Sandia light mixer makes 11 colors at once

First nanostructured material for broad mixing of light waves

By Mollie Rappe

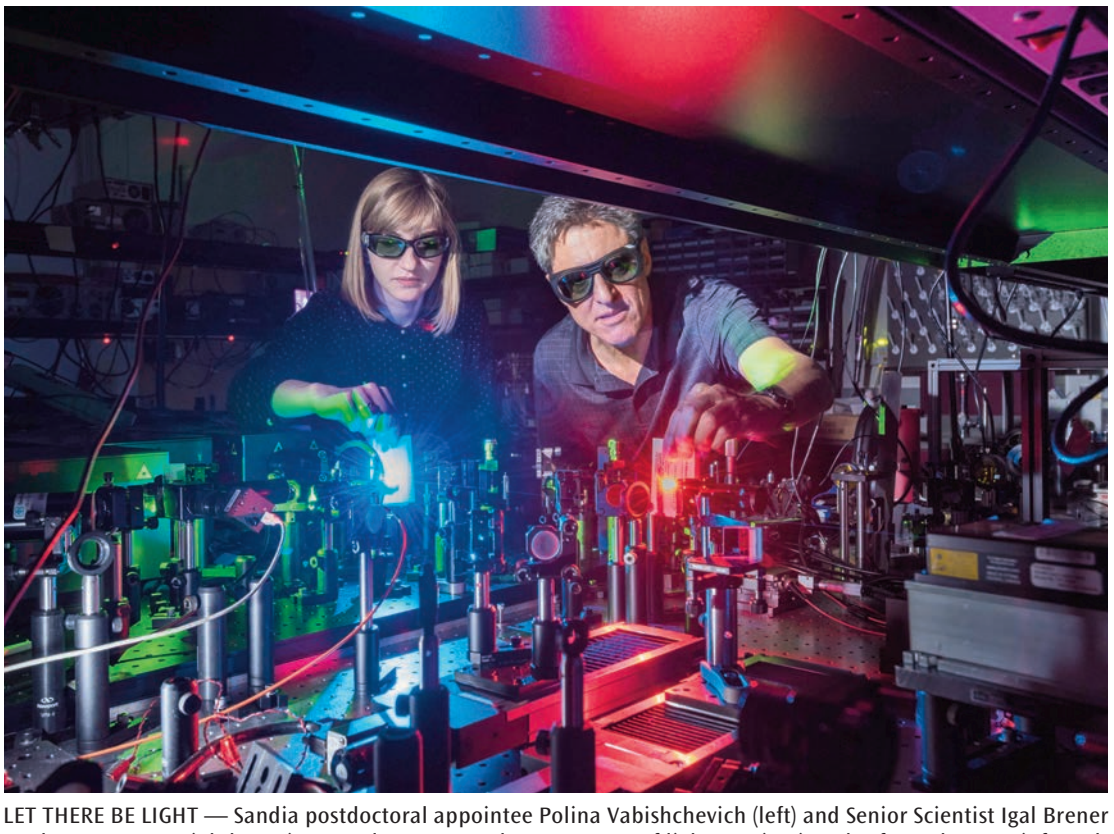
A multicolor laser pointer you can use to change the color of the laser with a button click — similar to a multicolor ballpoint pen — is one step closer to reality thanks to a new tiny synthetic material made at Sandia.

A flashy laser pointer may be fun to envision, but changing the color of a laser has many other uses, from discovering hidden archeological sites in dense forests and detecting signs of extraterrestrial life in the air to the possibility of speeding up and increasing the capacity of long-distance communication via fiber-optic networks.

Research on the new light-mixing metamaterial was published in *Nature Communications* last week. Sandia Senior Scientist Igal Brener led the work, along with collaborators at Friedrich Schiller University Jena, Germany. They describe how a metamaterial made up of an array of nanocylinders mixed two laser pulses of near infrared light to produce 11 light waves that ranged in color from the near infrared, through all the colors of the rainbow, to ultraviolet.

A metamaterial is a material made up of tiny, repeating structures that interact with electromagnetic waves in ways conventional materials cannot. The structures are much smaller than the wavelength of light they are designed to manipulate. They are somewhat similar to the natural structures that give blue morpho butterfly wings their spectacular iridescence. The wings have scales with tiny repeating structures, which reflect light to produce the blue color.

For this optical mixer, the team made the array of nanocylinders from gallium arsenide, a semiconductor used in many kinds of electronics. Gallium arsenide bends, or refracts, light strongly, which is essential for this kind of metamaterial, Igal said. Each nanocylinder is about 500 nanometers tall — or 100 times smaller than the width of a human hair — with a diameter of about 400 nanometers. They are laid out in a square pattern about 840 nanometers apart from one another.



LET THERE BE LIGHT — Sandia postdoctoral appointee Polina Vabishchevich (left) and Senior Scientist Igal Brener made a metamaterial that mixes two lasers to produce 11 waves of light ranging in color from the near infrared, through the colors of the rainbow, to ultraviolet. Research on the new light-mixing metamaterial was published in Nature Communications last week. (Photo by Randy Montoya)

Igal said the usual process of mixing light to make green laser pointers or other products currently requires phase matching, or perfectly aligning the light waves, with specially crafted crystals. Each crystal can only efficiently match the phases of one color of incoming light to produce one different color of light.

Sandia's metamaterial is completely different.

The team selects two near infrared lasers with wavelengths tuned to the metamaterial's resonant frequencies, or the wavelengths that bounce around inside the nanocylinders best, said

(Continued on page 4)

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Inside . . .

Generating electrical power from waste heat

New Sandia solid-state silicon device may one day power space missions

By Mollie Rappe

Directly converting electrical power to heat is easy. It regularly happens in your toaster, that is, if you make toast regularly. The opposite, converting heat into electrical power, isn't so easy.

Researchers from Sandia have developed a tiny silicon-based device that can harness what was previously called waste heat and turn it into DC power. Their advance was recently published in Physical Review Applied.

"We have developed a new method for essentially recovering energy from waste heat. Car engines produce a lot of heat and that heat is just waste, right? So, imagine if you could convert that engine heat into electrical power for a hybrid car. This is the first step in that direction, but much more work needs to be done," said Paul Davids, a physicist and the principal investigator for the study.

"In the short term we're looking to make a compact infrared power supply, perhaps to replace radioisotope thermoelectric generators." Called RTGs, the generators are used for such tasks as powering sensors for space missions that don't get enough direct sunlight to power solar panels. Think of the intrepid Mars rover Curiosity; the spectacular photos and wealth of data gathered by the Cassini mission to Saturn and the New Horizons mission to Pluto; and the Voyager probes — the only objects humans ever sent out of our solar system, now 13 and 11 billion miles away and still transmitting data back to Earth.

Silicon device catches, channels and converts heat into power

Paul's device is made of common and abundant materials, such as aluminum, silicon and silicon dioxide — or glass — combined in very uncommon ways.

