OAK RIDGE NATIONAL LABORATORY

Review

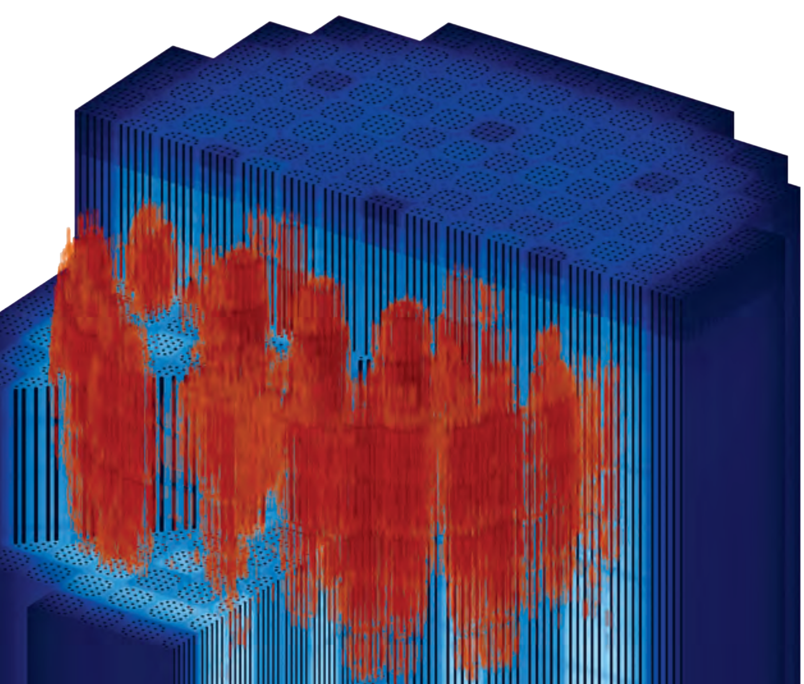
11 · START-UP SCIENCE

OAK RIDGE National Laboratory

Vol. 49 | No. 2 | 2016
www.ornl.gov/ornlreview

OAK RIDGE NATIONAL LABORATORY
Review
Vol. 49 | No. 2 | 2016

Contents



On the Cover

University of Tennessee grad students Patrick Caveney and Beth Papanek work at ORNL through UT's Bredesen Center. The pair recently turned a class project into a new company, Nano Elements Source LLC.

The past, present and future of clean energy R&D

ORNL has focused on energy independence and clean energy almost from its earliest days. Created in the early '40s to support America's war effort, the lab quickly pivoted to the promise of nuclear energy, and by the following decade, the lab's Homogeneous Reactor Experiment had generated electricity and put it on the power grid.

ORNL has also been a driving force in nonnuclear energy technologies, from renewables such as solar and biofuels, to improved energy storage, to the modernization of our aging power grid.

The challenges are vast. Since the Arab oil embargo of 1973, our need for energy independence has been a national priority. It has also become increasingly clear that we must meet our energy needs with technologies that don't damage the environment or accelerate climate change.

In this issue of *ORNL Review*, we explore the lab's commitment to developing clean, efficient, reliable sources of energy for the United States and the world. I sat for a Q&A to discuss the lab's long history of clean energy research and our aspirations for the future (Page 6). We discuss ORNL involvement in the Advanced Research Projects Agency-Energy program, better known as ARPA-E, which is devoted to practical, high-impact energy research (Page 9). We also look at our research ties around the Southeast (Page 16) and highlight a new company started by young entrepreneurs through their efforts at ORNL and the University of Tennessee (Page 11).

You will find ORNL's commitment to a healthy energy future throughout these pages. The lab remains deeply involved in advancing nuclear science and technology, as witnessed by efforts of the ORNL-led Consortium for Advanced Simulation of Light Water Reactors to use supercomputing to make nuclear power plants more efficient (Page 20) and the search for materials that can withstand the intense heat of a fusion reactor (Page 21).

I hope you'll also take a moment to read an update on our latest work in related areas of science, including the ORNL-led development of an aluminum–cerium alloy that promises to reinvigorate U.S. rare earth element production. It gives industry a material that is both less expensive than previous aluminum alloys and more useful in high-temperature applications (Page 14).

Researchers are using ORNL's Titan supercomputer to address tumors and blood-based diseases (Pages 24–25), and they continue to produce a lifesaving isotope (Page 18). You'll also find an update on our research into the promise of quantum computing (Page 12).

As always, this edition features young scientists who have come to ORNL as graduate students or postdoctoral fellows (Pages 30-31), as well as the established scientists who visited us to participate in the Eugene P. Wigner Distinguished Lecture Series in Science, Technology, and Policy (Pages 26-29).

We hope you enjoy your time with *ORNL Review*.

Thomas Mason

Thomas Mason
Laboratory Director

The HPC4Mfg program will give industrial users access to ORNL computing resources such as the Titan supercomputer. Image credit: Andy Sproles, ORNL

New projects pair U.S. manufacturers with ORNL computing resources

ORNL will support four new industry projects as part of DOE's High Performance Computing for Manufacturing Program.

The program pairs selected companies with national labs, including Oak Ridge, Lawrence Berkeley and Lawrence Livermore, that will provide expertise in and access to high-performance computing systems aimed at manufacturing challenges. Each of the initial 10 projects will be funded at approximately $300,000, for a total of $3 million.

The Advanced Manufacturing Office within DOE's Office of Energy Efficiency and Renewable Energy created the HPC4Mfg program to advance clean-energy technologies, increase the efficiency of manufacturing processes, accelerate innovation, shorten the time it takes to bring new technologies to market and improve the quality of products. The HPC4Mfg projects support DOE's broader Clean Energy Manufacturing Initiative.

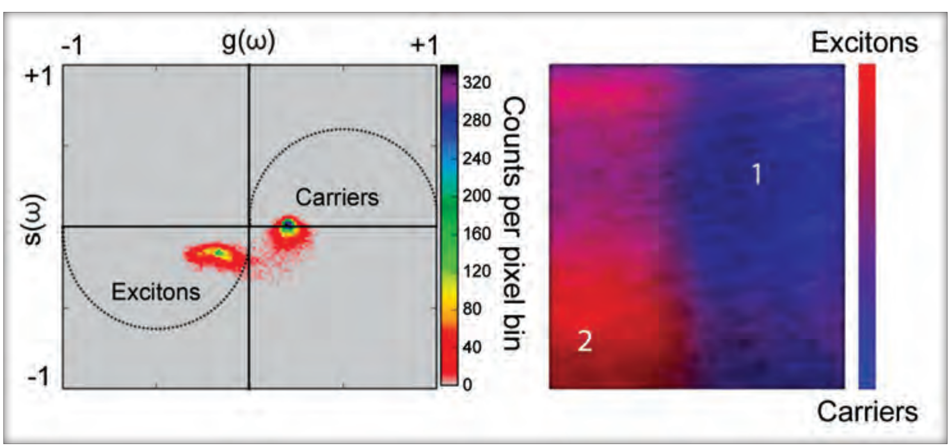
This effort also will advance President Obama's National Strategic Computing Initiative, which calls for public-private partnerships to increase industrial adoption of high-performance computing.

- **United Technologies Research Center**, located in East Hartford, Conn., will partner with ORNL and LLNL to develop and deploy simulation tools that predict material microstructure during the additive manufacturing process to ensure that critical aircraft parts meet design specifications for strength and fatigue resistance.
- **General Electric** in New York will partner with ORNL to assist in the local control of melt pool and microstructure in additive manufactured parts.
- In a separate project, GE will partner with ORNL and LLNL to improve the efficiency and component life of aircraft engines through design optimization.
- The AweSim program at the **Ohio Supercomputer Center** and the **Edison Welding Institute** will partner with ORNL to deploy a cloud-based advanced welding simulation tool for broad industry use.—*Morgan McCorkle*

For more information: http://go.usa.gov/cGsBx

New method could unleash solar power potential

Measurement and data analysis techniques developed at ORNL could provide new insight into performance-robbing flaws in crystalline structures, ultimately improving the performance of solar cells.



Absorption data (left) shows free charges and excitons. The image at right shows their contributions at different spatial positions. Image credit: ORNL

Solar cells made from light-harvesting perovskite (an organic-inorganic hybrid) have recently eclipsed the 20 percent efficiency mark, but researchers believe they could do better if they had a clearer picture of energy flow at the nanometer scale. Described in a paper published in *ACS Photonics*, the ORNL discovery synchronizes microscopy, ultra-short pulses of laser light and data analytics to extract images with single-pixel precision to provide unprecedented detail.

"If we can see exactly and in real time what is happening, we can map out the electronic processes in space instead of relying on snapshots gleaned from spatial averages," said Benjamin Doughty, one of the authors and a member of ORNL's Chemical Sciences Division.

Armed with information about what electrons are doing inside the material, researchers believe they can make improvements leading to solar cells that are more efficient and potentially less expensive.

"With conventional approaches of studying photovoltaic materials, we are unable to accurately map out electronic processes and how electrons are getting lost," Doughty said. "Those processes can translate into losses in efficiency."—*Ron Walli*

For more information: http://go.usa.gov/cADPd

BESC study seeks nature's best biocatalysts for biofuel production

Researchers at DOE's BioEnergy Science Center are looking beyond the usual suspects in the search for microbes that can efficiently break down inedible plant matter for conversion to biofuels. A new comparative study from the ORNL-based center finds the natural abilities of unconventional bacteria could help boost the efficiency of cellulosic biofuel production.

A team of researchers from five institutions analyzed the ability of six microorganisms to solubilize potential bioenergy feedstocks such as switchgrass that have evolved strong defenses against biological and chemical attack. Solubilization prepares the plant feedstocks for subsequent fermentation and, ultimately, use as fuel. The paper, published in *Biotechnology for Biofuels*, is the most comprehensive comparative study of its type to date.

"Starting with nature's best biomass-solubilizing systems may enable a reduction in the amount of nonbiological processing required to produce biofuels," ORNL coauthor Brian Davison said. "We're asking the question, 'What are nature's best biocatalysts?'"

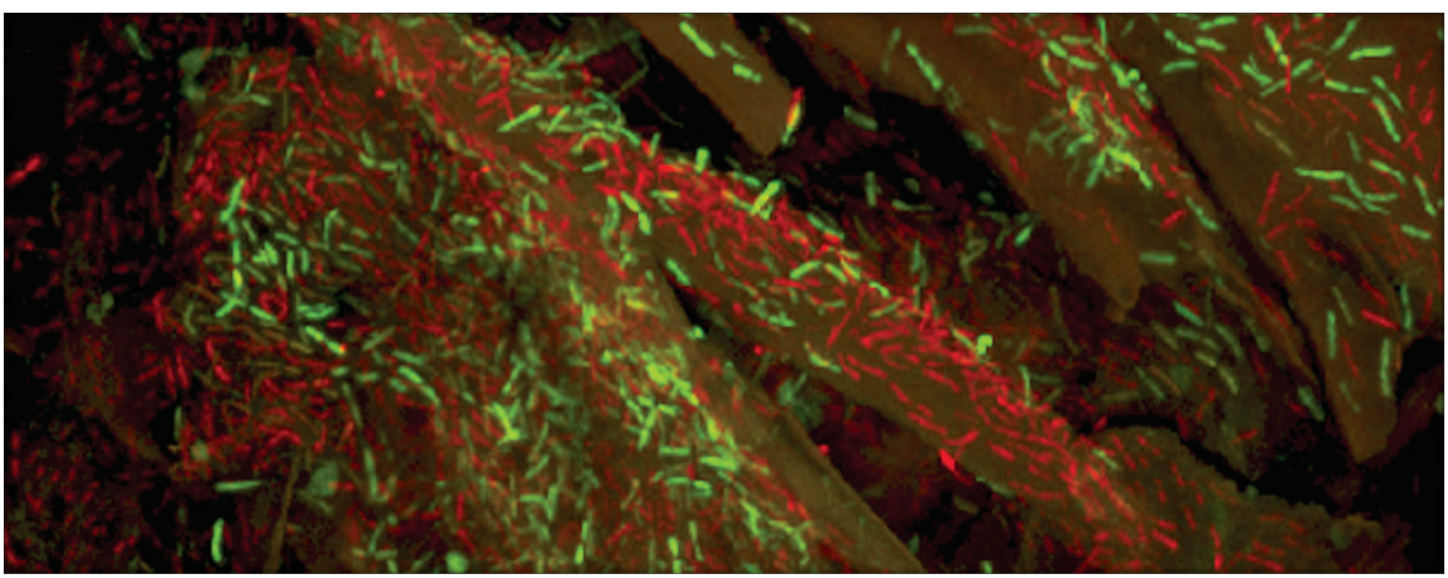
Their analysis demonstrated that under carefully controlled conditions, a microbe called *Clostridium thermocellum* is twice as effective as fungal enzymes used by industry today. The researchers also tested the different microbes' performance with minimal pretreatment of the plant materials, indicating it may be possible to reduce or eliminate use of heat and chemicals that make the feedstock accessible to biological processing.—*Ron Walli*

For more information: http://go.usa.gov/cADPF

ORNL partners with nine small businesses to advance clean energy tech

ORNL experts will help nine small companies move their innovative manufacturing, buildings, fuel cell, geothermal and vehicle technologies closer to the marketplace.

