

Sandia marks Women's History Month



Ann Campbell Miquelita Carrion Pierrette Gorman



Meet three remarkable Sandia women and find out about special activities organized by SWAN, the Sandia Women's Action NetworkPages 6-7

Exceptional service in the national interest

Sandia LabNews



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WeaselBoard bites infrastructure bad guys

By Stephanie Holinka

When you own or manage critical infrastructures, a day with a zero-day exploit is a horrible, no good, very bad day.

It means someone has compromised the most fundamental level of your system, allowing a potential evildoer access to all the things you've been attempting to protect,

"... Industrial control systems were not designed with security in mind."

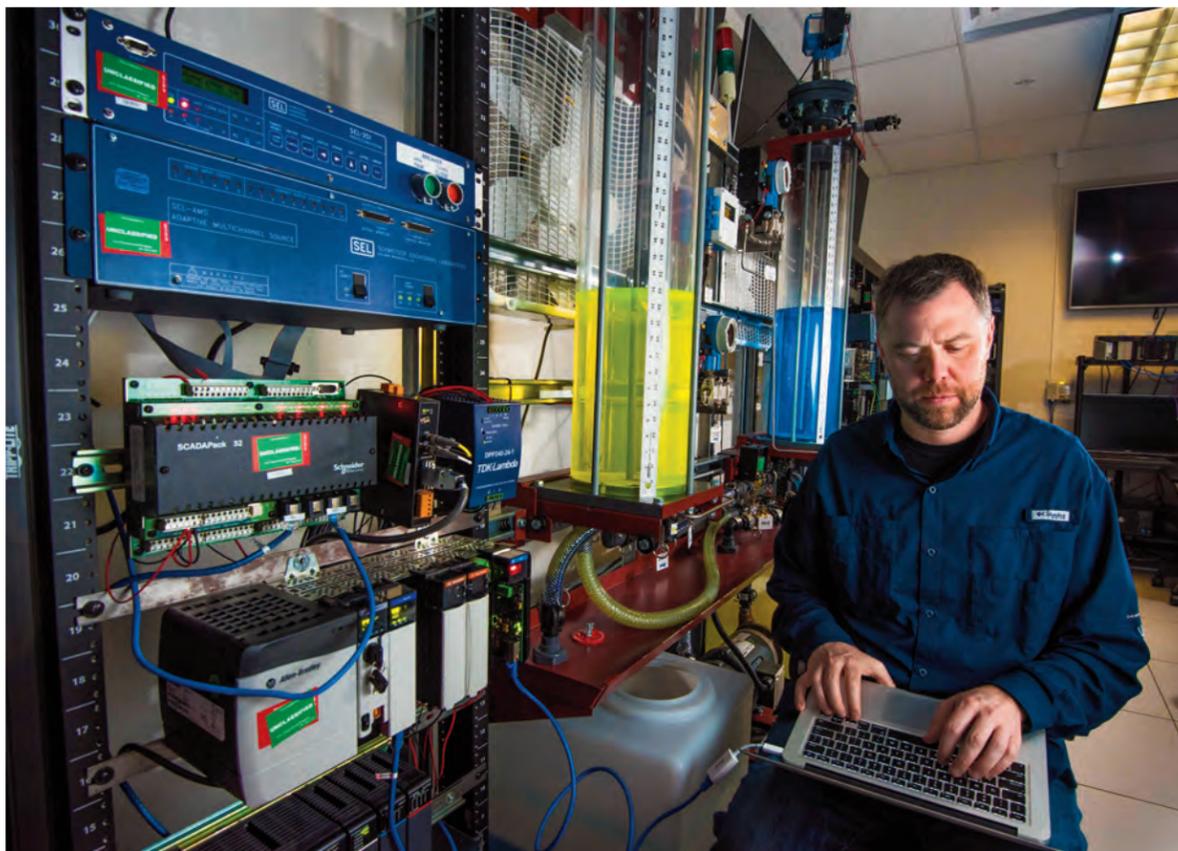
such as your manufacturing machinery, your solar array, your microgrid, or your nuclear power plant. And you have zero days to fix it before it's too late: In other words, it's already too late.

Sandia's WeaselBoard helps critical infrastructure owners protect their systems against zero-day exploits. It is a small card that plugs into the backplane of an industrial controller to detect illicit traffic. WeaselBoard creates an assurance platform for responding to attacks as systems network together and scale up in the future.

Attacks could be expensive and dangerous

Critical infrastructures, such as electrical power plants and oil refineries, rely on industrial controls, referred to as primary logic controllers (PLC) in industry, and supervisory control and data acquisition (SCADA) in government systems, to control essential processes.

Industrial control devices control billions of dollars worth



JOHN MULDER (5628) puts the WeaselBoard through its paces on a test apparatus.

(Photo by Randy Montoya)

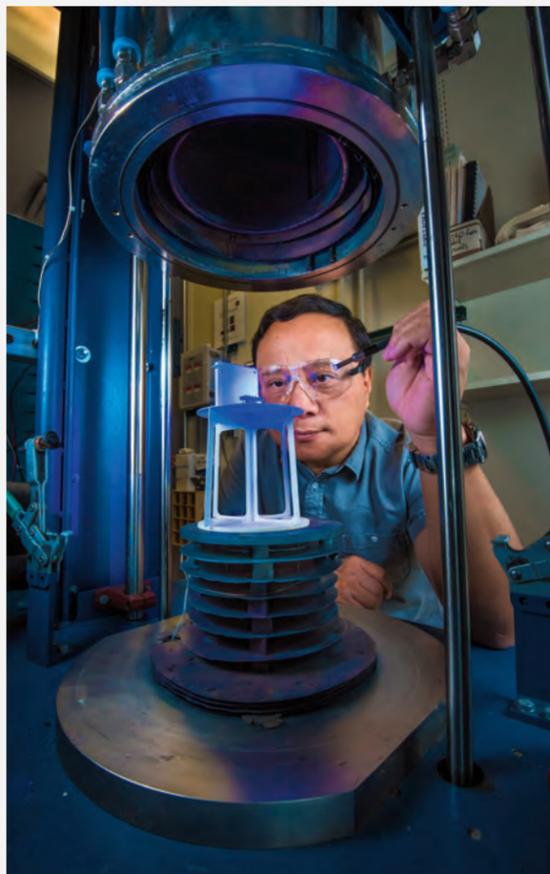
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Gravitation waves discovered!

Sandia physicist Mike Desjarlais discusses significance of greatest science breakthrough of the 21st century page 8



New ways of looking at glass-to-metal seals



RESEARCHER STEVE DAI (1833) has been working on bonding glass-ceramic materials to stainless steel. Strong bonds for airtight seals are important for applications in fields ranging from aerospace to defense. (Photo by Randy Montoya)

Sue Major Holmes

Components housed in stainless steel for protection against extreme environments seen in the aerospace and defense industries require paths for electricity to power them and communicate with them. Those paths in turn need a reliable insulation seal to prevent contact with the metal case that could short out the power and communication lines.

Strong bonds between materials for airtight, or hermetic, seals are crucial, and Sandia continues to advance how that's done.

Designing next-generation seals

Typically, material used to isolate electrical paths is either glass or a glass-ceramic composite. Work by Steve Dai (1833), principal investigator for a project on bonding glass-ceramic to stainless steel, aims to develop fundamental science in materials and processing for high-performance and high-reliability glass-ceramic-to-metal seals. That scientific foundation then could be used in designing, developing, and manufacturing next-generation seals.

Steve's team filed a provisional patent application in November for interfacial bonding oxides for glass-ceramic-to-metal seals.

A durable seal needs a strong chemical bond between the glass-ceramic and the metal and a close match of the coefficient of thermal expansion (CTE) between materials. The CTE defines how an object's size changes as temperatures change. A glass-ceramic with crystalline phases formed inside the original glass increases the CTE to better match the metal housing and reduce thermal stresses.

Since bonded glass-metals must be processed at very high temperatures, "we need to manage the thermal mis-

(Continued on page 4)

SANDIA/CALIFORNIA on March 8 marks its 60th anniversary. Read about the site's history, from its early years with a focus on the nuclear weapons mission to today, with roles across all mission areas. Story on page 3.



Rubber match

Materials scientists Mat Celina and Robert Bernstein (both 1853), along with co-author Ken Gillen, now retired, garnered the award for the best paper last fall from the American Chemical Society's Rubber Division. Story on page 5.

Quantum computing

Sandia researchers have supported post-doctoral fellow Meenakshi Singh in taking the first step toward creating a practical quantum computer, able to handle huge numbers of computations instantaneously. Story on page 7.



Also inside . . .

- "You know you're an engineer when . . ." winner 2
- Partnerships map shows Labs' impact across nation 9
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- Facilities sets safety record 10

Tian Ma named Most Promising Asian American Engineer of the Year

Sandia engineer Tian Ma (5521) immigrated to the US at age 11, not knowing English and unaware of the significant cultural challenges he would face. Now Tian has been named the 2016 Most Promising Asian American Engineer of the Year. Story on page 12.



That's that

Did you see the story we published in the last issue, the one about the contest where Sandians were asked to complete the sentence, "You know you're an engineer when . . ." The contest was part of our celebration of Engineers Week and the winning submission was announced during an eWeek presentation at the Steve Schiff Auditorium. For the winning submissions, chosen from dozens of entries, check out Sue Major Holmes' story at right.

We clearly had fun with this contest here at the Labs, but it turns out engineers across the country got a kick out of the story, too.

Knowing a good thing when he sees it, Sandia social media lead Darrick Hurst tweeted a linked to the version of the story we'd published on our external *Lab News* website. We weren't surprised it got picked up and retweeted all over the place; it got us some great visibility and probably introduced Sandia to a lot of folks who'd never heard of us before. According to the Measured Voice social media metrics service, the "You know you're an engineer when . . ." tweet was "the 21st most engaging Tweet from U.S. government Twitter accounts on February 22, 2016." Measured Voice estimates the tweet reached a potential 409,000 people on February 22 alone. The number one dot.gov tweet of the day was a photo posted by astronaut Scott Kelly from the International Space Station. Hard to top that one.

In the course of the widespread coverage, the folks in our office got a few laughs in return. One of the first news outlets to pick up the story and get the publicity ball rolling referred to us several times as "Scandia." With a name like that, it sounds like we ought to be based in the wilds of Norway doing top secret Viking R&D. I wonder if the reporter had seen the recent story by Neal Singer in the *Lab News* called Thor's Hammer about our new pulsed power machine? Anyhow, now that our secret is out, I've been authorized to disclose that we have a research team under principal investigator Grimfrost Grundosdottir working to optimize the hydrodynamics of dragon-ships.

* * *

Something really exciting is happening in the field of physics! Scientists at the Laser Interferometer Gravitational-Wave Observatory (LIGO), operated by Cal Tech and MIT and supported by the National Science Foundation, have announced that they have "observed ripples in the fabric of spacetime called gravitational waves, arriving at the earth from a cataclysmic event in the distant universe."

The detection of these waves, which confirms a major prediction of Albert Einstein's 1916 general theory of relativity, is being heralded as the greatest scientific discovery so far in this century.

The *Lab News* asked Sandia Senior Scientist and APS Fellow Mike DesJarlais to write an essay for us discussing the discovery and its significance. It's an excellent introduction to this subject; I think you'll come away from reading it with a better understanding of why physicists are so excited. Check it out on page 8.

Mike's contribution to the *Lab News* reminds me of why I love Sandia so much. When I heard about the gravitational waves discovery, I was just serenely confident that there'd be someone here at the Labs who could write authoritatively about it. The scope of our expertise seems unbounded.

My mother, who became a big fan of Sandia via reading the *Lab News* cover to cover every two weeks for the last 10 years of her life, once said that it seemed to her that whenever anything challenging or threatening was happening in the nation, Sandia was there, involved somehow. She was on to something, but she didn't know the half of it because, of course, there is an awful lot we do for the nation that is never openly discussed. We have the best people doing the most important work. What a privilege to be part of that in my own small way.

* * *

One last, quick item: Several folks have asked me to provide a follow-up on the column item I wrote a couple of issues back about my young neighbor, Nathan Barkocy, the teen who was struck by a car while on a bicycle training ride. Nathan, the grandson of two Sandians, awoke from his coma a couple of weeks ago and was recently deemed well enough to move to a rehab center in Denver, a facility that is regarded as maybe the best place in the nation to recover from the kind of injuries Nathan sustained. He is doing well and is gaining strength and mobility. He has a long road to a full recovery but he is definitely making progress. The expert care and attention he receives, an optimistic nature, a fighting spirit, and huge support network sustain him every day.