Smaller than a pinkie nail, the device is about 1/8 inch by 1/8 inch, half as thick as a dime and metallically shiny. The top is aluminum that is etched with

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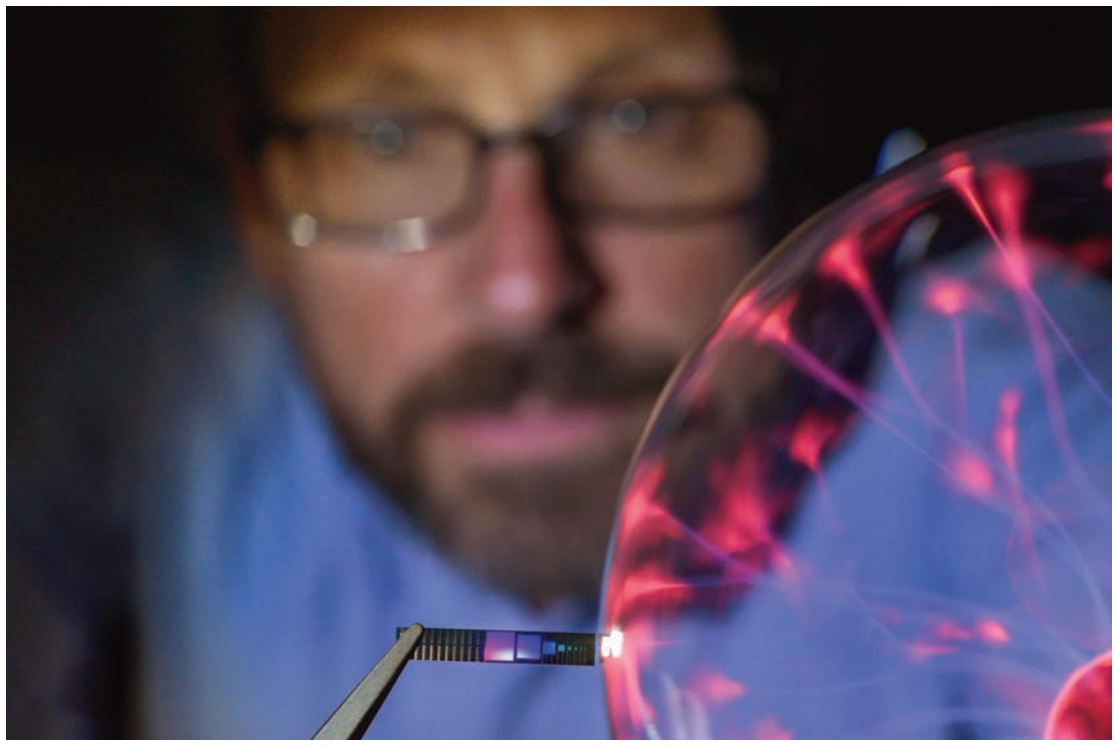

POWER PACKED — Sandia physicist Paul Davids hopes that his team's rectenna may someday replace radioisotope thermoelectric generators as the go-to compact power supply for deep space missions and other uses where you can't just go and replace the batteries. (Photo by Randy Montoya)

CYR wins DOE grant

Sandia researcher Eric C. Cyr receives 2018 Early Career Research Program award to improve deep neural networks

page 3

Cooking composites in the sun

Solar tower exposes materials to intense heat to test thermal response

By Sue Major Holmes

HEATING UP — Sandia is using its solar tower to help assess the impact of extreme temperature changes on materials for the Air Force. (Photo by Randy Montoya)

Sandia's solar tower is helping to assess how extreme temperature changes affect materials.

The tests for the Air Force, now in their second year, take advantage of the ability of Sandia's National Solar Thermal Test Facility to simulate a very rapid increase in temperature followed by an equally rapid decrease. Testing will continue for at least another year.

Researchers put a 4-by-4-inch sample of a composite material, called a coupon, into a test chamber, then expose it to a burst of intense heat. Different coupons are made of different types of materials.

Specialty ovens can reach the temperatures needed, but ovens can't heat up or cool down rapidly. "And it's hard to just stick a coupon in real fast and then take it out," test engineer Josh Christian said. "Our facility is really good at providing a fast ramp rate for these heating curves, and we also can produce a trailing curve by moving our mirrors in such a way to remove the heat from the sample."

The solar tower team places the coupon flush to a wall of a test chamber, basically a box, facing a quartz window that lets in the heat produced by the heliostats, or mirrors. The tests, which use about a quarter of the heliostat field, can change heat levels as needed.

Initially, the team closes sliding shutters in front of the window. They focus reflected light from the heliostats onto a calibration panel and use a heat flux gauge to measure the power that will hit the sample. Then they move that reflected light onto the shutters. When ready, the shutters slide open and close very quickly to produce the heating curves needed on the sample. At the same time, a wind tunnel with a blower on one end forces air across the sample to simulate convective cooling. Convective cooling impacts the heating rate since with convective cooling, materials survive longer under intense heat.

Sample could be heated several times

Researchers can subject a sample to heat multiple times to establish material response thresholds after exposure.

"The heat goes in, we close, that's the end of the test," Josh said. "We do this repeatedly, 10 to 30 times a day."

Before and after a test, another Sandia team checks the sample with a 3D scanner, which determines whether the heat produced bubbles or texture changes in the material, Josh said.

Still another group of Sandia researchers takes reflectivity measurements — how much light is reflected from the surface. For example, if a sample absorbs 90 percent of the light and reflects 10 percent, then 10 percent of the light did not heat it. Josh said that's important because, in real life, materials with a high reflective value heat up slower.

A third team uses nondestructive methods to look inside the sample after a test, checking for changes below the surface, which is particularly important for complex structures made of several different materials.

Testing continues all year

Tests go on year-round, but the Air Force program does not test every day since the solar tower does tests for other programs. Last summer, for example, Josh estimated 30 to 40 days were devoted to the project. Tests continue in the winter, but test periods are shorter due to the angle of the sun to the mirrors.

"For our facility, this is a major test that has started to become routine as we have tested hundreds of samples," said Josh, who has worked at the tower for eight years.

The project also has led to improvements at the facility, including a new tracking algorithm for the heliostats and advances in heat flux characterization techniques that allow researchers to quantify the heat applied to samples. Knowing the exact heat applied is critical to understand what conditions materials can survive, and researchers developed new tools to help perform that analysis.

The mirrors move with the sun to keep a reflected spot on the solar tower, "but we were finding that at certain times of the year and times of the day, the spot wouldn't be where we predicted it to be because of imperfections in how the mirrors were installed," Josh said. So, he said, the improved tracking algorithms not only help the Air Force project but also other Sandia tower projects and potentially other facilities that use heliostats, such as sites that generate power.

The tower has done similar tests for other agencies, including NASA, and other projects for the Air Force. "Now it's become a success on our side as well as their side," Josh said.

North to Alaska for Sandia at National Lab Day

By Kristen Meub
Photos by Laurie Burnham

Sandia researchers and leaders recently took part in the first Alaska National Lab Day at the University of Alaska, Fairbanks. Scientists from most of the DOE national labs, Alaska researchers and industry leaders presented recent work and discussed opportunities for future collaboration and partnerships. The two-day event focused on increasing awareness about Alaska's unique energy-related resources, infrastructure and environment. Participants identified several research areas and opportunities for the labs to use Alaska expertise and resources to support work on energy, climate and security issues at the national level. Sandia participated in multiple panel discussions on energy research, lab-university collaboration, the changing Arctic and the nature of a national lab.