The businesses are among 33 selected to participate in the first round of the Department of Energy's new Small Business Vouchers pilot. The DOE Office of Energy Efficiency and Renewable



The microbe Clostridium thermocellum *(stained green), seen growing on a piece of poplar biomass, is among several microorganisms recently evaluated in a BioEnergy Science Center comparative study.* Image credit: Jennifer Morrell-Falvey, ORNL

Energy will invest nearly $6.7 million in the projects.

"The Department of Energy is firmly committed to maximizing the impact of the national lab system on the clean energy economy," said David Danielson, assistant secretary for energy efficiency and renewable energy. "The Small Business Vouchers pilot allows innovative entrepreneurs greater access to the world-class resources and brilliant minds in our labs. These partnerships can help small businesses solve their most pressing technical challenges—and help bring clean energy technologies to commercialization much faster."

SBV is a collaborative national effort that will provide $20 million through two rounds of funding for U.S. companies to help improve industry awareness of national laboratory capabilities and provide small- and mid-size businesses access to the resources available within the national laboratory system. Vouchers range from $50,000 to $300,000. The companies were competitively chosen from a pool of hundreds of applications.

ORNL will collaborate with

- **Glucan Biorenewables**, Madison, Wis., to advance the development of a process targeted toward production of a bioderived, nontoxic lignin for energy storage applications.
- **Grid Logic, Inc.**, Auburn Hills, Mich., to develop a printing process using micro-induction sintering/melting, which will contribute to lower-cost manufacturing materials and processes.
- **GVD Corp.**, Cambridge, Mass., to measure and optimize hydrogen permeability of barrier coatings to dramatically reduce gas permeation for applications in hydrogen compression, storage and delivery infrastructure.
- **Be Power Tech**, Inc., Fort Lauderdale, Fla., to evaluate a natural gas–powered HVAC system that produces 5 kilowatts of continuous electrical power for commercial and residential buildings.
- **KCF Technologies Inc.**, State College, Pa., to demonstrate its wireless sensor for measuring pump efficiency.
- **Treadstone Technologies Inc.**, Princeton, N.J., to provide surface chemistry characterization and microstructure analysis of coatings on stainless steel substrates for long-term durability in fuel cell operations.
- **Geothermal Design Center Inc.**, Asheville, N.C., to evaluate the performance of a new approach in ground thermal conductivity testing for an advanced ground source heat pump system.
- **Cool-X, LLC**, Amherst, Mass., to understand the potential of nanolubricants, in particular nanodiamond additives, to improve the performance of high-mileage vehicles by modifying the surface finishes of wear components in engines, gearboxes and differentials.
- **United Silicon Carbide Inc.**, Monmouth Junction, N.J., to develop loss models to demonstrate system-level efficiencies using USCi's silicon carbide junction gate field-effect transistor cascodes for validation in meeting or exceeding current efficiency levels in commercially available inverters and reduce manufacturing costs for broad commercial adoption.

To see a full list of small businesses competitively selected under Round 1, please visit www.sbv.org.—*Bill Cabage*

ORNL postdoc Jagadamma secures faculty role

Sindhu Jagadamma, a postdoctoral fellow with ORNL and the University of Tennessee, has accepted a tenure-track faculty position at UT. Jagadamma began her role as assistant professor in the UT Institute of Agriculture's Biosystems Engineering and Soil Science department in April.

Jagadamma has been a postdoc at ORNL since 2010 and "absolutely recommends" the career-building fellowship. "A term at ORNL definitely makes a postdoc highly competitive on the job market," she said.

As a postdoc, Jagadamma unearthed mechanistic processes at the interface of organic matter and soil minerals that are responsible for long-term storage of carbon in soils. She worked with ORNL's Environmental Sciences Division and Climate Change Science Institute before

Sindhu Jagadamma

transitioning to the Department of Energy's multi-institutional project Ecosystems and Networks Integrated with Genes and Molecular Assemblies through ORNL's Biosciences Division and UT's Civil and Environmental Engineering Department.

Jagadamma also participated in outreach and student-mentoring activities through the program and played a key role in securing a substantial two-year Laboratory Directed Research and Development grant supporting R&D to advance microbial process-based terrestrial carbon cycle models.

"The collaborations and connections that I have established at ORNL—especially working with a diverse research group of physicists, chemists, computational scientists, ecologists and engineers—are going to make a positive impact in my career," Jagadamma said.

Though looking forward to the next chapter in her career, Jagadamma appreciates her experience at the lab. "The research, professional development and collaborative opportunities available at ORNL are limitless," Jagadamma said. "I couldn't have imagined getting such an awesome opportunity elsewhere."—*Ashanti B. Washington*

ORNL postdoc wins first place at MRS hackathon

Ryan Cooper, a postdoctoral researcher at ORNL, won first prize at the Materials Research Society's 2015 Materials Hackathon for his team's 3-D-printed Fermi surfaces.

The event challenged teams of scientists to brainstorm ways of attacking problems related to developing new materials—and to write computer code to support their solutions. The MRS hackathon competition is designed to quickly prototype materials science software to be presented before a panel of judges from industry, national laboratories and academia.

Dubbed team Firmi, Cooper, a scientist in the Materials Science & Technology Division, and partner David Strubbe of Massachusetts Institute of Technology's department of materials science and engineering had 24 hours to go from concept to prototype. During that time, the team created an algorithm to 3-D-print Fermi surfaces based upon density functional theory calculations.

Fermi surfaces, which are the dividing surface between occupied and unoccupied electronic states in crystals, are crucial for understanding things like superconductivity. These surfaces can be very intricate and their shapes difficult to explain. By using a 3-D printer, Cooper and Strubbe's project creates a physical example of the surfaces that makes them easier to understand.

The team's final product was a printed representation of the Fermi surface of lead.—*by Dawn Levy and Jenny Woodbery*

Ryan Cooper, winner of the MRS hackathon. Image credit: Dawn Levy, ORNL

ORNL, UT's Liu elected member of National Academy of Engineering

Yilu Liu, the Governor's Chair for Power Grids, has been elected to the National Academy of Engineering. The Governor's Chair is a joint appointment at ORNL and the University of Tennessee.

Being elected to the academy is among the highest professional distinctions accorded to an engineer. Liu was elected "for her innovations in electric power grid monitoring, situational awareness and dynamic modeling," according to the NAE. She is one of 80 engineers chosen from across the United States.

Yilu Liu

"To be recognized by the National Academy of Engineering is confirmation of the value that our work holds for the modern society," Liu said. "Not only that, but it validates all of the hours, effort and research put in by people at UT and ORNL."

Liu, a professor of electrical engineering and computer science, becomes the fourth member of the College of Engineering to receive this honor.

She joins John Fisher Distinguished Professor Mark Dean and University Distinguished Professor Jack Dongarra, both of computer science, and UT-ORNL Governor's Chair for Nuclear Materials Steven Zinkle of nuclear engineering.

Liu is also a fellow of the Institute of Electrical and Electronics Engineers and deputy director of the Center for Ultra-Wide-Area-Resilient Electric Energy Transmission Networks Engineering Research Center at UT.

Liu's research at UT, ORNL and CURENT focuses on smart-grid technologies in electrical power production and distribution, with an eye on developing new and better ways to monitor and understand the flow of electrical energy through the nation's power grid.—*Communications staff*

ORNL and clean energy

We sat down with ORNL Director Thom Mason to discuss the energy challenge: How is the national laboratory finding ways to provide the energy needed to support a higher quality of life for a growing global population without harm to the environment or intractable conflict over finite resources?

ORNL Review: How does ORNL approach clean energy research?

Thom Mason: The lab has been doing clean energy research since it was founded. If you look at the original strategic plan put together by Eugene Wigner after the end of World War II, it had a strong focus on nuclear energy and its underlying science and technology. That led us to work in related areas like high-temperature materials, computing, fusion, and isotopes.

Then, in the '60s, we began working on a better understanding of the environment and nonnuclear aspects of energy. In the '70s, after the Arab oil embargo, we grew our programs in energy efficiency, renewables and distribution. That is important to meeting energy challenges: finding more effective ways of transforming primary energy into a human-usable form. If you can do that with greater efficiency, you save money and reduce the environmental impacts associated with energy production, distribution and use.

Today, there are additional drivers, given the rapid growth in energy consumption in the developing world and its effect on global energy demand. We have an increasing realization that the environmental burdens of energy production are substantial, so we want an abundant supply of energy that's reliable, clean and low-cost. We want to support our standard of living while avoiding intractable conflicts over scarce global resources or unacceptable impacts from climate change and other emissions beyond CO_2.

We already have a lot of important scientific and technical assets contributing to this effort, such as the Oak Ridge Leadership Computing Facility, the Spallation Neutron Source, the High Flux Isotope Reactor and the Center for Nanophase Materials Sciences. Those allow us to understand at a fundamental level what's going on with new materials or complex systems. Our focus increasingly is to make sure the science we do gets translated into usable technologies and products that will be manufactured in the U.S. and sold around the world. We want to contribute to the creation of high-skilled, high-wage jobs in this country but also contribute to the benefits that accrue from better technology options.

OR: Why are ORNL's Southeastern university partnerships so important to the lab?

TM: First off, most of the problems we're trying to solve are pretty difficult. We don't have a monopoly on the expertise to solve them, so it makes sense for us to look to partners who complement our scientific skills. You see that in a lot of partnerships that formed to go after big proposals, like the Institute for Advanced Composites Manufacturing Innovation, the BioEnergy Science Center, the Consortium for Advanced Simulation of Light Water Reactors, or some of the energy frontier research centers. We look

See CLEAN ENERGY on page 8

In praise of the power grid

by Leo Williams
williamsjl2@ornl.gov

Electricity powers our work and our lives, keeps us warm in the winter and cool in the summer, and drives the economy. The distribution of electric power around the world—electrification, as it's called—is so important, it was named the greatest engineering achievement of the 20th century by the National Academy of Engineering.

Nevertheless, our electric grid is getting long in the tooth. When it was conceived and implemented, the grid's architects did not face many realities of the new millennium that challenge both the security of our modern electrical system and the business model of those companies that run it.