See you next time.

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

Channeling the inner geek: 'You know you're an engineer when' winners named



Barbara Lewis won bragging rights, as well as a pocket protector stocked with new pens, for her winning entry in the "You know you're an engineer when..." contest sponsored by Sandia's Engineering Sciences Center 1500 to help mark National Engineers Week in February.

The contest drew dozens of endings for the sentence, and Sandians voted on which they liked best.

Barbara (1342) took first place for finishing the sentence with, "...you're lying in the hospital bed asking the nurse how the light on your finger is measuring the oxygen level (and then you hold your breath to test it)."

"It actually happened, and that's when I realized engineers can annoy non-engineers without even trying," says Barbara, who also received a Star Wars mug and a restaurant gift certificate as prizes.

Second place went to Jerome Cap (1557) for, "...your kids say, 'Dad, I don't want to know the theory, all I want is the answer.'"

The other runners-up:

- Third: Michael Shaw (1719), "...you log the time it takes to get to your building's parking lot by weekday and the time you arrived at the Southern and Eubank intersection street light (the point where no backup has occurred yet due to the security gate authorization), then plot the data to determine the latest possible arrival at the intersection to get to the parking lot by 7:45 a.m. at the latest. However, you remove any outliers during weeks related to holiday weekends due to vacations and of course, school holidays when parents might have to take the day off. You determine the latest time to arrive at Southern and Eubank on average for Monday through Thursday is 7:15 a.m., but Fridays are as late as 7:40."

- Fourth: Taye Esho (0422), "...you create a spreadsheet to evaluate dating prospects."

- Fifth: Keith Kozlowski (0422), "...your spouse/significant other won't let you dress yourself."



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Bill Murphy, Editor 505/845-0845

Randy Montoya, Photographer 505/844-5605

Patti Koning, California site contact 925/294-4911

Michael Lanigan, Production 505/844-2297

Contributors: Michelle Fleming (Ads, Milepost photos, 844-4902), Neal Singer (845-7078), Stephanie Holinka (284-9227), Darrick Hurst (844-8009), Heather Clark (844-3511), Sue Holmes (844-6362), Nancy Salem (844-2739), Valerie Larkin (284-7879), Lindsey Kibler (844-7988), Tim Deshler (844-2502), Rebecca Brock (844-7772), Mollie Rappe (844-8220), Michael Padilla (925-294-2447), Valerie Smith, manager (844-6167)

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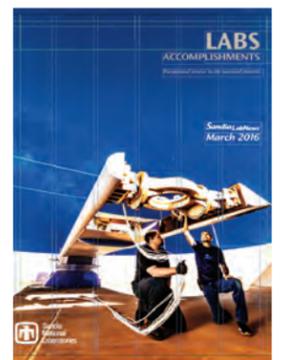
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Lab News Labs Accomplishments will be available in news racks at 25 locations throughout the Labs. A digital version of *Lab News* Labs Accomplishments will be available on Tech Web as well as on Sandia.gov.

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| 1. Bldg. 802, elevator lobby | 14. Bldg. 870, lobby |
| 2. Bldg. 810, east lobby | 15. Bldg. 701, 1st floor hall, |
| 3. Bldg. 822, south entrance | next to elevator |
| 4. Bldg. 858 EL, lobby | 16. IPOC, lobby |
| 5. Bldg. 880, Aisle D, north lobby | 17. CGSC, lobby |
| 6. Bldg. 892, lobby | 18. CRSI, lobby |
| 7. Bldg. 894, east entrance, lobby | 19. M.O. 308, lobby |
| 8. Bldg. 898, east lobby | 20. Bldg. 960, lobby |
| 9. Bldg. 887, lobby | 21. Bldg. 962 (TA III), lobby |
| 10. Bldg. 891, lobby | 22. Bldg. 6585 (TA V), lobby |
| 11. Bldg. 836, lobby | 23. Bldg. 905, lobby |
| 12. Bldg. 831/832 north lobby | 24. 800(A), outside of Vicki's |
| 13. Bldg. 861, cafeteria lobby | 25. Bldg. 823, lobby |

Sandia/California marks 60 years of engineering, science, and service



SANDIA/CALIFORNIA TODAY – From a small group of 24 employees, Sandia/California has grown to include some 900 staff and 250 contractors, postdoctoral fellows, and students, and has broadened in scope to play a vital role in Sandia's overall missions. (Photo by Randy Wong)

By Michael Padilla

On March 8, Sandia/California celebrates its 60th anniversary. The site, which began with a singular nuclear weapons mission, now supports all Sandia mission areas. Nuclear weapons still accounts for nearly half of the site's work, along with strong programs in homeland security, transportation energy, cyber, and chemical and biological defense.



SANDIA ORIGINALS – Fifteen of the 24 Sandia/California originals gathered for a group photo in 1956. Pictured are C.E. Barncord, Charles A. Gump, Clifford O. Erickson, Benjamin F. Fisher Jr., Robert L. Siglock, Stafford G. Cain, Vernon M. Field, Charles Winter, Wayne A. Grimshaw, Frank J. Thomas, Orval W. Wallen, James McMinn, Mary A. Van Brocklin, William B. Marsh, and Nora-Belle Byrd.

"From the Cold War to today, we've been providing exceptional service in the national interest in Livermore for six decades," says California Laboratory Div. 8000 VP Marianne Walck. "It has been a remarkable 60 years for the site. I'm grateful to be part of the continuing success in contributing to the security and well-being of our nation and the world."

To commemorate the 60th anniversary, Sandia/California on March 3 held an on-site event, "Honoring 60 Years of Engineering, Science, and Service." The event featured a panel of former Div. 8000 VPs (including two who went on to become Labs directors) and current VP Marianne Walck:

- John Crawford, 1987-1995
- Tom Hunter, 1995-1999; Labs Director 2005-2010
- Mim John, 1999-2006
- Paul Hommert, 2006-2009; Labs Director 2010-2015
- Rick Stulen, 2009-2013
- Steve Rottler, 2013-2015
- Marianne Walck, 2015-present

Current Labs Director Jill Hruby participated via a taped video. Bob Carling, Center 8300 director from 2008-2014, moderated the panel, which discussed the history of the site and its contributions to the nation.

Two additional events are planned to commemorate the 60th anniversary. Health, Benefits, and Employee Services will host a 60th birthday party on March 8. On May 21, Sandia/California will host a 60th anniversary community event in downtown Livermore.

Sandia/California through the decades

Many changes have occurred at Sandia/California throughout the past six decades. The site, which was estab-

lished by the Atomic Energy Commission to support projects for the University of California Radiation Laboratory (now Lawrence Livermore National Laboratory), continues to work closely with LLNL on various weapons programs.

The first decade was largely devoted to weapon projects, a dozen of which made it to the stockpile. The site provided early critical support functions in safety, use control, reliability, testing, and analysis. One of the largest and most successful programs during this time was the W47 warhead for the

Polaris missile. Environmental testing and systems studies were initiated during this time. The site also assumed responsibility for gas bottles and obtained its first computer system, the Elecom 125, to calculate flight trajectories and stress analysis. Early in the 1960s, the number of stockpile weapons rose as the Cold War ramped up. The site developed expertise in welding and microelectronics.

"Since the mid-50s, the California site has played a major role in ensuring the safety, security, and effectiveness of the current stockpile," says Russ Miller, Center 8200 director. "We developed and advanced the scientific and engineering capabilities required in meeting the needs of the national security missions."

1970s: Responding to the energy crisis

The 1970s were marked by the nation's first major energy crisis and the establishment of the new Department of Energy. Sandia/California quickly moved into energy with programs in solar and combustion. The Combustion Research Facility (CRF) opened in 1980 to meet research needs in this area. The CRF has greatly expanded fundamental knowledge of combustion processes and contributed to significant design innovations for diesel engines, pulse combustors for furnaces, and pollution reduction methods.

"The CRF has driven our scientific understanding of internal combustion engine processes that affect car efficiency and emissions," says Bob Hwang, Center 8300 director. "The CRF has had a major impact on every engine on the road today."

During the 1980s, the emphasis in weapons work expanded to include greater functionality, improved safety and control systems, and greater reliability. Sandia/California worked closely with LLNL on various stockpile nuclear weapons systems. The systems developed during this period included the W82 atomic projectile, the W84 warhead for the ground launched cruise missile, the B83 modern strategic bomb, the W87 warhead for the Peacekeeper missile, and the W89 warhead for the SRAM II missile.

From 1983 to 1992, Sandia/California was an active participant in research and development supporting the Strategic Defense Initiative (SDI). This was a period of intense activity at the Labs, with Sandia/California playing a leadership role within Sandia. Some of the site's responsibilities included understanding the requirements for SDI systems, conceptual engineering design, and development of advanced materials for use in several different concepts.

In the 1990s, the weapons program changed its focus from designing new warheads to maintaining and refurbish-

ing existing warheads. Sandia/California and LLNL were responsible for the first warhead Life Extension Program (LEP) that was initiated on the W87 warhead; other existing stockpile weapons were maintained and retired weapons were dismantled and disposed of.

A broadened national security mission

Technology transfer programs expanded in the 1990s, most notably the extreme ultraviolet lithography program, a Cooperative Research and Development Agreement with several semiconductor companies. The site continues to transfer technology externally and offers partners access to the Labs' science, people, and infrastructure.

The site's national security mission also broadened in the 1990s to include homeland security, cyber, and chemical and biological defense.

"The division has been addressing many emerging and evolving national security challenges," says Duane Lindner, director of 8100 and acting director of 8600. "We have been able to draw upon many of our core science, technology, and engineering capabilities to help invent, develop, demonstrate, and deploy homeland security systems that are now helping defend the nation."

The Livermore Valley Open Campus (LVOC) began to take shape in the 2000s. The LVOC was created along the boundaries of LLNL and Sandia/California as an innovation hub and

novel venue for collaborations between experts from within and outside the Labs.

The future of the site continues to evolve with Bldg. 926, scheduled to open by year-end. The new building will consolidate "front door" activities, house the site's human resources department, and host the training center for students and new hires. The new building will enable the site to bring Bldg. 911 into the Limited



SECURITY GUARD TOWERS around the site were removed during the early 1950s.

Area and repurpose it for expanding its national security mission work. In addition, when Bldg. 926 opens its doors, several substandard mobiles will be removed.

Plans for a new building called Collaboration in Research and Engineering for Advanced Technology and Education (CREATE) also will support the vision of an open campus. The proposed 86,000-square-foot building will provide additional collaboration space for engagement with industry and academia.

New ways of looking at glass-to-metal seals

(Continued from page 1)

match very carefully to make sure during any stage in the sealing process there's no tensile stress or tension on the glass that will cause a crack or unrecoverable separation from the metal housing," Steve says.

Potential industrial uses seen

A seal that's strong at high temperatures and pressures also has potential industrial uses, such as in fuel cells and aerospace or defense applications that operate in extreme environments.

Pure glass shrinks less in high temperatures than metal does. The mismatch causes metal to crimp, compressing the seal. That has both advantages and disadvantages. "The good thing is you don't have to have very good bonding because there's a lot of compression; the downside is that there could be too much compression, which could crack the glass over time," Steve says.

His team looked at making a chemical bond between metal and glass-ceramics, without adding steps to production, by establishing an interfacial bonding layer, a bridge material that bonds to both steel and glass. "It's very difficult because these are two very dissimilar materials, a piece of steel and a piece of glass-ceramic. They hardly share anything," Steve says.

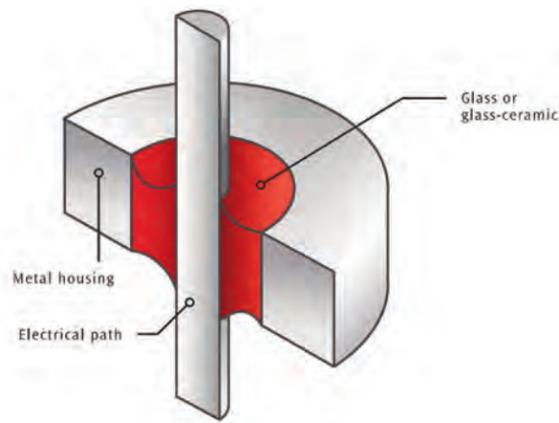
Glass-to-metal seals are processed in an inert atmosphere devoid of oxygen because metal grabs oxygen from the atmosphere, leading to oxidation and rust. But the process contains an inherent contradiction: A metal bond to a glass-ceramic requires an oxide, so the interfacial bonding layer is really an interfacial oxide layer.