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Sandia computational researcher wins DOE Early Career Research Program award

$2.5 million grant to 'pursue new directions' in neural networks

By Neal Singer

Sandia researcher Eric C. Cyr has received a 2018 Early Career Research Program award of $500,000 every year for five years to improve deep neural networks so they more efficiently combine experimental results with the most complex computer models.

The national award from the DOE's Office of Science is meant to "identify and provide support to those researchers early in their careers who have the potential to develop new scientific ideas, promote them and convince their peers to pursue them as new directions."

Eric's winning proposal was "Parallel-in-layer methods for Extreme-Scale Machine Learning." Machine learning in the form of deep neural networks has seen unprecedented success in the past few years, leading to innovations in self-driving cars, pattern recognition (including facial and speech recognition) and natural language processing.

A deep neural network is a model whose architecture is loosely inspired by the brain. It uses a sequence of mathematical operations collected in layers to automatically embed knowledge of previously observed data. Such models can make predictions and associations not previously observed; thus, machines "learn."

Commercial innovations driving machine learning

Eric attributes recent successes of these mainly commercial innovations to the advent of high-density computing devices and to the large data sets used to train the computer-generated models. For his project, he proposes to advance the technology further into the realm of more complex scientific devices. In particular, he wrote in his proposal, his goal is to develop "an algorithmic toolset for scientific machine learning that will transform how experts integrate experimental data and computer simulations through the use of deep neural networks."

Despite the success of deep neural networks, the cost of these approaches remains high, with training times measured in days on relatively small computer clusters, he said. Compared to the commercial applications of deep neural networks, scientific data sets are massive, measuring in terabytes to petabytes. To Eric, algorithmic advances are required to robustly apply machine learning technologies to these demanding data sets.

Another problem: approaches used in commercial deep-neural-network architectures don't generalize well to scientific data sets.

These issues limit the applicability of deep neural networks as a general tool for use in scientific machine learning.

Eric aims to reduce or eliminate these limitations.

GRANT WINNER — The Department of Energy's Office of Science has awarded Sandia National Laboratories researcher Eric Cyr an Early Career Research Program award for 2018. (Photo by Randy Montoya)

DOE supports lifetime discovery science

"Supporting talented researchers early in their career is key to building and maintaining a skilled and effective scientific workforce for the nation," said Energy Secretary Rick Perry in a DOE news release. By investing in the next generation of scientific researchers, we are supporting lifelong discovery science to fuel the nation's innovation system. We are proud of the accomplishments these young scientists have already made, and look forward to following their achievements in years to come."

Eric was a summer 2002 intern at Sandia's Computer Science Research Institute, before finishing his bachelor's at Clemson University in 2003 and earning a doctorate in computer science from the University of Illinois at Urbana-Champaign in 2008. He joined Sandia in January 2009 as a postdoctoral researcher, became a senior member of the technical staff in 2010 and a principal member of the technical staff in 2015. He is a joint author on 25 published papers.

DOE Early Career grants are available in the program areas of advanced scientific computing research, biological and environmental research, basic energy sciences, fusion energy sciences, high energy physics and nuclear physics. To be eligible for the DOE award, a researcher must be an untenured, tenure-track assistant or associate professor at a U.S. academic institution or a full-time employee at a DOE national laboratory, who received a doctorate within the past 10 years.

Thirty researchers from DOE's national laboratories and 54 from U.S. universities were selected for the prestigious award this year.

California Faculty Field Day

Sandia's relationship incubator

By Holly Larsen

It's a familiar refrain: Partnerships are good for Sandia. They bring new ideas, new minds, new employees and, potentially, new mission work for the labs. Even more importantly, large, diverse partnerships are crucial to national security.

"We need teams with different types of talent to solve the nation's biggest problems, problems that are beyond the scope of a single investigator or institution," said Ben Cook, senior manager in Sandia's Chief Research Office and lead of Sandia's academic partnerships programs.

However, pitfalls surface when moving from theory to practice. For Sandia, the difficulty lies in finding an external partner with the right expertise and sufficient enthusiasm to invest time and resources into starting and executing a project in a Sandia mission area. For academic partners, especially those early in their faculty careers, the show-stopper may be an institutional barrier: university tenure systems reward individual successes over collaborations.

Rebecca Horton, who manages Sandia's partnerships with the Georgia Institute of Technology, defined the key to surmounting these issues. "It all begins with relationships. You need to get to know people in other organizations to understand who can bring the right capabilities and colleagues to a given project."

Getting to know early career academics

To help incubate those relationships, Sandia welcomed more than 30 early career faculty from universities across the country to a Faculty Field Day at the California site last month.

The meeting was hosted by Sandia's Academic Alliance program, which takes a deliberate approach to building partnerships at five universities with close ties to Sandia and its mission: Georgia Tech, University of Illinois at Urbana-Champaign, University of New Mexico (UNM), Purdue University and the University of Texas at Austin (UT Austin).

Organized by Ken Patel, Sandia's Academic Alliance manager for Purdue — with help from Michelle Gonzalez, Carrie Burchard, Meg Davidson and a host of others — the Faculty Field Day included an introduction to Sandia, a panel on successful collaborations and lab tours.

BRAINSTORMING — At the Faculty Field Day, small group sessions allowed for a free flow of ideas, as well as lighter moments. (Photo by Randy Wong)

But the lion's share of activities brought Sandians and the faculty visitors together in small groups to explore interests and discuss capabilities for the big projects needed to solve national problems. The discussions, buoyed by a mixer reminiscent of speed dating and a social event at a local winery funded by Purdue, Georgia Tech and UNM, created a casual yet focused platform for developing relationships.

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The format seemed to work. Said Kathryn Huff, assistant professor of nuclear engineering at Illinois. "It was a great way to foster collaborations. I had anticipated something much more formal, but this was flexible and fun. I'm glad I came."

The more formal aspects of the program also provided value. "I really appreciated the panel on success stories, which directly answered my questions about how to collaborate with Sandia," added Andrew Miller, assistant professor in electrical and computer engineering at Illinois.

Big teams for big problems

Keynote speaker Oscar Dubon, vice chancellor for Equity and Inclusion at University of California, Berkeley, reinforced the themes of the event, emphasized the need for big teams to solve big problems and noted the importance of diversity. Having people with different expertise and experience on a team is critical to developing solutions that address the entirety of a problem, he said.

He also commented on the role of relationships in addressing the bias against collaborative work in the university promotion system. In a trusted relationship, faculty and other partners can deal openly with the issues of properly assigning credit for the work in ways that help, rather than hurt, the faculty collaborator.

Success that can't be quantified

Ken was pleased with the event. "It was a wonderful opportunity to have five powerhouse schools come together with Sandia."

Grant Heffelfinger, Sandia's deputy chief research officer and director of advanced science and technology, summed up potential outcomes. "We're always looking for classic markers to measure the success of an initiative to promote collaborations, such as the number of joint publications and level of customer support for new mission work."

But sometimes, Grant added, the numbers miss the point. "For example, as we see some really big results coming out of a collaboration, it could be that the success began as something very small, possibly years in the past — something like a relationship that started at a Faculty Field Day."