Consider renewable energy sources such as wind and solar power; they don't produce electricity so much when they're needed as when it's windy or sunny. Utilities, on the other hand, need to provide power whenever someone flips a switch, no matter the weather or the time of day. Or look to the homes and businesses that save money by installing their own solar generators. Power plants must be paid for, even when people spend most of their time off the grid.

"Utilities are extremely concerned about those distributed, renewable generation technologies and how to respond," ORNL's Tom King said.

In addition, consider the potential consequences of a disaster. Imagine a catastrophic storm or well-planned attack, whether physical or virtual. Our economic well-being—as well as our physical health—depends on our ability to avoid and, especially, to weather such events.

Recognizing the importance of our electrical grid, the Department of Energy has responded with the Grid Modernization Initiative, a program designed to bring this most important of technologies into the 21st century. The related Grid Modernization Laboratory Consortium is a partnership of DOE labs, including ORNL.

One focus of the initiative being led by ORNL is grid sensing and measurement. "To address a lot of these threats, we need to know what's going on and have more visibility throughout the entire system," King said.

FNET/GridEye, for instance, employs a network of frequency disturbance recorders. Each monitor, about the size of a small piece of stereo equipment, is a GPS-synchronized sensor that plugs into an electrical outlet and an Ethernet connection.

The network (FNET stands for Frequency Monitoring Network) is the brainchild of Yilu Liu, an electrical engineer and governor's chair with the University of Tennessee, Knoxville, and ORNL's Electrical and Electronics Systems Research Division. It keeps track of a system's electrical frequency and voltage angle, monitoring the health of the electrical grid in much the same way an electrocardiogram monitors the health of a person's heart.

"When a generator comes off line, it creates this ripple effect," King explained, noting that such disruptions could set off oscillations in the electric grid.

ORNL researchers are also developing low-cost, printed sensors that monitor a building's environment. The sensors themselves are passive, meaning they require no power of their own; instead, they draw power from the radio waves emitted by the device used to read them.

These Radio Frequency Surface Acoustic Wave devices—better known as RF SAW—use tiny sensors to measure conditions such as temperature and humidity.

"These can not only monitor and control buildings better," said ORNL physicist Tim McIntyre, "but allow them to be integrated with the grid. The way to make all the pieces of the grid play together better is to have large-scale sensor networks that give you detailed, real-time information about each of those pieces."

Because they will be printed—specifically with an aerosol jet printer—the sensors will be inexpensive, from less than a dollar to a few cents apiece. The project is in its early stages, McIntyre noted, adding that although RF SAW devices have been produced before, they have not been manufactured by direct printing.

CLEAN ENERGY from page 6

to universities to strengthen our research activities and make us more successful.

There's another component: Universities are training the next generation of scientists and engineers, and we want some of them to come work here. So we have undergraduates working on internships. We have an expanded graduate program, with graduate students doing their thesis research at the lab but getting their degrees from institutions like the University of Tennessee at Knoxville, Vanderbilt or Georgia Tech. Some may ultimately become our employees, while others will work in universities, other labs, or industry conducting research in tune with things we're trying to do. Those are all good outcomes.

It's our version of alumni networking.

OR: Why do we focus much of our effort regionally?

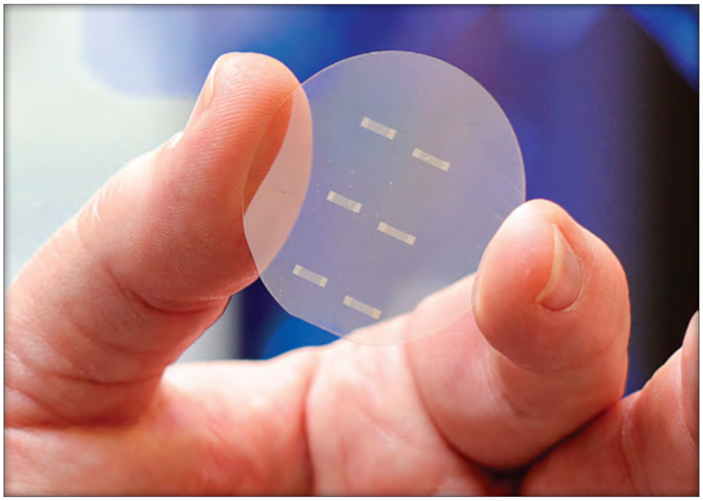
TM: Even though the national labs are national in terms of their scope and international in terms of the significance of their facilities, they also have a regional character. That's the natural way that a lot of collaboration and partnerships emerge—proximity matters.

That's certainly true for us. Our university partnerships and connections to industry extend all across the country, but they're more heavily weighted to the South and Southeast. It's true for the other national laboratories, too. It doesn't change the fact that we interact with companies and universities from all over the country, but it does mean we have our own natural partners.

The character of the energy infrastructure across the country is also very regional in nature, having to do with the assets that can be tapped and the state, local and regional regulatory environments. Even issues of public perception differ by region. In the South, we have a population that's generally more comfortable with nuclear energy than, say, in the Northeast or California. So it's no surprise that the new builds in nuclear are going on in the South.

For photovoltaics, Arizona and the Southwest are particularly favorable; wind is most valuable in areas where you have predictable, steady wind, so the Texas panhandle up through North Dakota tend to produce the most wind energy.

Tennessee Valley Authority's Watts Bar Nuclear Plant. Image credit: TVA



The printed gold lines on this surface acoustic wave reflector are only 10 microns wide (less than a 2,500th of an inch). The spaces between lines are also 10 microns. The reflector is intended as part of an environmental sensor. Image credit: Jason Richards, ORNL

What that means is, as the energy infrastructure modernizes, you're going to see the mixes vary depending on where you are in the country. For the labs, which already have these regional connections, it means that the local and regional interest in lab R&D is going to depend on the regional energy ecosystem.

Take nuclear, which is important for our region. It's also something that Oak Ridge is very active in, so you have things like the recent announcement of research projects with Southern Nuclear and TerraPower, looking at molten salt advanced reactor technology. That's a good example of our regional partnerships leveraging R&D at the lab in a way that promotes new, improved energy technology that's free of CO_2 emissions.

OR: How is ORNL positioned to lead clean energy efforts in the Southeast?

TM: Tennessee is a strong manufacturing state. It's got a lot of manufacturing associated with the automotive supply chain, but more broadly in the region you've got lots of companies interested in instrumentation and controls, which grew out of the lab's nuclear heritage. So there are a lot of natural partners that help us make that transition into the market.

We already have strong partnerships with regional research universities through the UT-Battelle core universities and other partners around the South. If you look at our involvement in regional innovation systems such as Knoxville-Oak Ridge Innovation Valley or our connections to entrepreneurial activities in Chattanooga, then add the expanded footprint we get with core universities such as Georgia Tech in Georgia, North Carolina State and Duke in North Carolina, and Florida State in Florida, you can imagine us leveraging our university partnerships to reach into private sector activities that are relevant in those states.

There's no reason we can't serve as a hub for the clean energy ecosystem in the Southeast. That's where the supply chain emerges

See CLEAN ENERGY on page 10

ORNL researchers go for a big impact

by Leo Williams
williamsjl2@ornl.gov

The Advanced Research Projects Agency-Energy lets researchers pursue projects with the potential to change the way we generate, store and use energy.

Established by 2007's America COMPETES Act, the agency has invested in more than 400 projects. Most recently, President Obama announced $1 billion-plus in private funding for ARPA-E projects.

Here is a sampling of ORNL's participation in the program.

Controlling power flow

A key factor in the continued growth of renewable energy is its dependability. You get wind power only when it's windy, solar power when it's sunny, and so on. In fact, you can get bursts of electricity from these interruptible sources at times when you already have more than enough power, making them downright inconvenient.

Researchers from ORNL worked with colleagues at SPX Transformer Solutions Inc., the University of Tennessee and the Bonneville Power Administration to create the Continuously Variable Series Reactor, a power flow controller that prevents overloads and routes excess current to lines that can handle it. Before the reactor's development, the same task would have required a prohibitively expensive superconducting magnet and powerful refrigeration.

The CVSR itself uses a standard ferromagnetic circuit, making it inexpensive enough for widespread adoption. *R&D Magazine* agreed that the power flow controller is a major breakthrough and gave its developers a 2014 R&D 100 Award. The CVSR, which was developed through ARPA-E's Green Electricity Network Integration Program, will be tested on the Bonneville network.

Protecting electric vehicles from fire

Vehicle collisions are dangerous under any circumstances, but an electric vehicle powered by a lithium-ion battery faces the added risk of fire from the battery's highly flammable electrolytes. As a result, manufacturers must build batteries with heavy armoring to prevent their positive and negative ends from touching and sparking a fire. This added weight substantially reduces the vehicle's driving range.

The Safe Impact Resistant Electrolyte project is creating an electrolyte that turns solid when an external pressure is applied, such as during collisions. The solidified electrolyte forms a barrier between electrodes, thereby preventing an electrical short. ORNL researchers teamed with battery-maker EnerDel and the University of Rochester to create the electrolyte through ARPA-E's Robust Affordable Next Generation Energy Storage Systems Program.

The work has led to three patent applications. In addition, the technology eventually may be used for soldiers carrying portable power units, allowing the battery to double as body armor.

Making natural gas fuel tanks fit vehicles

Vehicles powered with natural gas have several advantages over their gasoline-powered counterparts. Their emissions are less harmful and, in the United States, the fuel is both abundant and less expensive.

There are downsides, though, including the fact that cylindrical natural gas storage tanks are large and unwieldy. ORNL researchers supported an ARPA-E project led by United Technologies Research Center to produce lower-cost conformable natural gas tanks that can be assembled to fit into tight spots such as a vehicle's undercarriage. The project, Low Cost Hybrid Materials and Manufacturing for Conformable CNG Tanks, was supported through ARPA-E's Methane Opportunities for Vehicular Energy Program. ORNL provided information on alternative manufacturing processes and the potential for prototype tank liners using 3-D printing. The lab also helped to make tooling and assessed opportunities to use low-cost carbon fiber.

The project has paid off. UTRC has licensed the technology to New Jersey-based Adsorbed Natural Gas Products Inc. ANGP will combine the conformable technology with its own innovation—the use of activated carbon to store more natural gas at lower pressures—to produce conformable adsorbent-based low pressure storage tanks for vehicles.

An impact resistant electrolyte can reduce the chances of fire when an electric vehicle is involved in a collision.

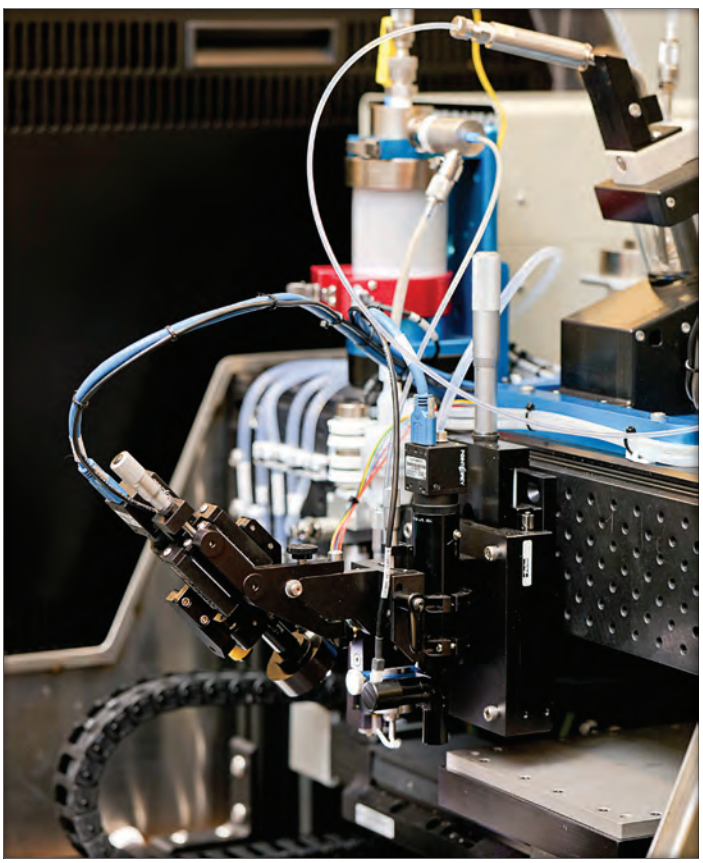
CLEAN ENERGY from page 8
for those energy technologies that are relevant for this part of the country. A lot of our research programs can help support that.

