

Exceptional service in the national interest

Sandia LabNews



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Remembering Dr. King

IN A PERSONAL REFLECTION written for the *Lab News*, HR & Communications Div. 3000 VP Melonie Parker recalls how the Rev. Martin Luther King Jr.'s words and example have inspired her life choices ever since she was a young child in High Point, North Carolina. Read Melonie's essay on page 8.



Got Solitons? Sandia researcher sees problem as a solution

By Sue Major Holmes

Sandia's Juan Elizondo-Decanini turned a long-standing problem into an idea he believes could lead to better and less expensive machines, from cell phones to pressure sensors.

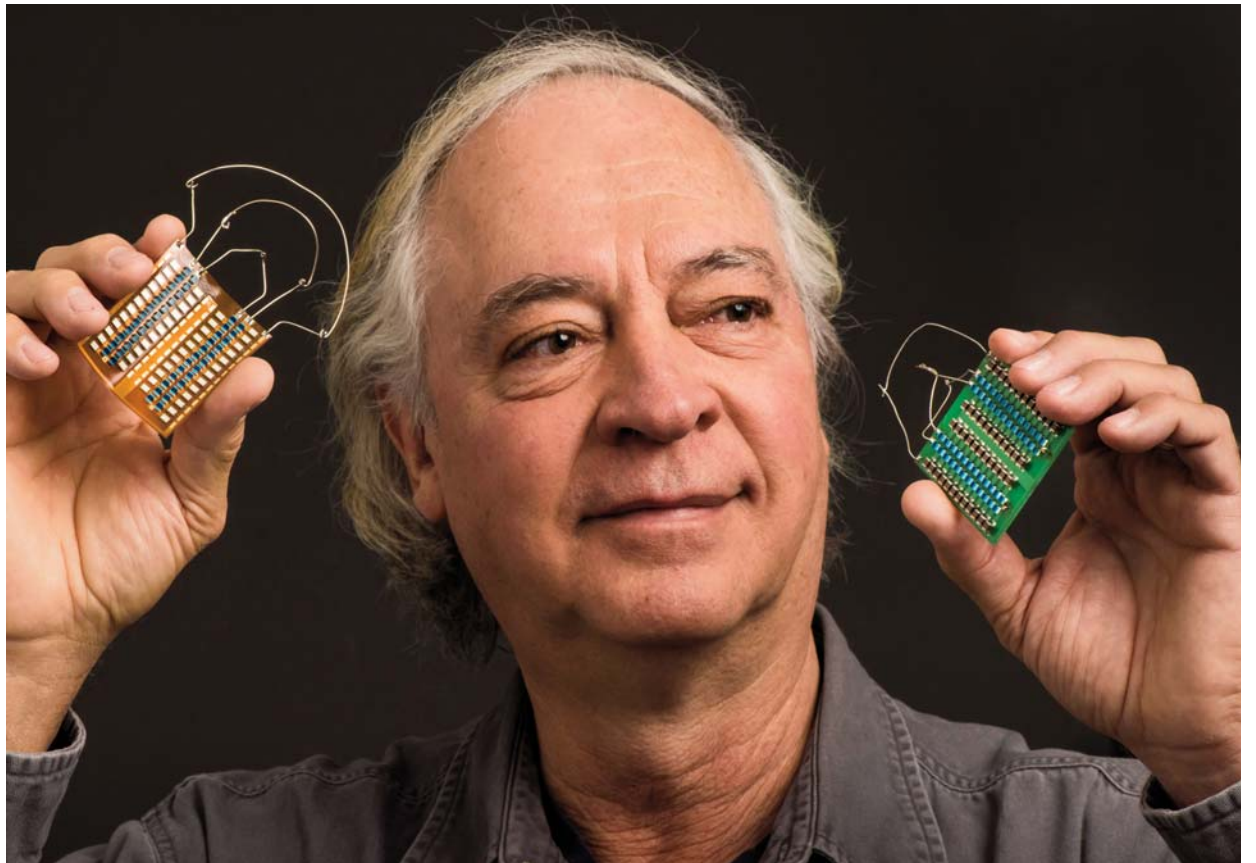
"This is one of those cases where it appears it's going to result in substantial savings and it's going to generate a whole suite of new gadgets," he says.

Juan (2624) leads a project on nonlinear behavior in materials — behavior that's usually shunned as too unpredictable. Instead of avoiding nonlinearity, he's embracing it using harmonic waves called solitons and studying, for example, how nonlinearity might be used in capacitors to further improve cell phone reception or lock out computer hackers.

Capacitors are fundamental elements in electronic circuits that store energy by accumulating electrical charge after voltage is applied to them. The stored charge is determined by the capacitance value: the more capacitance, the more charge stored and the more energy at a given "charge" voltage. High-quality capacitors are considered linear because capacitance value doesn't change as voltage is applied to store a charge. In a nonlinear capacitor, capacitance value changes as voltage is applied, so the energy or stored charge is different from what was expected.

In other words, there's no direct linear relationship between what's applied as an input and what's measured as the output in nonlinear behavior. For example, a liter of water remains a liter if it simmers below the boiling point, a linear behavior. But imagine if water could behave in a non-

(Continued on page 4)



RESEARCHER JUAN ELIZONDO-DECANINI (2624) holds two compact, high-voltage nonlinear transmission lines. Juan leads a project on nonlinear behavior in materials — behavior that's usually shunned because it's so unpredictable. (Photo by Randy Montoya)

New phononic filter technology could revolutionize signal processing systems



By Neal Singer

A unique filtering technology that combines light and sound waves on a single chip is expected to better detect radar and communications frequencies.

"We have developed a powerful signal-filtering technology that could revolutionize signal processing systems that rely solely on conventional electronics," says manager Patrick Chu (1765).

The radio frequency (RF) filters, which promise both high-bandwidth and wide functional flexibility, would form the basis for spectrometers that would let users "see" energies placed in various frequency bands across a wide spectral range.

The novel, very thin filter structures are still in the laboratory stage. A system demonstration — complete with lasers, modulators, detectors, and battery — should be a bit larger than a computer hard drive, weigh only a few pounds, and is expected to be available in three to five years.

Photon-to-phonon conversion

The filter uses a relatively new concept called photon/phonon coupling. This technique enables

(Continued on page 4)

SOMETHING NEW IN THE WORLD — Sandia researcher Charles Reinke studies a tiny phononic/photonic filter on a green, stamp-sized substrate toward the picture's bottom-right. (Photo by Randy Montoya)



A faster path to H₂ fuel

Sandia and the National Renewable Energy Laboratory have developed the Hydrogen Station Equipment Performance device, or HySTEP, that reduces the time to commission new H₂ fuel stations from months to just one week. See page 3.

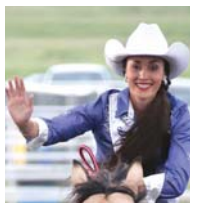


Employee Recognition Awards program adds category, expands eligibility to more members of the workforce.

Story on page 2.

Rodeo queen and engineer

Chemical engineering graduate student intern Cami Belcher sees her role as 2016 New Mexico State Fair queen as an opportunity to give back to the community. Story on page 5.



Showcase for postdocs

The 9th annual postdoc showcase drew a dozen posters for the California event and 32 posters for the New Mexico event, including seven from postdocs at LANL, invited to present for the first time. See the story on page 6.