Optical mixer

(Continued from page 1)

Polina Vabishchevich, a Sandia postdoctoral appointee and first author on the paper. The light from these two lasers — call them frequencies A and B — mix to produce 11 colors from different mixing products including A+A, A+B, B+B, A+A+B, A+B+B, and other more complex mixing products.

"With this tiny device and two laser pulses we were able to generate 11 new colors at the same time, which is so cool," Polina said. "We don't need to change angles or match phases."

Optical metamixer has potential for widespread research applications

The team used processes borrowed from semiconductor device fabrication to make the metamaterial. They made it at several Sandia facilities, principally the Microsystems Engineering, Sciences, and Applications complex and the Center for Integrated Nano-technologies, a DOE Office of Science user facility jointly operated with Los Alamos National Laboratory.

"If we didn't have access to the instrumentation we have at Sandia, this research would have been impossible," Igal said. "Without CINT's specialized femtosecond laser system, it would have been very challenging to perform these measurements." A femtosecond is one millionth of a billionth of a second; femtosecond lasers produce brighter light than traditional lasers.

Though the conversion efficiency for the optical metamixer is very low — for example, the resulting red-orange light is very weak compared to the incoming light — Igal believes they can greatly improve the efficiency, perhaps by stacking multiple layers of metamaterial.

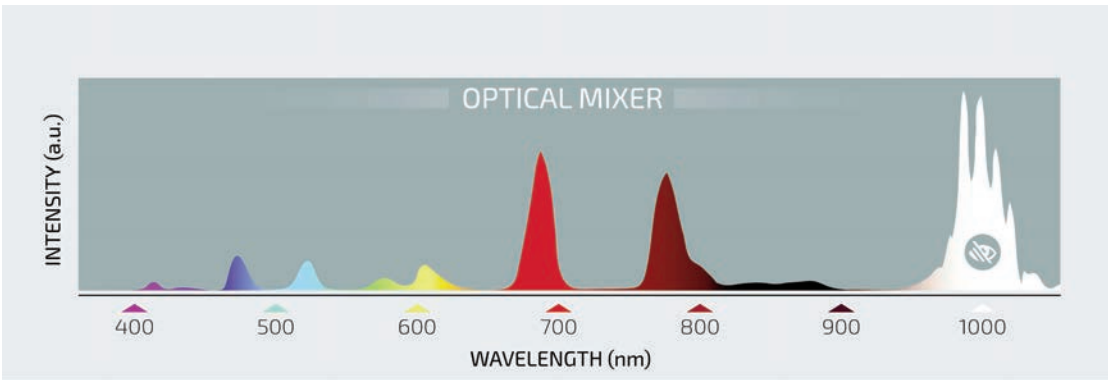
Many different areas of chemical and biological research require light at specific wavelengths, such as using specialized microscopes to study how diseases evade the immune system or studying the chemistry of combustion to improve vehicle efficiency. The optical metamixer could convert light from lasers to a new wavelength where a laser might not be available or allow researchers to switch from one wavelength to another without having to buy a different laser, Igal said.

Switchable, tunable lasers also could be valuable in biological, chemical and atmospheric research; remote sensing; fiber-optic communication; even quantum optics.

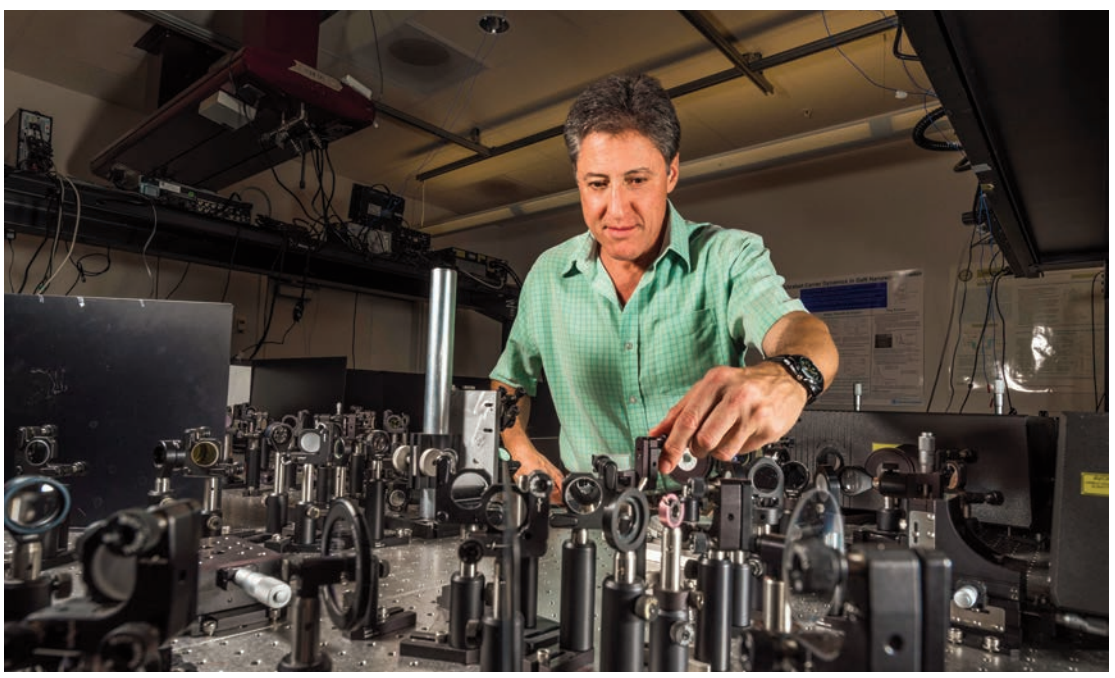
Igal is a leader for nanophotonics and optical nanomaterials research at CINT.

The research team included collaborators from Friedrich Schiller University Jena, Germany; John Reno, a CINT materials scientist who grew the semiconductors; Sandia physicist Mike Sinclair, who was involved in the modeling and theory; and former Sandia researchers Sheng Liu and Gordon Keeler.

This work was funded by the DOE Office of Science.



OPTICAL MIXER — The new light mixing metamaterial, made up of an array of nanocylinders, produces 11 colors at the same time. The infrared light is actually 10 times stronger than the red light. (Image by Michael Vittitow)



NO SMOKE, LOTS OF MIRRORS — Igal Brener doing some testing in his optical laboratory. (Photo by Randy Montoya)

Heat to power

(Continued from page 1)

stripes roughly 20 times smaller than the width of a human hair. This pattern, though far too small to be seen by eye, serves as an antenna to catch the infrared radiation.

Between the aluminum top and the silicon bottom is a very thin layer of silicon dioxide. This layer is about 20 silicon atoms thick or 16,000 times thinner than a human hair. The patterned and etched aluminum antenna channels the infrared radiation into this thin layer.

The infrared radiation trapped in the silicon dioxide creates very fast electrical oscillations, about 50 trillion times a second. This pushes electrons back and forth between the aluminum and the silicon in an asymmetric manner. This process, called rectification, generates net DC electrical current.

The team calls its device an infrared rectenna, a portmanteau of rectifying antenna. It is a solid-state device with no moving parts to jam, bend or break, and doesn't have to directly touch the heat source, which can cause thermal stress.