"That's the fundamental challenge, how do we do that?" Steve says. Some processes pre-oxidize the metal, but Sandia wanted to avoid that extra step.

Modifying glass-ceramic with oxidant

Steve's thermodynamic approach modified, or doped, the glass-ceramic sealant with an oxidant. That oxidant, serving as a sacrificial metal oxide, decomposes and migrates at high temperatures, providing oxygen to oxidize the metal chromium in the stainless steel. The chromium oxide bond formed at the glass-ceramic and metal interface results in hermetic seals.

The team made 24 potential modified glass-ceramic compositions using a variety of metal oxides that were non-toxic and reasonably easy to handle, such as cobalt oxide. "Most of the work is really saying, 'OK, how many metals from the periodic table can we use and when we dope our glass with these sacrificial metal oxides, what quantity do we need to dope it?'" Steve says.



ELECTRICAL PATHS IN COMPONENTS need a reliable insulation seal to the metal case that surrounds them. Sandia is working on a new glass-ceramic with linear expansion that is a better thermal match to the expansion of the metal case.

"If my metal housing gets that oxygen to form the bond oxide, that's all I want. If the graphite grabs that oxygen, it doesn't do any good. That delicate balance of the reaction is very challenging."

— Sandia researcher Steve Dai

Researchers want the doped ceramic-glass material to give up oxygen at the interface, not at the surface of glass-ceramics. "The idea is giving up oxygen in the right place. That's kind of a fine line that has to do with the properties of the materials and the way you process them," Steve says.

The team identified two modified glass-ceramic compositions that worked best. Steve says they're not perfect, but they're a big step forward. "Basically we see a chemical bond between the glass-ceramic and the metal, and it's a very strong bond," he says. "If we break it, we break the glass."

Sandia also developed a way to test both whether interfacial bonding is established and, if so, whether it's strong enough to ensure the glass won't break.

Taking all factors into account

Other factors have to be considered. Without careful processing, the glass sticks to other surfaces as well as to the metal housing. To prevent that, the bonding process uses

graphite for the fixtures that hold metal and glass-ceramic pieces while the bond is formed.

But graphite, like stainless steel, fights for oxygen.

"Essentially, that's a kind of competition thermodynamically," Steve says. "If my metal housing gets that oxygen to form the bond oxide, that's all I want. If the graphite grabs that oxygen, it doesn't do any good. That delicate balance of the reaction is very challenging."

The first two years of Steve's three-year Laboratory Directed Research and Development (LDRD) project centered on the bonding process. The final year studied how to control glass-ceramic crystallization to ensure the best thermal match. LDRD funding has ended, but the work continues with other funds because of its potential to aid production. Although the project wasn't aimed at an immediate application, researchers found a near-term opportunity to help a weapons production team with a better thermal match between glass-ceramic and metal.

During sealing, glass-ceramic goes through a crystallization phase, which allows formation of a high-expansion crystalline phase, increasing the CTE of the glass-ceramic to better match high-CTE metals like stainless steel. However, because of the abrupt volume change associated with that crystalline phase, the glass-ceramic expansion is not well distributed over the temperature change that occurs during processing. Thus, the rate of thermal strain between the metal and glass-ceramic doesn't match.

Managing crystalline phase difficult but important

The team was interested in managing the crystallization process by breaking it to form two or three high-expansion crystalline phases, with the abrupt volume changes in each phase occurring at temperatures several hundred degrees apart. The concept requires understanding what temperatures produce certain crystalline phases.

"We try to do two or more multiple crystallizations to smooth the thermal strain of the glass-ceramic," Steve says. "As a result, you no longer have this nonlinear, almost step-like strain change in the glass-ceramic. It's a more near-linear strain curve and matches a lot better to the metals."

Managing multiple crystallization phases at very high temperatures is challenging. "We need to learn that part of the process to make sure we have a good balance of all the phases, have them all crystallize in the right sequence, and ideally in the right proportion," Steve says. He believes the effort will result in a consistent way to improve hermetic seals.

His team is developing verification methods to see if the process works for production applications. Then researchers will study whether the process consistently produces the desired results.

"Once we reach that point, we will make sure the right specifications are in place and that the processed parts have certain properties so that the production agency can do the process on a continual basis using their equipment," Steve says.

Weaselboard

(Continued from page 1)

of production, manufacturing, and utility equipment in the US Industrial control processes require high availability and any cyberattack could result in something expensive and dangerous. And most industrial processes are unprotected.

"Most machines weren't initially designed to be networked together, so industrial control systems were not designed with security in mind," says principal investigator John Mulder (5628).

Most attacks on control systems focus on network communications and computer software, so industrial control systems, which are embedded at the hardware or firmware level, are not often monitored for security compromise.

"Because industrial control systems aren't monitored routinely, current industry practice forces critical infrastructure owners to wait for the zero-day exploit before they know something is wrong. This means that owners can only react to malicious attacks after the damage has occurred, which can lead to expensive equipment damage, lost uptime, and in some cases, casualties among operating personnel," John says.

Identifying malicious behavior

WeaselBoard works by detecting changes in the controllers and its processes, such as control settings, sensor values, module configuration information, firmware updates, and process control program (logic) updates. It forwards inter-module traffic to an external analysis system that detects changes. The analysis workstation then extracts fields at each protocol layer.

These fields are tested using mechanisms to identify malicious behavior: a rule set and a machine-learning algorithm. The rules-based mechanism causes an alert when predeter-

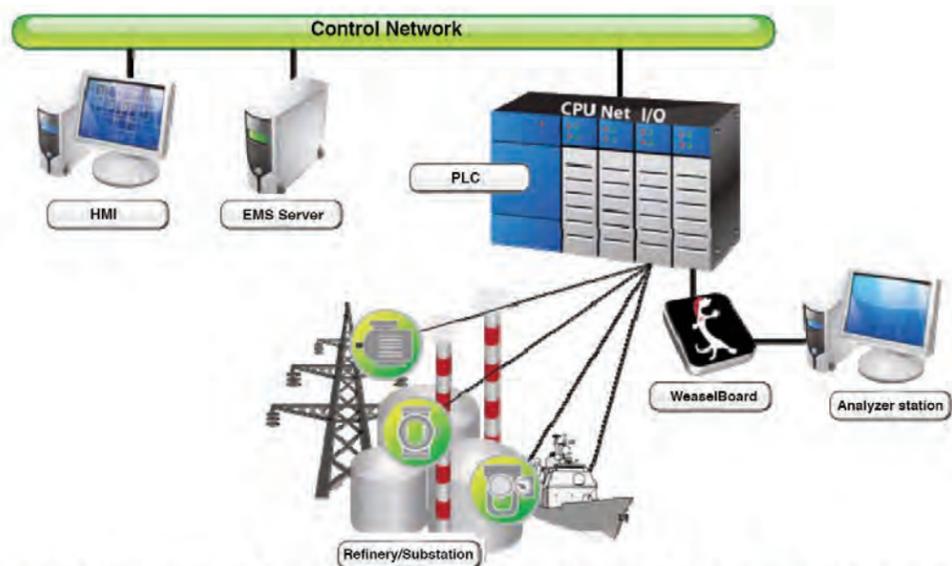


Figure 1. WeaselBoard in an industrial control system. WeaselBoard is connected directly to the PLC backplane and sends captured backplane traffic to a separate analysis workstation.

mined behavior is seen, and can be customized to process-specific limits.

"WeaselBoard allows operators to detect compromises as they are in progress, because it alerts on the effects of the attack in progress, and not on signatures of previously catalogued attacks. This allows zero-day exploits to be detected, unlike systems using signature-based detection methods," John says.

WeaselBoard is currently being piloted in an operational environment.

Through the DHS Transition to Practice program, Sandia is seeking additional pilot partners to test the patented

WeaselBoard technology in other environments.

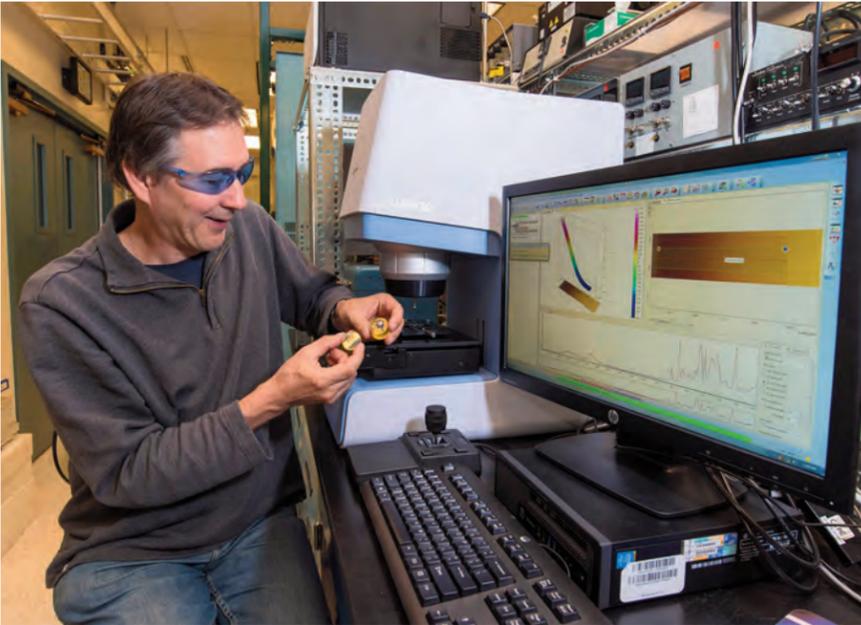
This work was funded under Sandia's Laboratory Directed Research and Development program.

Highlighting WeaselBoard's potential use for many types of cyber-physical systems, senior manager for Renewable Energy Technologies Juan Torres (6120) recently took WeaselBoard to the Hill as part of the Grid Modernization Lab Consortium discussion on security and resilience. It was also showcased at July Lab Day on the Hill in Washington, D.C.

"Weaselboard is an example of cyber technology that Sandia developed with potential application to energy systems," Juan says.

Burning Rubber

Sandia researchers win best paper award for review of how rubber ages



SANDIA MATERIALS SCIENTIST Mat Celina with an imaging infrared spectrometer used to look at chemical degradation of rubber objects. Mat, Robert Bernstein, and Ken Gillen (retired) received the ACS best paper award for a review of rubber aging. Understanding how rubber ages is important for car tires, solar panels, and nuclear power plant cable insulations. (Photo by Randy Montoya)

By Mollie Rappe

The space shuttle *Challenger* blew up in 1986 because a rubber O-ring froze in the solid rocket booster. It may have shattered like an old rubber band, or at least it became too stiff to provide an air-tight seal, which released the pressurized burning gas from the rocket booster.

Picking the right rubber for the job and determining how long it will last are the specialties of Sandia materials scientists Mat Celina and Robert Bernstein (both 1853). Their comprehensive review — co-authored with Ken Gillen, now retired — garnered the award for the best paper last fall from the American Chemical Society Rubber Division.

Understanding how rubber materials perform at a fundamental level is critical in selecting the right material for the job, says Mat. Applications run the gamut from car tires and timing belts to waterproof sealants for flat New Mexico roofs, seals around solar panels to keep out moisture, nuclear power plant cable insulation, or O-rings in space shuttles and nuclear weapons.

Rubber ages due to the reaction between atmospheric oxygen and the elastic polymer. First the oxygen has to diffuse into the material, which is a physical process. Then the oxygen chemically reacts with the polymer. For more than 30 years, Sandia's strength has been understanding both processes and combining them into a reactive diffusion model, says Mat.

Ken and fellow retiree Roger Clough began Sandia's forays into developing better models and techniques for predicting the lifetime of different rubbers and elastic polymers in the late 1970s, establishing a foundation for polymer materials aging science at Sandia.