Jeff Brinker honored

Sandia researcher and UNM professor Jeff Brinker is among 168 distinguished innovators from around the world named as Fellows in 2015 by the National Academy of Inventors. Story on page 6.



That's that

In a free-ranging discussion the other day with a colleague about what sort of qualities make for good managers and leaders, I thought about an old friend with whom I had lost contact decades ago. If that sounds like an odd bit of free association, I should probably explain.

A few weeks ago I found myself wondering whatever became of Joe, a friend I'd met in college back in the 1970s. Joe was a master's student in 18th century English lit, while I was a student in the college's journalism school. We shared an interest in bardic poetry and local public houses (sometimes called "pubs"). In due course, I graduated and took a job as a newspaper reporter, while Joe left the master's program to join his family's very successful marketing firm back East. That was the last I heard of him; in the era before social media, it was very easy – too easy – to lose touch with friends.

Motivated by nothing much more than simple curiosity, really, I typed in his name in Google and got some hits. It became clear to me very quickly that Joe had become a highly regarded figure nationally in his industry, and a much beloved one. But the tone of the references was a bit odd: It seemed I was reading what amounted to obituaries, with all of the allusions cast in the past tense. Digging deeper, I finally put two and two together and figured out that Joe had not died but had been diagnosed, at the age of 50, with early onset Alzheimer's. He faced his situation with courage and character, even to the point of starting a blog to chronicle the progression of the illness and his response to it. The blog entries were haunting and beautiful, but increasingly sketchy – and suddenly they stopped. What happened?

Back to Google: I found a brief reference that Joe was admitted into a long-term facility that specializes in providing care for those who can no longer provide for themselves. Among the many tributes that poured in as Joe receded from the industry, the most poignant was by a woman who had been a protégé of his.

She wrote about how excited she had been to be hired by Joe, who had become a legend in the business, the kind of guy everyone wants to work for and learn from. About a year after joining the firm, she writes, Joe called her into his office. After a few pleasantries, he said to her, "I want to ask you something. Do you think you need a boss? . . ." Taken aback, the woman hesitated for a few moments before Joe added, ". . . because I don't think you do." He had recognized that she was ready for more responsibility and he gave it to her, making her a VP in the firm at the age of 26. As her tribute made clear, Joe was never a "boss." He was a leader and mentor and champion, identifying the very best in people and helping them realize that in themselves. And that made him, it seems to me, the very best sort of boss to have.

Since reading that tribute, I've thought a lot about Joe and I've thought a lot about his question. I've asked it of myself: Do I need a boss? I don't know, but I do believe that being able to answer "no" is something to aspire to in the new year.

* * *

On the subject of losing track of friends, the cultural scolds out there have been warning us for years that the growing prevalence of social media in our personal interactions is having a dehumanizing effect on society, one with long-term implications that are hard to predict but are bound to be bad, bad, bad. In this view, using Facebook and other tools to keep in touch with friends is somehow debasing us in subtle and insidious ways. To all of which I say "hokey." How I wish I'd had Facebook back in the early 1980s, what a blessing it would have been, to stay connected to Joe and all the other friends who have passed through my life, in many cases literally forgotten now. I think 2016 is going to be a good year to connect again. Or at least to try.

See you next time.

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

Employee Recognition Awards program enhancements

More members of the workforce eligible this year

By Karli Massey



The Employee Recognition Awards program is expanding this year with new categories and enhanced communication and recognition of award winners.

Students, limited-term employees (LTEs), post-doctoral appointees, and foreign national employees are now eligible for nomination. In addition, a brand new award category will highlight achievements related to Sandia's safety mission.

"This year our leadership updated our list of core values to include 'We live safe and healthy lives,'" says Chief of Safety Jaime Moya (4100). "This is a natural progression in our safety culture journey to establish an ERA that recognizes Sandians for their commitment to working safely."

"This year our leadership updated our list of core values to include 'We live safe and healthy lives.' This is a natural progression in our safety culture journey to establish an ERA that recognizes Sandians for their commitment to working safely."



SANDIA CHIEF OF SAFETY
JAIME MOYA

Individual and team safety awards added

Added to the categories for individual achievements is the Safety Leader and Influencer award for individuals who demonstrate commitment to improving personal and organizational safety performance and whose actions reflect immediate or sustainable impact.

"Criteria for the award stipulate that the employee leads by example and inspires high safety performance," adds Jaime. "Also, we want to recognize those who completed a distinct project or milestone that solves a broad safety concern."

The team award for safety will recognize teams whose passion for safety has positively influenced and matured safety culture, fortified Sandia's physical safety infrastructure, or created or improved safety programs.

"These new safety awards are really about honoring those who exemplify safety as an essential Sandia value," Jaime says.

The ERA nomination process is open Jan. 12-29. ERA winners will be announced at division-level celebrations this year, allowing for greater recognition of team and individual achievements. Watch for more information about program enhancements from HBE and your division-level ERA coordinators.

More information on the eligibility of employees and how to submit nominations is available at: https://hbeupdate.custhelp.com/app/answers/detail/a_id/5536/kw/5536.



Retiree death correction

Sandia Lab News reported Robert Reed passing last October. Sandia retiree Robert E. Reed reported to us that he indeed is still with us and would we please clarify. Robert J. Reed passed away Oct. 24.

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HyStEP device will bring hydrogen refueling stations online quicker

Under old serial testing approach, commissioning could take months

By Patti Koning

Drivers are seeing more hydrogen fuel cell electric vehicles (FCEVs) on the road, but refueling stations for those vehicles are still few and far between. This is about to change, and one reason is a new testing device being validated at California refueling stations that will greatly accelerate station commissioning.

Developed by Sandia and the National Renewable Energy Laboratory (NREL), the Hydrogen Station Equipment Performance device, or HyStEP, could reduce the time to commission new stations from months to just one week. HyStEP is funded by the DOE Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office as part of the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project.

"Industry stakeholders identified station commissioning as a challenge that the national laboratories have the resources to address," says Joe Pratt (8366), the Sandia H2FIRST project lead. Sandia and NREL contracted with Powertech Labs to build the HyStEP device.

As zero-emission vehicles, FCEVs are leading the revolution in clean energy personal transportation. And California is leading the nation with the most FCEVs on the road of any state and plans to open 35 new retail hydrogen stations by the end of 2016.

Sandia and NREL's work on H2FIRST and in enabling modern codes and standards for the design, construction and operation of hydrogen refueling stations is helping drive that momentum.

Serial testing slows station commissioning

The current practice of commissioning hydrogen refueling stations is slow because each automotive manufacturer performs its own validation tests to measure the performance of hydrogen dispensers with respect to fueling protocol standards. Each test takes one to two weeks, so commissioning can take months.

HyStEP acts as a surrogate for vehicles, eliminating the need for each automotive manufacturer to test separately. HyStEP is equipped with modular tanks and all of the instrumentation that automotive manufacturers would use in performing their own tests.

"HyStEP addresses the two primary concerns of automotive manufacturers: keeping their testing data proprietary and ensuring the performance of the hydrogen dispenser," says Sandia mechanical engineer Terry Johnson (8366), project lead for HyStEP.

Since automotive manufacturers must trust the device's ability to provide the same results they'd achieve with their own test vehicles, manufacturers needed to be involved from the start. In addition to Sandia and NREL, the project team included Air Liquide, Boyd Hydrogen, the California Air Resources Board, and Toyota Motor Corp.

