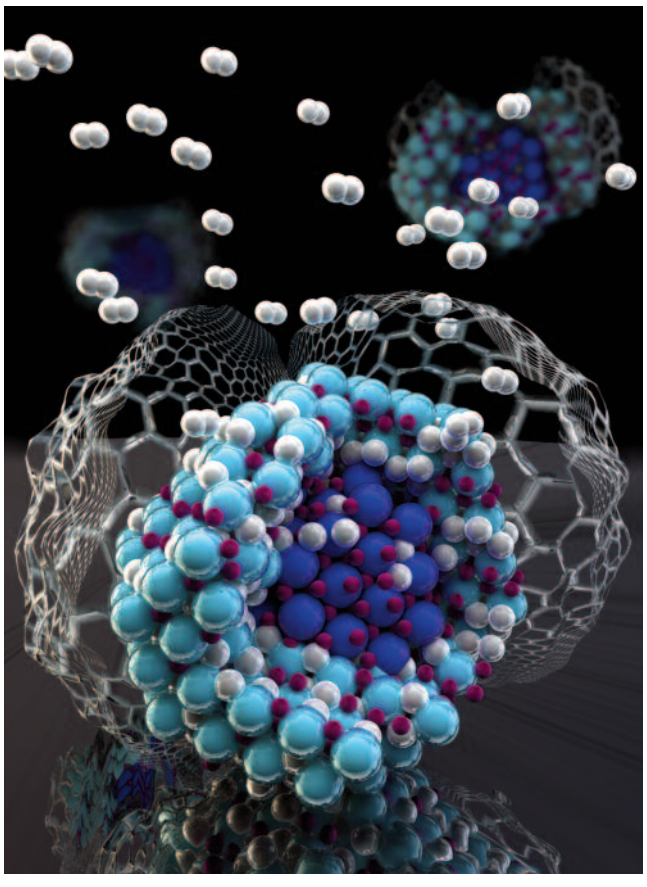
Accelerating the uptake and release of hydrogen

Hydrogen fuel cell vehicles are powered by an electrochemical reaction between hydrogen and oxygen inside a fuel cell. While oxygen is provided by air, the hydrogen must be stored separately on the vehicle. Current fuel cell electric vehicles store hydrogen as a high-pressure gas.

A solid material can act like a sponge for the absorption and release of hydrogen — in chemical terms, hydrogenation and dehydrogenation. Thus, using such a hydrogen storage material could increase how much hydrogen can be stored. The material must be able to store enough hydrogen for the vehicle to go at least 300 miles before refueling.

"There are two critical problems with existing sponges for hydrogen storage," says Sandia chemist Vitalie Stavila (8341). "Most can't soak up enough hydrogen for cars. Also, the sponges don't release and absorb hydrogen fast enough, especially compared to the five minutes needed for fueling."

In this effort, Vitalie says, the interdisciplinary team of scientists worked closely on the synthesis, characterization, and modeling to improve the properties of lithium nitride, a promising hydrogen storage sponge. The team also developed a fundamental understanding of why nanosizing improves the hydrogen storage properties of this material.



HYDROGENATION forms a mixture of lithium amide and hydride (light blue) as an outer shell around a lithium nitride particle (dark blue) nanoconfined in carbon. Nanoconfinement suppresses all other intermediate phases to prevent interface formation, which has the effect of dramatically improving the hydrogen storage performance.

Confining the space

The idea came from Mahidol University graduate student Natchapol "Golf" Poonyayant, who approached Sandia with the idea of using nanoconfinement to enhance hydrogen storage reactions in nitrogen-containing compounds. Working with the Sandia researchers, Poonyayant, his adviser Pasit Pakawatpanurut, and fellow Mahidol student Natee "Game" Angboonpong found that liquid ammonia could be used as a gentle and efficient solvent for introducing metals and nitrogen into the pockets of carbon nanoparticles, producing nanoconfined lithium nitride particles.

The new material that emerged from Poonyayant's idea showed some unusual and unexpected properties. First, the amount of lithium nitride in the carbon nanoparticle host was quite high for a nanoconfined system, about 40 percent. Second, the nanoconfined lithium nitride absorbed and released hydrogen more rapidly than the bulk material. Furthermore, once the lithium nitride had been hydrogenated, it also released hydrogen in only one step and much faster than the bulk system that took two steps.

"In other words, the chemical pathways for both hydrogen absorption and release in this hydrogen storage material were dramatically changed for the better," says Sandia chemist Lennie Klebanoff (8367).

Understanding the puzzle

To better understand the mechanism responsible for this improvement, the Sandia scientists reached out to computational scientist Brandon Wood of LLNL, a leading expert in the theory of solid-state reactions. Wood and his LLNL colleagues Tae Wook Heo, Jonathan Lee, and Keith Ray discovered that the reason for the unusual behavior was the energy associated with two material interfaces.

Since the lithium nitride nanoparticles are only three nanometers wide, even the smallest energetically unfavorable process is avoided in the hydrogen storage properties. For lithium nitride nanoparticles undergoing hydrogenation reactions, the avoidance of unfavorable intermediates — extra steps in the chemical process — increases efficiency.

Taking the path of least resistance, the material undergoes a single-step path to full hydrogenation. Similarly, once hydrogenated, the nanoparticles release hydrogen by the lowest energy pathway available, which in this case is direct hydrogen release back to lithium nitride.

"In this way, the nanointerfaces drive the hydrogen storage properties when the materials are made very small, for example with nanoconfinement," says Wood. "The purposeful control of nanointerfaces offers a new way to optimize hydrogen storage reaction chemistry."

The next step

According to the Sandia and LLNL researchers, the next step is to further understand how the dehydrogenated and hydrogenated phases of lithium nitride change at the nanoscale. This is a stiff challenge to the team, as it requires imaging different chemical phases within a particle that is just a few nanometers wide.

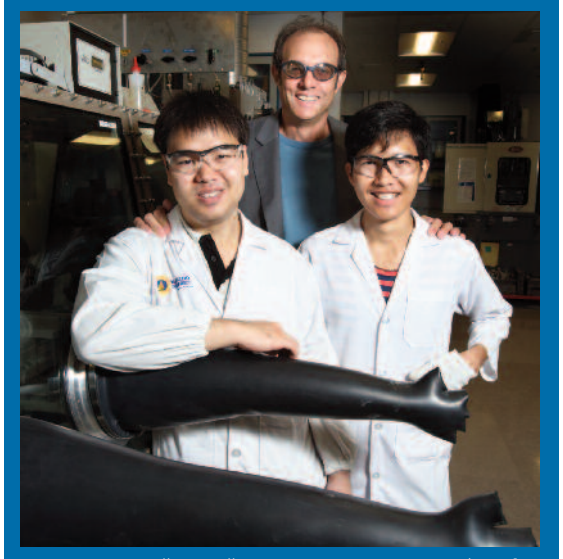
The team will draw on the capabilities in DOE's Hydrogen Storage Materials Advanced Research Consortium (HyMARC), led by Sandia and which includes scientists from LLNL and Lawrence Berkeley National Laboratory. The team plans to use spatially resolved synchrotron radiation from LBNL's Advanced Light Source to probe interface chemistry and structure.

In addition, since the nanoporous carbon host is "dead weight" from a hydrogen storage perspective, the team is examining ways to "lighten the load" and find carbon materials with more nanopockets for a given carbon mass.

Remembering 'Golf'

Colleagues mourn loss of dear friend and gifted researcher Natchapol 'Golf' Poonyayant

"We are thrilled with this technical advance and excited to take on the work ahead," says Lennie Klebanoff. "But it's bittersweet. Golf, who inspired this work and conducted many of the syntheses, died tragically at the age of 25 during the writing of this paper. The world has lost a talented young man and we have lost a dear friend whom we miss. This work and its published account are dedicated to Golf and his family."



NATCHAPOL "GOLF" POONYAYANT, Lennie Klebanoff, and Natee "Game" Angboonpong in the lab. (Photo by Randy Wong)

Metamaterials

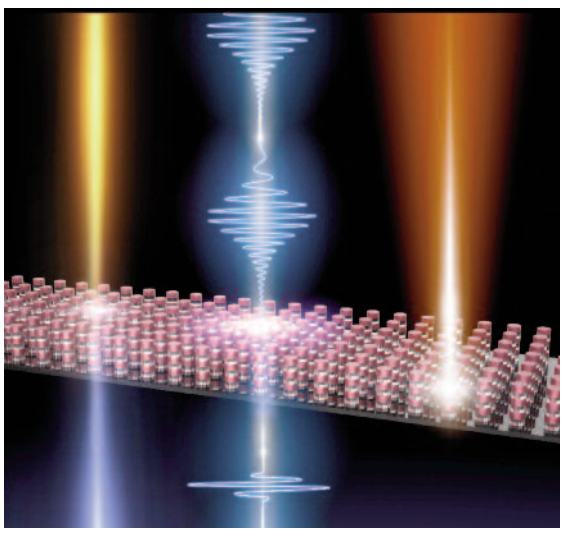
(Continued from page 1)

shorter wavelengths and can only operate effectively at low frequencies, such as the radio frequencies used by radar, before being overwhelmed by their own absorption. Silicon doesn't emit light and can transmit it only in a limited wavelength range because of its narrow bandgap. Neither material can create a metamaterial that will operate in the infrared and optical ranges.

Optical metamaterials enter the arena

Now Sandia researchers have published technical papers — three in the past year — that are helping lead the way to the use of III-V semiconductors as the building blocks of metamaterials. More efficient than metals for optical metamaterial applications, with wider bandgaps than silicon, the III-V work featuring materials like gallium-arsenide and aluminum-arsenide is promising enough to have been featured by covers for two technical journals. (III-V refers to columns in the periodic table of elements.)

"There is very little work worldwide on all-dielectric metamaterials using III-V semiconductors," says Igal Brener (1765), who has led the Sandia work with Mike Sinclair (1816) and Sheng Liu (1765). "Our advantage is Sandia's vast access to III-V technology, be it growth or processing, so we can move pretty fast."