Best paper award

Ken retired from Sandia in 2004 after 30 years, but stayed involved. He was a part-time consultant helping Sandia colleagues with research strategies, talks, papers, and reports until 2015. He also continued serving as an editor for the international scientific journal *Polymer Degradation and Stability* until 2006. Mat was selected to replace him and served as editor from 2006 to 2011.

In 2014, Ken, Mat, and Robert submitted an invited conference paper to the 186th

Technical Meeting of the American Chemical Society Rubber Division. It was selected as the best paper "for presenting the best critical analysis and broadening the basic understanding of concepts in rubber science and technology," according to the citation. Ken accepted the award last October in Cleveland.

The best paper award is an acknowledgement of Sandia's contributions to the study of polymer aging, says Mat. "It's an independent validation for the quality of the work that we're doing."

The paper was reprinted as a review, "Challenges of Accelerated Aging Techniques for Elastomer Lifetime Predictions," in 2015. It offered such a thorough review of 30 years of polymer aging research that it will be translated and reprinted in a German technical journal for wider dissemination.

"Ken Gillen has spent 30 years in research related to materials aging, so when he was asked to give a review paper he really went back and looked at what has been accomplished over the decades in terms of research activities in this particular area. He offered a really nice review," says Mat.

Superior techniques

One challenge to accurately determining rubber lifetime is properly extrapolating from accelerated aging experiments. Sandia has developed specialized techniques that help predict the lifetime of a material during normal use by

looking at the physical and chemical changes during high-temperature aging.

Ken, Roger, and Carlos Quintana, also retired, envisioned and built a unique instrument called a modulus profiler to test the mechanical changes during rubber aging. For some applications such as tires, developing a crusty outer edge is fine; in others such as rocket booster seals, it spells disaster. The machine pokes a slice of an aged rubber object to test the elasticity. The tip of the machine is so fine it can sample spots that are one-third the diameter of a human hair apart.

Mat also uses a technique called attenuated total reflectance infrared spectroscopy to look at the chemical changes within a rubber object after accelerated aging. Signals from distinguishing chemical structures can fade or disappear during aging. This indicates how the polymer is degraded by oxygen. How fast this happens at various temperatures can be used to predict an object's normal lifetime.

Creating predictive aging models

Robert's expertise is in compression stress relaxation tests, a technique for monitoring how rubber's mechanical properties change under continuous pressure. Comparing the compression stress relaxation results with the chemical changes allows the researchers to match damage due to oxidation with changes to the mechanical properties, a key capability needed to create predictive aging models.

Sandia's experimental expertise with polymers complements its decades of success in applied modeling. Ken, Mat, and Roger over the years have combined experimental data with a diffusion-limited oxidation model to improve predictions of rubber lifetimes. This modeling is especially useful if the chemical reaction pathways change at higher temperatures, and also show important distinctions between surface and bulk aging.

"Investment in fundamental materials science research, which includes a linkage between experimental and computational approaches to address complex problems in materials science, is essential to maintaining scientific leadership at Sandia. Receiving an external competitive award for our work is an indirect validation that tax dollars have been well invested. We also received this award for our passionate dedication to R&D over the past decades," says Mat.



SANDIA RETIREE Ken Gillen (left) received the ACS best paper award for a review of rubber aging, co-authored by Ken and researchers Mat Celina and Robert Bernstein.

NNSA Administrator Gen. Frank Klotz, Sen. Heinrich, Rep. Lujan Grisham visit Sandia



Lt. Gen. Frank Klotz, left, DOE undersecretary for nuclear security and administrator of DOE's National Nuclear Security Administration, on Feb. 18 hosted Rep. Michelle Lujan Grisham and Sen. Martin Heinrich on a tour of the aging buildings at NNSA's Albuquerque Complex on Kirtland Air Force Base. Jeff Harrell, right, manager of NNSA's Sandia Field Office, led the tour. NNSA proposes to build a new facility on Kirtland Air Force Base for the Albuquerque Complex and is requesting funding authority from Congress for the construction. Many of the 1,200 employees at the complex are currently housed in former military barracks that date to the 1950s. Earlier in the day, Klotz and the New Mexico congressional delegation, including Heinrich and Lujan Grisham, participated in a small business supplier roundtable in downtown Albuquerque. In the afternoon, Klotz visited Sandia to personally thank members of Region 4 Radiological Assistance Program team members for their service. The team includes representatives from Sandia, Los Alamos National Laboratory, and NNSA's Sandia Field Office. Also on Feb. 18, Heinrich visited Sandia for briefings on several areas of the Labs' mission work, including battery testing, cybersecurity, and nuclear weapons component testing.

(Photo by Al Stotts)

Service-driven women

**Sandia marks
Women's History Month**



March is Women's History Month, and the 2016 theme, "Working to form a more perfect union," celebrates women who have shaped America's history and its future through their public service and government leadership.

It's a fitting theme for the women of Sandia who embody the Laboratories' core purpose: "To render exceptional service in the national interest."

Sandia has a long history of promoting the success and contributions of women in the workplace, particularly in science, technology, engineering, and math (STEM) leadership. Notably, in 2015, Sandia President and Laboratories Director Jill Hruby became the first woman to lead a nuclear weapons laboratory.

Sandia's outreach program, SWAN (Sandia Women's Action Network), brings together women from all facets of

the Laboratories and partners with the Sandia Women's Committee at Sandia/California. SWAN exists to create and maintain a welcoming environment where women can advance their careers with ongoing networking and professional development opportunities.

The SWAN council, led by co-chairs Amy Tapia (3652) and Lori Parrott (6924), is proud to recognize the courage and dedication of the outstanding women at Sandia.

Stories by Rebecca Brock • Photos by Stephanie Blackwell

Ann Campbell, director of Center 5900

The importance of contributing to something bigger



Ann Campbell grew up in Jamestown, a small city in western New York state. She comes from a long line of independent women.

Ann's great grandmother, Matilda Lundburg, left Sweden in her teens by herself seeking a better life in America.

Ann's grandmother, Isabel Campbell, was an amateur champion golfer at a time when there were few women in the sport. "She was comfortable in a man's world," Ann says, "I learned a lot from her as a role model."

Ann's mother, Helen Nelson Campbell, joined the Navy during World War II to serve in the WAVES (Women Accepted for Volunteer Emergency Service), the women's branch of the US Naval Reserve.

"In her early 20s, my mother moved far away from home to work in the Supply Corps at the Charlestown Navy Yard, provisioning ships for the war effort. I have always found her example inspiring, because my mom says she was painfully shy as a young woman," Ann says.

"What I got from my mom is the importance of service and contributing to something bigger."

Fast forward to today, and Ann serves as director of Sandia's Systems Assessment and Research Center (5900). She leads a team of approximately 200 staff and managers who work on a range of national security issues related to nuclear weapons worldwide. Her program, she says, consists of a variety of activities including analysis, threat and vulnerability assessments, and research and technology development to support a broad range of US Government missions.

"Ann is amazing," says Div. 5000 VP James Peery. "She is very humble, and likely won't tell you about the activities she has led to strategically position the Labs. Perhaps the most significant example is cyber. Ann worked effectively to transform a small area into a synergistic mission area for the Labs. When we discuss future customer stewardship models, most of today's examples have Ann's fingerprints on them."

Ann began her career at Sandia 30 years ago as a materials scientist. She earned her bachelor's degree in materials engineering from Rensselaer Polytechnic Institute and her PhD in Applied Physics from Harvard University. At Harvard she was one of the first women in her program.

Ann says the key to her professional success has been a willingness to try new things.

"Sandia was the only national lab that I considered. The attraction for me was the breadth of the programs. I have learned so much from moving around and doing a lot of different things. I've had multiple careers under the same roof."

Regarding the future of women in STEM careers, Ann says, "I'm very inspired by the women who I see come into the laboratory today. They are smart, creative, and they know what they want to do. My concern is that we don't see enough young women going into STEM fields."

What is the best advice she has ever received? "Be true to yourself," she says. "I learned that from my mom."

Outside of her busy work schedule, Ann enjoys being outdoors and spending time with her husband and their dog.

Miquelita Carrion, Project Manager in 2131

Inspiring hundreds of at-risk youth in the community



Miquelita Carrion (2131) began her career at Sandia at age 16. She grew up in Albuquerque's South Valley, where, she says, "I was taught family is first, and not your career." A student at Rio Grande High School, she joined Business Professionals of America (BPA). Interested in the prospect of working in an office setting, she accepted an opportunity through BPA to work as a secretarial trainee with Sandia's Yucca Mountain Project.

"I did not even know what Sandia Labs was," she says. "In my community, I was never exposed. I had never met an engineer."

Today, Miquelita serves as a project manager in the nuclear weapons stockpile program and a principal member of staff. Her manager, Valerie Mendoza (2131) says, "Miquelita has a passion to work on the hard problems, and she always finds a solution. We are very fortunate to have her on our team."

First-generation college educated, Miquelita holds a bachelor's degree in business management and a master's degree in business administration. Her example has inspired hundreds of at-risk youth in the community.

Miquelita serves as the program coordinator for Manos, a Sandia-sponsored science and engineering outreach program for local, Hispanic middle school students. She has led Manos for more than 10 years and has volunteered since 1995. She gives hundreds of hours of community service because, she says, all young people, especially from economically challenged areas of the city, need to be introduced to STEM careers.

Manos reaches more than 150 students a year. This year, it has grown in collaboration with the National Hispanic Cultural Center and Albuquerque Public Schools.

"The Manos program is something much bigger than myself — it takes an entire village effort," she says.

Manos is a partnership of Sandia's HLOC (Hispanic Leadership Outreach Committee) and Community Involvement Dept.

3652. Community Involvement manager and SWAN co-chair Amy Tapia says, "Miquelita continuously strives to improve the Manos program and is willing to think outside the box to create more impact on students."

Miquelita says Manos' growth over the years is a testimony to how effective it is. "It started more than 25 years ago as a four-week program, and this year we have transitioned to year-round," she says. "Now these students will have somewhere to go all year."

Asked how she balances work and community with a blended family of five children and two granddaughters, Miquelita says, "It takes a lot of organization and a lot of juggling, just like my role as a project manager."

Miquelita credits her success to the men and women mentors she has had at Sandia. "When I worked in human resources, I had a phenomenal manager named Linda Duffy. The moment I finished my bachelor's degree, Linda told me I needed a master's degree. She was always pushing me to further myself. I'm grateful she did and I really try to pay it forward with others."

What is Miquelita's advice for working mothers? "It's about the quality of time you spend, not the quantity," she says. "By supporting other women in the workplace with positive networks like SWAN (Sandia Women's Action Network) and sharing our stories, we can have successful careers and happy families, too."

SWAN activities for Women's History Month

All members of the workforce are invited to attend the following events in March to help celebrate Women's History Month:

- **Women's Leadership Panel:** On Monday, March 21, noon-1 p.m. in the Steve Schiff Auditorium, a panel of women executive leaders will engage in a candid and lively discussion about the paths they have taken to leadership at Sandia, the challenges they faced, and their most meaningful achievements. The panel will be video linked to Sandia/California Bldg. 915, Rm. W133, 11 a.m.-noon PST.

- **Diversity Cinema:** On Wednesday, March 23, 11:30 a.m.-12:30 p.m. in Bldg. 895, Rm. 1015, Diversity Cinema will present: "Implicit Bias in Science."

Never too late

Welding engineer traded sewing for a shot at a science career

By Nancy Salem

Pierrette Gorman built a successful career as a seamstress and tailor, working her way from bridal and clothing stores to owning a business in upstate New York. But something was wrong.

"I wanted to go to college. I wanted a college education," Pierrette (1831) says. Even more daunting, she wanted to be an engineer.

"I knew my ability as a seamstress and differentiated myself from a home sewer," she says. "I excelled in science and math, and there is a lot of engineering in tailoring. I especially enjoyed working with people who had disfigurements, and I could pad and fit their clothing so they looked complete."

Pierrette started college in her 40s. She earned a degree in welding engineering, worked in industry, and found her way to Sandia Labs.