HyStEP initially will be used to accelerate commissioning of refueling stations in California. Eventually it could be used in other states as they develop hydrogen refueling networks.



MECHANICAL ENGINEER Terry Johnson, left, the project leader for the Hydrogen Station Equipment Performance (HyStEP) device, and National Renewable Energy Laboratory researcher Chris Ainscough prepare HyStEP for testing at NREL's Energy Systems Integration Lab. HyStEP will accelerate hydrogen refueling station commissioning. (Photo by Dennis Schroeder/NREL)

HyStEP essential to ambitious California plans

HyStEP recently underwent validation testing at NREL's Energy Systems Integration Facility in Golden, Colorado, and is now undergoing pre-deployment testing at refueling stations at California State University Los Angeles and the South Coast Air Quality Management District headquarters. Early in 2016, the Air Resources Board in collaboration with other state agencies will begin using HyStEP to support the commissioning of new stations. Additional automotive manufacturers, including Daimler AG, BMW, and Honda, are contributing to that effort.

"H2FIRST was conceived to help the deployment of hydrogen fueling infrastructure," says Chris Ainscough, lead NREL engineer on the project. "HyStEP is an example of DOE and the national laboratories partnering with states to achieve this goal of accelerating clean energy technologies."

HyStEP will help California meet its ambitious goal of commissioning up to 35 new refueling stations by the end of 2016, which translates to one new station every one to two

weeks. The target is a hydrogen-refueling network of more than 50 retail stations in this timeframe, primarily in the Los Angeles metro area, Orange County, and the Bay Area.

"This test device will help speed up and streamline how we validate retail stations to meet customer demands for high-performance fueling. This is essential to a successful market, as fuel cell vehicles are already being shipped to California and we expect many new customers using hydrogen stations in 2016," says Catherine Dunwoody, chief of the fuel cell program at the California Air Resources Board.

Sandia and NREL will use the data from the validation tests to further develop codes and standards for hydrogen infrastructure. In addition to his role as HyStEP lead, Terry is also on the CSA Group committee that is developing test methods for the Society of Automotive Engineers' standard defining refueling protocols.

"HyStEP is going to be very busy in the coming year," says Terry. "We expect this device to transform commissioning of refueling stations in a way that makes it possible to commission a new station every week or two."

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Acting deputy administrator for NNSA Defense Programs visits California site

Brig. Gen. Stephen L. Davis (USAF), acting deputy administrator for Defense Programs at NNSA, was at Sandia/California on Dec. 16 to participate in several meetings on California's nuclear weapons mission. While at the Livermore campus, Davis met with California Laboratory Div. 8000 VP Marianne Walck, who updated him on the site's activities. In the photo here, Marianne discusses a California project that was reported in the *Sandia Lab News*.

(Photo by Loren Stacks)



Solitons

(Continued from page 1)

linear manner, where a liter might expand to 5 liters when simmered.

“People try to stay away from nonlinear behavior because they want everything to be very simply predictable,” Juan says. “When it’s linear you need to put as much effort into it as you get out of it. When it’s nonlinear, sometimes you put in a little bit of effort and it just takes off. In a nonlinear circuit, as energy is conserved, you may change or amplify the voltage at the expense of the current or the other way around, depending on the nonlinear component.”

Nonlinear concept receives patent

Sandia received US patent 8,922,973 this year for “a detonator comprising a nonlinear transmission line” Juan developed. The patent describes using a nonlinear feature to obtain very high voltages. Juan and collaborators have since filed technical advances for other applications. A technical advance is a very preliminary draft of a patent application that discloses the technical idea by the inventors to patent

“If this approach is successful, it is a revolutionary use of nonlinear transmission line circuit topologies with solid-state capacitors based on ultra-wide bandgap for many applications.”

— Juan Elizondo-Decanini

attorneys, who use it to create a patent application.

Nonlinear behavior would seem undesirable in detonators, where safety is paramount. The main safety feature in a detonator is a driver circuit and switch that prevent accidental activation. Detonator drivers use high-quality linear capacitors to ensure exact current so the detonator works only when the switch is flipped.

However, high-quality capacitors are expensive due to the huge research investments needed to explore linear materials and the sophisticated designs those materials require, Juan says. So he turned the problem on its head: “What if we can use the worst characteristic of capacitor material, being nonlinear, to our advantage?”

His team focused on electrical solitons for a high-resistance detonator made with cheap capacitors. Solitons, used in laser and fiber optic communication, are harmonic waves that travel long distances without losing shape. They can be generated with nonlinear materials arranged as a transmission line; hence the patent’s name.

“Solitons like nonlinear material. The advantage is that if one manipulates the transmission line timing, the pulse width is compressed, resulting in amplified voltage,” Juan says. “Instead of putting in 300 volts to get out 300 volts, perhaps you put in 100 and get out 1,000. So far the team has demonstrated as much as 75 kilovolts from a 7-kilovolt input pulse.”

Initially, to test solitons for nonlinear transmission lines, the team used nonlinear capacitors, which are so roundly hated many companies don’t even make them anymore. Juan obtained cheap, out-of-production capacitors that behaved so nonlinearly they were used only in devices where linear behavior isn’t important, such as starter motors.

Working with other research projects on potential applications

Juan’s Laboratory Directed Research and Development (LDRD) project is now testing the concept in experiments with other Sandia research groups.

One grand challenge project examines ultra-wide bandgap materials, part of Sandia’s Power on Demand Research Challenge. “If this approach is successful, it is a revolutionary use of nonlinear transmission line circuit topologies with solid-state capacitors based on ultra-wide bandgap for many applications,” Juan says.

For example, it might extend cell phone range. When a cell phone starts to lose reception, it shifts frequency a little to lock into a stronger signal. “Sometimes you hear noise and then it comes back and it locks again. What this does is enhance that locking a little bit, so that eventually you will not hear that drift,” Juan says.

The grand challenge, headed by Bob Kaplar (1768), came into the mix because of the diodes Bob’s team is investigating. They consist of negative and positive material, with neu-

“It’s not a code, it’s not digital, it’s a signal. That makes a difference for security. Even if they [hackers] have your password, as long as they don’t punch it on your phone, it’s useless. From the outside, nobody can hack into it from the phone line, from the Internet, whatever.”

— Juan Elizondo-Decanini

tral material in between, that form a capacitor — and also has unwelcome nonlinearity.

In addition to the normal positive-to-negative flow, diodes can be used with a negative-to-positive or reversed bias, which takes advantage of their nonlinear capacitance. This is possible because as the applied reversed voltage is increased, such as with a voltage pulse applied to a transmission line, the negative and positive semiconductor materials respond by abruptly reducing the size of the neutral region between them. That dramatically amplifies the voltage as it travels through the line. Juan says that if the grand challenge can design diodes with very high reversed bias voltage, it opens the possibility of replacing high voltage capacitors with diodes, taking full advantage of the nonlinearity.

“A high voltage ultra-wide bandgap-based nonlinear transmission line is a revolutionary approach that can replace magnetic-core-based, high-voltage pulsed transformers such as automotive coil packs, among other things,” he says.