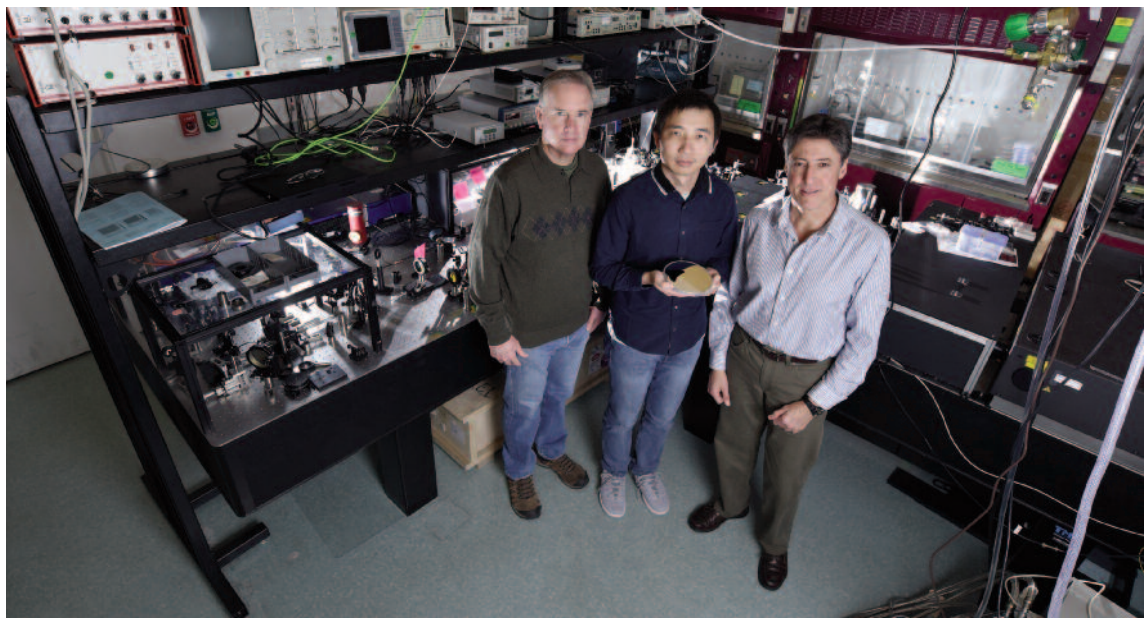


THIS THREE-RESONATOR-THICK III-V metasurface of cylindrical resonators illustrates three possible uses: The left light beam changes color as it passes through the metasurfaces, signifying that nonlinear harmonic generation is taking place that converts the light beam to a shorter wavelength. The blue trace in the middle shows a train of pulses passing through the surface. As they pass, the pulse width decreases due to pulse compression, which requires that the phase of the transmitted optical wave vary with the wavelength. The multilayer metasurfaces are able to achieve the correct phase variation — something not possible with single layer metasurfaces. The beam on the right signifies that these metasurfaces can act as efficient emitters of light.

Shinier than gold

The new Sandia dielectric materials not only lose little incoming energy but can even be fabricated in multiple 3-D layers to form complex meta-atoms that reflect more light than shiny gold surfaces, usually considered the ultimate in infrared reflectivity. The III-V materials also can emit photons when excited — something that silicon, which can reflect, transmit, and absorb — can't do. Another advantage of these dielectric materials is their highly nonlinear responses, enabling the generation of light at different colors that could be used for extending the wavelength range of lasers or for generating "entangled photons" for quantum computing.

Another attractive aspect of the Sandia approach is the relatively simple method of forming the artificial atoms, known as resonators, that are the guts of the metamaterial.



META-PHORICALLY SPEAKING — Mike Sinclair, left, Sheng Liu, and Igal Brener stand in the laboratory where work was done to create metamaterials on substrates. One version here is presented by Sheng.

(Photo by Randy Montoya)

"In one simulation, we happened to cut a corner of the cube and all of a sudden very sharp reflection bands appeared."

— Sandia researcher Mike Sinclair

Created under the supervision of Sheng Liu, hired as a post-doc five years ago and converted to staff a year ago, the meta-atoms are a few hundred nanometers in diameter and composed of many actual atoms. One of Sheng's insights was to oxidize these tiny groupings around their perimeters to create layered coatings with a low index of refraction, rather than use a more expensive, time-consuming "flip-chip" bonding process. The complexity of previous methods was an obstacle to cost- and time-efficiency in achieving the same result. His simplification, he says, previously had been used by other researchers in 1700 to make lasers, but not metamaterials.

The oxidized, low-index surface surrounds the high-index core "like in winter time, you have a coat surrounding you," Sheng says. "To confine light, you need a high refractive-index contrast." Put colloquially, interior light bumping into the low-indexed oxide surface is herded back by the refractive difference into travelling along the high-index core.

Gordon Keeler (1764) achieved controlled oxidation simply by putting III-V materials in a hot oven and flowing water vapor over the sample. "It will oxidize at a certain rate," Sheng says. "The more material, the longer it takes."

The manmade meta-atoms are sculpted in place during a lithographic process that permits researchers to make whatever pattern they chose for the placement of the metamaterial components. "We use simulations to direct us," Sheng says. Spacing to some extent is determined by the size of the manmade atoms.

Fractured cubic nanostructures store unusually large amounts of energy

The researchers experimented with cylindrical and cubic nanostructures, reducing the symmetry of the latter to achieve even better properties.

"Cylinders are much easier to fabricate and typically can be used for conventional metasurfaces," says Igal. "But in the *ACS Photonics* paper [that concerned cubic shapes], broken symmetry cubes are crucial to obtain very sharp resonances. That's the key issue of the paper."

The idea of intentionally reducing the symmetry of a cubic resonator nanostructure originated five or six years ago, says Mike, with a serendipitous design that happened to break the intentionally symmetrical shape of the meta-atoms in an attempt to mimic a possible manufacturing flaw. "During a Grand Challenge Laboratory Directed Research & Development (LDRD) project on metamaterials, when we were first fabricating cubic resonators in our effort to see if we could get beyond microwaves into infrared and optical metamaterials," says Mike, "we were playing with the shape of resonators to try to simulate the effect of lithography errors. In one simulation, we happened to cut a corner of the cube and all of a sudden very sharp reflection bands appeared." Prior to that discovery, dielectric resonator metamaterials only showed broad bands that didn't trap much energy. The researchers found that the new sharp resonances allowed larger amounts of energy to be stored in the design — beneficial for efficient frequency conversion, and perhaps even for light emission and lasing.

The exploration of the crimped resonator didn't fit under the Grand Challenge, and was explored later under the auspices of DOE's Basic Energy Science office. Salvatore Campione, building on previous work by Lorena Basilio, Larry Warne, and William Langston (all 1352) used electromagnetic simulations to unravel precisely how the cubes trap light. Willie Luk (1131) measured the cubes' reflective properties. Another LDRD project currently supports research into metamaterial lasing.

"We feel we've created a pretty flexible platform for a lot of different kinds of devices," says Mike.

The ongoing work is aided by John Reno (1131), nationally known for growing extremely precise crystalline structures, who contributed the III-V wafers.

Three patents on aspects of the work have been submitted to the US Patent Office.

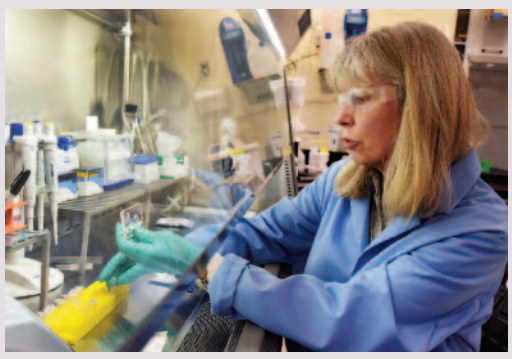
A large part of the work took place at the Sandia/Los Alamos Center for Integrated Nanotechnologies, a DOE Office of Science user facility.

Three papers of interest led by Sandia researchers

1. *Nanoletters*: Resonantly Enhanced Second-Harmonic Generation Using III–V Semiconductor All-Dielectric Metasurfaces
2. *Advanced Optical Materials*: Dielectric Resonators: III–V Semiconductor Nanoresonators — A New Strategy for Passive, Active, and Nonlinear All-Dielectric Metamaterials.
3. *ACS Photonics*: Broken Symmetry Dielectric Resonators for High Quality Factor Fano Metasurfaces.

Jill Hruby ranked 2nd most powerful woman in tech

In what it called its "shout out" to the most powerful women engineers in US tech, *Business Insider* has placed Sandia President and Laboratories Director Jill Hruby No. 2 on its list of 43 women, ranking her behind only Microsoft's Peggy Johnson, executive vice president of the company's business development efforts.



Jill was cited as the first woman to run one of the nation's three nuclear weapons labs.

Before becoming Labs director, Jill served as VP of Energy, Nonproliferation, and High-Consequence Security Div. 6000 and head of Sandia's International, Homeland, and Nuclear Security Program Management Unit.

"It is an honor to receive this recognition," Jill said. "I owe this distinction to the highly dedicated and innovative engineers and scientists I've had the privilege to work alongside for the past 34 years. I hope the list of women engineers, and the many other activities that promote STEM careers during National Engineer's Week, will inspire talented students to choose technical work focused on public service."

Jill joined the technical staff at Sandia's California laboratory in January 1983, working in thermal and fluid sciences, solar energy research, and nuclear weapon component research and development. During her career, she also has done research in nanoscience, hydrogen storage, mechanical-component design, and microfluidics.

She holds an MS in mechanical engineering from the University of California, Berkeley.

In 2016, the Society of Women Engineers honored her with its "upward mobility" award for breaking the glass ceiling in one of the world's most respected engineering organizations and for helping other women in the field as well.

AN OPEN-SHUTTER PHOTOGRAPH of fireball EN091214 taken Dec. 9, 2014. This fireball event was the focus of a paper published Feb. 1 in *Scientific Reports* by authors from Sandia and the Astronomical Institute of the Czech Republic. (Photo provided by Pavel Spurny of the Czech Academy of Sciences)

Meteor sounds

(Continued from page 1)

But these auditory warnings, which do occur, would be contrary to the laws of physics if they were assigned to the friction of a fast-moving meteor or asteroid plunging into Earth's dense atmosphere. Because sound travels far slower than light, the sounds should arrive several minutes after the meteor hits, rather than accompany or even precede it.

So maybe atmospheric shock waves from the meteor aren't an accurate supposition for the cause of the spooky noises.