Infrared rectenna production uses common, scalable processes

Because the team makes the infrared rectenna with the same processes used by the integrated circuit industry, it's readily scalable, said Joshua Shank, electrical engineer and the paper's first author, who tested the devices and modeled the underlying physics while he was a Sandia postdoctoral fellow.

He added, "We've deliberately focused on common materials and processes that are scalable. In theory, any commercial integrated circuit fabrication facility could make these rectennas."

That isn't to say creating the current device was easy. Rob Jarecki, the fabrication engineer who led process development, said, "There's immense complexity under the hood and the devices require all kinds of processing tricks to build them."

One of the biggest fabrication challenges was inserting small amounts of other elements into the silicon, or doping it, so that it would reflect infrared light like a metal, said Rob. "Typically you don't dope silicon to death, you don't try to turn it into a metal, because you have metals for that. In this case we needed it doped as much as possible without wrecking the material."

The devices were made at Sandia's Microsystems Engineering, Science, and Applications complex. The team has been issued a patent for the infrared rectenna and has filed several additional patents.

The version of the infrared rectenna the team reported in Physical Review Applied produces 8 nanowatts of power per square centimeter from a specialized heat lamp at 840 degrees. For context, a typical solar-powered calculator uses about 5 microwatts, so they would need a sheet of infrared rectennas slightly larger than a standard piece of paper to power a calculator.

Future work to improve infrared rectenna efficiency

But they have a lot of ideas to improve efficiency.

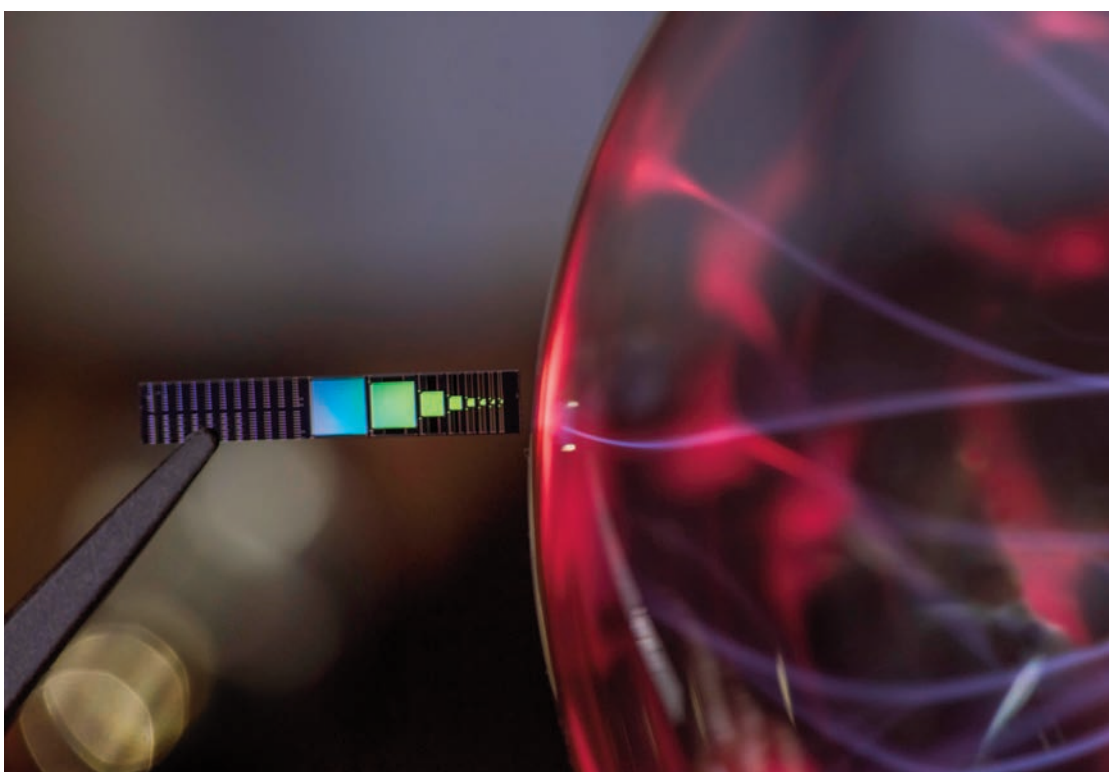
They include making the rectenna's top pattern 2D x's instead of 1D stripes, in order to absorb infrared light over all polarizations; redesigning the rectifying layer to be a full-wave rectifier instead of the current half-wave rectifier; and making the infrared rectenna on a thinner silicon wafer to minimize power loss due to resistance.

Through improved design and greater conversion efficiency, the power output per unit area will increase. Paul thinks that within five years, the infrared rectenna may be a good alternative to RTGs for compact power supplies.

Joshua said, "We need to continue to improve in order to be comparable to RTGs, but the rectennas will be useful for any application where you need something to work reliably for a long time and where you can't go in and just change the battery. However, we're not going to be an alternative for solar panels as a source of grid-scale power, at least not in the near term."

Paul added, "We've been whittling away at the problem and now we're beginning to get to the point where we're seeing relatively large gains in power conversion and I think that there's a path forward as an alternative to thermoelectrics. It feels good to get to this point. It would be great if we could scale it up and change the world."

The research was funded by Sandia's Laboratory Directed Research and Development program.



ELECTRIFYING — This tiny silicon-based device developed at Sandia can catch and convert waste heat into electrical power. The rectenna, short for rectifying antenna, is made of common aluminum, silicon and silicon dioxide using standard processes from the integrated circuit industry. (Photo by Randy Montoya)

SMART BRIDGE — Sandia National Laboratories mechanical engineer Stephen Neidigk positions a Comparative Vacuum Monitoring sensor on a bridge. In his other hand is the control system to periodically check the sensors and a wireless transmitting device to autonomously alert the maintenance engineers if it detects a crack.
(Photo by Randy Montoya)

Smarter, safer bridges with Sandia sensors

Real-time structural health monitoring to detect bridge cracks

By Mollie Rappe

Along with flying cars and instantaneous teleportation, smart bridges, roads and subway lines that can send out warnings when they're damaged are staples of futuristic transportation systems in science fiction.

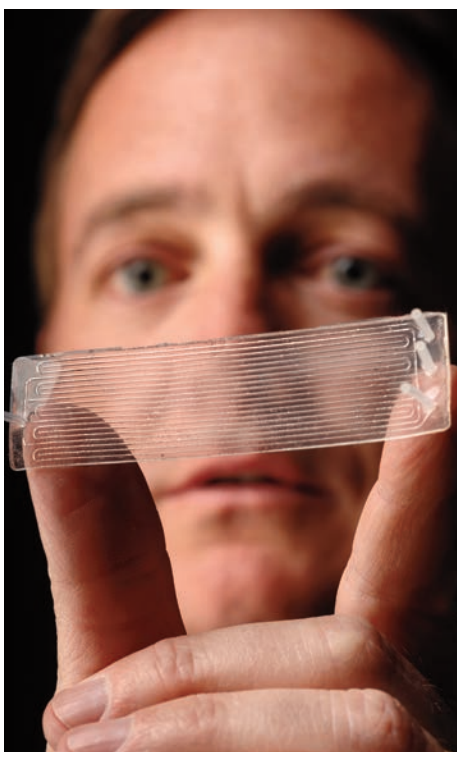
Sandia National Laboratories has worked with Structural Monitoring Systems PLC, a U.K.-based manufacturer of structural health monitoring sensors, for over 15 years to turn this science fiction into science fact. They outfitted a U.S. bridge with a network of eight real-time sensors able to alert maintenance engineers when they detect a crack or when a crack reaches a length that requires repair.