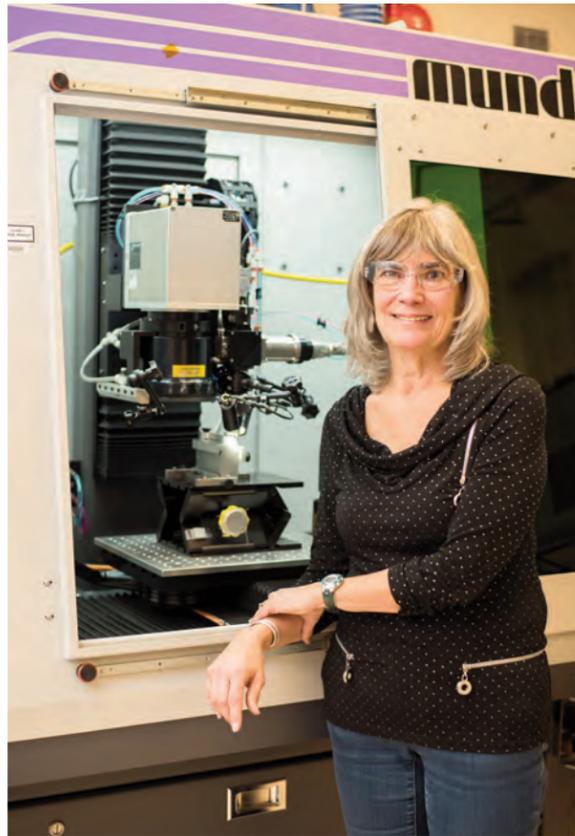
This month, Pierrette was named the winner of a 2016 STEP Ahead award by the Manufacturing Institute. The institute in 2012 launched the Science, Technology, Engineering and Production (STEP) Ahead initiative to honor and promote the role of women in the manufacturing industry through recognition, research, and leadership. The national honor identifies the best women in manufacturing and encourages them to mentor and support the next generation of women in manufacturing careers.

"It's great to bring this award to Sandia," says Pierrette, who will be honored at an April 21 gala in Washington, D.C. "Women who have received it in the past are from major companies like Toyota and 3M. I'm proud to add Sandia to that list."

Welding was the best fit

Pierrette says she's also proud to have started college later in life. She moved from New York to Utah in the early 1990s and left her business behind to enroll in a two-year pre-engineering program at Salt Lake City Community College, earning an associate's degree. "That was where I first heard welding mentioned as a profession," she says. "But I discounted it at the time."

She moved to Ohio and was accepted into the Ohio State University College of Engineering, where she looked into various disciplines. Welding was the best fit. "They had 100 percent placement and they promised me I wouldn't sit in an office all day long. I'd spend time in a lab, production floor,



PIERRETTE GORMAN says Sandia has been a great place to build a career in welding engineering. "The Labs provides equal opportunity for women in science and technology," she says.

(Photo by Randy Montoya)

or field," Pierrette says. "And welding engineers were one of the highest paid right out of college."

While in school, Pierrette worked at the Edison Welding Institute in Columbus, Ohio, a 120-mile commute. "If you want something bad enough you do what you have to do to get it," she says. "And I absolutely wanted it."

She earned a bachelor's degree in welding engineering and worked three years at Greatbatch Ltd. in Buffalo, New York, which makes implantable batteries for pacemakers, cochlear implants, and defibrillators.

In 1999, her husband's work brought Pierrette to Albuquerque and a job at the laser deposition company Optimec. She joined Sandia in 2002 as a welding and soldering process engineer in neutron generators. She moved two and a half years ago to Metallurgy & Materials Joining, where she does research and development.

Pierrette is the single point of contact for welding requests to be processed in the Metallurgy & Materials Joining lab, conveying customer requirements to the welding technologists. She is also liaison between the design and the production agencies at the NNSA National Security Campus at Kansas City. "I team with both Sandia and Kansas City to write welding specifications, consult on weld joint design, and participate in the product development," she says. "I also consult with contractors who build components for Sandia and for the National Security Campus."

Women make great welders

Pierrette takes time to mentor young women interested in welding because that was missing in her life. "In high school girls were not allowed to take mechanical drawing," she says. "There were absolutely no mentors. I didn't know any women who were good in math and science."

She speaks at high schools and community colleges, letting women know they can have careers in technical areas. And she's on the board of directors of the American Welding Society with a vast district that stretches to Idaho and Montana, which gives her other opportunities to mentor women.

"Welding is thought of as a man's field," she says. "There is a huge need for all the different facets of welding careers, from engineers to solderers to inspectors. There are more jobs than people to fill them. The gap is huge and this is where we really need to get the word out to women that this is a good career. Women make great welders. It's a precision skill."

Pierrette says she often speaks to young women but would like to reach out as well to women in their 30s and 40s, perhaps displaced homemakers who didn't go to college. "I want to show them they can do it, and how," she says. "Sometimes I'll speak at colleges and the guys will come up and say they are going to talk to their moms about it."

Pierrette says that even though she started her welding career late there is plenty of time ahead. She says she feels lucky but that her husband says luck had nothing to do with it. "He says, no, you engineered your career," she says. "I feel like I accomplished my number one goal of getting a college degree. Next I feel I'm still learning and excited. My career is still young."

Precise atom implants in silicon provide first step toward quantum computers

By Neal Singer

Sandia researchers have supported post-doctoral fellow Meenakshi Singh (1132) in taking the first step toward creating a practical quantum computer, able to handle huge numbers of computations instantaneously. Here's the recipe:

A "donor" atom propelled by an ion beam is inserted very precisely into industry-standard silicon.

The donor atom, in this case antimony (Sb), carries one more electron (five) than a silicon atom (four). Because electrons pair up, the odd Sb electron remains free.

Instruments monitor the free electron to determine if, under pressure from an electromagnetic field, it faces up or down, a property called "spin." Electrons in this role, called qubits, signal "yes" or "no" from the subatomic scale and are the information bearers of a quantum computer.

The ability to precisely place a donor atom in silicon means that it should be possible to precisely place another donor atom just far enough away, in the "Goldilocks" zone where communication is neither lost through distance nor muffled by too-close contact. Attempts to do this will be made later this year, says Meenakshi. Qubits "talking" to each other are the basis of quantum computing circuits.

Quantum dot operates like a transistor

The successful Sandia first step, reported in mid-February (vol. 108, issue 6) in the journal *Applied Physics Letters*, makes use of electromagnetic forces provided by a neighboring quantum dot pre-embedded in the silicon. The quantum dot — itself a tiny sea of electrons — contains a variety of energy levels and operates like a transistor to block or pass the qubit.

If an available dot energy level is compatible with the electron, the transistor gate is effectually open and the electron jumps into the dot. If not, the electron stays put. That action is reported back to the surface by a photodiode sensor sensitive to current flows rather than photon movement. Because of the multiple "gates" in the quantum dot, many electrons at different energy levels could pass through the

transistor, or be denied passage, theoretically making possible an extremely wide array of information processing

"Our method is promising because since our method reads the electron's spin rather than its electrical charge, its information is not swallowed by background static and instead remains coherent for a relatively long time," Meenakshi says. "Also, we use silicon as our basic material, for which commercial fabrication technologies are already developed, rather than employing superconducting components, which can be expensive."

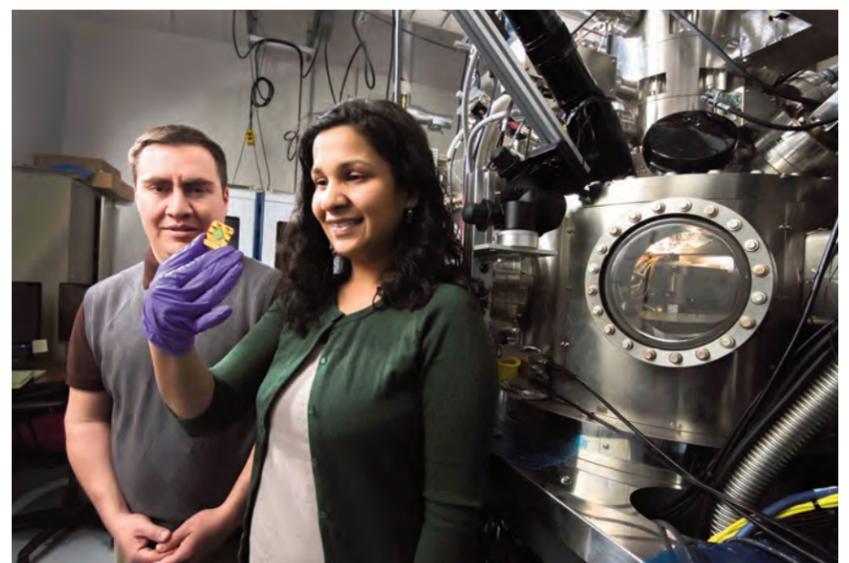
Precisely place donor atoms

A third unique quality of the Sandia work is its ability to precisely place donor atoms exactly where they should be, rather than relying on a buckshot approach that places qubits where they only statistically average to Goldilocks distances.

While components of this experiment have been demonstrated before, this is first time that all the components have worked together on a single chip, with researchers knowing accurately the vertical and horizontal placement of each qubit, instead of mere statistical approximations.

Sandia researcher and paper author Mike Lilly (1132) expects that "the Sandia technique will allow fabrication of more complicated multi-qubit structures and do so at higher yield than existing donor-implant approaches."

Components of the successful device were fabricated in



POST-DOC FELLOWS Meenakshi Singh and Jose Pacheco stand in front of Sandia's ion beam generator. Project PI Meenakshi holds a sample qubit structure embedded in silicon.

(Photo by Randy Montoya)

Sandia's MESA facility. The donor atoms were placed in Sandia's Ion Beam Laboratory, under the supervision of post-doc Jose Pacheco (1111). Experiment measurements were made at the Sandia/Los Alamos Center for Integrated Nanotechnologies, a user facility supported by DOE's Office of Basic Energy Sciences.

The method in its entirety is straightforward but requires a range of technical expertise and machinery, Meenakshi says. "We used ion beams, silicon fabrication facilities, low-temperature measurements, and simulations. It's hard to find a non-commercial place outside of a national lab that can do all of this."

The work was supported by NNSA, DOE's Office of Science, and the Center for Integrated Nanotechnologies.

A new era of astronomy begins

Detection of gravitational waves called one of the century's great science breakthroughs

Image credit: R. Hurt/Caltech-JPL

By Mike Desjarlais

Note: When the news broke that scientists at the Laser Interferometer Gravitational Wave Observatory had for the first time detected gravitational waves emanating from the collision of two black holes, we asked Sandia Senior Scientist and Fellow of the American Physical Society Mike Desjarlais if he'd write something for the Lab News discussing the significance of the discovery. His essay here conveys the excitement shared by physicists around the world as a new era of astronomy begins.

Something really remarkable has just happened in the world of physics, the sort of thing that leads to Nobel Prizes. For the first time since their prediction by Albert Einstein in 1916, gravitational waves have been detected.

On Sept. 14, the two detectors of the Laser Interferometer Gravitational Wave Observatory (LIGO), one in Livingston, Louisiana, and the other in Hanford, Washington, picked up the gravitational wave signature of two black holes in the final stages of their death spiral as they merged together, forming one larger black hole. Lasting no more than one quarter of a second and with a frequency that chirped from 35 to 250 Hz, the "sound" was that of ripples in space. Through characteristic variations in the amplitude and frequency of the wave, astronomers identified the source as two merging black holes. Located 1.3 billion light years from Earth, far outside our Milky Way galaxy, one of the black holes had a mass of around 36 times the mass of our sun, the other 29 times. The final black hole has a mass of around 62 times the mass our sun, revealing that an astonishing three solar masses were radiated away in the energy of gravitational waves.

Einstein thought they'd never be observed

For several decades after Einstein's calculation, there was considerable disagreement as to whether gravitational waves were real or measureable.

The waves Einstein found in his calculations travel at the speed of light and alternately stretch and contract space in the directions perpendicular to their direction of travel. Picture a circle distorted into an ellipse, first along one axis and then the other. However, the magnitudes of these changes in the metric of space are so incredibly small, Einstein concluded they would never be observed. A critical advance came in 1972 in the form of an unpublished MIT

lab report by Rainer Weiss titled Electromagnetically Coupled Broad-band Gravitational Antenna. A young physics professor at the time, Weiss laid out a very detailed proposal to use interferometers to detect gravitational waves and provided the technical foundation for LIGO.