Collaborating research could lead to new gadgets

Bob says Juan’s potential application is one of two demonstration projects within the grand challenge. “It’s a cool thing,” he says. “It’s not your traditional application, but it so happens the things we’re doing are very well-suited for his work. It’s basically making use of the properties of the semiconductor to do some of the things he wants.

“In theory, by changing the design and growth of the device, you could get a particular capacitance versus voltage curve that you want,” Bob says. “That’s where wide bandgap and ultra-wide bandgap are good.”

In another collaboration, Juan and colleagues filed a technical advance for pressure sensors for vacuums that would sense very small variations in pressure by using nonlinear capacitor behavior coupled with concepts developed by an LDRD project on micro-discharge plasma. “By combining those two with an oscillator, we can measure pressure in a way that’s never been done before,” Juan says. “It may be more sensitive, it will be miniature, and it can be embedded inside devices.”

Micro-sensor researchers Ron Manginell and Matt Moorman (both 1714) are working with Juan because his theory is an extension of their work to reduce large-scale plasmas to micron-size dimensions. “In plasmas, if you increase the pressure to atmospheric pressure you can decrease the size,” Ron says. “The scaling works in your favor and you can build really tiny plasma devices.”

Microplasma devices produce intense light spanning the range from deep ultraviolet through the visible spectrum and into the infrared. Their excellent light emission is useful for applications in atomic, chemical, and solid-state physics. That includes light-induced modulation of diodes near each other, in which light emission from the microplasma shining on a diode generates electrical charges in it — akin to common roof-top solar panels in which sunlight creates charges in a solar cell diode to use for household electricity. Similarly, light from the microplasma generates charges in an adjacent diode, changing its capacitance, Ron says. Since the diode has a nonlinear capacitance, it’s a way to create a nonlinear capacitance change, he says.

Another technical advance was filed for encryption that would take advantage of nonlinearity in analog hardware as a physical barrier against hacking. Juan says the concept needs more work, but the idea is that a user punches in a code that generates a unique electrical signal to unlock the computer, phone, or other device.

“It’s not a code, it’s not digital, it’s a signal,” he says. “That makes a difference for security.” Hackers can’t get in without the device itself because unlocking it is linked to a circuit on a chip inside. “Even if they have your password, as long as they don’t punch it on your phone, it’s useless. From the outside, nobody can hack into it from the phone line, from the Internet, whatever.”

Potential uses arose as his team developed nonlinear behaviors in materials, “and we started combining that with other technologies developing around Sandia,” Juan says. “All of a sudden we’re creating new devices together.”

Phononic filter

(Continued from page 1)

the hybrid device to temporarily change RF signals propagating as photons (light) into phonons (sound), enabling efficient analog manipulation of those slower-moving signals.

With this hybrid approach, also known as nano-optomechanical coupling, the researchers were able to combine the high bandwidth offered by light — demonstrated at frequencies up to 20 gigahertz and easily extended to 100 gigahertz — with the linearity and sharp resonances provided by phononic filters. The energy cost of this photon-to-phonon conversion is offset by the high-resolution filter responses that exhibit very little signal distortion over a wide frequency range, says Charles Reinke (1765), who leads the Sandia effort.

Tin can analogy

A simple analogy for the photon-phonon information transfer is the tin can telephone: two cans connected by a string that transmits sound between a speaker and listener. The speaker’s cup is like the emitter waveguide; it converts audible sound to vibration in the

string. The cup by the ear is the receiver waveguide, which converts the vibration back into sound. The string, representing an engineered material called a phononic crystal, not only carries the message but changes its tone by filtering out high-pitch sounds — a kind of signal processing.

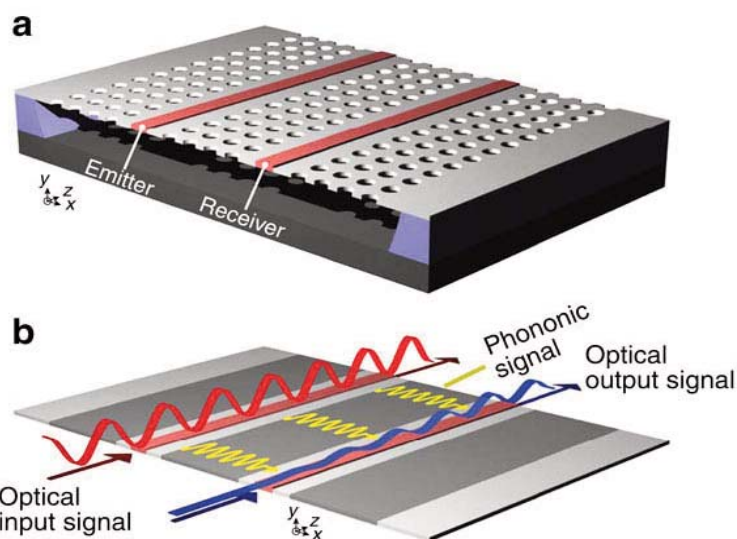
Creating a phononic crystal requires taking a thin film of material, in this case silicon nitride, and modifying its mechanical properties by creating patterns on it. The resultant crystal exhibits propagation properties not normally found in nature for mechanical waves like sound. The properties are dependent on the geometry and pattern of the film.

For the filtering system, two materials are key: silicon nitride to form membranes in which the acoustic signals propagate, and silicon to create waveguides that confine the optical signals. The dual system allows optimization of the acoustic and optical properties of the device independent of each other.

The photonic-phononic devices also could be incorporated with on-chip photodetectors and other electronics.

A paper published in March in *Nature Communications*, “Control of coherent information via on-chip photonic-phononic emitter-receivers,” describes the work, initiated by Sandia’s Laboratory Directed Research and Development (LDRD) office and currently funded for almost \$5 million by the Defense Advanced Research Projects Agency (DARPA). Lead researcher Peter Rakich, now a professor at Yale University, began the work at Sandia, and the collaboration continues to evolve with research partners at

the University of Texas at Austin and the industrial firm Rockwell Collins. First author Heedeuk Shin, who was a post-doctoral employee at Sandia under Rakich’s mentorship, is a professor at Pohang University of Science and Technology in South Korea.



IN THE UPPER IMAGE, two red silicon optical waveguides are shown embedded in a gray photonic crystal membrane. In the bottom image, the red and blue curves represent optical input and output signals; the yellow curves represent transduced phonon waves.



RODEO QUEEN Cami Belcher (1853) charges in on Sox, her Quarter Horse, at the Raton Pro Rodeo June 19, 2015. (Photo by Marty Mayfield)

By Mollie Rappe

Cami Belcher (1853), a graduate student intern, has looked up to the New Mexico State Fair Queen ever since she was little.

“That girl with her hat and crown, riding around the arena; that’s what I always wanted to be,” says Cami.

This September, Cami became that girl. She was crowned in front of more than 6,000 people in a sold-out Tingley Coliseum. Cami was astonished by the overwhelming feeling of support and approval as she walked through the cheering crowds on coronation night.

James McElhanon (1853), manager of Organic Materials Science Dept. 1853, says, “Cami has been great addition to our department as both an undergraduate, and now, graduate student intern. Cami has demonstrated a keen interest in organic materials synthesis, characterization, and development of new materials. We couldn’t be more proud of Cami’s accomplishments both at Sandia and as New Mexico State Fair Queen.”