Next week, Sandia Senior Scientist Dennis Roach will present his team's work at the ninth International Conference on Bridge Maintenance, Safety and Management. His presentation will include data on the trial bridge, a general assessment of the sensors used and his proposal for how to make structural health monitoring more routine in transportation infrastructure.

The goal of structural health monitoring is to increase supervision of critical areas, extend the lifetime of structures and ultimately reduce operating costs and improve safety. To assess the condition of a bridge or other transportation infrastructure, researchers mount sensors on the structure and carefully analyze the data.

In 2016, more than 54,000 bridges in the U.S. were classified as "structurally deficient" by the Federal Highway Administration's National Bridge Inventory. This means about 9 percent of U.S. bridges need regular monitoring.

"Areas that are difficult to access or things that are remotely located like bridges, pipelines and other critical structures present significant challenges to properly monitoring the health of the structure or equipment," Dennis said. "A network of structural health monitoring sensors could be a solution, or at least help ensure the necessary vigilance over these components."



ETCHED SENSOR — Senior Scientist Dennis Roach with a Comparative Vacuum Monitoring (CVM) sensor showing galleries etched into the sensor's underside. (Photo by Randy Montoya)

'Fool-proof' vacuum monitoring sensors

The structural health monitoring system for the trial bridge consists of eight Comparative Vacuum Monitoring sensors, a vacuum pump to form the vacuum, a control system to turn on the vacuum pump and periodically check the sensors and a wireless transmitting device to autonomously call or text the maintenance engineers if a sensor detects a crack. The whole system is powered by a lithium ion battery, which is recharged by a solar panel.

The team placed sensors along several welds on a truss 100 feet above the deck, or flat road surface, on a suspension bridge.

Recently, Sandia and Structural Monitoring Systems, which has a significant presence in North America, worked with Delta Air Lines Inc. and the Federal Aviation Administration to get the Comparative Vacuum Monitoring sensors industry-certified for crack detection on commercial aircraft. Roach's work with structural health monitoring for commercial aircraft began in 2001 through the FAA's Airworthiness Assurance Center, which Sandia has operated for the FAA since 1990.

The Comparative Vacuum Monitoring sensors produced by Structural Monitoring Systems are made of thin, flexible Teflon and have rows of little channels, called galleries. They can be stuck onto critical joints or welds or placed near other places cracks are likely to form.

When the metal is whole, the pump can remove all of the air out of the galleries and form a vacuum. When a tiny crack forms in the metal underneath the sensor, it can no longer form a vacuum, like a vacuum cleaner stops working when the hose leaks. These sensors can detect cracks smaller than the thickness of a dime.

The sensors can be produced in many different shapes, depending on the region that needs to be monitored, such as across a long weld or around a series of bolts. They can even be placed in a series in front of a tiny crack, to see whether it grows and if so, how fast. Each sensor has numerous control galleries and monitoring hardware so it can tell if there's something wrong with the sensor or connecting tubes. Because of these control galleries, the sensors are practically fool-proof.

Henry Kroker, a Structural Monitoring Systems engineer who played a key role in the bridge monitoring project, said, "Comparative Vacuum Monitoring sensors provide an elegant 'Green-Light, Red-Light' method for constantly surveying critical components. In many years of trial and permanent use in the aviation and now civil industries, theses sensors have not produced any false calls."

Future of structural health monitoring

The team's work on smart infrastructure began in 2005 through a Sandia-sponsored Laboratory Directed Research and Development project that used mounted sensors and wireless data transfer to continuously monitor a wide array of civil structures, everything from heavy mining equipment to railway systems and bridges. These sensors monitor the health of structures and mechanical devices by detecting the presence of corrosion and cracks and even the condition of critical moving parts.

Roach and his team also use piezoelectric sensors, fiber optics and printed eddy current sensors for structural health monitoring.

Printed eddy current sensors, a Sandia-patented technology, can be installed on curved surfaces and use changes in a magnetic field to detect cracks. On the other hand, a network of piezoelectric sensors can monitor a wide area instead of just a few patches. Each sensor takes turns sending a vibration through the underlying material that the other sensors receive. Cracks or other damage within the sensor network change the "pitch" of these vibrations. However, such pitch changes are more complex than the "yes" or "no" provided by comparative vacuum monitoring. Comparative Vacuum Monitoring is ready and certified for commercial use, while the other technologies are still in different stages of lab and field testing.

"In 15 years of testing Comparative Vacuum Monitoring sensors, they have achieved a tremendous track record for producing dependable structural health monitoring," said Tom Rice, the Sandia mechanical test engineer in charge of testing various structural health monitoring systems. "Once they get incorporated into more systems, in areas of concern, it's just going to make aircraft, trains and bridges safer as time goes on."

Structural health monitoring is especially good for hard-to-reach or remote areas, but it's not a panacea for all inspection needs, Dennis said.

"There's still plenty of times when you want a human in there with a flashlight or other inspection equipment, reasoning it out." With that caveat, he added "Structural health monitoring is only beginning to scratch the surface of the varied types of infrastructure it could be used for."

Railcars and rail lines, ships, wind turbines, power plants, remote pipelines, storage tanks, vehicles, even buildings could benefit from real-time, remote structural health monitoring. "The civil infrastructure industry is becoming more aware of the benefits structural health monitoring can provide and is now interested in using them," Dennis said.

Mileposts

New Mexico photos by Michelle Fleming
California photos by Randy Wong

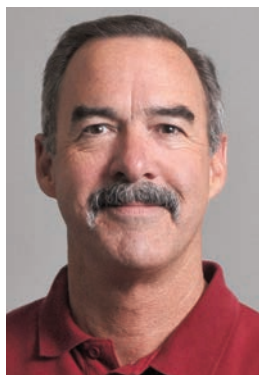

William Noel 35


Diane Peebles 35


Tom Zarick 35


John Dec 30

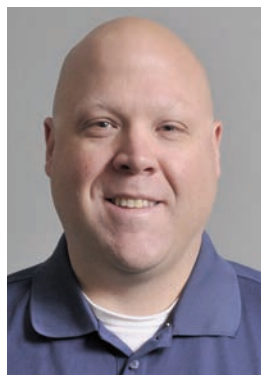

Joe DiMambro 15


Kevin Halbig 15


Stacey Hanks 15


Steve Hill 15


Wayne Itokazu 15

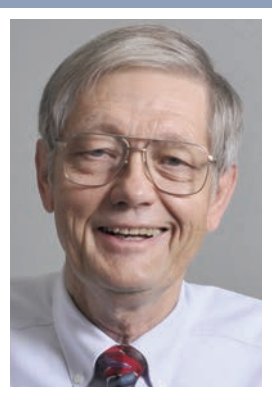

Karl Lindblom 15


Brian Miller 15


Gary Moses 15

Recent Retirees

New Mexico photos by Michelle Fleming
California photos by Randy Wong


Terry Stalker 44


Joe Chavez 43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Victor Rimkus 37


Barbara Surbey 36


Craig Boney 35


Bruce Malm 35


John Norwalk 35


Richard Kuehn 34


Mark Nissen 34


Danelle Tanner 34


W.R. “Chip” Olson 30


Steven Schafer 30


Carol Meincke 28


Kent Robbins 28


Roy Gideon 26


Dwight Coles 23


David Theriot 20


Sally Uebelacker 13

SANDIA CLASSIFIED ADS

MISCELLANEOUS

TABLE SAW, Craftsman, 10-in., flex drive, more, $150; DeWalt model DW705 12-in. compound saw, $75; DeWalt DC970 1/2-in. cordless drill, $25. Jacobson, 505-898-1397.