Another theory is that the sounds are created by radio frequency emissions. That seems unlikely without designated receivers.

But what if the sounds are caused by the brilliant, pulsating light emitted as the asteroid burns up in Earth's atmosphere?

In an article published Feb. 1 in the journal *Scientific Reports*, the late Dick Spalding, a recently retired Sandian, reasoned that such intense light could suddenly heat the surface of objects many miles away, which in turn would heat the surrounding air. Colleagues John Tencer and Roy Hogan (both 1514), William Sweatt (1516), Ben Conley and Gigi Gonzales (both 5784), and Mark Boslough (1446), along with Pavel Spurny from the Astronomical Institute of the Czech Republic, experimentally demonstrated and analyzed that effect.

They found that objects with low conductivity, such as leaves, grass, dark paint, and even hair, could rapidly warm, transmit heat into nearby air, and generate pressure waves by subtle oscillations that create a variety of sounds. The process is called photoacoustic coupling.

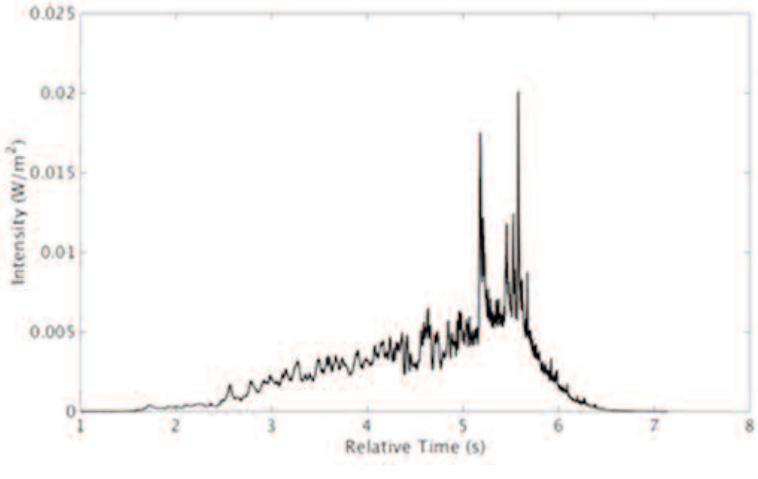
Sounds concurrent with a meteor's arrival "must be associated with some form of electromagnetic energy generated by the meteor, propagated to the vicinity of the observer, and transduced into acoustic waves," according to the article. "A succession of light-pulse-produced pressure waves can then manifest as sound to a nearby observer."

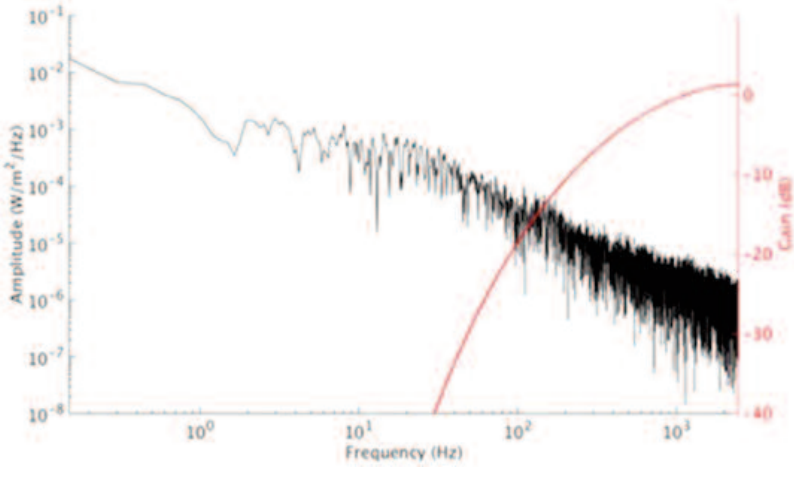
The experimenters exposed several kinds of dark cloth and a wig, among other materials, to intense pulsing light akin to that produced by a fireball. The process produced faint sounds similar to rustling leaves or faint whispers. Computer models bear out the results.

A less extreme version of the photoacoustic effect had been observed in 1880 by Alexander Graham Bell. Testing the possibilities of light for long-distance phone transmission, he intermittently interrupted sunlight shining on a variety of materials and noted the sounds produced.

METEORITES RECOVERED from the Dec. 9, 2014, event that is the focus of the paper published Feb. 1 in *Scientific Reports*. This particular event was chosen because not only was Pavel Spurny of the Czech Academy of Sciences able to record really high quality optical data but it also was observed by many casual witnesses and a few of them reported sounds (popping, sizzling) concurrent with the light.

IN THE GRAPHS BELOW, the image on the left is the intensity-time history of fireball EN091214 as recorded by the Czech Fireball Network18. The fireball's average apparent magnitude was reported as -15, about 10 times brighter than the full moon. Concurrent sounds from this early evening fireball were heard by people in several nearby locations. At right, the graph shows the Fourier transform of the light intensity, along with the normalized sensitivity of the human ear.





BLASTING DOWN THE TRACK — Sandia sends a B61-12 down its rocket sled track in a calibration test.

Evaluating nuclear weapons: A key Sandia mission

By Sue Major Holmes

Sandia is transforming how it assesses nuclear weapons in a stockpile made up of weapons at different stages in their lifecycles — some systems that have existed for decades alongside those that have undergone life extension programs.

Back when the United States was developing new nuclear weapon systems, weapons typically were either in production or were retired before they aged much more than about 10 years. The US today is no longer designing new systems, so scientists and engineers refurbish weapons to ensure the stockpile will function as intended and that weapons are safe, secure, and reliable.

Sandia is responsible for developing as much as 97 percent of a weapon system's non-nuclear components. It has created ever-more sophisticated tests and computer models to qualify those systems under its stockpile stewardship role — certifying they always will work as designed when authorized by the president but will never work in any other circumstance, says Deputy Chief Engineer Scott Holswade (2200).

The stockpile surveillance program assesses each nuclear weapon system to detect or anticipate potential problems.

Nuclear weapons components age, and scientists and engineers address that through life extension programs or less comprehensive alterations. A life extension program refurbishes components nearing the end of their life, remanufacturing or redesigning them. Some components are reused by being requalified to go back into a weapon without change. Remanufacturing means using the original specifications to remake components that have aged. However, sometimes the original technology is no longer available, so Sandia redesigns parts using modern technology — think switching out vacuum tubes for solid state technology.

"A pediatrician does not look at the same things that a geriatrics expert would. The things you're looking for in 'pediatrics,' the defects in design and production, are different than if you're looking for aging effects late in its life cycle," Scott says. "I think that's been the big evolution of the program, to start implementing changes that recognize this, and change the [stockpile evaluation] program to optimize for each system, depending on where it is in the life cycle."

The US last conducted underground nuclear testing in 1992 and has been in a moratorium ever since. Since then, Sandia has used non-nuclear tests, experiments, and computer simulations to study environments weapons might face, such as vibration, radiation, or extreme cold or heat. Sandia must design and engineer systems to handle those conditions and do extensive testing to make sure designs meet requirements established by the departments of Defense and Energy, says senior manager Toby Townsend (2220). Once refurbished weapons enter the stockpile, Sandia conducts tests to assure the systems continue to meet requirements as they age.

Gauging a weapon's lifespan is big part of stockpile work

"We're often asked, 'How much longer could the weapon potentially be good for?' That's a major part of the stewardship mission," Toby says.

When nuclear weapons were first developed, they were expected to be useful for a so-called protected period, the lifespan of the design. To mimic that lifespan, engineers use environmental test chambers to speed up conditions the weapon could face over time, a process called accelerated aging. They also do a multitude of tests on refurbished weapons coming into the stockpile, such as the W76-1, to catch possible "birth defects" due to design or manufacturing problems.

The question for a weapon in the stockpile for decades

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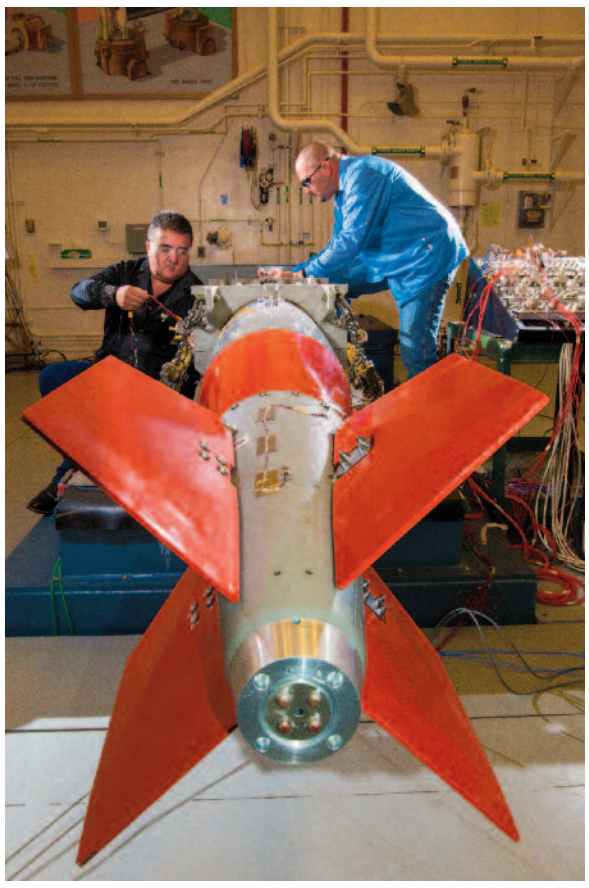
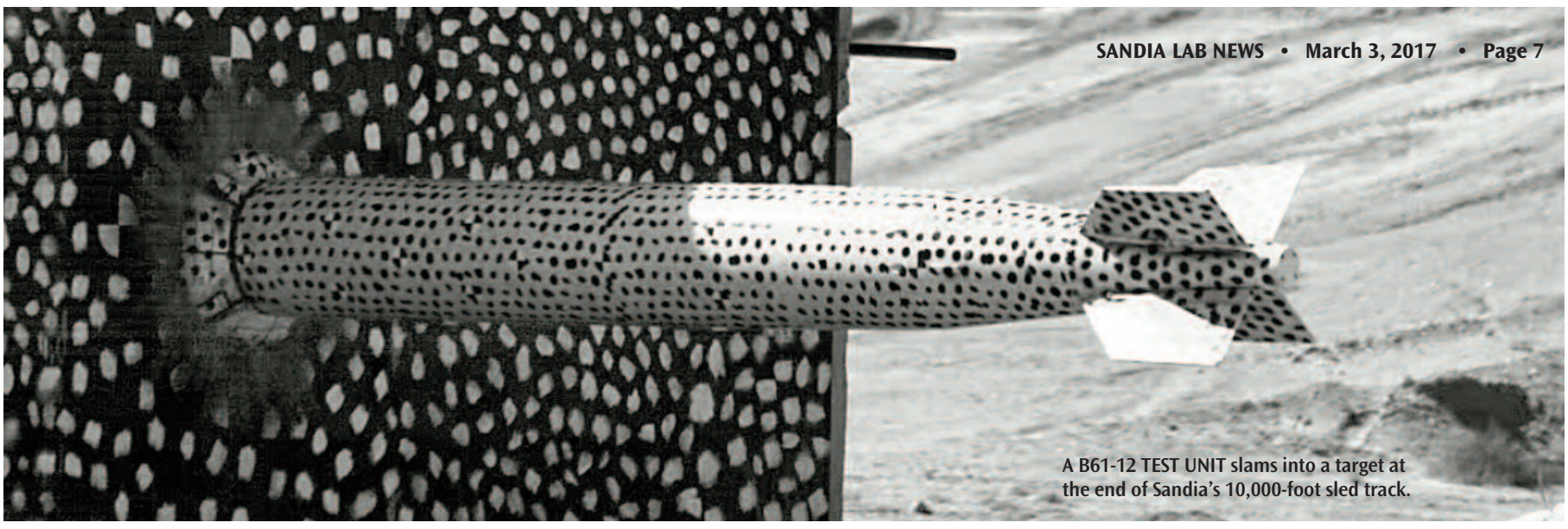