As a chemical engineering master’s student at the University of New Mexico and as a technical intern at Sandia, Cami doesn’t exactly fit the traditional rodeo queen mold. Her advice for the next generation of little girls looking up to her as the 2016 New Mexico State Fair Queen is to stay true to who they are.

Cross-pollination

Cami fell in love with chemistry during her first, required, college chemistry course, and her professional goal now is to become a chemical engineer. In her work in the Organic Materials Science department, Cami is creating and characterizing better capacitor materials. One of her previous projects involved working on capacitors for hybrid cars. These capacitors store the energy lost when braking a hybrid car, and then discharge the energy to accelerate the car again. However, current capacitors can only do this so many times before they’re toast. The team Cami is a part of makes polymer films to go into renewable energy programs and other capacitor programs at Sandia.



SANDIA TECHNICAL INTERN Cami Belcher (1853) and an Exceptional Rodeo cowboy share a moment at the New Mexico State Fair Sept. 15, 2015. Cami loves the Exceptional Rodeo — a mini rodeo for children with special needs. (Photo courtesy of Cami Belcher)

Rodeo queen and chemical engineer

Sandians make holiday gift wishes come true for more than 500 foster children



Sandia’s annual holiday giving traditions continued with its holiday gift drive for foster children at the New Mexico Children, Youth, and Families Department (CYFD). Sandia employees and contractors sponsored individual foster children who specified what they wanted for the holidays.

Generous employees snatched up all the sponsor slots within 48 hours of the gift drive announcement.

More than 500 unwrapped gifts, each labeled with a foster child’s name, were delivered to NMCYFD Dec. 15 to be wrapped. The program organized by Sandia’s Community Involvement department helps make Christmas a little brighter for foster children throughout New Mexico.

It is almost a truism that you need patience in lab. Things frequently don’t go right, or maybe you get results that are completely unexpected. You need patience to take a step back and re-evaluate the situation. Cami has lots of patience, an ability she honed while riding.

“You’re riding this 1,200-pound animal that you have no control over, you just think you have control, and you just hope that they concur with what you want to do that day,” Cami says with a chuckle.

Riding is also Cami’s stress reliever, for when things don’t go smoothly in the lab, “I can be on a horse and nothing else in the world matters at that moment. There’s just this connection, this bond, between the horse and rider that you don’t understand unless you ride.”

‘Strategic balancing act’

But competing in rodeos takes a lot of time, and the commitments that follow winning the title of rodeo queen take even more. In the off-season Cami has been spending about half of her weekends going to rodeos or attending rodeo queen appearances. Next summer she’ll be even busier, attending a rodeo or country fair practically every weekend.

“It’s a very strategic balancing act,” Cami says.

She squeezes in studying chemical engineering while her best friend, also a rodeo queen, is driving them to the next rodeo, a loaded horse trailer hitched to the truck, chemical engineering textbooks strewn over the dash.

“It’s a crazy-busy life right now,” says Cami, “but I enjoy everything I do.”

Giving back

The rules for the New Mexico State Fair Queen Contest describe the queen as an ambassador of the New Mexico State Fair with responsibilities to attend certain designated public appearances and exhibit exceptional sportsmanship throughout the year.

Cami sees her reign as a way for her to give back to her community, especially by sharing the Western lifestyle with children. Cami loves events such as visits to the University of New Mexico Hospital and participating in riding clinics for children.

One of her favorite events is the Exceptional Rodeo, where children with special needs get to take part in a mini-rodeo. They get to ride a real horse, learn to rope a hay steer, and even run barrels on a stick horse.

These activities introduce the children to the fundamentals of what rodeo is, says Cami, adding, “It’s a blast!”

A family affair

Attending rodeos and fairs was a regular family activity when Cami was growing up. Also, Cami’s two older brothers roped and rode broncos in 4-H rodeos since before she was born, winning numerous belt buckles and multiple titles each.

One of Cami’s older brothers, Curtis Belcher (6012), and her sister-in-law, Lori Belcher (5792), also work at Sandia, making both rodeos and working at the Labs truly a family affair.

Cami was the 2015 Bernalillo County Queen, and the first attendant at last year’s New Mexico State Fair Queen contest. She has also won several local barrel races.

Postdoc showcase highlights work of next-generation researchers

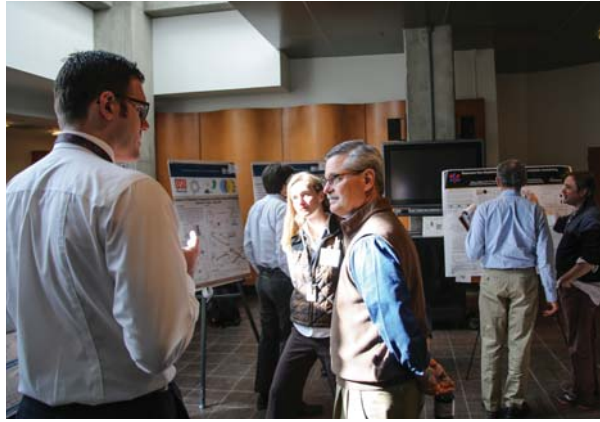
By Sue Major Holmes

Sandia's annual Postdoctoral Technical Showcase offers postdoctoral employees the chance to meet the Labs' decision-makers and gives Sandia a close look at the upcoming generation of scientists and engineers.

The 9th annual showcase in December drew a dozen posters for the California event and 32 posters for the New Mexico event, including seven from postdocs at Los Alamos National Laboratory, invited to present for the first time. Posters fell under the categories of biology, chemistry, computer science, energy, geosciences, material sciences, robotics, metamaterials, optics, plasma physics, and semiconductor science.

Sandia's Postdoctoral Professional Development Program (PD2P) sponsors the showcase to highlight postdocs' work, give them opportunities to advance professional skills, and help them move into research careers. Sandia has about 180 postdocs divided between California and New Mexico.

Judges evaluated each poster's scientific content and quality and the author's oral presentation. Christopher Lino (8631) took first place in New Mexico for "Rapid Selection of Nipah and Hendra Virus Vaccine Candidates from a Complex, Random Peptide Library Displayed on Virus-Like Particles of MS2 Bacteriophage." The California winner was Aashish Priye (8621) for "An Automated Smartphone-Based Detection Platform that Enables Real-time Isothermal Amplifica-



CHRISTOPHER LINO (8631) talks with Steve Rottler, deputy Laboratories director and executive VP of National Security Programs, during the Postdoctoral Technical Showcase last month at Sandia's New Mexico campus. Christopher took first place at the poster session in New Mexico.

tion (RT-lamp) for Mobile Healthcare."

Event also recognized distinguished mentors

New Mexico runners-up were Diane Oyen, Los Alamos, "Analyzing ChemCam Spectroscopy with Graphical Model Structural Learning," and, tied, Kirsten Chojnicki (6914), "Understanding Pore-Scale Chemo-Physical Coupling for Carbon Storage Applications" and Alessandro Cattaneo, Los Alamos, "Microgrid Transient Dynamics for the Development of Survivability Constraints in the Economic Dispatch Problem." California's runner-up was Kan Zha (8362), "Piston Geometry Effects on In-cylinder Swirl Asymmetry in a Light-Duty Optical Diesel Engine."