The technology of the LIGO interferometers is a tremendous feat of science and engineering. The interferometers, each with L-shaped arms some 4 km long, are carefully tuned for complete destructive interference of the outgoing and incoming laser photons traveling between the interferometer's mirrors. When a gravitational wave passes through the earth, the minute distortion of space between the mirrors causes a less than perfect cancellation of the light beams and produces a measureable signal. To detect the gravitational waves, the LIGO interferometers must be sensitive to a fractional change of the distance between the interferometer's mirrors by one part in 10^{21} . That is equivalent to changing the diameter of the Earth by something on the order of a typical atomic nucleus.

Pinning down the direction

In addition to their critical role in helping discriminate noise from real signal, having two detectors provides some indication as to where in the universe the gravitational waves originated. The straight-line distance between the two detectors amounts to 10 milliseconds of travel time at the speed of light. The signal observed at Hanford actually arrived about 6.9 milliseconds after the signal at Livingston. This timing difference allows the astronomers to pin down the direction of the source to a rough arc in the sky. When the European Gravitational Observatory's Virgo detector located in Italy is finished being upgraded to higher sensitivity, astronomers will be able to use the timing of all three detectors to get a much better idea as to where gravitational waves originate.

Astronomers have found convincing evidence of gravitational waves once before, without actually detecting them. In 1974, Russell Hulse and Joseph Taylor, then at the University of Massachusetts, and making observations with the Arecibo



MIKE DESJARLAIS

radio telescope in Puerto Rico, detected a very unusual binary system that consisted of a pulsar (a rotating neutron star that emits a beacon of light or radio waves, like a lighthouse) orbiting an invisible dark companion, the latter revealed only by the regular periodic change in the frequency at which the pulsar light beams reached the Earth. If the theory of gravitational radiation was correct, they expected to see, over time, a gradual reduction in the orbital period as gravitational energy of the binary system was radiated away and the two objects slowly spun closer together. After accumulating data for seven years their analysis showed that indeed the decay of the orbital period was in excellent agreement with Einstein's theory of General Relativity. Hulse and Taylor won the 1993 Nobel Prize in Physics for their discovery.

The path from Einstein's first prediction to Rainer Weiss' 1972 MIT lab report, from the indirect evidence obtained from Hulse and Taylor's binary pulsar to the direct detection of gravitational waves announced by the thousand members of the LIGO Scientific Collaboration and Virgo Collaboration will go down in history as one of the greatest successes of modern science and a testament to the power of international scientific collaboration.

Clues to the quantum nature of gravity

The Sept. 14 LIGO signal is the first direct evidence that black holes exist on the scale of many solar masses and can merge. Any evidence of frequency dispersion in the signal, an unexpected shift in arrival time with frequency, would hint at mass for the graviton, the theorized quantum gravitational equivalent of the photon. That in turn has implications on the possible sources of dark energy and the ultimate fate of the universe. Analysis of gravitational waves from extreme events could give clues to the quantum nature of gravity. Ideally, astronomers would like to correlate the arrival of gravitational waves with the detection of gamma ray bursts, neutrinos, or visible observations. As the number and sensitivity of these detectors increases, astronomers might be able to detect such things as quakes on neutron stars, the gravitational blast from a supernova, and perhaps the remnant waves of the Big Bang. Based on our current understanding of the universe and the likely abundance of black holes, gravitational wave astronomers are anxiously anticipating more signals in the months ahead. LIGO has already detected a second candidate event, but much weaker than the first. The era of gravitational wave astronomy has begun. The world now has a new way to observe the universe.

A big reach Sandia partnerships map shows impact across the US

By Nancy Salem

Sandia signed more than 5,000 US partnership agreements in the past five years touching every state in the country, and has created an online map that brings them to life. “The map illustrates the amazing breadth of work Sandia does with industrial, university, government, and lab partners around the United States,” says Pete Atherton, senior manager of Industry Partnerships Dept. 1930.

The Partnerships National Reach map has been in development for three years. Pete says it came about because many people inside and outside Sandia didn’t know the extent of the Labs’ collaborations. “People often ask how many industrial partners we work with and when I ask them to guess, I hear 20, 30, 40. Actually, in 2014 we worked with 830 unique industrial partners,” he says. “The map takes it further to other types of partnerships. We wanted to tell the full Sandia story. This shows how much collaboration and technology transfer is really going on, and it doesn’t include the Labs’ many global partners. That would be an even bigger picture.”

The map includes Cooperative Research and Development Agreements, Government Use Notices, technology licenses, Non-Federal Entity Funds-In agreements, the New Mexico Small Business Assistance program, and the University Partnerships program. It is on Sandia’s website and interactively displays the number of agreements and partners in each state as the mouse hovers above it. Filters include partner type, fiscal year, and agreement type. “Our trusted partnerships limit the amount of information we display, like a company name,” Pete says. “But there are many neat examples described in videos and documents accessible on the left side of the web page.”

Lozanne Chavez (1931) led the software team that developed the map. “A lot of effort went into the data gathering and cleanup,” she says. “We pulled from five



Pete Atherton, senior manager of Industry Partnerships Dept. 1930, goes over New Mexico information on the Partnerships National Reach Map with software developer Lozanne Chavez (1931). The map shows the numbers and types of Sandia partnership agreements across the country. (Photo by Randy Montoya)

Check out the map

The Sandia Partnerships Reach data map is online at www.sandia.gov/partnerships_reach/. Drop-down menus on the right filter the data by partner and agreement type, and fiscal year. Hold the cursor over a particular state and its data pops up, reflecting the selected filters. Partnerships publications and videos have links on the left side of the page.

different data sources.” She says the site will be updated yearly to provide a current snapshot of Sandia’s partnerships.

Pete says he hopes the map will contribute to data-informed decision making by business people, economic developers, and policymakers. He says people can see the breadth of partnerships and build on them.

“With partnerships in every state, Sandia further demonstrates that we are a national lab in every sense,” says Andy McIlroy, director of Research Strategy & Partnerships Dept. 1900 and deputy chief technology officer. “This tells a compelling story of technology transfer.”

Patricia Knighten, manager of the Office of Science and Technology at the state Economic Development Department, says the map is a useful tool that shows how a national lab can contribute to economic development. “This is great work, not just the website, but the partnerships,” she says.

Here are some key figures from the map. The data includes fiscal years 2010-2014.

All partner types	University partners
Total agreements: 5,080	Total agreements: 1,796
New Mexico: 1,574	New Mexico: 324
California: 560	Texas: 226
Texas: 341	California: 174
Industrial partners	
Total agreements: 2,534	
New Mexico: 1,150	
California: 275	
Texas: 103	

Algae raceway paves path from lab to real-world applications

By Patti Koning

In a twist of geometry, an oval can make a line. The new algae raceway testing facility at Sandia/California may be oval in shape, but it paves a direct path between laboratory research and solving the demand for clean energy.

As the nation and California adopt policies to promote clean transportation fuels, that path could help bring the promise of algal biofuels closer to reality. As one of the fastest growing plants on the planet, algae are an ideal source of biomass, but researchers have not yet found a cost-competitive way to use algae for fuels.

The facility will help bridge the gap from the lab to the real world by providing an environmentally controlled raceway in which to monitor, test, and fine tune technological innovations. “The success of moving technologies from a research lab to large outdoor facilities is tenuous. The scale-up from flask to a 150,000-liter outdoor raceway pond is just too big,” said Ben Wu (8624), Sandia’s Biomass Science and Conversion Technology manager.

Celebrating the new facility

On Feb. 4, Sandia/California held a ribbon-cutting ceremony to celebrate the opening of the new facility in the Livermore Valley Open Campus.

“As someone who drives her minivan back and forth to the state Capitol every day, I’m looking forward to the day I have the option to fill up with an algal biofuel,” State Assemblywoman Catharine Baker (16th District) told the audience at the event. “As a collaborative effort that involves industry, academia, state and federal resources, and scientists from our community, this project is a model.”

Livermore Mayor John Marchand thanked Sandia for being a great asset to the community and the nation. “We will never have true national security until we have energy security,” he said. “There is tremendous potential here to develop sustainable biofuels that could some day replace fossil fuels.”

The collaborative effort that Baker referenced was clear in the diverse audience at the event. This included Alison Goss Eng, program manager for DOE’s Bioenergy Technologies Office (BETO) and her colleague at BETO, Daniel Fishman; representatives from the offices of US Reps. Mark DeSaulnier (Calif.-11th), Jeff Denham (Calif.-10th), Eric Swalwell (Calif.-15th), and Jerry McNerney (Calif.-9th); industrial

partners; the state Water Resources Board; the California Energy Commission; Lawrence Berkeley National Laboratory; and Lawrence Livermore National Laboratory.

Raceway will advance research

The new Sandia algae testing facility consists of three 1,000-liter raceway ponds with advanced monitoring. The same experiments will be conducted in all three ponds, enabling statistical reproduction of results.

The algae raceway is fully contained for testing genetic strains and crop protection strategies. Customizable lighting and temperature controls, operational by year end, enable researchers to simulate the climate conditions of locations across the country.

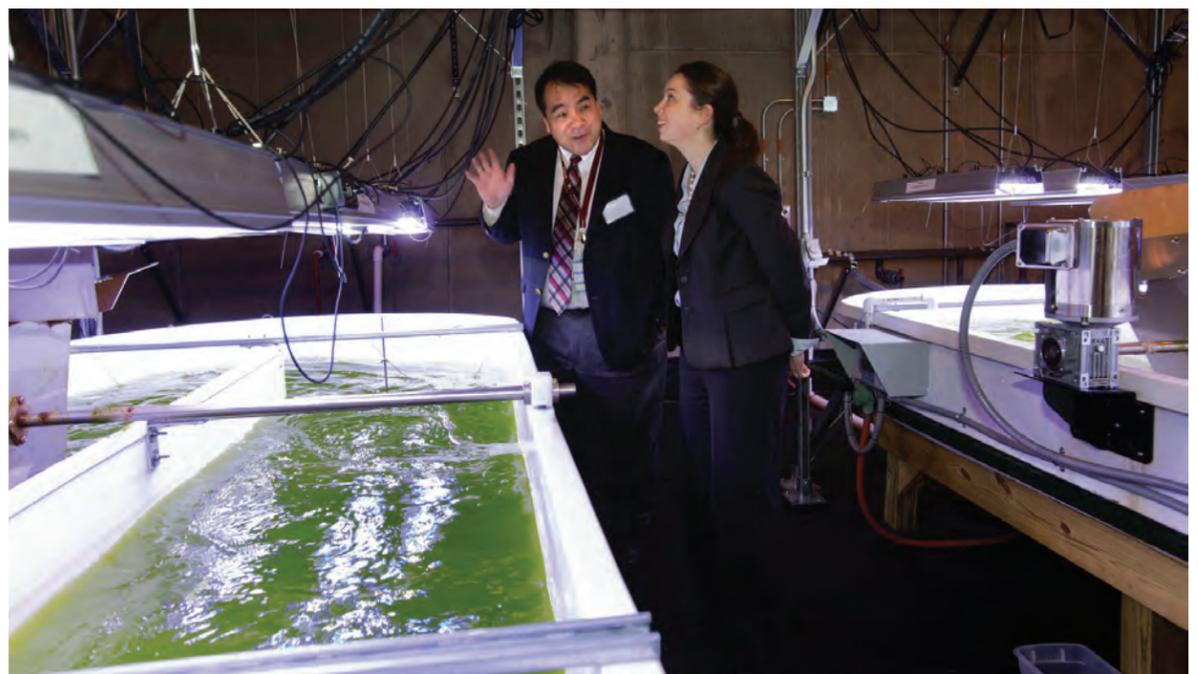
Several projects already underway will use the new capability. Anne Ruffing (8631) and Todd Lane (8633) will test genetically modified algae strains as part of a project funded by Sandia’s Laboratory Directed Research and

Development program. The algae raceway will allow the researchers to more quickly identify strains that promise improved performance.

Todd is also part of a BETO-funded project partnership with Lawrence Livermore National Laboratory that is investigating a probiotic approach to algae crop protection. Another BETO project seeks to convert algae proteins into useful chemical compounds such as butanol.

Ben expects the facility will expand opportunities for Sandia researchers to develop algae as a robust source of biofuels and increase collaborations and partnerships with the private sector, particularly in California where efforts to transform transportation energy are prevalent.

“The bioeconomy is gaining momentum,” he said. Biofuels from algae may be further off, but algae has sugar and proteins that can make fuel or higher valued products, such as butanol or nylon — products that currently come from fossil fuels.