BACKYARD PLAYHOUSE, cedar, $75; Pink Panther Pachislo Skill-Stop machine, $300. Graham, 505-293-7302.

REFRIGERATOR, Summit, freestanding, stainless steel, 27"x75"x29", bottom freezer, frost free, 3 glass shelves, pristine condition, $550. Wagner, 505-504-8783.

ELLIPTICAL TRAINER, Kettler Vito XL HKS-Selection, photos on internet, used price ranges $460-$725, asking $175. Kendall, 505-205-7511, ask for Doug.

BEDROOM FURNITURE: queen bed, 2 nightstands, 9-drawer dresser, dark wood, high quality, good condition, $1,000. Pholphiboun, 505-400-1457.

SOLAR THERMAL SYSTEM COMPONENTS: panel pumps, storage tanks, heat exchanger, misc. $750 OBO. Lebien, 505-459-4074.

TABLE SAW, Ridgid R4510, heavy duty, 10-in., portable, w/stand, new condition, $350. Bradley, 505-379-7028.

SAUNA, Heavenly Heat, infra-red, no steam, seats 2, poplar wood, no glues, $2,100. Amador, 505-259-8919.

HUTCH, Ethan Allen, dark cherry, glass shelves, excellent condition, $475. Podgurski, 505-850-7417.

PICNIC TABLE, Rainbow, wood needs an awning, good condition, $50; swing set, Rainbow, 3 swings, rope swing, slide, more, good condition, $600; call for photos. Martinez, 505-792-3608.

CNM NURSING BOOKS, almost full set, great condition, will sell for half price. Garduno, 505-401-2872, leave message.

EXERCISE BICYCLE, NordicTrack Grand Tour Pro, 10-in. touch screen, iFit, Bluetooth, practically new, $750 OBO. Schriner, 505-275-3312.

RECLINER, leather, Furniture Row, good condition, stylish, comfortable, some cracking on seat, originally $400, asking $125. Cantrell, 505-688-0343.

PATIO FURNITURE, handmade, Adirondack chairs, tables, ottomans, call for more info. Underwood, 505-652-3123.

BABY YARD SALE, girls' clothing, swing, exerciser, maternity clothes, etc. July 13 & 14, 12000 block of Pocono Rd. SE, 87123. Ruiz, 575-650-2858.

TRANSPORTATION

'02 CAMARO SS, 35th Anniversary edition, pewter, 33.3K miles, call for more info, $15,900. Rainey, 330-685-6224.

'85 BMW 635 CSi, manual, leather, red, good condition, $5,900 OBO. Pellegrino, 505-234-5284, send text.

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: From Techweb search for 'NewsCenter', at the bottom of that page choose to submit an ad under, 'Submit an article'. 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.

'04 BUICK LESABRE LTD. 4-dr., AT, leather, seats 6, 1 owner, 57K miles, $3,995. Smith, 505-821-0024.

'83 MERCEDES 380SL, 2-dr. roadster, convertible, w/hard top, leather, 120K miles, great condition, $10,000 OBO. Eckert, 505-362-6148.

'03 TOYOTA HIGHLANDER LIMITED, FWD, white, roof rack, leather, cruise, moon roof, 65K miles, $7,500. Sapunar, 505-553-5215.

'08 MERCEDES SLK55 AMG, arctic white w/tan interior, 50K miles, mint condition, $25,000 OBO. Duncan, 505-835-4243.

'16 MITSUBISHI OUTLANDER SE, rear view camera, touchscreen control panel, 24K miles, great condition. Hidalgo, 505-239-1479.

'16 BUICK VERANO SPORT, touring sedan, heated seats, warranty, 5-star safety, 13,695 miles, $16,000. Gallegos, rkgalle@gmail.com.

'06 HONDA ACCORD EX-L, 4-dr., 4-cyl., manual, leather heated seats, sunroof, 202K miles, great car, $3,450. Hunt, 505-681-9960.

'16 TOYOTA TACOMA TRD SPORT, 4x4, V6, heated seats, sunroof, 30K miles, excellent condition, $34,500 OBO. Sanborn, 505-681-0197.

'11 JAGUAR XF, 5.0 V8, 385-hp, 6-spd., AT, fully loaded, heated/cooled seats, AM/FM/CD/USB/satellite/iPod, always garaged, $15,500. Embry, 505-205-2618.

'13 TOYOTA TACOMA, regular base cab, upgraded rims & tires, camper, hitch, running bars, 55K miles, excellent condition, $17,000. Hernandez, 505-239-0255.

'04 TOYOTA TACOMA, double cab, 4WD, camper shell, roof rack, 145K miles, good condition, $12,000. Maldonado, 505-980-9478.

RECREATION

'17 AVENGER TRAVEL TRAILER, 17-ft., used 1 time, stored inside, full bath, paid $14,000, asking $11,000. Hapka, 505-220-9114.

'15 NOVARA BIG BUZZ BIKE, large, commuted 10 miles roundtrip for 1-1/2 yrs., great condition, $200 OBO. Kubal, 505-903-8501.

REAL ESTATE

4-BDR. HOME, 3 baths, 3,939-sq. ft., contemporary, 1624 Soplo Rd. SE, 4 Hills neighborhood, price reduced, $499,000. Mohagheghi, 505-321-3399.

WANTED

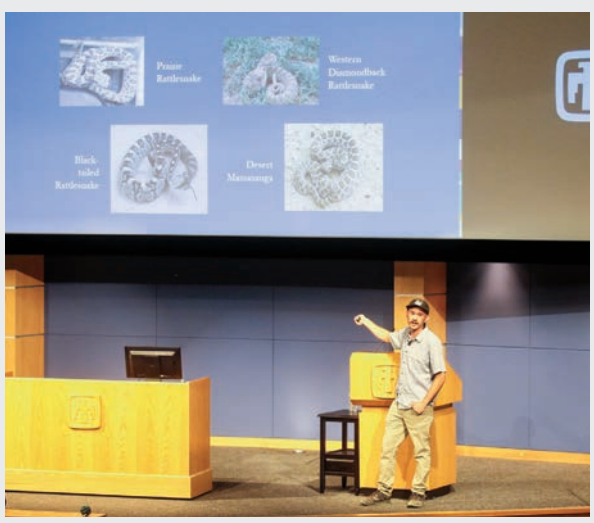
ROOMMATE, in townhouse, washer/dryer, quiet community, pool, close to KAFB, month-to-month, $650/mo., 1/2 utilities. Barlow, 505-410-6243.