Amanda Dodd (8253) received PD2P's Distinguished Mentor Award for the California site and John Ihlefeld (1816) received the award in New Mexico. The honor acknowledges the value of mentoring postdoctoral employees. A certificate to mentor nominees recognizes their outstanding mentorship and guidance in "providing postdocs with experience and opportunities to prepare them for the next stage of their career."

Steve Rottler, deputy Laboratories director and executive VP of National Security Programs, told the Albuquerque showcase the posters demonstrate that

postdocs understand the deep connection between the science and engineering in their work and its application to national security. Postdoctoral employees contribute to the national labs but also allow the labs to create a talent



WINNING POSTER — Aashish Priye (8621) shows his winning poster in the annual Postdoctoral Technical Showcase at Sandia California. The showcase is held each December at Sandia's campuses in New Mexico and California to display the breadth of research by postdoctoral employees.

(Photo by Jasmine King-Bush)

pipeline, he said, and encouraged the crowd "to get around the room and see the fantastic work that's going on."

Marianne Walck, Div. 8000 VP, addressing California's showcase, talked about her personal history with hiring postdocs as a department manager in the 1990s. Marianne emphasized that postdocs enable Sandia to develop new technical capabilities at the same time the postdocs benefit from tackling national security challenges. She mentioned the importance of Sandia management engaging with postdocs on their career trajectories, and noted that PD2P provides valuable support to postdocs in California through brown-bag sessions and resume-writing workshops.

Brinker among distinguished innovators elected Fellows of National Academy of Inventors

By Neal Singer

Sandia researcher and University of New Mexico professor Jeff Brinker is among 168 distinguished innovators from around the world announced as 2015 Fellows by the National Academy of Inventors.

Election and induction into NAI Fellow Program is considered a high professional distinction among academic inventors who have demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and the welfare of society.

Jeff, a Sandia Fellow, UNM Regent's and Distinguished Professor of Chemical and Nuclear Engineering and member of UNM's cancer center, was nominated by the STC.UNM



JEFF BRINKER

board of directors for this national honor.

"Dr. Brinker is an outstanding scientist and inventor who is internationally known for his innovative technologies in advanced materials and who has pioneered the field of sol-gel processing. His nanoparticle technologies, engineering marvels, have a broad range of applications, but none more compelling than in the field of medicine," STC.UNM CEO Lisa Kuuttilla says.

Jeff also received the 2015 Innovation Fellow Award as a top innovator at UNM. Sandia's Tribal Energy Program Lead, who also serves as STC board chair, Sandra Begay-Campbell (6124) says Jeff was recognized as a result of his achievements in developing new technologies and receiving a large number of patents that generated significant commercialization activities from licenses and the formation of new companies.

Internationally known for his work in advanced materials, Jeff has pioneered sol-

gel processing, a method for making inorganic materials molecule-by-molecule. Over the past two decades his research team has developed self-assembly (wherein molecules spontaneously organize into nanostructures) as a robust and efficient means to create porous and composite thin film and particulate nanostructures with optimized properties and/or complex functionalities.

Jeff is able to translate the properties of nature into new materials that are technology innovations. His inventions combine advanced materials science and biology to produce innovative membranes, sensors, thin films, and nanoparticles that are having a far-reaching impact on cancer treatment, environmental remediation and protection, and low-cost, green materials for industrial processes.

Jeff will be inducted as an NAI Fellow on April 15 as part of the NAI Fifth Annual Conference at the US Patent and Trademark Office (USPTO) in Alexandria, Virginia.

Jeff has won six R&D 100 awards and was presented with the UNM Presidential Award of Distinction by university president Robert Frank at the Dec. 11 fall commencement ceremony.

Recent Patents

David Ingersoll (2500), Travis Mark Anderson (2546), Chad Staiger (6124) and Harry Pratt (2546): Synthesis of Electroactive Ionic Liquids for Flow Battery Applications. Patent No. 9,123,943.

Thomas Dewers (6914), Jason E. Heath (6914), Yifeng Wang (6222) and Charles R. Bryan (6225): Method For Carbon Dioxide Sequestration. Patent No. 9,139,364.

Robert Riley (5342) and Bobby G. Rush (5342): Pre-Processing SAR Image Stream To Facilitate Compression For Transport On Bandwidth-Limited-Link. Patent No. 9,146,312.

Travis Wayne Eubanks (5345) and Hung Loui (5345): Metal-Free Magnetic Conductor Substrates for Placement-Immune Antenna Assemblies. Patent No. 9,147,931.

Gerald M. Boyd (5355) and Jeffrey Farrow (5355): Embedded Instrumentation Architecture. Patent No. 9,148,481.

Kurt W. Larson (5563), Jason W. Wheeler (6533) and

Jovana Helms (8116): Sparse Sampling And Reconstruction For Electron And Scanning Probe Microscope Imaging. Patent No. 9,093,249.

Jason Hamlet (5627) and Jackson Mayo (8953): Approximate Circuits For Increased Reliability. Patent No. 9,112,490.

William A. Zortman (5645): Methods And Devices For Optimizing The Operation Of a Semiconductor Optical Modulator. Patent No. 9,083,460.

Clifford K. Ho (6123): Computation of Glint, Glare, and Solar Irradiance Distribution. Patent No. 9,103,719.

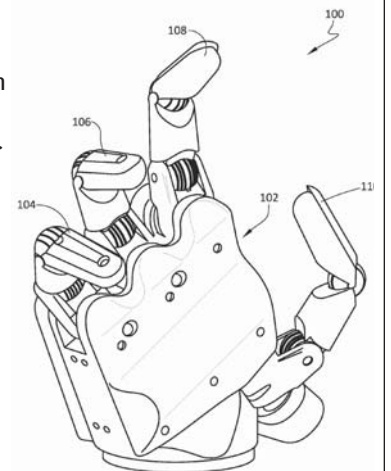
Vipin P. Gupta (6124): Photovoltaic Solar Concentrator. Patent No. 9,130,092.

Dennis P. Roach (6620), Randy L. Duvall (6626) and Stephen Neidigk (6626): Ultrasonic Testing Device Having an Adjustable Water Column. Patent No. 9,121,817.

Patrick V. Brady (6910): PH Adjustment of Power Plant Cooling Water With Flue Gas/Fly Ash. Patent No. 9,140,145.

John J. Mason (5332): Differential Emitter Geolocation. Patent No. 9,110,147.

Kevin J. Dullea (6533): Mechanisms For Employment With Robotic Extensions. Patent No. 9,138,897.



SANDIA CLASSIFIED ADS

MISCELLANEOUS

DOG HOUSE, insulated, for small dog, \$50. Kimberly, 980-6381.
 DINING SET, medium size, pub-high, 4 chairs, solid wood, w/half hutch, \$500/both. Rhodes, 505-480-0030.
 BOOKSHELF, wood, 6'x3', \$50 OBO; adjustable flat screen TV wall-mount, \$50 OBO; photos available. North, 514-7878.
 ELECTRIC GUITAR, Jay Turser JT133, semi-hollow body, set neck, w/HSC, \$300 OBO. Gonzales, 505-238-0662.
 BACKUP GENERATOR, Predator, 4-cyl, gasoline engine, 3200/4000-W power output, essentially new, w/wheel kit, \$300. Harding, 505-977-0897.
 FUTON, wood arms, steel frame, 8-in. mattress & cover, good condition, \$150. Paquette, 505-366-4391.
 MINT AUTOMATIC ROBOTIC CLEANER 4200, hard floor, new, \$75; men's bike jersey, XL, Castelli-Podio, new, \$25. O'Grady, 720-587-9857.
 PIANO, YPG-625, \$250; slate pool table, \$300; 12-ft. boat, w/trolling motor, \$300; photos available. Baca, 350-4180.
 TREADMILL, Vision Fitness T9250, excellent condition, \$250 OBO. Nunez, 515-9084.
 FUTON COUCH, full size, wood frame, Southwestern cover, easy setup, great for guests, photos available, \$165 OBO. MacCormic, 967-7891.