SANDIA TECHNOLOGISTS Curt Tenorio, left, and Jessie Fowler (both 1521) install instrumentation on a B61-12 unit for a vibration and shaker-shock test. Sandia has sophisticated tests and computer models to qualify non-nuclear systems under its stockpile stewardship role.

(Photo by Randy Montoya)

FLIGHT TEST — A joint test assembly undergoes a flight test at Tonopah Test Range in Nevada. This test unit began as a B61-4, which was removed from the stockpile, disassembled, and used to build the non-nuclear test assembly to collect performance data during flight environments similar to operational conditions. Sandia, as part of its stockpile stewardship responsibilities, does both testing and computer modeling to qualify weapons systems, certifying they will reliably work as designed when authorized by the president but will never work in any other circumstance.

(Photo courtesy of Tonopah Test Range)



A B61-12 TEST UNIT slams into a target at the end of Sandia's 10,000-foot sled track.

DANA PULLIAM enters information before running an operation in Sandia's MESA complex. (Photo by Lloyd Wilson)

LEONARD MARTINEZ makes an adjustment at the Lightning Simulator lab as part of a test series to further knowledge of lightning protection systems. (Photo by Randy Montoya)

(Continued from preceding page)

is different: What happens as it ages?

"That's one thing we're trying to get to: What are the risks and knowledge gaps, and focus on those rather than continuing to do things that aren't returning a lot of differentiating information," Scott says.

Life extension programs and alterations test everything from individual components to nearly complete systems without nuclear material.

"There will be temperature cycling, there'll be vibration, there'll be shock, there will be radiation, there might be voltage changes, all kinds of things that the system is subjected to, done in accordance with a plan that combines testing with simulation to make sure we're working through in a systematic way what's required to qualify the weapon for operation," Scott says. "The goal is absolute certainty that the design as manufactured is good to perform."

Many areas test systems, components

Senior manager Jay Vinson (2950) says assessing non-nuclear systems includes laboratory testing, system-level flight testing of gravity bombs, cruise missiles flights, ballistic missile flights, and navy submarine-launched missile flights, all with the nuclear explosive packages removed. In addition, numerous sites including Sandia, the Kansas City National Security Campus, and the Weapon Evaluation Test Laboratory test non-nuclear components.

Once a weapon is in production, the program must assure it conforms to the design, an example of an early life cycle concern. "You can have production errors, or you might have missed something in the design process that only reveals itself as you get to higher volumes," Scott says.

As production ramps up, Sandia pulls units before they go into the stockpile to catch possible production errors or early-onset failures, Jay says.

Weapons also are pulled from the field for tests later in their life cycle, where they've been handled by military personnel and might have been on a submarine or a missile. Engineers want to study whether field conditions exposed a problem.

Some weapons from the field are built into joint test assemblies, mock weapons without nuclear materials but fitted with sensors and instrumentation to assess performance. Flight testing is part of the qualification process for refurbished weapons, and its main objective is to obtain reliability, accuracy, and performance data under operational conditions. Scientists and engineers use the test data in computer simulations developed by Sandia to evaluate systems' reliability and to verify they functioned as designed.

SYSTEMS ENGINEER Davinia Rizzo checks part of Sandia's vibration machine, which can shake test items in multiple directions simultaneously. (Photo by Randy Montoya)

W80-1 joint test assembly

Last June, the W80-1 Air Launched Cruise Missile Surveillance Flight Test Program conducted a long flight of a joint test assembly to a target and performed arming maneuvers.

"In this case, the nuclear explosive package is replaced by the testing assembly, so the system won't detonate, but it will function with all the Sandia componentry along that trajectory," Jay says. "The various safety functions and other weapon functions will occur as if it were a wartime environment. We need to assess that all of that works properly because it indicates we have a safe and reliable weapon."

Weapons in some flight tests contain high explosives along with instruments that send out data during flight until the explosives detonate. In other tests without explosives, additional sensors check that the detonation chain would have functioned. In all cases, the nuclear material is removed before the test.

Sensors in non-explosives tests send data during flight, but engineers also recover the system to gather more diagnostics. For B61-12 flight tests at Tonopah Test Range, telemetry data gathered during flight are verified at the range's test operations center and main telemetry ground station, and transmitted to Sandia in Albuquerque.

Engineers do additional tests on components and subsystems for so-called "corner cases," such as the hottest day with the biggest shock condition or the coldest day with more vibration.

"We can't fly every potential trajectory because you're limited by where you can launch from and where you can land. We can't fly every weather condition because you're stuck with the weather you have when the flight's scheduled," Scott says.

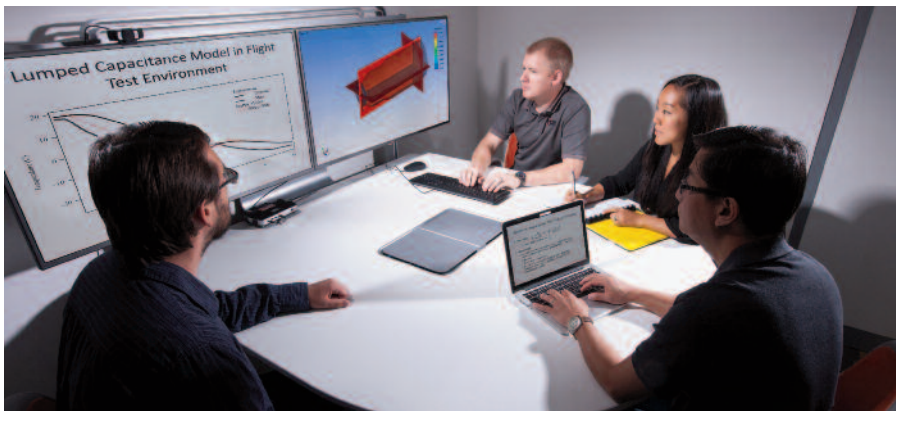
One problem with testing a non-nuclear system as a whole is that the system works or it doesn't, and the test can't always pinpoint something specific that might have worked, but only marginally. Weapons programs supplement system testing with component testing, allowing engineers to understand whether there were changes in the components.

Sandia's large environmental test facilities can evaluate subsystems and components under all kinds of conditions. That doesn't mean testing is easy, since combining environments is especially challenging. Engineers might test how well a component works in a radiation environment and separately in a shock environment, but it's difficult to combine radiation and shock testing, for example.

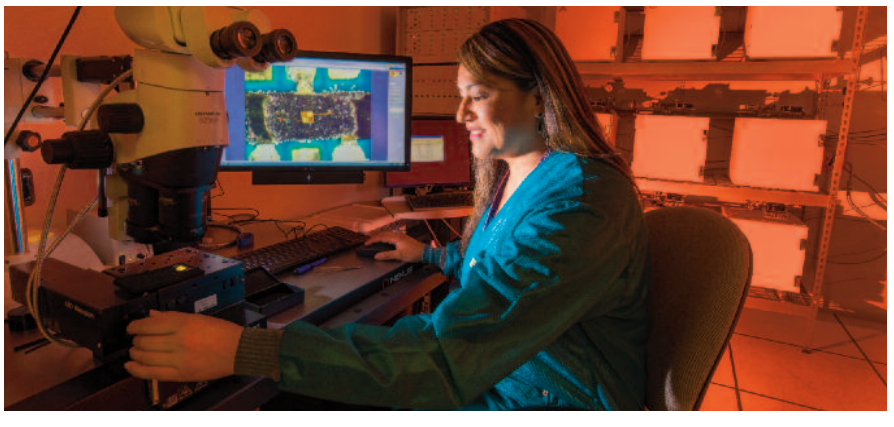
So researchers use simulation. First they perform experiments to gather information to anchor their models, then use those models to simulate thousands of different environments.

"It gives us a lot more confidence across the spectrum of environments," Toby says. "We would never be able to run that many experiments. As long as we continue to anchor our models with experimental evidence, it allows us to have an ability to really assess that component in an environment that it may never be realistic to test in."

EVALUATING WEAPONS — Members of the mechanical team for the W80-4 Life Extension Program review the results of a thermal analysis at Sandia/California. (Photo by Randy Wong)



RACHELLE THOMPSON inspects an electronic device that's part of a 30-year Sandia program to study how environments could affect the performance of electronics inside a W76-1 warhead. (Photo by Randy Montoya)



On Deterrence:

Exploring the evolution of nuclear deterrence through interviews, historical footage

By Sue Major Holmes

Sandia is exploring the evolution of nuclear deterrence in a documentary that combines modern and historical footage with a wide range of interviews.