HOUSEKEEPER, Los Lunas area, must provide references. Garcia, 505-699-6844, ask for Mike.

Sandia gets safer and healthier at information fair

ES&H and Employee Health Services banded together to host a Safety + Health Fair on June 13 and more than 700 people enjoyed more than 60 different demonstrations, educational presentations and information booths, plus food trucks. Participants, including Tim Lewandowski (waving in upper left photo), senior manager for safety and health, learned from operator John Milloway how to be safe on an aerial lift; got sleep and other health tips (upper right) from health educator Jon Pier (left) and nurse coordinator Johanna Grassham; learned (lower left) a NASA astronaut's perspective on safety and health from Sandia subcontractor Danny Olivas, who journeyed to the International Space shuttle in 2007 and 2009; and saw some Sandia wildlife (lower right) courtesy of Evan Fahy from environmental stewardship. The purpose of the four-hour event at three locations was to promote healthy and safe lives at work and at home, with the theme, "The Greatest Wealth is Safety and Health." Organizers included Cynthia Rivera and Jenn Perea.

(Photos by Lonnie Anderson)



‘Don’t let work stress you out’

Technologist shares secrets of 50-year Sandia career

By Manette Newbold Fisher

READY FOR ANOTHER 50 — Manny Gonzales reached his 50-year milestone at Sandia on June 24. He credits working with great people and continuous learning to his decades-long career. (Photo by Randy Montoya)

Manny Gonzales was 18 when he walked into the Sandia mail room for his first day at the Labs. His supervisor, who was twice his age, had been employed by Sandia for about as long as Manny had been alive, and to a kid right out of high school, that sounded like “forever and half a day.”

“I don’t think I’ll ever be here 18 years, I told him,” Manny says. “And now it’s been forever and half a day back!”

June 24 marked 50 years since Manny began a Sandia career that took him from the mail room, to addressing and sending thousands of bulletins using an addressograph, to a film bank where he printed drawings for draftsman, to a department working with semiconductors. Then Manny moved again to a technologist position where he’s been making parts, ordering and stocking chemicals, and been involved in building operations for the past 30 years.

“He’s one of those guys who knows where everything is, he knows how to help people, and he knows who to call. He’s a great resource,” says Manny’s manager Joyce Lujan. “He is really good about making things magically appear.”

Joyce can call Manny with a soft description of a department need, and he always figures it out. He has a deep knowledge of his building and operations, takes pride in helping people, and is skilled at solving problems, she says.

Around 1975, Manny says Sandia started working with semiconductors and a manager challenged him to learn automated equipment that separates, dices and encapsulates chips. It was the same equipment Motorola was using at the time.

“My manager walked up and says here’s the books on the equipment and here’s the books on how things are done. I want you to read them, start playing around with them, and when you feel comfortable – it’s probably going to take you close to a year – we’ll take you to Motorola in Phoenix and let you tour the plant and see if they do the job like you learned it. And if you’re doing OK, then you can keep on doing this.”

Eventually, Manny did take that tour and learned he was running the equipment the same as Motorola. He was asked to write procedures and, after a couple of years, Manny started training other Sandia workers. It was a continuous learning process, he says, where he was surrounded by great people and given opportunities to learn new skills.

“I was like, ‘Wow, I actually figured it out.’ Talk about self-satisfaction. I was pretty proud of that because I’d never done that before.”

According to Manny, satisfaction has been one of the biggest motivators that has sustained his decades-long career.

BORN TO RIDE — Brothers Manny Gonzales and John Gonzales ride motorcycles at Arizona Bike Week in Scottsdale in April. They have been riding for decades in New Mexico, Arizona, Colorado, Nevada and beyond. (Photos by Southern Exposure)

“I think everybody should have that in order to do their job. If all you’re doing is working for the money, you might be disappointed because you’re always looking at everybody else’s check too, comparing,” Manny says. “But if you’re satisfied with your work, you’re proud of yourself.”

Terri Wallis, an ES&H coordinator, has known Manny for about six years. She says she appreciates that he’s in the mix of everything.

“As a technologist, he has his finger on the pulse of a lot of different activities that are going on,” she says. “He's cheerful and funny, and makes a lot of jokes. I admire him. He's helped me a lot and if I do something that doesn't make sense, he doesn't hesitate to ask me about it.”

‘I knew thousands of people’

Plenty has changed at the Labs since that day in 1968. Manny survived longer than some of the buildings he has worked in, experienced three Sandia contract changes and saw major advances in technology.

“Back in the day, you had to interact with people. I knew thousands of people. I had to interact with everybody so I was back and forth across the tech area. I knew where everything was and who had what, and if you needed to do a job and you didn’t have it, you could go and talk to them. Now everybody is tied to these or cellphones,” Manny says, pointing to a computer.

Manny’s advice for new employees is to get as much education as possible, and be proud of wearing a badge.

“It’s really refreshing for people like me when young people tell me, ‘Manny, Manny, guess what?! I just got my clearance!’” he says. “You know, sometimes as you get older, you start losing your excitement, I guess. I like to see people get excited.”

Loyal to a good thing

“What makes it easy to work and not think about retiring all the time is that, first off, you don’t let work stress you out,” Manny says.

Outside Sandia, Manny has been riding motorcycles for more than 40 years and is always looking forward to the next trip: to southern New Mexico, Arizona, Colorado, Nevada and beyond, with his brother and fellow Sandia employee, John Gonzales.

“We ride Harleys. That’s my main hobby, that’s my main passion. We don’t like to haul our bikes, we like to ride them,” Manny says.

John said one of their favorite rides is to Sturgis, South Dakota, in the Black Hills for the annual motorcycle rally that draws around 500,000 bikers.

“We’ve been there 16 times now. We’ve both been to the 50th anniversary and the 75th anniversary and I hope we both make the 100th anniversary,” John says. “Black Hills is one of the most beautiful places on planet Earth. It’s so green, there’s Mount Rushmore, and fantastic lakes.”

John’s 20th anniversary at Sandia is this fall. He says employment longevity runs in the family.

“Once we get into something, we're usually pretty loyal to it if it's a good thing,” John says. “Our dad worked at Kirtland Civil Engineering for 42 years.”

And there’s another thing that runs in the family that Manny exemplifies, John says. Leadership.

“We always kind of try to help guide people. We both do that,” John says. “He's probably done it a lot more than me. It's always nice to try and help somebody who's trying to get ahead, to point them in the direction that might help.”

Lab News wants YOU . . . to write

Got an idea for a story about one of Sandia’s many accomplishments or exciting work? Let the Lab News know. Jot down some ideas and background information, or draft a story detailing the who, what, when, where, why and how so Lab News readers can learn more. Lab News also seeks guest columnists with observations on life at the Labs or on science and technology in the news and in contemporary life. If you’ve written a column (500-750 words) or have an idea for a column or a story to submit, please contact acting editor Jim Danneskiold at jddanne@sandia.gov.