OR: Neutron sciences are an important mission for the lab. How do they contribute to clean energy and energy efficiency?

TM: Neutrons are a great structural probe for complicated materials, because you have sensitivity to atoms all across the periodic table. In the complicated structures that occur in batteries, you have light elements and heavy elements, and as you cycle the battery, they're moving back and forth.

You want to understand why battery performance degrades over the lifetime of the battery, because that's a real barrier to getting wider-spread use of electrical energy storage either for transportation or for grid storage. Being able as you're cycling a battery to nondestructively observe structural changes in the battery materials is one way we can understand the degradation. Then, hopefully, we can develop new and better materials that perform better over the extremes that batteries are exposed to.

Another example, one we're pushing pretty hard on now, is imaging. It makes use of the fact that neutrons have very different contrasts than the X-ray imaging people are familiar with. In the case of a chest X-ray, for example, you see the heavy elements, so you see bones but not tissue. With neutrons you have sensitivity to light elements as well, so you get very different contrasts.



Close-up view of the aerosol jet printer head used to create printed building sensors. Image credit: Jason Richards, ORNL

We're using neutron imaging to study how additively manufactured components compare to the computer models used in the design loaded into the 3-D printer. The question is, deep inside that complicated structure, does it really look like the model? And that's hard to do without smashing apart the thing you've built.

But neutrons are penetrating, so they'll go through an entire component, and you can tomographically reconstruct a 3-D image with quite good resolution. It allows you to see how the cooling channels, for instance, are formed in a heat exchanger, which might be important for automotive applications, or for a turbine blade in a jet engine. It's probably the only technique that you can do that with.

OR: One problem promoting clean energy is what's known as the "valley of death," where promising technologies fail to make it into the economy or into manufacturing. How can you address that?

TM: Most federal investments in R&D, not just at Oak Ridge, are focused on longer-term, more fundamental understandings of what's going on. These enable the development of technology but often themselves are not market-ready technological products.

It's the science that creates those opportunities, but at the end of the day we don't make anything and we don't sell anything. If our technology is going to get deployed, someone who makes and sells stuff needs to turn it into an actual product.

The challenge is, how do you go from the underlying science, through the applied R&D, to the point where a company is making something which they're going to sell? That's tricky.

We like to think of this nice linear process where the university or the lab has some fundamental insight, you work on the design, and then you sell it, but it's rarely that straightforward. You run into problems.

I think that's one of the reasons that ORNL, as a lab with a very broad span of fundamental science to end-use applications, is well-equipped to deal with those turbulent flows of information. But it's still a tricky thing to do. The thing we have been trying to focus on, particularly over the last several years, is that final piece of the chain, which is the hand-off to industry and getting the engagement earlier in the process to make the handoff smoother.

We have a variety of different mechanisms for doing that: traditional tech transfer, collaborative research with industry, and students who come in through graduate programs and go off and start companies. So there are all kinds of pathways that things can take. I think we need to work on all of them, because there's no one single, simple method.

Grad students

create biotech company, continue research project

by Ashanti B. Washington
ORNLReview@ornl.gov

Patrick Caveney and Beth Papanek. Image credit: Jason Richards, ORNL

A class project to explore the commercial potential of an ORNL-developed technology has evolved into a full licensing agreement for two students at the Bredesen Center for Interdisciplinary Research and Graduate Education.

Beth Papanek and Patrick Caveney formed biotechnology startup Nano Elements Source LLC in 2014, after a Bredesen Center class project sparked their interest in entrepreneurship. Paired with TopFive, a Chattanooga-based private equity firm that previously partnered with ORNL on low-cost carbon fiber technology, the graduate students were asked to analyze the economic viability of ORNL's patented and award-winning quantum dot fermentation technology.

The Bredesen Center is an educational partnership between ORNL and the University of Tennessee, Knoxville, focused on solving energy challenges through collective science and engineering resources. Papanek and Caveney are graduate students in the center's interdisciplinary Energy Science and Engineering Ph.D. program, which emphasizes student engagement in policymaking, entrepreneurship and outreach.

At the end of their class project, the students pitched their results to TopFive's founders. The equity firm's leaders were so impressed that they asked Papanek and Caveney to continue their work through a full patent license deal with Nano Elements Source LLC.

Quantum dot particles glow a specific color when hit with different types of light. This signal specificity in semiconductors means greater energy savings and has brought on a new wave of enhanced optoelectronic devices such as solar cells, light-emitting diodes and televisions—at a cost.

"Think of a Coca-Cola label," said Caveney, a third-year graduate student studying genetic "noise" in protein production at ORNL's Center for Nanophase Materials Sciences. "It's such a distinctive red, and traditional televisions can't display that particular color yet.

"On the other hand, ultra high-definition TVs, which are getting more popular, enhance color, but they're made with toxic material," Caveney said.

Better options exist, such as a method of using powdery zinc sulfide instead of cadmium to generate the light-sensitive quantum dot particles, for which ORNL researchers won an R&D award in 2006.

"Students like Beth and I are seeing problems and are just trying to solve them," Caveney said.

Papanek is focused on expanding Nano Elements' industry presence while she prepares to defend her doctoral dissertation this spring.

"I knew very early on that I wanted to apply science beyond bench work," said Papanek, a fourth-year student who researches metabolic engineering of microorganisms for biofuel with ORNL's BioEnergy Science Center.

"As Bredesen Center students, we've received an incredible amount of support from Tom Rogers and the Partnerships Office to allow us to explore entrepreneurial career opportunities outside of traditional science academia," she said.

Caveney agreed. "It's wonderful that we can do that without leaving grad school," he said.

Staying ahead of Moore's law

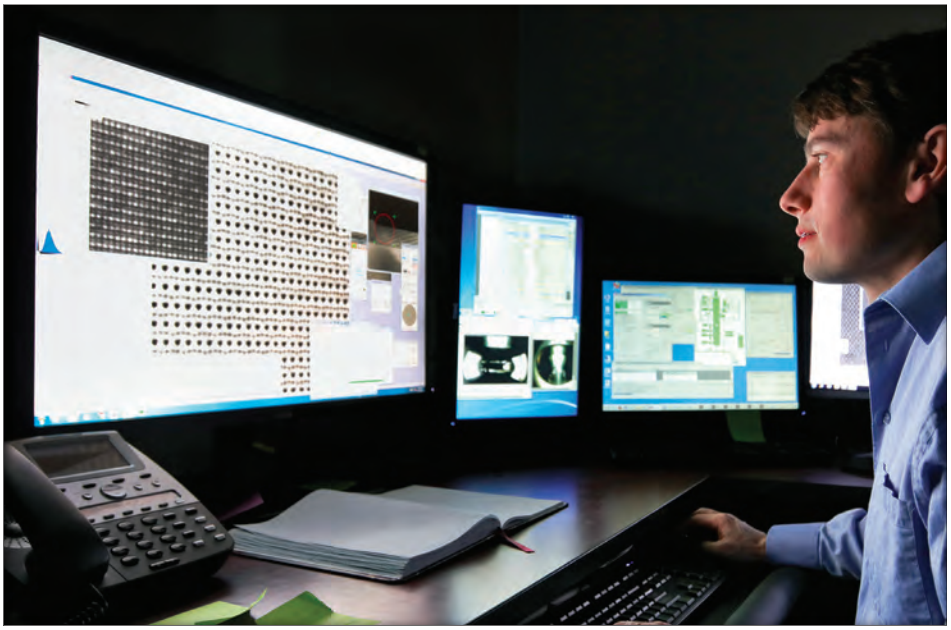
ORNL researchers delve into quantum computing's quandaries

by Morgan McCorkle
mccorkleml@ornl.gov

For all the power and complexity of today's computers, they can still be boiled down to the binary basics—using a code of 1's and 0's to calculate and store information. Since the 1980s, though, some computer scientists have strayed from this simple language. They suggest that computers could speak a different dialect, one that taps into the world of quantum mechanics.

Quantum mechanics describes how very small particles such as atoms, nuclei and electrons behave and interact; it entails sharp departures from the phenomena found in classical physics. Take the physics of an electron's spin, where it's possible for the particle to be spin-up, spin-down or simultaneously both. This mind-bending property of superposition underlies the concept of quantum computing.

"You can use that one piece of quantum mechanics, the superposition of states, to create a computer that can hold more information than a classical computer ever could," said David Dean, director of ORNL's Physics Division.



The monitor shows a highly magnified image of a crystal tilted to align with the direction of the microscope's electron beam. The black-and-white spots on the screen are columns of atoms. Image credit: Jason Richards, ORNL

The freaky physics of quantum mechanics morphs the binary "bit" of classical computing—either a 0 or 1—into a "qubit," a bit that can take the form of a 0, 1, or both. Harnessing this power would enable computers to store much more information in a smaller area and run through certain kinds of calculations exponentially faster.

Initially considered a theoretical exercise, quantum computing has progressed to proof-of-principle demonstrations of single- and multi-unit qubits, implemented physically through photons, electrons, quantum dots and other approaches. Yet the intriguing properties that give rise to quantum systems make them equally fragile. The introduction of an errant atom, a magnetic field or other phenomena can disrupt the balance in a quantum computing system; in fact, today's state-of-the-art qubits last a matter of microseconds to milliseconds, depending on the physical type of qubit, before breaking down.

"We've always been able to beat Moore's Law (which says the number of transistors on a computer chip doubles every two years), but we're getting to the point where our current methods are likely to fail in the future."