On Deterrence features interviews with former secretaries of defense, general officers, policymakers, analysts, scholars, and scientists with varied viewpoints to describe the impact of nuclear deterrence since the end of World War II. The film presents a broad look at nuclear deterrence and explores how the concept might evolve in response to changes in the global strategic balance and the twin threats of proliferation and terrorism.

"Sandia has a role to play in the national debate on deterrence, and this documentary can contribute to that discussion."

— Labs President and Director Jill Hruby

Sandia President and Laboratories Director Jill Hruby says deterrence is a cornerstone of defense for the US and its allies and remains important 25 years after the end of the Cold War.

"Sandia has a role to play in the national debate on deterrence, and this documentary can contribute to that discussion," she says.

Sandia filmmaker Dan Curry, now retired, began work on the film in 2011. The documentary, which runs an hour and 42 minutes, builds on his earlier Sandia documentaries, *Always/Never: the Quest for Safety, Control & Survivability*, released in 2015, and *US Strategic Nuclear Policy*.

Curry spent about six months studying the evolution of nuclear deterrence. "It has such breadth and depth that I struggled to narrow the topic," he says. The goal "was not to tell the story of, but to follow the evolution of deterrence."

History as a springboard

Curry used history as a springboard to discuss important concepts like credibility, which underpins deterrent threats. He says he relied on those interviewed to narrate the history and to describe and define how nuclear deterrence operates today.

Steve Rottler, deputy Labs director and executive VP for National Security Programs, says Sandia is pleased to be a part of deterrence history and further national conversation because of its unique responsibilities in nuclear weapon design, production, and maintenance.

"The intent of this film is to make a lasting contribution to the history of deterrence and to the long-term dialogue about the role of US nuclear weapons as a deterrent, not to advocate any one viewpoint," he says. "We're very proud of Dan's efforts to present a balanced, intellectual, and deeply insightful perspective on the complex topic of deterrence. We're grateful to him and to all of the experts who gave their time for this."

Jerry McDowell, who preceded Steve as deputy Labs director before retiring in 2015, asked after seeing *Always/Never* whether he could commission Curry to do a documentary on the relevance of nuclear weapons in the current era.

"I realized that Sandia had hired so many new people, some of whom had not come of age until after the Cold War," he says. "There's a generation of people for whom this topic feels like a legacy; I wondered if they would benefit from added context in which to understand the history of nuclear deterrence and its impact on global security today."

Among those interviewed for *On Deterrence* are NNSA head Gen. Frank Klotz; Stephen Younger, a senior policy scholar at the Woodrow Wilson Center at the time and now designated as Sandia's next Labs director; former Los Alamos National Laboratory director Sig Hecker; former US Sens. Sam Nunn of Georgia and Jon Kyl of Arizona; Stanford University senior fellow Scott Sagan, author of *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons;* former secretaries of Defense James Schlesinger, Robert Gates, and William Perry; Ploughshares Fund president Joseph Cirincione; Carnegie Endowment for International Peace senior associates Ashley Tellis and James Acton; and Rose Gottemoeller, former undersecretary for arms control and international security at the State Department.

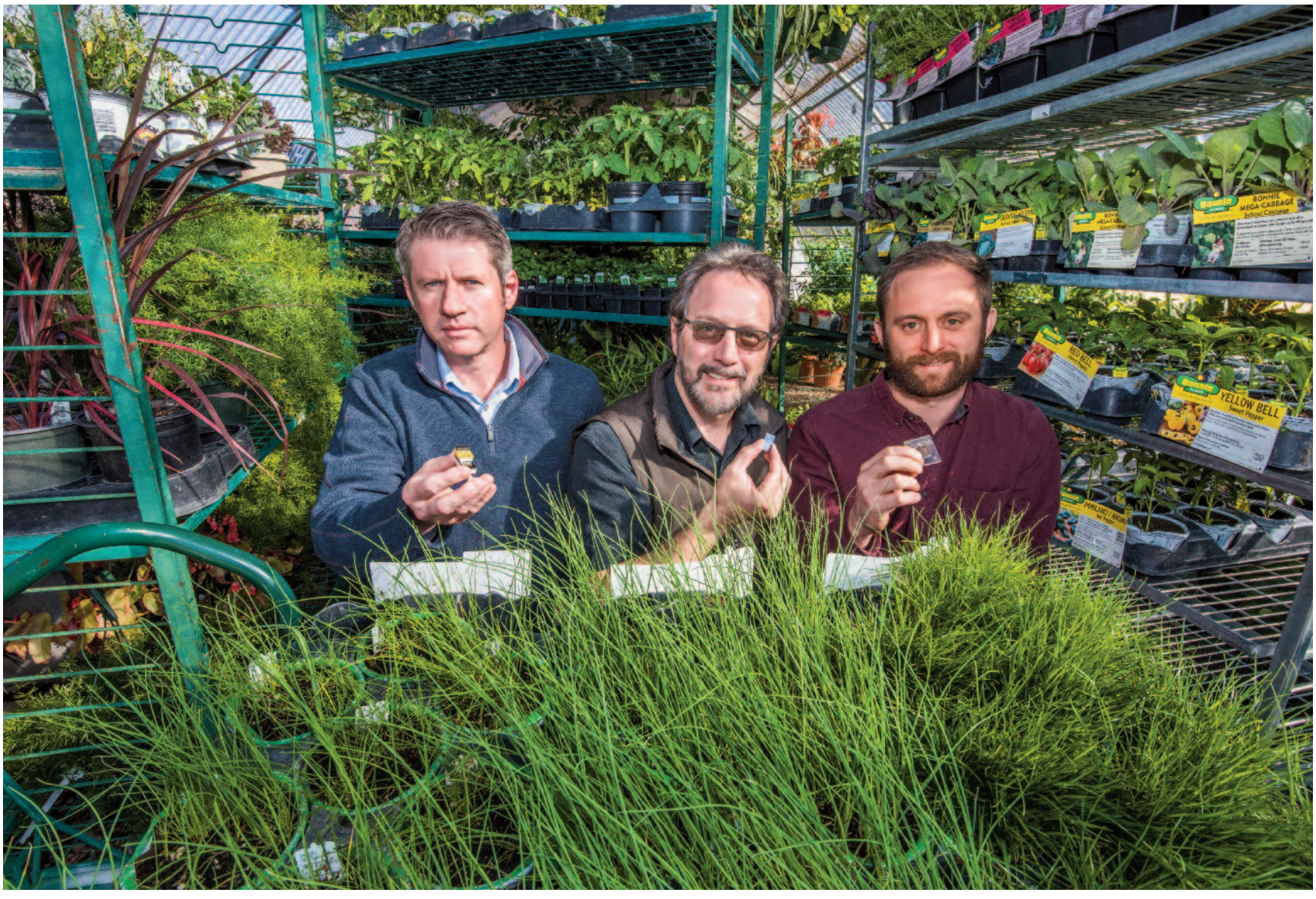
On Deterrence can be viewed on Sandia's YouTube channel at https://youtu.be/tQBLpJFi6f0.

SHORTLY AFTER HE WAS SWORN IN as president in January, 1961, John F. Kennedy met with Soviet Premier Nikita Khrushchev in Vienna to explore solutions to areas of contention. The outcome of the summit is regarded by historians as ambivalent, though there is some thought that Khrushchev misread Kennedy's inexperience as weakness, which may have contributed to Cold War confrontations in Berlin, Southeast Asia, and Cuba. (Image from *On Deterrence*)

SANDIA FILMMAKER Dan Curry, at right, interviews Chris Yeaw, founder/director of the Center for Assurance, Deterrence, Escalation, and Nonproliferation Science & Education at the Louisiana Tech Research Institute. (Photo courtesy of Dan Curry)

AN AMERICAN GI stands sentinel at a lonely outpost, a visual metaphor for the chasm separating East and West during the Cold War. (Image from *On Deterrence*)

AT THE VERY HEIGHT OF THE COLD WAR, just months after the confrontation between the US and Soviet Union known as the Cuban Missile Crisis, President Kennedy traveled to Berlin to express American solidarity with the citizens of that besieged city, hailing it as an outpost of freedom behind the Iron Curtain. (Image from *On Deterrence*)



ROOT CAUSES — Ronen Polsky (left), Ron Manginell (center), and Philip Miller show off their miniature sensors.These detection systems were originally developed for national security applications but are being adapted for monitoring crop health. (Photo by Randy Montoya)

Sandia will adapt tech to monitor plant health and breed better crops

Super plants need super ROOTS

By Mollie Rappe

Agriculture consumes about 80 percent of US water. Making fertilizers uses 1 to 2 percent of all the world's energy each year.

Sandia is involved in a new DOE program aimed at developing better crops — super plants that are drought-resistant, use less fertilizer, and remove more carbon dioxide from the atmosphere.

The program, ROOTS, or Rhizosphere Observations Optimizing Terrestrial Sequestration, is sponsored by DOE's Advanced Research Project Agency-Energy (ARPA-E). Sandia has received $2.4 million to adapt previously developed sensors to monitor root function and plant health in new, noninvasive ways through one ROOTS project.

The insights gained from these sensors, with plant experts from the University of New Mexico (UNM) and the New Mexico Institute of Mining and Technology, will guide breeding of better varieties of sorghum, a drought-tolerant grain mostly grown for animal fodder and biofuels in the US but relied upon as an important food crop in Africa and parts of Asia.

The sensors will be easy to adapt to other crops too, says Eric Ackerman, manager of Sandia's Nanobiology Dept. 8635 and principal investigator for the ROOTS project.

Though roots are hard to access and study, thoroughly understanding how they work and how to improve them is essential for drought-resistant crops that need less fertilizer. Deep roots can tap additional water sources and extensive root systems can gather more nutrients, says Eric. Roots also are critical for depositing carbon into the soil, instead of the air.

"It is really exciting to see how Eric Ackerman and his team are repurposing miniaturized sensing technologies originally developed for national security applications such as warfighter health monitoring or detection of chemical agents for real-time monitoring of hard-to-access root systems," says Anup Singh, director of Sandia's Biological and Engineering Sciences Center 8600.