ALL THAT GLITTERS IS GREEN — Ben Wu, Biomass Science and Conversion Technology manager, shares the highlights of the algae raceway testbed with Alison Goss Eng, program manager with DOE’s Bioenergy Technologies Office. (Photo by Dino Vournas)

Safety First: Facilities ends 2015 with stellar safety record

By Miguel Gonzales

‘We live safe and healthy lives.’

That is a new core value Sandia introduced this year, one that resonates strongly with Facilities Management and Operations Center 4800, which just experienced its best annual safety record ever.

For FY15, Facilities had a total recordable case rate (TRCR) of 1.15 as compared to the corporate rate of 1.31. The TRCR is a metric used to quantify work-related injuries per 100 equivalent full-time workers over an entire year.

Making this TRCR even more significant are the number of personnel and amount of work performed by Facilities on a daily basis.

Lynne Schluter (4870), Facilities senior manager, says, “This is a remarkable feat given that every day we have more than 300 maintenance, 300 construction, and 60 service workers performing activity-level work throughout Sandia.”

This work often includes performing heavy industrial operations at height, hoisting and rigging heavy equipment, and conducting electrical work. Digging deeper into the data shows that Facilities had what Lynne calls an “incredible” TRCR of zero in construction-related activities for FY15. With more than 624,000 hours of construction work performed last year, zero recordable incidents is an amazing accomplishment, Lynne says.

Anthony Chavez (4878), Facilities Environmental, Safety, and Health manager, notes this success did not happen overnight. In fact, he says, Facilities has improved year after year by continually decreasing its TRCR, culminating in this year’s stellar performance: 2.57 in FY12, 2.20 in FY13, 1.72 in FY14, and 1.15 in FY15.

“The safety philosophy within Facilities has shifted over the years from safety being prescribed to a mindset of employees critically thinking about safety and taking personal responsibility for ensuring all situations and job sites are safe,” Anthony says, noting that members of the workforce are encouraged and empowered to recognize unsafe work situations and to stop work if they feel it is unsafe.

Lynne echoes this belief. “This culture of safety has been embraced by the staff and the success we have is due to their collective efforts,” he says.



FACILITIES ENVIRONMENTAL, SAFETY, AND HEALTH (FESH) Manager Anthony Chavez reviews construction plans with Greg Kirsch, FESH lead. Center 4800 recorded its best annual safety record ever in fiscal year 2015. (Photo by Miguel Gonzales)

Among the programs and activities that have helped support and enhance the safety culture within Facilities are the Work Planning and Control (WP&C) and the Behavioral Based Safety (BBS) programs. WP&C allows the team to identify and mitigate risks when planning and performing activity-level work, while the BBS program yields workplace observations that identify potential safety concerns before an incident occurs.

While Facilities’ TRCR was impressive last year, Lynne and Anthony both emphasize there is still work to do. The goal, they say, is to keep everyone safe and return workers home safely every day, a goal Facilities refers to as Target Zero.

To that end, Facilities has continued to build upon this strong foundation by developing leading indicators, strengthening training, and fortifying established safety programs, Lynne says.

“It really is a team approach with open communication that allows us to promote safe practices, build upon our success, and continuously improve,” says Enrico Garcia (4878), a Facilities ES&H analyst.

Anthony summarizes the importance and the stance the entire team has embraced with regard to safety: “Everyone on the team takes safety personally. The people we work with are our friends and family.”

We live safe and healthy lives

When the Labs’ leadership unveiled a new strategic plan last fall, we also revisited our core values to ensure they accurately reflected our culture.

First, we aligned our value of teaming for great results with our value of delivering with excellence in recognition of the fact these two concepts must both be present to achieve greatest success.

Most notably, we added a new value to reflect our ongoing commitment to safety and health: We live safe and healthy lives.

With engineered safety, we have made significant progress on our safety journey, and safety is one of the foremost considerations in every job we perform. The addition of safety and health to our core values reflects a new milestone on this journey.

The article about Center 4800 and its much-improved safety record is just one example of how Sandians are demonstrating their commitment to safety and health through their actions and values.



MIKE HAZEN

Michael Hazen, VP, Infrastructure Operations Div. 4000

Dear Read to Me,

Thank you for the books you donated to us. I am enjoying them and they are very interesting. Every time I read this book I will remember about you people. You make our lives filled with books.

Sincerely, Melanie

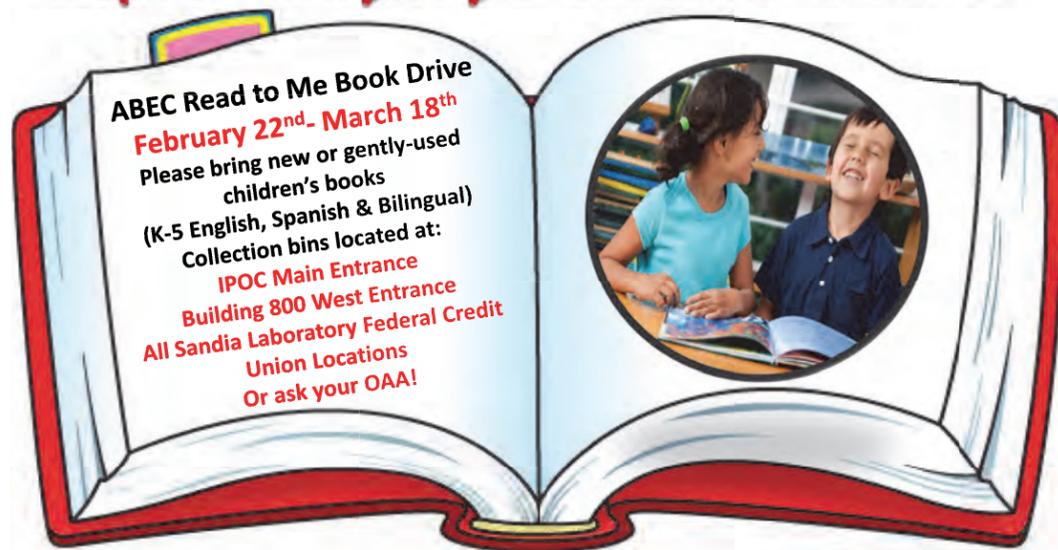
Dear Read to Me,

Thank you for the books. The books are fun and interesting and good for our education. We enjoyed the books very much. Thank you for the books. Now we have some at our homes. They were awesome books. They can help us with our fluency. I enjoyed the books very much. I appreciated all the books you have given out. We love to read!

Sincerely, Karina

These are just two of the many thank-you notes received from the 2014 book drive. With the community’s help, the Read to Me Book Drive has collected thousands of books over the years to be distributed through local schools and community groups, enriching many thousands of children and their families. You are making a difference with your contribution.

Inspire Albuquerque Children to Read!



Contact Linda Muhlberger (Community Involvement) 284-5200



SANDIA CLASSIFIED ADS

There will be NO classified ads for March 18. Classified ads will resume with the April 1 edition of the Lab News.

MISCELLANEOUS

CHAIN SAW, Husqvarna 50, clean, 20-in. bar, new chain, electric sharpener, carry case, manuals, \$325. Murphy, 797-8779.

BARSTOOLS, 3, 30-in. tall, suede seats, \$100; wedding dress, Alfred Angelo, size 0-4, corset back, worn once, needs to be cleaned, paid >\$2,000; asking \$500. Martinez, 417-3242.

3D TV, Sony Bravia, XBR-46HX909, new, never used, \$1,000 OBO; TiVo Premiere, 320 GB, brand new, never used, \$60 OBO. Lujan, 299-2218.

ELECTRIC WASHER & DRYER, bought new Dec. 2014, excellent condition, \$500 firm. Bergemann, 659-1510.

ELLIPTICAL EXERCISE MACHINE, Octane Q37 Fitness, like new, \$1,200. Blanton, 856-2076.

VACATION CONDO, premium, Las Vegas, 1-bdr., sleeps 4, MWC tournament week, March 9-14, \$650 OBO. Lloyd, 331-9025.

CALIFORNIA KING BED, leather padded headboard, w/pillars on both head & foot boards, sheets, comforter, shams, beautiful, excellent condition, \$350 OBO. Scherer, 505-228-8869.

'JOSEPH AND THE AMAZING TECHNICOLOR DREAMCOAT' TICKETS, 2, April 21, Popejoy, 7:30 p.m., seats E303-E304, \$100/pair. Wood, 505-228-0193.

SERVER RACK, Tripplite, 18U, SRW18US, w/3 sets of custom rack rails, \$500 OBO. Fierro, 432-528-9773.

DINING SET; futon; wood table & 2 chairs; desk; file cabinet; good/excellent, photos available, must sell. Miller, 303-868-2227.

FUTON, wood frame, brown/black cover, spring mattress, like new, \$175; Haro 27-spd. all-terrain bike, \$100. Fromm-Lewis, 220-5772.

CAR TRAILER, 16-ft., w/2-ft. dovetail, dual axle/brakes, wood deck, ~5,000-lb. capacity, good condition, \$1,800. Echert, 505-948-3079.

'DISNEY'S NEWSIES' TICKETS, 2, June 25, 8 p.m., Popejoy, seats AA105/106, mezzanine, \$67.65 ea. Verley, 221-7827.

TIRES, 2, Goodyear Assurance Comfort-ed Touring, 225/55R18, great condition, need to pay student loans, \$60 OBO. Cioce, 201-575-0319.

TRANSPORTATION

'95 CHEVY CAVALIER, AT, 1 owner, 72K miles, \$2,000 OBO. Newell, 896-3133.

'06 TOYOTA TACOMA TRD, sport pkg., double cab, 4WD, AT, hard Tonneau cover, 90K miles, \$17,500; '05 GMC ENVOY, 4WD, 71K miles, blue book \$7,250, make cash offer. Galaz, 505-331-9689.

'99 PONTIAC GRAND PRIX, 118K miles, runs great, good overall condition, \$2,300 OBO. Maurer, 296-4869.

'06 HONDA CIVIC EX, 4-dr., manual, galaxy gray, EPA 30/40-mpg, sun roof, tinted, 99K miles, excellent mechanical condition, \$6,300. Emery, 407-0830.

'08 MAZDA MIATA MX-5, convertible, 5-spd. manual, garaged, 72K miles, runs great, great fun, \$8,000. Blanchat, 505-239-5258.

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.

'08 LEXUS ES350, FWD, all power, heated/cooled seats, royal ruby metallic, 113.7K miles, new Michelins, great car, \$12,500 OBO. Smith, 505-514-2561.

'99 BUICK LESABRE CUSTOM, 4-dr., all power, white, gray interior, needs tires, 100K miles, \$3,500 OBO. Duran, 259-9084.

'85 RIVIERA, original owner, Crate 307 V8 engine, rebuilt, blue carriage top, white, \$5,500. Gurule, 857-9116.

RECREATION

'08 POP-UP CAMPER, 1,822-lbs., heater, fans, sleeps 6, w/manuals, great condition, \$5,900. Kelly, 505-266-0722.

REAL ESTATE

3-BDR. HOME, 2-1/2 baths, 1,400-sq. ft., 2-car garage, Northeast, gated community, refrigerated air, great storage, KAFB close, \$171,250. Cox, 319-1714.

~3-ACRES, La Puebla, north of Santa Fe, great for farming, \$180,000 OBO. Montoya, 505-660-3142.

4-BDR. HOME, 3 baths, 3,260-sq. ft., South foothills home, great lot & location, perfect for family & entertaining, \$405,000. Gordon, 505-366-4780.

3-BDR. HOME, 1-3/4 baths, 1,990-sq. ft., 2-car garage, large back yard, wood ceilings, Constitution/Wyoming, MLS#853350, \$159,600. Fullmer, 505-730-7474.

CUSTOM HOME, Pueblo-style, updated, Siesta Hills community, close to KAFB/VA Hospital, 2,722-sq. ft., .38-acre lot, fabulous, \$375,000. Gilliland, 366-3217.

3-BDR. HOME, 3 baths, near Tramway & Indian School, MLS#859544, \$230,000. Zumwalt, 505-400-3699.

WANTED

IT/WEB EXPERTS/VOLUNTEERS, for virtual docent app & solar monitor system at the Nuclear Museum. Lorber, 206-7456 or Hanks, 977-3372.

ROAD BIKE, new employee wants to ride to work, ~54 cm, ~\$500. Tarin, 505-720-9906.