TRANSPORTATION

'04 HONDA CRV, AWD, red, sunroof, 1 owner, 215K miles, good condition, \$2,900 OBO. Larson, 286-8237.
 '10 LANCER EVOLUTION MR, AWD, turbocharged, ~51K miles, \$27,500 OBO. Van Loo, 505-440-7075.
 '07 KIA RONDO LX, AT, V6, volcano red, 3rd row seats, 1 owner, 91K miles, great condition, \$6,000. Baca, 270-4652, ask for Jeremy.
 '06 HONDA ACCORD EX, V6, 4-dr., navigation, black leather, moon roof, 96K miles, good condition, \$7,500. Magill, 607-821-9117.
 '08 VOLKSWAGEN GTI, 6-spd. manual, gray, new tires, heated seats, 125K miles, \$9,800. VanGemert, 505-620-7145.
 '01 FORD FOCUS SE, 1 owner, AC needs work but otherwise runs great, new tires, \$2,000 OBO. Rodgers, 573-356-8914.
 '06 HONDA CIVIC EX, 4-dr., manual, galaxy gray, EPA 30/40-mpg, sunroof/tinted, 99K miles, runs great, \$7,100. Emery, 505-407-0830.
 '12 NISSAN ALTIMA, white, black interior, push button start, 67K miles, great condition, moved to mountain, need AWD vehicle. Pohl, 917-5188.
 '12 SCION XB HATCHBACK, 5-spd., manual, lots of cargo room, excellent condition, photos on AutoTrader/Craigslist, \$11,500. Wolfgang, 414-1483.
 '11 JEEP WRANGLER SAHARA, tan, excellent condition, \$24,999. Ramos, 972-951-0290.

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.

'05 DODGE STRATUS, complete engine repair, new tires, touch-up paint, good first car, \$5,500 firm. Madrid, 296-2419.

RECREATION

GEORGIE BOY MOTORHOME, 24-ft., excellent condition, 4000K generator, fully self-contained, 27K miles, Ford chassis w/V10 engine, \$18,000. Martin, 280-6924 or 980-0456.

1-BDR. CONDO, Angel Fire, Christi Villa, \$45,000, will trade an RV for equivalent value. Sanchez, 505-363-2822.

5-BDR. HOME, Taos, 3 baths, 2 master suites, 4,000-sq. ft., 1 acre, art studio/family room, furniture, fireplaces, mature trees, garage, \$424,000. Connelly, 575-770-0252.


WANTED

LADY GOLFERS, join Tijeras Arroyo Women's Golf Association, season begins in February. Langdon, 505-263-9558, ask for Margaret.


REAL ESTATE

1/3 OWNERSHIP ANGEL FIRE CABIN, 4-bdr., 2 full baths, close to ski area, lake, hiking. Rockwell, 505-250-3737.

Recent Retiree



New Mexico photos
by Michelle Fleming



David Gallegos
28 5540

Mileposts



New Mexico photos by Michelle Fleming



Victor Johnson
35 2800



Ed Young
35 2991



Martina Baca
30 4237



Lynn Fitzpatrick
30 4256



Tommy Serna
30 4237



Anthony Wagner
30 5555



Bernadette Edge
15 9538



Steven Etherington
15 4254



Brian Kellogg
15 5634



Thomas Mattsson
15 1641



Jesus Ontiveros
15 10590



Sara Sokolowski
15 5786

Recent patents

Note: Patents listed here include the names of active and retired Sandians only; former Sandians and non-Sandia inventors are not included. Following the listing for each patent is a patent number, which is searchable at the US Patent and Trademark Office website (www.uspto.gov).

Tina M. Nenoff (1100), Terry J. Garin (1816) and Florentina Dorina Sava Gallis (1124): Densified Waste Form and Method for Forming. Patent No. 9,117,560.

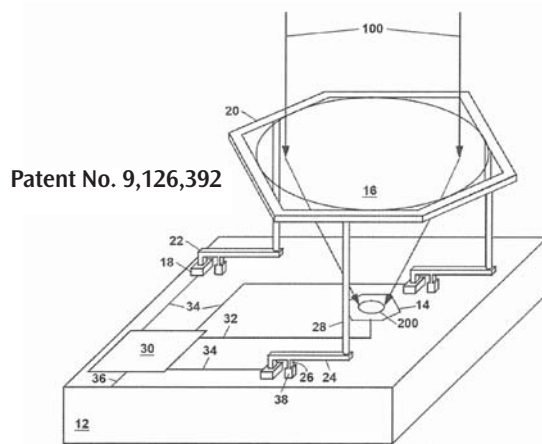
Eric A. Shaner (1118), John L. Reno (1131) and Gregory Conrad Dyer, (5785): Tunable Plasmonic Crystal. Patent No. 9,105,791.

Jeffrey S. Nelson (1131): Pixelated Silicon Cells for Integrated Circuits. Patent No. 9,112,100.

David G. Wilson (1353) and Diana L. Bull (6122): Controller for a Wave Energy Converter. Patent No. 9,140,231.

Darren W. Branch (1714), Conrad D. James (1714), and Jaime L. McClain (1719): Microfluidic Device for Acoustic Cell Lysis. Patent No. 9,096,823.

Mark S. Derzon (1719), Michael David Henry (1746), Todd Bauer (1746), Randolph R. Kay (1753) and Liam D. Claus (1753): Multiple-Mode Radiation Detector. Patent No. 9,116,249.



Patent No. 9,126,392
 Daniel A. Bender (5774): Precise Annealing Of Focal Plane Arrays For Optical Detection. Patent No. 9,142,465.

Paul J. Resnick (1719) and Vipin P. Gupta (6124): Optimized Microsystems-Enabled Photovoltaics. Patent No. 9,141,413.

Paul J. Resnick (1719), Peggy J. Clews (1746), Vipin P. Gupta (6124) and Carlos Anthony Sanchez (1747): Photovoltaic Solar Concentrator. Patent No. 9,126,392.

Hayden James Evans McGuinness (1725) and Grant Biedermann (1728): High Data Rate Atom Interferometric Device. Patent No. 9,086,429.

Adam Jones (1747) and William A. Zortman (5645): Methods and Devices For Maintaining a Resonant Wavelength Of A Photonic Microresonator. Patent No. 9,081,135.

Igal Brener (1765): Electrically Tunable Infrared Metamaterial Devices. Patent No. 9,086,510.

Anthony L. Lentine (1765), Alexander H. Hsia (1767), and William A. Zortman (5645): Low-Voltage Differentially-Signaled Modulators. Patent No. 9,128,308.

Paul Davids (1765) and Christopher DeRose (1765): Method And Apparatus Of Wide-Angle Optical Beamsteering From a Nanoantenna Phased Array. Patent No. 9,104,086.