— ORNL quantum computer scientist Travis Humble

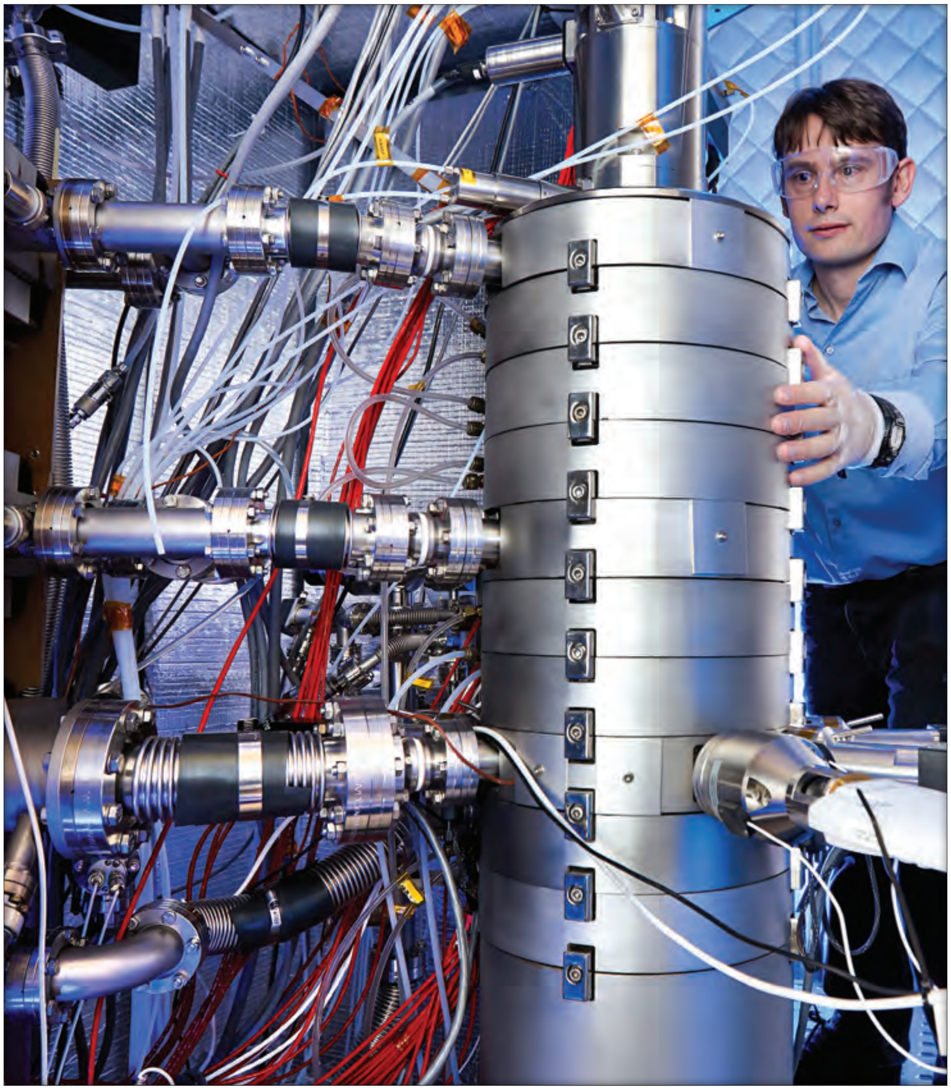
"Those kinds of material issues make it so that the qubit cannot live long enough to actually do any useful computation," said Dean, who oversees a new lab-funded initiative aimed at addressing challenges in quantum computing.

In one project, ORNL researchers seek to overcome the trouble caused by wayward atoms by using advanced microscopy techniques to detect and control single atoms in a semiconductor. Another effort focuses on understanding the refrigeration challenge: To avoid atomic vibrations that disrupt qubit operation, quantum experiments are usually cooled to near absolute zero. The refrigeration systems can introduce interference, however, so ORNL researchers are examining ways to control and balance the effects of temperature on qubits.

Other research projects are directed at improving characterization, modeling and communications systems to enable practical applications of quantum computing systems.

"The joke is that you need a quantum computer to program a quantum computer," said ORNL researcher Travis Humble, who leads a project to develop a virtual testbed for silicon-based qubits.

Quantum technologies aren't expected to replace traditional computing architectures but rather to provide a quantum boost. Quantum accelerators, akin to graphics processing units, could be used to more efficiently solve certain types of problems—simulations of quantum mechanical systems such as chemical systems or quantum gravity, for example, or encryption and decryption calculations.



ORNL's Andrew Lupini with the UltraSTEM200, a 200 kilovolt scanning transmission electron microscope that is able to see single atoms. Image credit: Jason Richards, ORNL

"I don't see this as a one-or-the-other situation," Humble said. "It's much more likely that we will use quantum computing the way we use other methodologies, by integrating them into a larger computer."

Scientists like Humble believe quantum research is key to sustaining the demand for increasingly faster, smaller and more powerful computing devices, given that transistors on traditional computer chips are fast approaching the limits of miniaturization.

"We've always been able to beat Moore's Law (which says the number of transistors on a computer chip doubles every two years), but we're getting to the point where our current methods are likely to fail in the future," Humble said. "As we decrease the feature size, we're reaching the point where the physics models used to describe the behaviors of the features begin to break down. This is where the quantum aspect begins to become very real.

"The question," Humble said, "is what do we do in the face of that challenge? We need to embrace the quantum effects and make something out of them."

Two birds, one stone

Alloy promises better engines, more rare earth production

by Leo Williams
williamsjl2@ornl.gov

ORNL researchers and partners at Lawrence Livermore National Laboratory and Wisconsin-based Eck Industries have developed aluminum alloys that are both easier to work with and more heat tolerant than existing products.

What may be more important, however, is that the alloys—which contain cerium—have the potential to jump-start the United States' struggling production of rare earth elements.

The team will discuss the technical and economic possibilities for aluminum–cerium alloys in the June issue of *JOM*, a publication of the Minerals, Metals & Materials Society.

They're working as part of the Critical Materials Institute, a DOE Energy Innovation Hub. Based at the Ames Laboratory in Iowa, the institute works to increase the availability of rare earth metals and other materials critical for U.S. energy security.

Rare earth elements are used in electronics, alternative energy and other modern technologies. Modern windmills and hybrid vehicles, for example, rely on strong permanent magnets made with the rare earth elements neodymium and dysprosium. More than 90 percent of rare earth production, however, comes from China, with no production occurring in North America.

Alloyed metals being poured from a furnace into a ladle, to be used to fill molds. Image credit: Zachary Sims, ORNL

One problem is that cerium accounts for up to half of the rare earth content of many rare earth ores, including those in the United States, and it has been difficult to find a market for all of the cerium mined. The United States' most common rare earth ore, in fact, contains three times more cerium than neodymium and 500 times more cerium than dysprosium.

Aluminum–cerium alloys promise to boost domestic rare earth mining by increasing the demand and, eventually, the value of cerium. If, for example, the new alloys find a place in internal combustion engines, the new market could quickly transform cerium from an inconvenient byproduct of rare earth mining to a valuable product in itself.

"The aluminum industry is huge," explained ORNL materials scientist Orlando Rios. "A lot of aluminum is used in the auto industry, so even a very small implementation into that market would use an enormous amount of cerium." A 1 percent penetration into the market for aluminum alloys would translate to 3,000 tons of cerium, he explained.

Rios said components made with aluminum–cerium alloys offer several advantages over those made from existing aluminum alloys, including low cost, high castability, reduced heat-treatment requirements and exceptional high-temperature stability.

"Most alloys with exceptional properties are more difficult to cast," said David Weiss, vice president for engineering and research and development at Eck Industries, "but the aluminum–cerium system has equivalent casting characteristics to aluminum–silicon alloys."

The key to the alloys' high-temperature performance is a specific aluminum–cerium compound, or intermetallic, which forms inside the alloys as they are melted and cast. This intermetallic melts only at temperatures above 2,000 degrees Fahrenheit.

That heat tolerance makes aluminum–cerium alloys attractive for use in internal combustion engines, Rios noted. Tests have shown the new alloys to be stable at 300 degrees Celsius (572 degrees Fahrenheit), a temperature that would cause traditional alloys to begin disintegrating.

Not only would aluminum–cerium alloys allow engines to increase fuel efficiency directly by running hotter, but they may also increase fuel efficiency indirectly by paving the way for lighter engines that use small aluminum-based components or that use aluminum alloys to replace cast iron components.

"Three-dimensional printed molds are typically very hard to fill. But aluminum–cerium alloys can completely fill the mold thanks to their exceptional castability."

—ORNL physicist Zachary Sims

The team has already cast prototype aircraft cylinder heads in conventional sand molds, as well as a fully functional cylinder head for a fossil fuel-powered electric generator in 3-D-printed sand molds. This first-of-a-kind demonstration led to a successful engine test in which the engine was shown to handle exhaust temperatures of over 600 degrees Celsius.

Green sand mold of an aerospace engine head. Molten metal is poured in and allowed to cool.
Image Credit: Zachary Sims, ORNL

"Three-dimensional printed molds are typically very hard to fill," said ORNL physicist Zachary Sims, "but aluminum–cerium alloys can completely fill the mold thanks to their exceptional castability."

Aluminum–cerium–magnesium engine head.
Image credit: Carlos Jones, ORNL

ORNL regional partnerships

National laboratories have partners across the country and around the globe, but they also find valuable collaborators close to home. This is certainly true at ORNL, where we take pride in close relationships across the region.

CORE UNIVERSITIES

ORNL's unique relationship with major research universities paves the way for joint appointments, collaborative research and opportunities for grad students. The core universities are part of the management team for ORNL's management and operating contractor, UT-Battelle, and broaden the lab's benefits and presence.

USER AGREEMENTS

ORNL is home to a variety of unique and sophisticated experimental facilities unavailable at universities or in the private sector. User agreements allow scientists and engineers to conduct research that would be impossible without the lab's instruments and expertise. **Worldwide, almost 900 universities, companies and other government labs have agreements that enable their staff to use ORNL facilities.**

INDUSTRIAL PARTNERSHIPS

Strategic Partnership Projects. Known previously as Work for Others, the SPP program allows ORNL to conduct work for universities, industry, small businesses and other federal agencies, as long as it doesn't compete with capabilities available in the private sector.

Cooperative Research and Development Agreements. CRADAs enable research collaborations between ORNL and non-federal organizations such as universities, private businesses and nonprofit organizations. ORNL is involved in 80 CRADAs around the world.

Licenses. More than 100 companies, large and small, have licensed ORNL-developed technologies for commercialization.

RESEARCH COLLABORATIONS

Additive Manufacturing Integrated Energy demonstration project. The ORNL-led AMIE project involved 20 partners in 3-D-printing a building and a vehicle that wirelessly share energy.

Institute for Advanced Composites Manufacturing Innovation. With 146 partners and more on the way, IACMI's goal is to increase U.S. capacity and production of composites to create American jobs.

BioEnergy Science Center. BESC's 18 partners focus on improving biofuel yields by eliminating biomass recalcitrance.

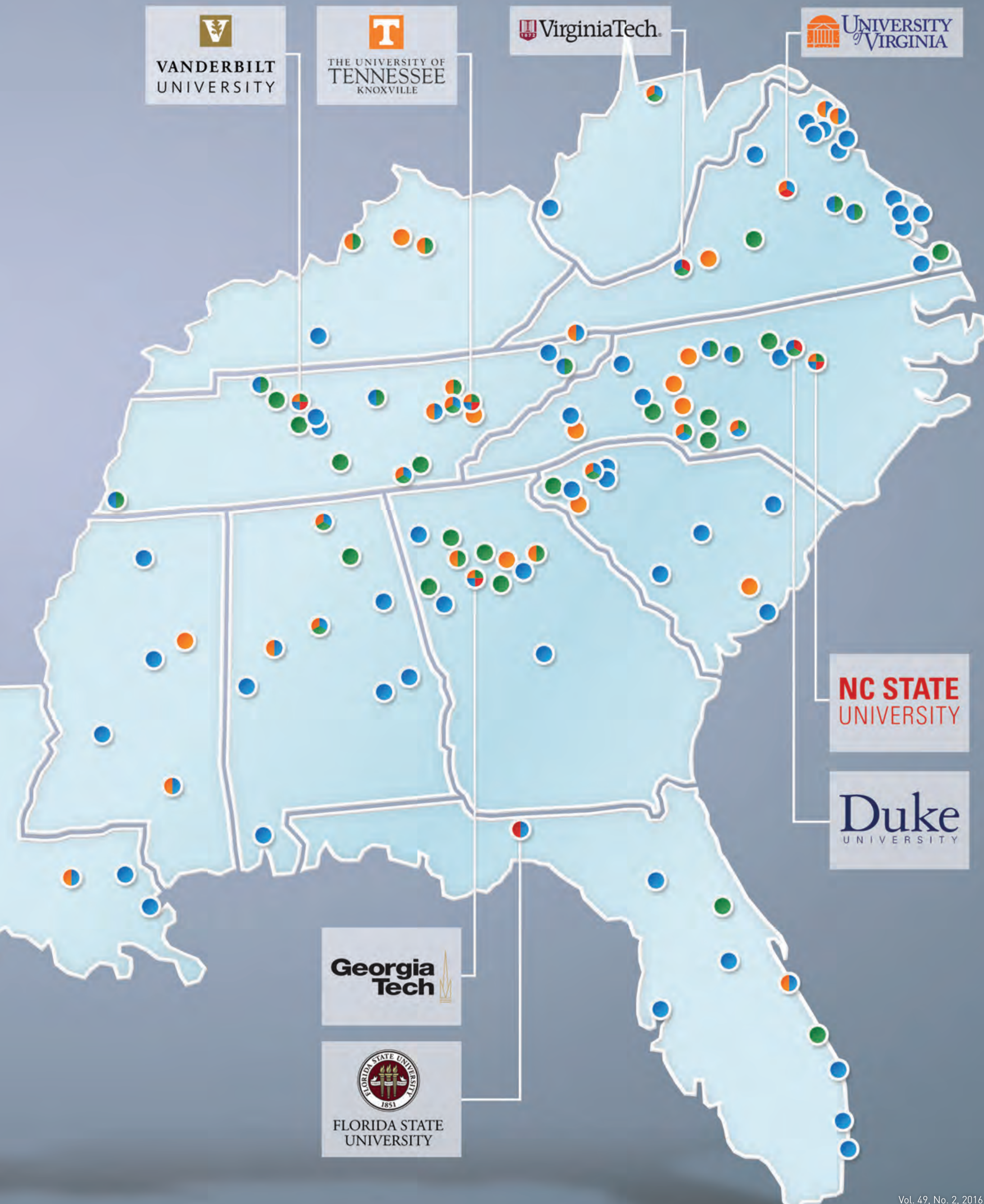
Consortium for Advanced Simulation of Light Water Reactors. CASL provides modeling and simulation capability from ORNL's supercomputing center that is enabling its 10 partners to improve the performance of light water reactors.