Minimally invasive microneedles to monitor plant productivity

One technology researchers will adapt is a microneedle-based fluidic sensor. This matchbox-size device was originally developed for biomedical applications such as the painless detection of electrolyte levels of warfighters on arduous missions. However, due to its size, minimally invasive set-up, and ability to constantly measure the levels of important chemicals, Sandia researchers believe it's valuable for other research such as plant monitoring.

For the ROOTS project, researchers are interested in monitoring the products of photosynthesis such as simple sugars, important root excretions such as oxalic acid, and water pressure. Water pressure, or turgor pressure, is an important measure of plant health, even before they wilt. Current methods for measuring these critical indicators are costly, too invasive, or don't provide continual data.

"The microneedles will help us measure sugars transported by the plant to and from the roots before soil microbes can use them, and will give us a better understanding of how plants add to soil carbon," says Ben Duval, a plant and soil expert and professor at the New Mexico Institute of Mining and Technology.

Ronen Polsky (8634), who leads the microneedles research, doesn't think the detection chemistry or the needles themselves will need much tweaking to work with plants, but one challenge will be determining the best way to attach the sensors to the plants. "The cool thing with our task on ROOTS," he says, "is that nobody has done this in plants before. It's such an intriguing project to take these sensors and apply them to plants."

Initial support for developing the microneedle sensors came from Sandia's Laboratory Directed Research and Development program with additional funding by the Defense Threat Reduction Agency (DTRA). The sensor was also the subject of doctoral work by Philip Miller (8634), a postdoctoral researcher at Sandia working on the ROOTS project.

Mini gas detectors to monitor plant health above and below ground

The other Sandia technology used in the ROOTS project is a micro gas chromatography system, or micro-GC. Sandia has been working on hand-held systems that detect and analyze gases indicative of chemical, biological, and other threats for almost 20 years.

For ROOTS, researchers will use the micro-GC systems to measure volatile organic compounds (VOCs) above and in the ground. Ethylene, a common VOC that triggers fruit ripening, also can signal drought-related stress. Plants also use chemicals related to menthol and a component eucalyptus smell as distress signals, for instance, if they are plagued by pests.

UNM plant biologist Dave Hanson, co-principal investigator, says the "micro-GCs will be used to detect signals from environmental stress, such as drought, heat, and nutrients, and biological stress, such as insect and pathogen attacks, as well as assess root growth."

By placing very thin sample collection spikes in the ground and using cutting-edge detectors, Ron Manginell (8634), who leads the micro-GC research, plans to monitor normal plant VOCs and these stress signals in almost real-time.

"First, we have to figure out what the important VOCs actually are, which is always a challenging problem," Ron says. "Once we figure out what those are, the challenge is putting together the miniaturized system to go after those." Then Ron's team will take their prototype hand-held system and test it in the field.

Initial support for developing the micro-GC system came from Sandia's Laboratory Directed Research and Development program with additional funding from the DOE, Defense Advanced Research Projects Agency, and DTRA. Systems based on the same body of research are being used to analyze water quality and could be used to monitor diseases by just "smelling" a patient's breath, says Ron.

'Usher in a new era'

Sandia's project is one of 10 ROOTS projects funded by ARPA-E. Lawrence Berkeley National Laboratory and a number of universities will use other approaches and technologies to tackle the challenge of breeding better crops to reduce atmospheric carbon dioxide levels.

"The microneedles and micro-GC developed by Sandia are extremely exciting because of their potential to provide critical data on plant function that have been unattainable in any setting," says Hanson, "If successful, these technologies will usher in a new era for research on plant function. They would also contribute to economic growth."

Since both technologies are small, less expensive than alternatives, and offer critical insights, the team hopes they could directly aid agricultural research and even commercial farming quickly and easily.

The Bioscience Seminar Speaker Series, which is supported by Talent Management and Development Dept. 3520, was invaluable for bringing researchers from Sandia and UNM together to share expertise and brainstorm, says Eric.

Eric adds, "The overall hope for Sandia is that this could open an important new national security area for the biology program to study beyond our current focus on bio-threats and biofuels. It brings us into the energy, water, climate, agriculture nexus, and we are hoping that there will be more opportunities in the future to use even more Sandia technologies."

Dan Sinars represents Sandia in first energy leadership class

By Mollie Rappe

Dan Sinars (1680), a senior manager in Sandia's pulsed power center, is the sole representative from a nuclear weapons lab in a DOE leadership cohort that recently visited Sandia.

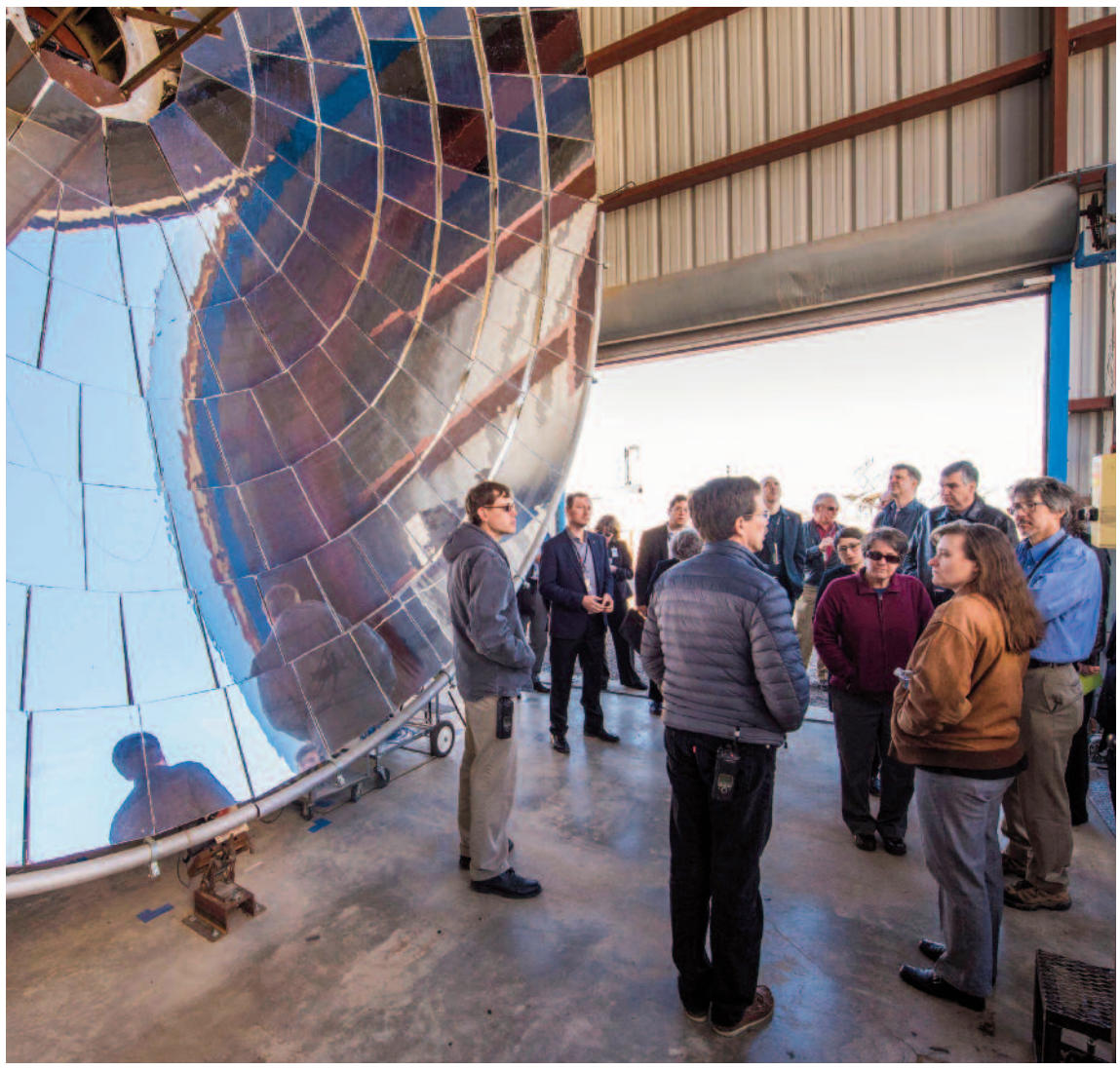
Members of the Oppenheimer Science and Energy Leadership Program (OSELP) are up-and-coming leaders from the 17 DOE labs selected to learn about the DOE complex and how it fits within the national research landscape.

DOE chose Dan for the inaugural OSELP class after Sandia leadership nominated him. His research focuses on z-pinch phenomena and high energy density physics, which could lead to useable fusion-based energy. The nominations went to an advisory committee of former laboratory directors, which chose him and 13 others from a pool of internal leaders and external collaborators proposed by each of the labs.

Dan is the only participant from an NNSA lab. The first class includes researchers from Brookhaven, Pacific Northwest, and Lawrence Berkeley national laboratories; SLAC and Fermi national accelerator laboratories; the National Renewable Energy Laboratory; the Princeton Plasma Physics Laboratory; Nova Photonics; and Stony Brook University, Iowa State University, and the University of Washington.

The OSELP gives Dan a good opportunity to learn about the other DOE labs from site visits and the other members. "It's enlightening to talk to people from different labs and find out how they do things there. As an NNSA lab, Sandia is pretty different, but it's the same too," he says.

Dan is no stranger to national recognition. He has received a DOE Early Career investigator award and Presidential Early Career Award for Scientists and Engineers (PECASE) award in addition to American Physical Society awards.



DOE OPPENHEIMER SCIENCE AND ENERGY Leadership Program group explores Sandia's National Solar Thermal Test Facility during a site visit in early February. (Photo by Randy Montoya)

Visiting academic, industry, and DOE labs

A major component of the OSELP program is site visits where the leaders get a chance to talk with laboratory executives about their experiences and leadership challenges. The first was to the San Francisco Bay Area last June, which included conversations with leaders and tours of Lawrence Berkeley, Lawrence Livermore, and SLAC as well as Stanford and Google. One highlight was a presentation by Paul Alivisatos, former director of Lawrence Berkeley National Laboratory, who discussed the spectrum of missions and approaches at DOE laboratories ranging from the academic and to more applied, recalls Dan.

Of course, the group went to Washington, D.C., to meet with leaders at DOE and other federal agencies, and later to the National Renewable Energy Laboratory in Colorado.