William A. Zortman (5645): Silicon Photonic Heater-Modulator. Patent No. 9,081,215.

Anthony L. Lentine (1765): Microinverters For Employment In Connection With Photovoltaic Modules. Patent No. 9,143,053.

Anthony L. Lentine (1765): Photovoltaic Power Generation System Free of Bypass Diodes. Patent No. 9,093,586.

Anthony L. Lentine (1765) and Jonathan Albert Cox (5621): Systems And Methods For Controlling An Operating Wavelength. Patent No. 9,127,983.

Shawn M. Dirk (2241) and David R. Wheeler (5964): Lignin Nanoparticle Synthesis. Patent No. 9,102,801.

More patents on page 6

Dr. King's dream continues to motivate and inspire

By Melonie Parker, VP, HR and Communications Div. 3000

When I was a child growing up in the 1970s, most homes in my predominantly black neighborhood in High Point, North Carolina, had three pictures on their walls: Jesus, Martin Luther King Jr., and John F. Kennedy. These three pictures were generally grouped together either vertically or horizontally and were velvet hangings or framed art. Most of the cities near me had a Martin Luther King Drive in the black community. Every year during Black History Month there were oratorical and essay writing contests that gave tribute to Dr. King and I proudly participated along with my schoolmates. Additionally, we had programs, pageants, and parades to honor Dr. King on his birthday. Dr. King was lauded in our homes, our churches, and in civic organizations such as the Girl Scouts, Boy Scouts, 4-H club, and the Elks.

My parents marched with Dr. King in the 1960s in Greensboro, North Carolina, and a friend's dad, Franklin McCain, was a member of the now infamous Greensboro Four.

I was taught at an early age that I needed to be better, smarter, and faster than my white peers to compete at the same level. Leveling the playing field literally meant striving to be better than your contemporaries. We were constantly reminded of Dr. King's "I Have a Dream" speech, which described his dream of a nation of freedom and equality, one where the evils of slavery and hatred were banished to the past. His vision became our quest.

Dr. King has impacted my life since my earliest years. As a child I dreamed of extending my borders beyond my neighborhood and my hometown. I believed that with hard work and commitment to education I could actually achieve my dreams. I have benefited from the affirmative action programs that were put in place thanks to the efforts of Dr. King and his followers. Dr. King's leadership shaped the environment that made possible the passage of the landmark Civil Rights Act and the Voting Rights Act in the mid-1960s.

I also grew up to have sensitivity toward others outside my circle of family, friends, and peers. It's easy to miss circumstances that affect others, to not understand perspectives different than your own when your consciousness is not awakened. Dr. King's inspiration helped awaken mine. In his August 1967 speech, "Where do we go from here?" he said, "True compassion is more than flinging a coin to a beggar; it is not haphazard and superficial. It comes to see that an edifice which produced beggars needs restructuring." Dr. King had a vision that race would not be a factor in how people were treated or how they were allowed to live their lives.

Recently, a childhood friend who happens to be white wrote that when we were in the 5th grade, she was put in charge of a Thanksgiving mural in our classroom, which was a big deal at that time and place. She recalled that when a boy named Earl took his turn to add his contribution to the mural, he painted in a brown-skinned pilgrim. The teacher, whom my friend loved, adored, and would have done anything for, was irate, and told her to "fix it." So my friend cut out a blue-eyed, blond-haired face on "flesh-colored" construction paper and covered Earl's handiwork, obliterating his painting completely. And she was praised for it. In a poignant reflection, she wrote that she felt guilty about that for 40 years, adding that the injustice and her role in it have haunted her all this time. Based on that experience of so long ago, she said she learned that "classrooms are not a pass-through. They shape us."

Is Dr. King's vision still relevant in my life today? I say unequivocally yes, it most definitely is! As it should be relevant for all of us. His words are still words to live by, his dream still our inspiration.

Underpinning his brave and tireless fight for racial equality was a deeply held conviction that success must be attained through nonviolence. His principled stand gave him — and his cause — a moral authority that still resonates deeply today. We do a disservice to Dr. King's memory if we do not acknowledge the progress that we have made as a society, thanks in very large part to his courageous example. We do a disservice to ourselves, though, if we do not recognize that much needs to be done to fully achieve the ideals Dr. King expressed in his "I Have a Dream" speech, that "we will be able to transform the jangling discords of our nation into a beautiful symphony of brotherhood."



HR AND COMMUNICATIONS DIV. 3000 VP Melonie Parker keeps a portrait of the Rev. Martin Luther King Jr. in her office as a source of inspiration and motivation. Melonie's parents marched with Dr. King in the 1960s in Greensboro, North Carolina. (Photo by Randy Montoya)



'I have a dream today.'

Excerpt from the speech made by the Rev. Martin Luther King Jr. at the Lincoln Memorial in Washington D.C., on Aug. 28, 1963. More than a quarter of a million Americans of all races and creeds were on hand to hear his words, words of such truth and power that they forever changed a nation.

I have a dream that one day this nation will rise up and live out the true meaning of its creed: "We hold these truths to be self-evident; that all men are created equal."

I have a dream that one day on the red hills of Georgia the sons of former slaves and the sons of former slave owners will be able to sit down together at the table of brotherhood.

I have a dream that one day even the state of Mississippi, a state sweltering with the heat of injustice, sweltering with the heat of oppression, will be transformed into an oasis of freedom and justice.

I have a dream that my four little children will one day live in a nation where they will not be judged by the color of their skin but by the content of their character.

I have a dream today.

I have a dream that one day down in Alabama, with its vicious racists, with its governor having his lips dripping with the words of interposition and nullification, that one day right down in Alabama little black boys and black girls will be able to join hands with little white boys and white girls as sisters and brothers.

I have a dream today.

I have a dream that one day every valley shall be exalted, every hill and mountain shall be made low, the rough places will be made plain, and the crooked places will be made straight, and the glory of the Lord shall be revealed, and all flesh shall see it together.

This is our hope. This is the faith that I will go back to the South with. With this faith we will be able to hew out of the mountain of despair a stone of hope. With this faith we will be able to transform the jangling discords of our nation into a beautiful symphony of brotherhood.

With this faith we will be able to work together, to pray together, to struggle together, to go to jail together, to stand up for freedom together, knowing that we will be free one day.

This will be the day when all of God's children will be able to sing with new meaning, "My country 'tis of thee, sweet land of liberty, of thee I sing. Land where my fathers died, land of the Pilgrims' pride, from every mountainside, let freedom ring."

And if America is to be a great nation, this must become true. So let freedom ring from the prodigious hilltops of New Hampshire. Let freedom ring from the mighty mountains of New York. Let freedom ring from the heightening Alleghenies of Pennsylvania.

Let freedom ring from the snow-capped Rockies of Colorado. Let freedom ring from the curvaceous slopes of California. But not only that; let freedom ring from the Stone Mountain of Georgia. Let freedom ring from Lookout Mountain of Tennessee.

Let freedom ring from every hill and molehill of Mississippi. From every mountainside, let freedom ring.

And when this happens, when we allow freedom to ring, when we let it ring from every village and every hamlet, from every state and every city, we will be able to speed up that day when all of God's children, black men and white men, Jews and gentiles, Protestants and Catholics, will be able to join hands and sing in the words of the old Negro spiritual, "Free at last! Free at last! Thank God Almighty, we are free at last!"