Center for Understanding and Control of Acid Gas-Induced Evolution of Materials for Energy. UNCAGE-ME is advancing understanding of the interaction between acid gases and energy-related materials. Based at Georgia Tech, this program's partners include ORNL and universities in five states.

Energy Dissipation to Defect Evolution. The EDDE Center aims to control the evolution of defects in a radioactive environment and to develop new design principles for radiation-tolerant structural alloys. Partners include Lawrence Livermore and Los Alamos national laboratories and the universities of Tennessee, Michigan and Wisconsin.

Fluid Interface Reactions, Structures and Transport. The FIRST Center explores fluid-solid interfaces at the nanoscale to advance electrical energy storage and electrocatalysis. FIRST Center partners include Argonne National Laboratory and seven universities across the country.

Image credit: Brett Hopwood, ORNL


VANDERBILT UNIVERSITY
THE UNIVERSITY OF TENNESSEE KNOXVILLE
VirginiaTech
UNIVERSITY of VIRGINIA
NC STATE UNIVERSITY
Duke UNIVERSITY
Georgia Tech
FLORIDA STATE UNIVERSITY

Methods for medicine

ORNL supplies isotopes used in cancer therapy

by Morgan McCorkle
mccorkleml@ornl.gov

Rose Boll had just stepped out of a long staff meeting at ORNL when she got an unexpected call. Expecting a sales pitch, she heard instead the story of a patient in Germany who had recently been treated with a medical isotope produced by Boll and a team of ORNL researchers and technicians.

The treatment, enabled by the use of actinium-225, had significantly reduced the patient's tumors from golf ball- to pea-size and allowed him to once again run marathons and accomplish his goal of seeing his son learn to drive.

"He made me promise to pass his thanks on to everyone who works in the production of Ac-225," Boll said.

Actinium-225 and its "daughter" bismuth-213 are short-lived radioactive isotopes used in a cancer treatment technique known as targeted alpha therapy. The isotopes are attached to engineered antibodies that home in on specific antigens on cancerous cells, whether they are concentrated in a solid tumor or diffused throughout the bloodstream in cases such as leukemia.

"It's the simplest form of drug delivery," said ORNL physical chemist Saed Mirzadeh. "It's like a torpedo that has a warhead on it. The torpedo is the antibody, and the warhead is the attached radioisotope."

Sample of actinium-225 in a glovebox at ORNL's Radiochemical Engineering Development Center.
Image credit: Jason Richards, ORNL

Because the radioisotopes emit radiation in the form of alpha particles that deposit significant energy over a short distance, the cell damage is primarily focused on the target cells—minimizing damage to surrounding healthy tissue or cells.

"If you can directly send it to where you want them to go, then you only destroy a small cluster of cells," Mirzadeh said. "That's consistent with the future of medicine—aiming for a smaller and smaller target, ultimately single-cell therapy."

ORNL's path to producing Ac-225 for use in cancer therapy began in 1994, when Mirzadeh obtained a small amount of thorium-229, a waste material from the production of fuel in the lab's 1960s-era Molten Salt Reactor Experiment. He led the development of a multistep chemical process to first purify the valuable Th-229 and then extract, or "milk," isotopically pure Ac-225 from the thorium.

Today, the lab's production of medical isotopes makes use of specialized hot cells and radiological and chemical processing facilities, including ORNL's Radiochemical Engineering Development Center.

The lab sent its first shipment of Ac-225 to the National Institutes of Health in 1997; since then, approximately 900 shipments have been distributed to hospitals, clinical centers and universities through the Department of Energy's Isotopes Business Office, conveniently located at ORNL.

Initial preclinical studies in the late 1990s, led by former ORNL biochemist Steve Kennel, demonstrated Ac-225's potential for treating lung tumors in mice. They were followed by several U.S.-based clinical trials focused on the treatment of acute myeloid leukemia at Memorial Sloan Kettering Cancer Center. European researchers have also examined Ac-225's therapeutic applications on other tumor types, such as brain and prostate cancers. Its use in acute myeloid leukemia treatment, supported by a private company, is entering phase two trials with hopes for Food and Drug Administration approval in the near future.

Recognizing the potential value of Ac-225, DOE's Office of Science in 2012 initiated a project to develop an alternative method capable of producing greater quantities of the isotope.

"Because we have a limited amount of the parent material at this time, we're looking for ways to make more," Boll said. "We are maxed out on how much actinium we can harvest from our current Th-229 stock. Both the recovery and production of additional thorium and direct production of Ac-225 are needed to meet therapeutic needs."

The new process involves irradiating natural thorium targets with high-energy protons in accelerators at Los Alamos and Brookhaven national laboratories, followed by extensive chemical processing of targets at ORNL to produce sufficiently pure actinium for medical applications. The resulting material is now being studied to evaluate its safety, and clinical trials are expected to begin in the next two to three years.

After nearly 20 years of Ac-225 production, the relevance of the mission—extending and even saving lives—continues to motivate the entire ORNL team, from chemical technicians to transportation and maintenance staff. In particular, the researchers point to three members of the technical staff: Greg Groover, Karen Murphy and Shelley Van Cleve.

Receiving phone calls from patients, says Boll, is a welcome reminder of the work's significance.

"Everyone has known someone with cancer, so the work has been very personal," Boll said. "We know we have a patient who's waiting to be treated."

ORNL researchers Rose Boll, foreground, and Joseph Rayburn operate the ORNL actinium-225/bismuth-213 biomedical generator. Image credit: Jason Richards, ORNL

Researchers

re-create reactor in virtual form

by Leo Williams
williamsjl2@ornl.gov

Researchers with the ORNL-based Consortium for Advanced Simulation of Light Water Reactors have performed their first major computational simulation of an operating nuclear reactor.

Using a software suite known as the Virtual Environment for Reactor Applications, or VERA, they modeled the first 18 years of operation at Unit 1 of the Watts Bar Nuclear Plant, located near Spring City, Tenn., about 50 miles southeast of ORNL.

Watts Bar 1, which began operation in 1996, is about halfway through its 40-year licensing period. So far, CASL has modeled a dozen 18-month fuel cycles, calculating levels of atom-splitting neutrons, fuel temperatures, radiation transport and the behavior of the water coolant.

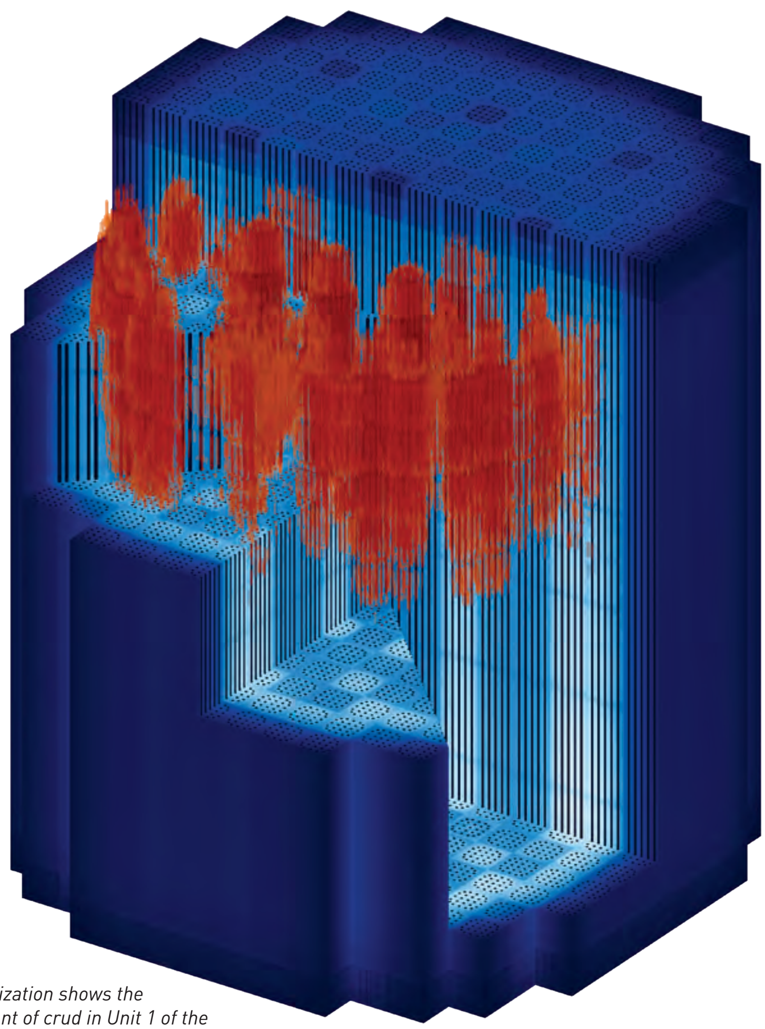
"We've modeled the history of Watts Bar 1's reactor core in very high detail," said CASL director and ORNL nuclear engineer Jess Gehin. "That allows us to test our capabilities against measured plant data and confirms that we're accurately calculating the plant's performance."

The consortium also modeled the buildup of unwanted iron and nickel deposits on the fuel rods. The deposits, known in the industry as "crud," come from the corrosion of equipment elsewhere in the plant—primarily piping and the steam generators—and can affect the distribution of power generation in the reactor core.