Recently, the OSELP visited Sandia and Los Alamos national laboratories. At Sandia, the group toured CINT, MESA, the solar tower, battery lab, and the Z machine facility, where Dan works. They also got a chance to talk with Sandia leaders, including Labs Director Jill Hruby.

"The most interesting thing about Sandia is the diversity of programs and people. All this research grew from one core mission to many different areas," says Amy Marschilok, a researcher focusing on developing better batteries and OSELP participant from Brookhaven National Laboratory and Stony Brook University.

In March, the OSELP plans to attend DOE's Big Ideas Summit. There, participants will present "think pieces" developed over the past year about DOE's challenges and role in the research landscape. Dan is writing about attracting and retaining the best researchers. His group surveyed previous DOE Early Career award winners to learn what the DOE is doing well to attract and keep these top performers, and will use the results to make recommendations for future DOE recruiting efforts, Dan says.

Gary Polansky named Fellow of AIAA for diverse contributions to aeronautics, space research

By Heather Clark

Gary Polansky (5400), the chief scientist for hypersonic technology development and applications at Sandia, has been named a fellow of the American Institute of Aeronautics and Astronautics (AIAA).

"Gary's engineering and leadership skills have led to more than a decade of technological innovation in conventional global strike programs," says David Plummer, director of Sandia's Integrated Military Systems Center 5400. "Over his career, he has helped the US become a global leader in advanced hypersonic flight systems."

GARY POLANSKY

Gary's expertise leads to successful 2011 Advanced Hypersonic Weapon test flight

In his nearly 35-year career at the Labs, Gary's leadership has helped advance the US role in the deployment of hypersonic and space nuclear technology in support of Sandia's national security missions.

His career-long achievements resulted in the first successful test flight of the Advanced Hypersonic Weapon (AHW) from a test facility in 2011. A year later, the Labs team received Lockheed Martin's highest honor, the NOVA award, for its AHW work.

In 2013, Gary won the 2013 Precision Strike Association Richard H. Johnson Technical Achievement Award for his technical leadership of several hypersonic flight systems and hypersonic-delivered warhead systems.

Widely recognized for his expertise, Gary is a trusted consultant for other government agencies on hypersonics and national security topics.

Nuclear safety in space also highlight of Gary's work

He advised the Interagency Nuclear Safety Review Panel (INSRP) on nuclear safety for the launches of the *Pluto New Horizons* and *Mars Science Laboratory* space missions.

The *Pluto New Horizons* launch in 2006 was challenging from a nuclear safety perspective because aged nuclear fuel pellets had to be used due to a fuel shortage.

AIAA

Shaping the Future of Aerospace

Gary led efforts to recover the historical data on fuel aging, analyze the data in the context of the space mission, and develop models to characterize the uncertainty associated with aged fuel.

His contributions were important to the INSRP independent safety assessment and the presidential decision to proceed with the launch. He received a NASA Certificate of Commendation for this effort.

Earlier in his career, Gary led the development and rocket sled testing of Kinetic Energy Projectile (KEP) warheads in 2006 and the technical team that conducted sled track tests of an advanced fuze for high-speed penetrators. He also was instrumental in developing new rocket-sled, payload-separation technology that enabled the longest-ever free-flight of a separated vehicle to target impact.

Gary holds a doctorate from the University of Texas at Austin. He has authored or co-authored more than 50 technical publications in computational physics, nuclear technology, and hypersonic systems.

Gary was a founding member of AIAA's Nuclear Thermal Propulsion Technical Committee (now the Nuclear and Future Flight Propulsion Technical Committee), including serving as conference coordinator for three years. He also chaired the first Soviet Threat Technology Invited Lecture Series, an Albuquerque section activity later adopted by the national AIAA.

AIAA, the world's largest aerospace professional society, confers the distinction of fellow to recognize professionals' notable and valuable contributions to the arts, sciences, or technology of aeronautics and astronautics. AIAA serves more than 30,000 individual members from 88 countries and 95 corporate members.

Since the honor's 1934 inception, there have been 1,848 fellows elected, according to AIAA.

The induction ceremony will take place at the AIAA Aerospace Spotlight Awards Gala on May 3 in Washington, D.C.

SANDIA CLASSIFIED ADS

MISCELLANEOUS

TIMESHARE, Holiday Inn Club Vacations, Desert Club Resort, Las Vegas, 7 nights, 1-bdr., deluxe w/full amenities, $750. Chavez, 550-8095.

CHINA CABINET, 4'W x 6'H x 16"D, $200 OBO; twin bed, $25; secretary desk, w/sliding lid, $25. Smith, 209-815-2176.

TREADMILL, Image 10.6Q model, variable speed, incline, numerous programs, large running belt, $900 new, asking $200. Morrison, 505-850-0401.

DINING SET, 10-person, mango wood, 6 chairs, w/bench, $1,200; antique blanket chest, cedar-lined, $125; 2-drawer antique chest, $125; secretary/teacher's desk, solid wood, $75; can email photos. Jenkins-Knight, 239-5364.

'THE ILLUSIONISTS' TICKETS, 2, Popejoy, May 7, 6:30 p.m., great orchestra seats, east side, row P, inside isle, $52.25 ea. Hoyal, 505-823-1421.

GYM EQUIPMENT, Bowflex Ultimate, w/leg bench, $500; Horizon Elite 1.1T treadmill, $300; ProForm Spincycle, $225. Bruskas, 323-1055.

TALL SQUARE TABLE, Southwest-style, wood w/stone tile top, w/4 matching chairs, $350 OBO. Dinge, 505-818-8933.

FLIP-AND-LEARN COLORFUL FLIP CHARTS, 20, for children, spiral bound, Tormount Publications, 12" x 18", very good condition, $6. Wagner, 505-504-8783.

DRILL PRESS, bench top, Omega Machinery FLD-14, 1/2-hp, 5-spd., good condition, $50. Mirate, 505-286-2664.

INNER TUBES, w/sheaths for snow or water, inflates to >5-ft., $25 ea. Melkey, 319-538-6152.

TREADMILL, ProForm Crosswalk 405E, $100; elliptical Reebok RL1500, $400; great condition, you pick up. Romero, 505-228-3454.

FINAL ESTATE SALE, art; crystal & pewter pcs.; classical LPs, furniture; luggage; camping & bicycle gear; non-fiction books, see weekdays 9 a.m.- 3 p.m., weekends by appointment, 11620 Del Rey Ave NE. Joseph, 480-521-4989 or 505-822-0536.

DINING ROOM CHAIRS, 6, Ashley Furniture, black metal, brown baroque fabric seats, good condition, photos available, $180. de la Fe, 505-610-2700.

HOME GYM, Bowflex Blaze, great condition, paid $800, asking $400 OBO. Schriner, 275-3312.

QUEEN BDR. SUITE, Amish Connection, 6-pc., oak, bed, end tables, armoire, dresser, lingerie drawer, $3,000. Beach, 238-9869.

CONVECTION OVEN, new, Maytag, stainless steel, 30-in., 5.8-cu. ft., in gas range, finger print resistant, $1,200. Nelson, 235-3825.

ELTON JOHN TICKETS, 2, Tingley, March 22, section J, row 18, seats 5&6, $200. Bennett, 505-238-5527.

LEGOS, castle #6075; space cruiser #487; space command #493; radar truck #889; case w/5-lbs. parts. Newcom, 293-5180.

OVERSTUFFED COUCH & CHAIR, leather, w/ottoman, medium brown, soft, great condition, couch $300, chair & ottoman $300. Kelly, 299-3527.

INVERTER MACHINE, very nice, never used, good condition, $100 or any reasonable offer. Cleland, 323-1824.

GIRL'S TWIN BDR. SET, 7-pc., light wood, $600 OBO; 4-pc. bdr. set, queen, cherry wood, $700 OBO; photos upon request. Kilbane, 715-7681.

MATTRESS & BOX SPRING, queen, Sealy, w/bed frame, very good condition, $175 OBO. Martinez, 359-5580.

WEDDING RING SET, gold w/diamonds, matching, size 6-1/2 & 9-1/2, beautiful, call for photos, $800. Garcia, 505-974-7864.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday.
Submit by one of these methods:

- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: On internal web homepage, click on News Center, then on *Lab News* link, and then on the very top of *Lab News* homepage "Submit a Classified Ad."**

If you have questions, call Michelle at 844-4902.
Because of space constraints, ads will be printed on a first-come basis.

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

TRANSPORTATION

'78 OLDSMOBILE TORONADO BROUGHAM COUPE, 35K miles, stored, purchased new, owner manual, cruise control, sun-ray tinted windows, $8,000. Brunacini, 505-883-2557.

'12 MAZDA 5, light blue, serviced by Mazda, 2nd owner, clean Carfax, 30K miles, $12,500. Castelluccio, 347-575-2539 ask for Gustavo.

'05 TOYOTA COROLLA S, many extras, dark blue metallic, 105K miles, very good condition, $5,500. Weagley, 505-385-4059.

'73 VW BEETLE, original paint, 8K original miles, garaged since purchased in '73, $12,000 OBO. Montoya, 505-227-7217.

'72 CLASSIC CHEVY STEPSIDE PICKUP, new 350 V8 AT, fully restored, yet room to personalize, $23,500. Aragon, 505-250-3013.

'12 HONDA CROSSTOUR, 4-cyl. AT, ~70K miles, warranty included, excellent condition, $12,500 OBO. Gibson, 505-977-3021.

RECREATION

'06 FOUR WINDS TRAVEL TRAILER, 27-ft., excellent condition, $10,900 OBO. Mathews, 505-321-7650.

INFLATABLE KAYAK, AIRE Sawtooth, 2 seats, new side bladders, reinforced bottom, w/foot pump, $450. Manko, 412-719-2766.

'07 TRIUMPH BONNEVILLE T100, lots of upgrades, $3,500 OBO. Schanning, 505-328-2320, ask for Don.

'07 FLEETWOOD POP-UP CAMPER, AC, shower/bathroom, refrigerator/stove, awning, dining room slide out, excellent condition, $5,500. Garner, 505-260-9151.

'07 CROSSROADS CRUISER 5TH WHEEL, 27-ft., 1K highway miles, stored inside, interior like new, $15,000. Endres, 505-263-1616, ask for John.