WOODEN PLAYSET, slides, swings, good-decent condition, will disassemble & pick up. Turcich, 505-720-0279.

HUNTERS, have any old meat in your freezer you want gone, will take it off your hands. Beggs, 414-2757.

ROOMMATE, looking for room to rent or split rental home, 28-yr. old male. Larsen, 801-641-6515.

ROOMMATE, furnished room, just south of UNM, walking distance to Nob Hill, \$500/month. Brown, 452-7202.

SUMMER RENTAL, for Sandia grad student, quiet, no pets, non-smoking couple, mid-May-August. Montoya, 296-4268.

FURNISHED ROOMS, 2 male Sandia interns, for reasonable price over the summer. Casper, 312-650-9246.

LOST AND FOUND

LOST: oval diamond earring, on Feb. 24, around Bldgs. 802, MO307, 856 or 822. Lackie, 844-8393.



Mileposts

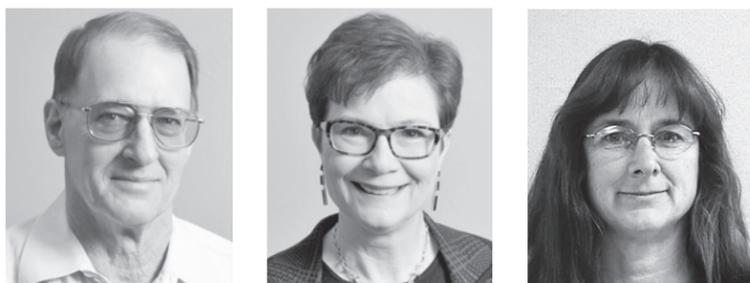


New Mexico photos by Michelle Fleming

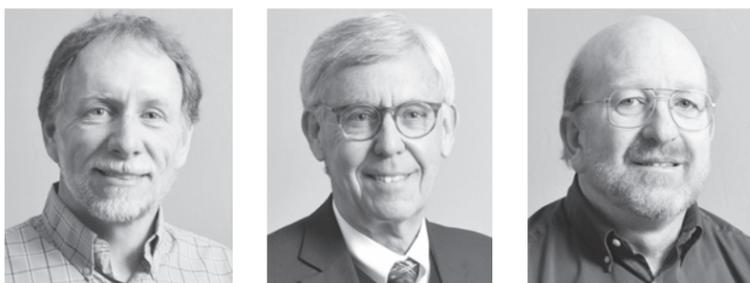
Recent Retirees



New Mexico photos by Michelle Fleming



Tom Lutz 40 1521
Mary Clare Stoddard 35 6831
Shannon Letourneau 30 10223



David Marks 30 5963
Ron Pate 30 6926
Dan Porter 30 5792



Eric Schindwolf 30 5420
Curt Nelson 25 5343
Mark Van Benthem 15 1814



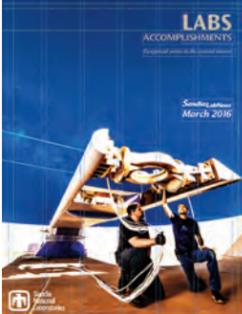
David Sinton 36 4128
Kent Schubert 35 1718
Daniel Horschel 34 6925
Paul Justice 33 6811



Joe Jones 27 6232
Jim Wiseman 27 5959
Daniel Roberts 15 3521
Ann Adams 11 5030



Finis Long 39 1678
Mary Cocco 37 10679



Sandia Labs Accomplishments 2016 available March 18

Sandia Lab News Labs Accomplishments will be available in news racks at 25 locations throughout the Labs. A digital version of Lab News Labs Accomplishments will be available on sandia.gov soon after its hard-copy publication.

Labs Accomplishments cover photo by Randy Montoya

The apple doesn't fall far

Sandia innovator named Most Promising Asian American Engineer

By Rebecca Brock

Sandia engineer Tian Ma (5521) immigrated to the US at age 11, not knowing English and unaware of the significant cultural challenges he would face. "In China I was outgoing, and I had a lot of friends. But when I came to the US, I did not know how to talk to people. I became more quiet and reserved," Tian says.

Meet Tian today, and he is all smiles. In fact, his cheerful nature and passion for engineering are contagious.

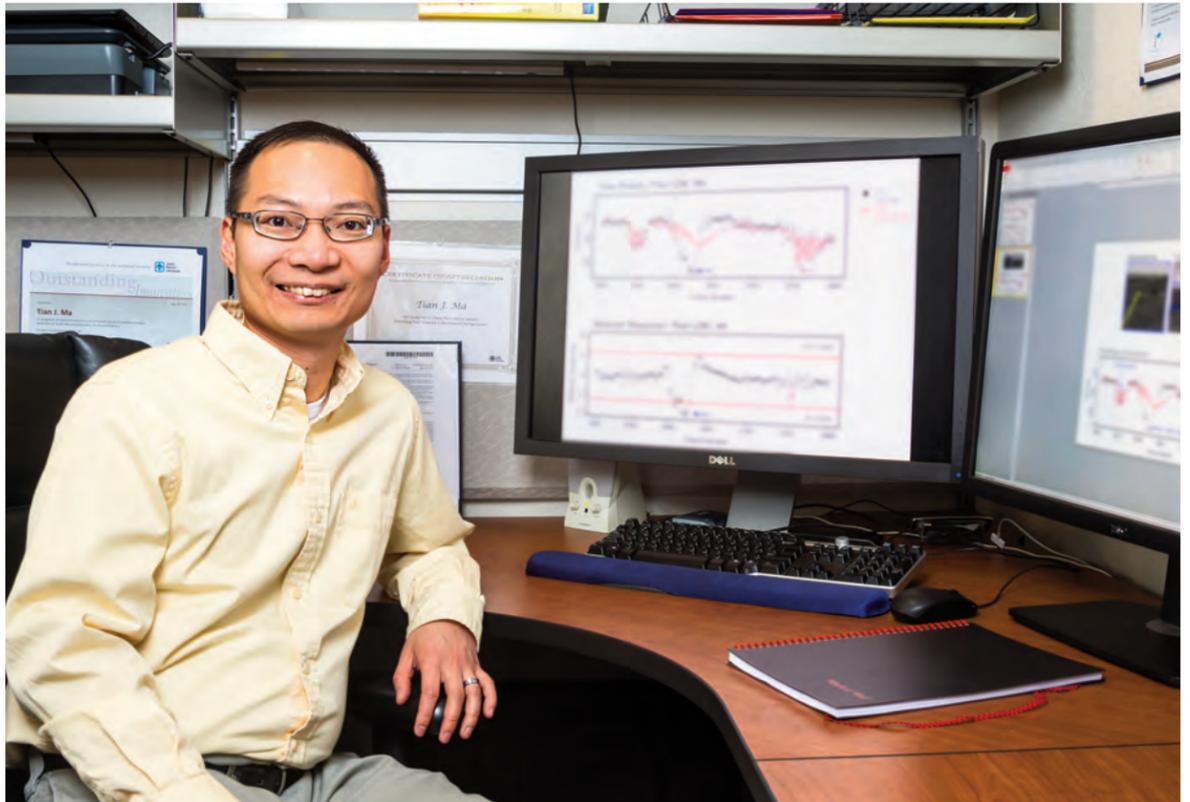
Tian is the 2016 Most Promising Asian American Engineer of the Year (AAEOY) and will be honored in a ceremony on March 12 at the Hyatt Regency Hotel in New Brunswick, New Jersey. The prestigious AAEOY awards are a National Engineers Week program hosted by the Chinese Institute of Engineers-USA (CIE-USA) to salute Asian American professionals who demonstrate exceptional leadership, technical achievements, and public service in science, technology, engineering, and math. Past winners have included astronauts, key corporate executives, and Nobel Laureates. Nominees come from a range of corporations, academia, government, and scientific institutions.

"I am delighted, deeply humbled, and honored," says Tian. "It is motivating to gain recognition considering that there are so many talented Asian American engineers across the country."

Detecting and tracking movement of objects

Tian is a principal member of technical staff. Over the past 12 years he has developed many detection and tracking algorithms for remote sensing systems under Sandia's nuclear non-proliferation program. His work focuses on designing algorithms to better detect and track the movement of objects. At Sandia Tian has served as the technical lead on several multiyear projects. His advancements in multiple hypothesis tracking and jitter suppression algorithms have enabled US government agencies to pursue entirely new remote sensing missions.

"Tian's work is highly regarded in the remote sensing community," says John Vonderheide, senior manager of Decision Support Systems Org. 5520. "Tian has combined his tremendous insight and creativity with a strong personal



SANDIA ENGINEER TIAN MA was named the 2016 Most Promising Asian American Engineer by the Chinese Institute of Engineers-USA (CIE-USA). Tian is being recognized for his achievements in developing new tracking algorithms for a class of remote sensing systems that have enhanced national security. (Photo by Stephanie Blackwell)

commitment in such a way that he has continually solved very complex problems within very rigid constraints."

Tian's expertise has led to one issued patent and three patents pending, along with three technical advances and multiple publications. Tian enjoys the challenges that come from being an innovator. "For me it is gratifying to solve a problem that no one has solved before. The moment that it hits you when you realize you may have a solution is very exciting," he says.

Bridging research and reality

What makes Tian stand out is his uncommon ability to innovate from research through to real-world application, says Tian's manager, John Feddema (5521). "Tian is one of those individuals who make the entire team better by being a role model for creating new technical innovations and ensuring that these technologies transition into applications," he says.

Tian recently completed an MBA in Management of Technology from the University of New Mexico with an A+ grade point average (GPA: 4.14). This builds upon his credentials from the University of Illinois at Chicago, a bachelor's degree in computer engineering and a master's degree in electrical and computer engineering.

"At Sandia I developed a lot of technologies, and I wanted to learn how to commercialize them. My motivation to get my MBA was to learn the business side of how to extend our technology into the commercial world," Tian says.

Tian was hired into the Labs in 2003 through Sandia's highly selective Master's Fellowship Program, which paid for his full graduate tuition and provided a salary. "I am very grateful for what Sandia has done for my education," Tian says.

Inspiring minds through STEM

Serving the community is a strong part of Tian's character and another reason for his AAEOY award. As co-chair of the mentor committee for the Future City Competition Project in New Mexico, he pairs Sandia technical mentors with local 6th- and 7th-grade students to help them imagine, design, and build cities of the future.

"I like to give back because I personally benefitted from my community. When I first came to the US, I really struggled with language. Fortunately there was a church located right across the street from my elementary school, and they had an after-school education program that offered free tutoring."

Tian is the former co-chair of Sandia's Asian Leadership Outreach Committee (ALOC), and he is highly involved with the Albuquerque Chinese Baptist Church.

Tian credits his personal success to his parents for the sacrifices they made for his education. Immigrating from Guangzhou, China, to a poor area of Chicago, they left their own careers behind so Tian would have better educational opportunities in the United States. Tian says his biggest inspiration is his dad.

"My dad is the smartest person that I've encountered in my life. He has a much higher IQ than me. I've witnessed him solving many complex problems in our daily lives. However, he grew up during China's Cultural Revolution where he wasn't presented with opportunities for higher education. I want to make sure I put into good use the opportunities that my parents helped create," Tian says.

Tian and his wife Valerie, a special education teacher, are parents to a 2-year-old daughter, Vania. "I love being a father. Seeing her curiosity inspires me every day," Tian says.



Faster than a garbage disposal, more powerful than a trash compactor, able to leap tall landfills a in single bound...

About the AAEOY awards

AAEOY stands for Asian American Engineer of the Year award, an annual recognition event on the national platform to honor the most distinguished professionals of Asian heritage. Since it was first introduced in 2002, AAEOY has become a prestigious and important forum for corporate America, academia, and government entities in the field of STEM to recognize outstanding Asian American professionals for their leadership, technical achievements, and public services.

Since 2002, hundreds of Asian-American professionals from leading US technology corporations, prestigious research institutions, and the US Armed Forces have been selected as recipients of AAEOY awards. The past awardees have included Nobel Laureates, academia, key corporate

executives and astronauts.

Besides recognizing outstanding Asian American engineers and scientists from across the country, AAEOY also honors and celebrates the achievements of Asian Americans of global stature and influence with the Distinguished Awards. The distinguished awardees have served as role models and a source of inspiration for the STEM community as a whole. Many internationally known individuals have received these Distinguished Awards at the AAEOY events since 2002.