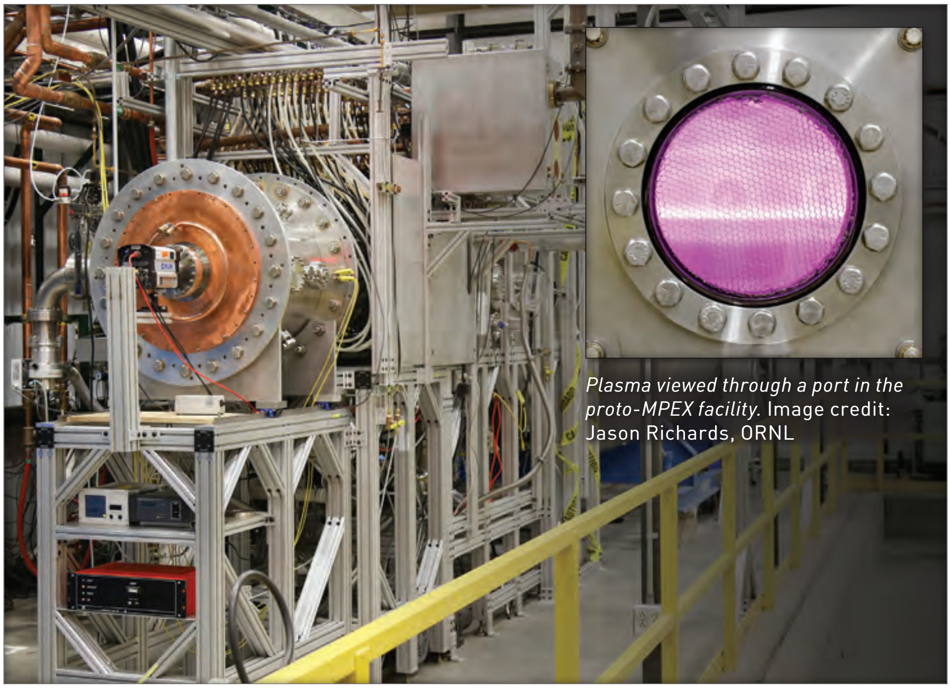
The two simulations validate both CASL's partnerships and its methods. By including Watts Bar's designer and fuel vendor, Westinghouse Electric Company, and its owner, the Tennessee Valley Authority, the consortium leverages industry expertise as well as design and operating data from its partners.

In addition, VERA's use of supercomputers including ORNL's Titan and CASL partner computers—in this case the Falcon system at Idaho National Laboratory—allows it to model the reactor in far more detail than what is possible with existing industry tools. As a result, VERA holds the promise of providing information that is currently unavailable—such as when and where crud is likely to appear.

For more information: http://go.usa.gov/cfgcm



This visualization shows the development of crud in Unit 1 of the Watts Bar Nuclear Plant. Image credit: Benjamin Collins, ORNL



Plasma viewed through a port in the proto-MPEX facility. Image credit: Jason Richards, ORNL

The proto-MPEX explores plasma-material interactions under conditions similar to those on the surface of the sun. Image credit: Jason Richards, ORNL

Materials

research brings fusion power closer to reality

by Jim Pearce
pearcejw@ornl.gov

The search for materials that can withstand the extreme environment inside advanced fusion research facilities and fusion power reactors is becoming more intense.

A focal point for this search is ORNL's Material Plasma Exposure Experiment. At the heart of the experiment is a device that enables scientists to study the characteristics of both fusion plasma and materials that have been exposed to the plasma.

MPEX will likely test some of the materials used at ITER, the large-scale fusion reactor experiment under construction in France. But its primary purpose is to develop materials for research facilities that will complement ITER, as well as for the first generation of experimental fusion power reactors. ORNL is the U.S. headquarters for ITER.

"Developing materials for a fusion reactor is like developing a heat shield for the space shuttle," says the MPEX program manager, Juergen Rapp. "However, the heat fluxes encountered by a reentry vehicle are nothing in comparison to the fluxes materials will experience inside a fusion reactor."

> *"These are the sorts of conditions you would experience on the surface of the sun."*
>
> —Juergen Rapp, MPEX program manager

Adding to the challenge is the fact that these materials will be exposed to high-energy neutrons, ions and electrons that damage and degrade materials.

"These are the sorts of conditions you would experience on the surface of the sun," Rapp says.

Material insights

The plan is for MPEX to test materials developed by the laboratory's Materials Science and Technologies Division. Researchers are looking for materials that are able to resist the surface erosion and deeper structural defects caused by heat fluxes and high-energy particles.

The current facility, dubbed proto-MPEX, tests materials using brief bursts from a plasma source.

"When we build the more powerful MPEX facility, we'll run the source 24 hours a day, seven days a week," Rapp says.

"After MPEX, we hope to pursue the Fusion Nuclear Science Facility. This facility will work in parallel with ITER. So while ITER studies the physics of fusion plasma, FNSF will study the technology needed to harness that power."

The idea is that knowledge gained from ITER and FNSF combined with the material insights provided by the MPEX facilities should provide the knowledge needed to build a fusion power reactor—bringing practical fusion power generation that much closer to reality.

For more information: http://go.usa.gov/cfgYJ

Solvents save steps in solar cell manufacturing

by Jeremy Rumsey
rumseyjp@ornl.gov

Advances in ultrathin films—layered material a fraction of the thickness of a human hair—have made technologies such as solar panels and other electronic devices more efficient and less costly. Now, ORNL researchers say a simple solvent can be used to manufacture the films more easily, too.

Typically the films—used by organic photovoltaic bulk heterojunction solar cells, or BHJs, to convert solar energy into electricity—are created in a solution by mixing conjugated polymers and fullerenes, soccer ball-like carbon molecules also known as buckyballs.

Next, a small amount of the mixture is deposited on a flat substrate, spinning at a low speed to ensure uniformity, and then sent to post-processing to be annealed. Annealing the material—heating and then cooling it—reduces the material's hardness while increasing its toughness, which makes it easier to work with.

Pliability makes BHJs more appealing than their more costly crystalline silicon counterparts in certain applications, but the annealing process is time-consuming.

Now ORNL researchers say a simple solvent may make thermal annealing a thing of the past.

In a collaboration between ORNL's Spallation Neutron Source and Center for Nanophase Materials Sciences, postdoctoral researcher Nuradhika Herath led a team of neutron and materials scientists in a study of the morphology, or structure, of BHJ films.

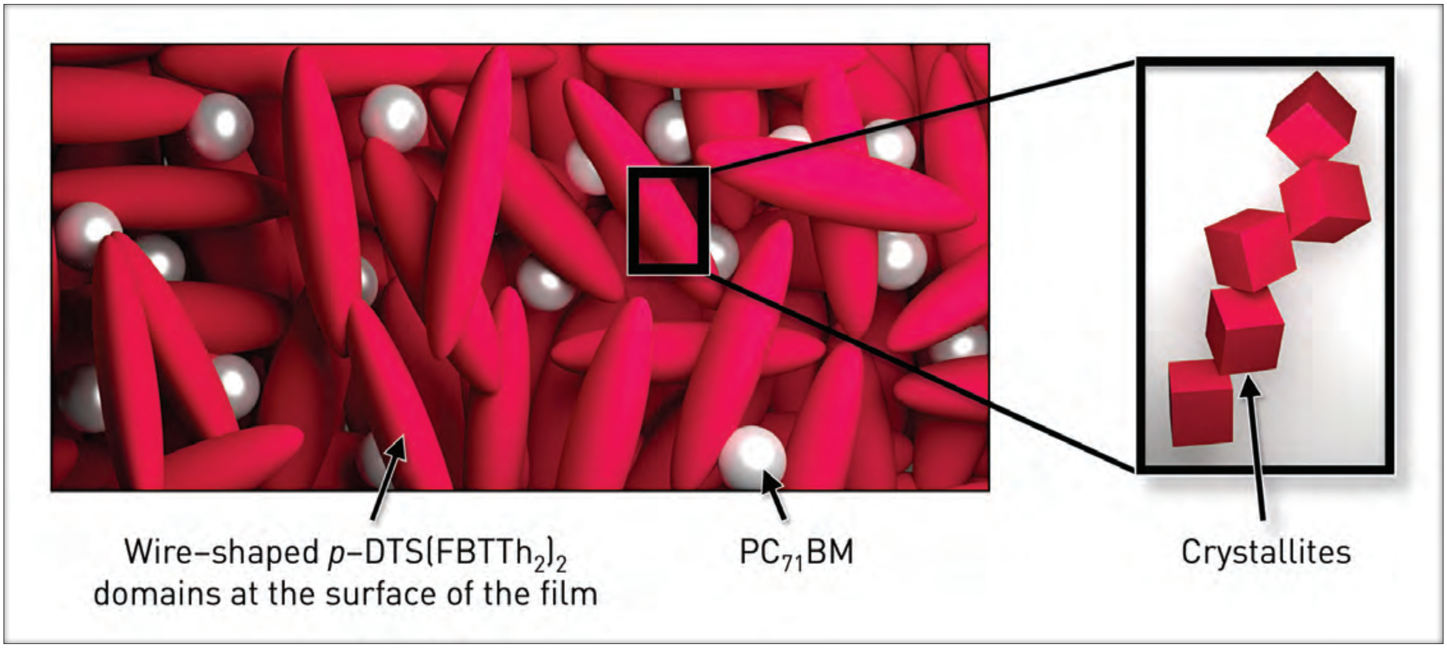
"Optimizing a film's morphology is the key to improving device performance," Herath said. "What we want to find out is the relationship between the blend structures and photovoltaic performance." Finding ways to tune the film's morphology is as important as answering why certain film morphologies are more favorable than others, she added.

Researchers compared thermal annealing with a method that adds a small amount of solvent that aids in dissolving the fullerenes within the blend and helps to make the film's structure more uniform.

The idea is to get the most uniform mixture of light-absorbing molecules (e.g., polymers or other molecules) and fullerenes throughout the film. If the mixture is not uniform, clusters form and cause passing electrons to get absorbed, weakening the film's ability to transport electrical current, which in turn decreases device performance.

Because the films are typically about 100 nanometers thick (for comparison, a human hair is about 75,000 nanometers

"Optimizing a film's morphology is the key to improving device performance. What we want to find out is the relationship between the blend structures and photovoltaic performance."
—Nuradhika Herath, postdoctoral researcher



Fullerenes appear as small silver spheres spread consistently throughout a network of small molecules, or polymers, in this schematic illustration of the morphology of a BHJ film with solvent additives. Image credit: ORNL

in diameter) and the depth profile of the composition is highly complex, special instruments are needed to measure the material's morphology. For this, researchers turned to neutron scattering.

After mixing and spin casting two different samples at CNMS—one annealed, the other with solvent additive—the team put both films under the eye of SNS's Magnetism Reflectometer. The MR provided them with an accurate depiction of the 3-D structural profiles, which revealed exactly how the polymers and fullerenes were arranging themselves throughout both films.

The difference was evident. Whereas the annealed sample's morphology clearly showed significant separation between the polymers and fullerenes, the sample containing the solvent additive was remarkably consistent throughout and performed better.

The information obtained from neutrons will help increase the efficiency of solar cells' performance and streamline the manufacturing process. Using solvent additives to optimize the morphology of BHJ films could negate the need to invest more in a less-effective process, thereby saving time, money and resources.

"In addition, optimization of photovoltaic properties provides information to manufacture solar cells with fully controlled morphology and device performance," Herath said. "These findings will aid in developing ideal photovoltaics, which gets us one step closer to producing commercialized devices."