'10 COACHMAN CATALINA TRAVEL TRAILER, 26-ft., loaded w/options, just serviced, like new, $9,500 OBO. Williams, 903-6397.

REAL ESTATE

2-ACRE BUILDING LOT, Cedar Crest, w/utilities, mountain views, new road, owner financed, w/easy terms, $120,000. Mihalik, 505-281-1306.

3-BDR. HOME, 2 baths, 2,467-sq. ft., High Desert neighborhood, city/mountain views, 15 mins. from base, $389,000. Fernandez, 505-459-1638.

3-BDR. HOME, w/office, 1-3/4 baths, 1,770-sq. ft., new water heater & Master Cool unit, well maintained, SE Heights neighborhood, mins. to Louisiana gate, MLS#873495, $145,000. Chavez, 505-450-2739 or 296-9265.

4-BDR. HOME, 2-3/4 bath, 2,700-sq. ft., well maintained, lots of storage, Sandia High School district, $185,000. Mozley, 884-3453.

5-BDR. HOME, 3 baths, 4,280-sq. ft., separate in-law quarters, swimming pool, Zillow, 817 Lamp Post Circle SE, 87123. Ramos, 972-951-0290.

WANTED

FEMALE ROOMMATE, for 2-bdr. apt., 15 min. from Sandia, $420/mo. Reif, 505-681-9350.

SENIOR WOMEN'S SOFTBALL LEAGUE, 50+, now forming 2017, bring a team or yourself. Campos, 505-715-2605, patalonis@aol.com.

STEP LADDER, 9-10-ft. extension ladder, tall?, reasonable price, mine was stolen. Colgan, 344-3776.

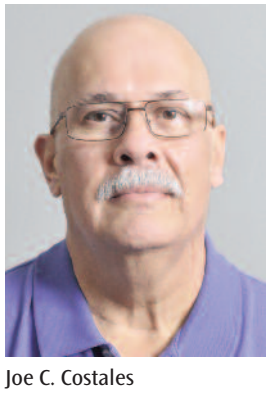
Recent Retirees

New Mexico photos by Michelle Fleming
California photos by Randy Wong


Michael A. Pacheco
40 4878


Mike Coltrin
37 1126


Patrick Sena
37 2200


Joe C. Costales
36 10261


Victor Johnson
36 2000


Pamela Mincey
36 4847


Lisa Mondy
36 1516


Ann Gutierrez
34 810


Scott Neely
33 10265


Keith Paulson
33 4842


Evan Ashcraft
30 10520


Greg Shirley
24 10624


John Hofer
15 1521


Ginnie Steiner
11 4128

Mileposts

New Mexico photos by Michelle Fleming
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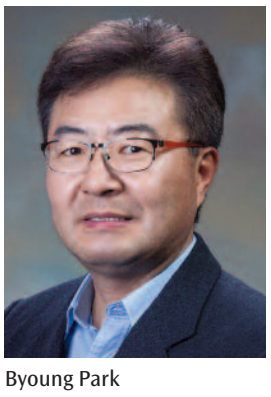
Lisa Hooper
25 4127


Robert Reese
25 4131


Patricia Buckles
15 3643


Craig Carmignani
15 6112


Melisa Regina Marquez
15 10667


Byoung Park
15 6912


Greg Valdez
15 10261

One day in the life of a custodian

By Jennifer Sawayda
Infographic by Alicia Bustillos

In the cleaning industry, if you want to learn from the best you learn from Sandia's custodial team. With its standardized cleaning process based on engineering practices, combined with the crew's daily commitment and dedication, the department has received "best audit" for nine consecutive years from a third-party industry audit agency. That's why custodial professionals from New York-based Brookhaven National Laboratory visited Sandia recently to watch the custodial team in action.

They use the Operating System 1 (OS1) tools and prescriptive processes and procedures to provide safer, simpler, and more comprehensive custodial services. A team cleaning approach uses in-depth training from upper management down to the worker level. Work is divided into four tasks performed by specialists: restroom, light-duty, vacuuming, and utility. Custodians rotate specialties by week. Team cleaning allows each team member to focus on a specific specialty to ensure an area is thoroughly serviced.

According to custodial Team Supervisor Chris Romero (4848-6), OS1 views custodians as professionals who add value to the organization, cleaning for health first and appearance second. The department incorporates engineering, science, and professionalism as part of the training curriculum.

> *"It is our crew's commitment and sense of ownership that truly make them the best of the best."*
>
> **— Chris Romero custodial Team Supervisor**

"It is our crew's commitment and sense of ownership that truly make them the best of the best," Chris says. "Their expertise assures they are cleaning for health rather than polluting."

Five members of the day-shift custodial teams shared their thoughts on what constitutes a typical day for a Sandia custodian. They are Cheryl Cuoco (4848-5), a Sandia custodian for 18 years; Lead Custodian Dorothy Sauceda (4848-6), 14 years; Jaye Sandoval (4848-4), six years; Isaac Silva (4848-4), two years; and Michael Flores (4848-6), five months.

What is a typical work day like for you?

Jaye – We get here at 6 a.m. We start off by stretching in the morning to get warmed up and then head out to the buildings. We follow the job cards; one of us does restrooms, one of us does light duty, one of us does vacuuming, and when we have time we do utility. There is a morning break from 9:00–9:15 and an afternoon break at 1:30–1:40. We have our lunch break from 11:00–11:30.

Dorothy – As lead custodian, my day starts at 5:30 a.m. I get all the teams ready. I have four teams, and they have different buildings. If someone is out, then I will go and help out wherever is needed. I order supplies, take out supplies, and do training first thing in the morning. I also have to account for all the chemicals going in and out.

What do you like about working as part of the custodial staff at Sandia?

Michael – I like that it's very hands on. I get to move around and meet a lot of people on the job. It's a gateway for some of us to do something bigger.

Isaac – We have health insurance and tuition assistance. Our custodians often go on to do a number of things at Sandia. Several of the managers started out as custodians.

What do you think about safety at Sandia? How does this apply when you discover something unusual in a building, such as flooding?

Isaac – Safety is the number one priority.

Cheryl – During an emergency, we'll go to our team lead and, depending on what the situation is, we all kind of tackle it together. First, they talk to the incident commander to determine whether it's safe to go in. Once it's deemed safe, we put our other duties aside for the time being and handle the situation.

How do you see yourself adding value to Sandia?

Dorothy – We are keeping the environment healthy for our customers to come in and do their work. We clean for health first, then appearance. First impressions are the most important. We have a lot of high-profile people who visit Sandia.

Why do you think the custodial team is so effective at Sandia?

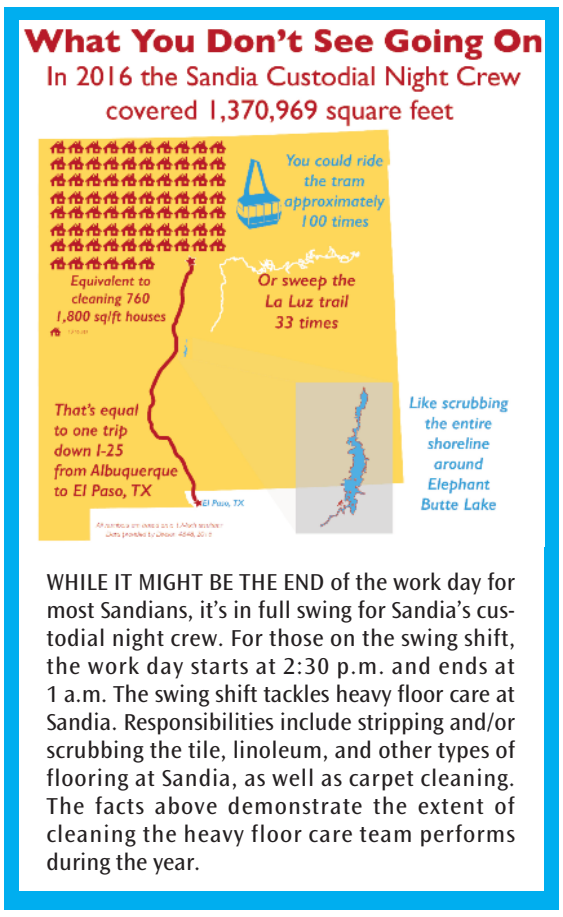
Cheryl – We have better quality control processes, and they're more cost-effective. Team cleaning provides greater simplicity. Everything we do is on a consistent basis where everybody is on the same page, as opposed to zone cleaning when you had your own building and everything was scattered.

Dorothy – Other companies we compete against are at our door. I think that while others have adopted OS1, we as Sandians go above and beyond. When audit time comes, they are blown away.

How are you treated at Sandia?

Michael – I'm grateful to be here. They treat us with respect. We also brighten up their days. We can talk to the customers and cheer them up.

Jaye – People thank us a lot for what we do.



WHILE IT MIGHT BE THE END of the work day for most Sandians, it's in full swing for Sandia's custodial night crew. For those on the swing shift, the work day starts at 2:30 p.m. and ends at 1 a.m. The swing shift tackles heavy floor care at Sandia. Responsibilities include stripping and/or scrubbing the tile, linoleum, and other types of flooring at Sandia, as well as carpet cleaning. The facts above demonstrate the extent of cleaning the heavy floor care team performs during the year.

CHERYL CUOCO (4848-5) vacuums Bldg. 880. The vacuum is fitted to Cheryl's size to reduce strain on the body. An ergonomic handle makes it more comfortable to use the vacuum wand.

MICHAEL FLORES (4848-6) disinfects a restroom in Bldg. 858EL. Restroom specialist is one of the four tasks in which custodians specialize.

LEAD CUSTODIAN Dorothy Sauceda (4848-6) prepares the daily kitting for her teams.

ISAAC SILVA (4848-4) dusts as one of the tasks of a light duty specialist. Isaac views the custodial staff as "the backbone of the organization."

AS UTILITY SPECIALIST, Jaye Sandoval (4848-4) mops the floor in Bldg. 836. Some responsibilities of the utility specialist include mopping floors, vacuuming stairwells, and cleaning common areas.

CUSTODIAL SERVICES keeps a detailed Daily Kitting Safety Log. Like all other departments at Sandia, safety is the number one priority for the Custodial Services teams.

CUSTODIAL MANAGER Josh Konetzni (4848) left and custodial Team Supervisor Chris Romero (4848-6) both started out as custodians.