The researchers discussed their findings in a recent issue of the journal *Scientific Reports.*

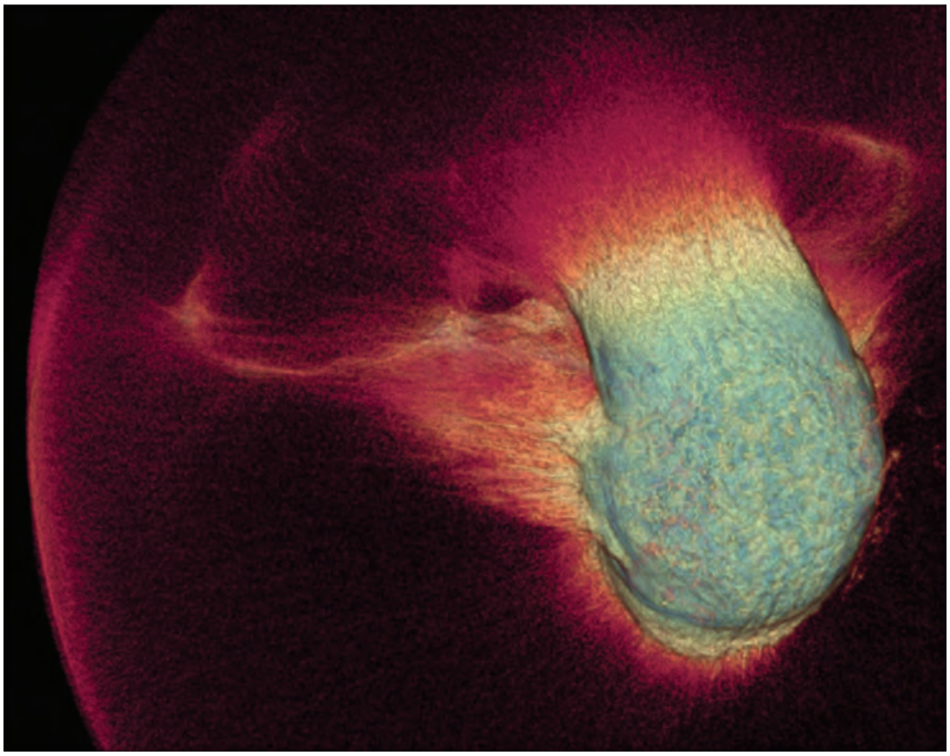
Modeling

next-generation lasers for tumor removal

by Eric Gedenk
gedenked@ornl.gov

Researchers from the Helmholtz-Zentrum Dresden-Rossendorf laboratory in Germany are using ORNL's Titan supercomputer to bring down the cost of cancer treatment. Along the way, they are benefiting from a promising young team member who made major contributions to the project while still in his teens.

Specifically, the team is exploring the possibility that high-powered lasers can replace the traditional particle accelerators used to remove tumors. Although the technique is very promising, the use of particle accelerators makes it prohibitively expensive. If the lasers successfully take over the job of accelerating heavy particles such as protons and ions, this treatment can become accessible to many more patients.



Proton density after laser impact on a spherical solid-density target. Scientists are searching for optimal regimes to accelerate high-quality, directed ion beams to destroy tumors. Image credits: Axel Huebl, HZDR, and David Pugmire, ORNL

The project requires both high-powered computers and talented computer scientists. The computing power comes from Titan, America's most powerful supercomputer.

"I need to simulate a huge volume of atoms over a very long time scale," explained team leader Michael Bussmann, adding that Titan's GPU accelerators are critical to the project's success.

The computer science talent came in part from an impressive teenager. In August 2008, the team got an unlikely boost in its computational capabilities in the form of 17-year-old high school student Heiko Burau, who won the "Jugend forscht," or youth research award, allowing him to work with experts at a prestigious German research institution.

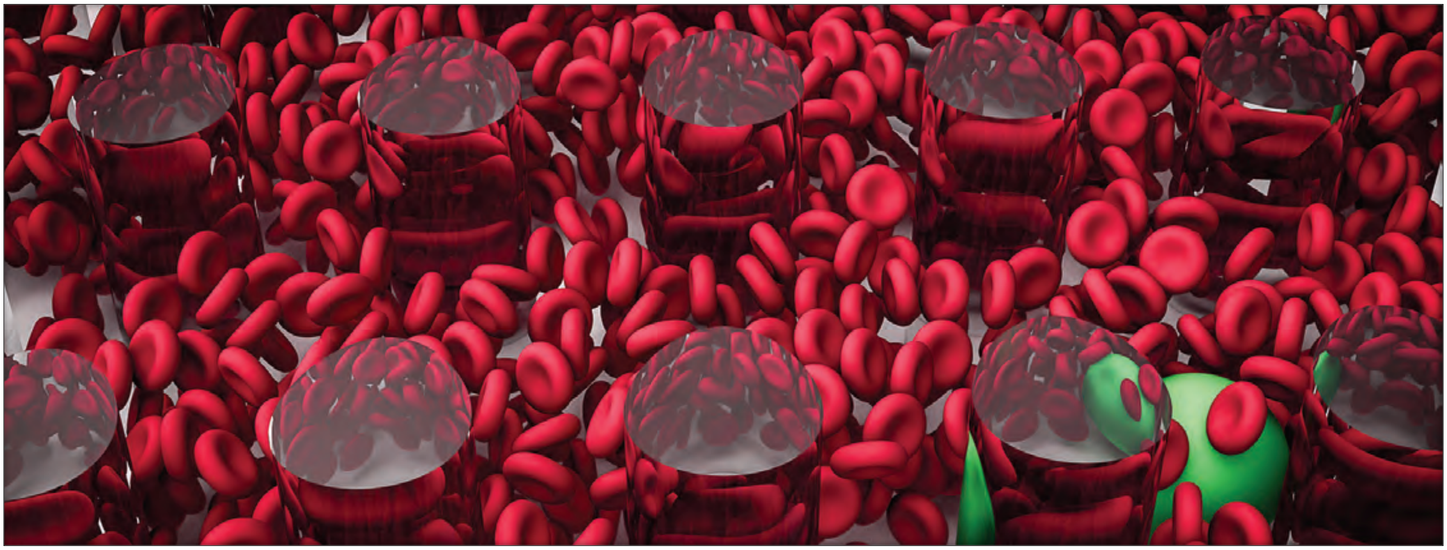
Burau joined Bussmann's group, and the results were immediately noticeable—within six weeks, the student programmer had created the team's first GPU accelerated two-dimensional simulation. Burau is now starting his diploma thesis—still as part of the HZDR team.

"I need to simulate a huge volume of atoms over a very long time scale."

— Michael Bussmann, team leader

Burau's initial work has been picked up by an ever-growing team of young researchers. Axel Huebl, who joined the team a year after Burau, has pushed the code to make optimal use of all of Titan's GPUs, helping the team win time on Titan through the Innovative and Novel Computational Impact on Theory and Experiment program.

For more information: http://go.usa.gov/cmbAG



Red blood cells and circulating tumor cells (green) traveling through a microfluidic cell sorting device as simulated by uDeviceX. Image credit: Yu-Hang Tang, Brown University

Simulating

tumor cells, sickle cell anemia and drug delivery

by Eric Gedenk
gedenked@ornl.gov

ORNL's Titan supercomputer is giving a team of American and European researchers the means to understand and fight blood-based diseases.

Led by Brown University's George Karniadakis, the team is simulating hundreds of millions of red blood cells to develop better drug delivery methods and diagnostic tools to fight tumor formation and sickle cell anemia.

During the first year of three-year allocations on Titan and Argonne National Laboratory's Mira system, the team has analyzed diseases and drug delivery methods to better predict, diagnose and treat several mysterious hematological, or blood-based, diseases.

At the Oak Ridge Leadership Computing Facility, the team has focused primarily on studies of sickle cell anemia and tumor cells and the development of better drug delivery methods. Thus far, it has simulated blood and cancer cell separation using microfluidic devices, which can manipulate fluids in amounts of a millionth of a liter or less.

Such microfluidic devices would allow doctors to take a very small sample of blood and quickly identify whether someone had a malignant tumor. This "lab on a chip" could help doctors test for illness in the least invasive way possible.

The team also exploited Titan's GPU accelerators and developed uDeviceX, a GPU-driven particle solver. Developed by Brown's Yu-Hang Tang, the solver is an important part of the team's code that helps plot individual particles in the simulation. In fact, it showed a 45-fold decrease in time to solution compared with competing state-of-the-art methods.

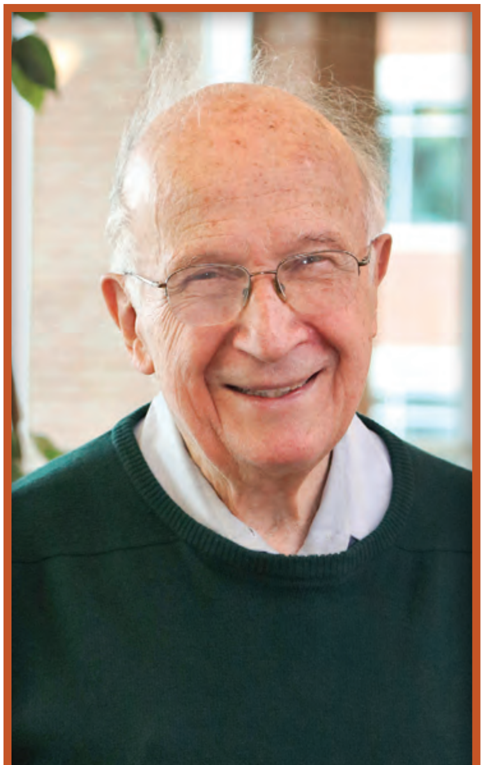
The achievement made the team a finalist for the 2015 Association for Computing Machinery Gordon Bell Prize—one of the most prestigious awards in high-performance computing.

Besides Brown, researchers on the team come from ETH Zurich, the Universita della Svizzera Italiana, and Consiglio Nazionale delle Ricerche.

For more information: http://go.usa.gov/cmbAk

Distinguished

Roald Hoffmann



Roald Hoffmann, a corecipient of the 1981 Nobel Prize in Chemistry, is the Frank H.T. Rhodes Professor of Humane Letters Emeritus at Cornell University. Having survived World War II, he came to the U.S. in 1949. Besides his scientific achievements, Hoffmann is an accomplished author who has published a number of plays and collections of poems, essays and lectures.

Dr. Hoffmann delivered the Eugene Wigner Distinguished Lecture Feb. 9, 2016, on the topic "The Chemical Imagination at Work in Very Tight Places." We asked him about the study of matter under high pressure, his experience as a Holocaust survivor and his work in the arts.

1. **What can we gain from studying matter under high pressure?**

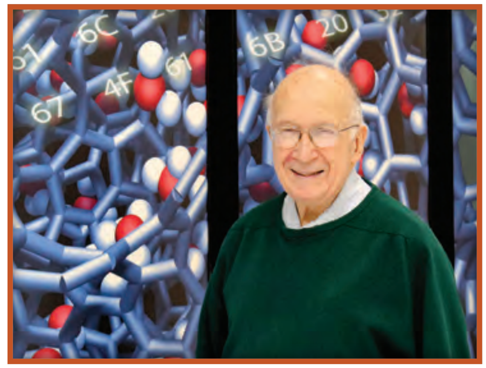
Under high pressure, there could be chemical compounds formed that are not formed under normal conditions on Earth. If we can go back from there and retrieve them, they could be useful. An example is the synthesis of industrial diamonds under pressure from coal, from graphite. I'm a theoretician, and there is also a kind of intellectual depth that I gain from looking at something under extreme conditions. It's a little bit akin to what philosophers do by forming paradoxes. That is, by exploring paradoxes, you get some understanding of the basic rules in the normal world. So if I can understand the behavior of matter under extreme conditions, like high pressure or high temperature—or low pressure, low temperature—if my methods for studying these things work under extreme conditions, I gain confidence that they will work under normal conditions. And sometimes, I explore limits. So the limits help me understand what is wrong with my theory. They, in a sense, stress my theory. And by stressing it, I get insight.

2. **You are a published poet and playwright as well as a scientist. What is the connection between your work as a scientist and your work in the arts?**

I think it's very personal, in the first place. It all began in college for me with an inspiration by literature to write, but I didn't do it until middle age. If one asked the question, "How have the two influenced each other," I think poetry and writing in general have influenced my science. I learned the power of concision, of something said in a few words. I learned how to touch somebody emotionally. I write lots of papers. The average graduate student, who is the audience for my papers, I need to reach them. They are a remote reader, a remote learner. There is no way I can grab them by their neck and say, "This is what I meant, and not that." They're looking at my text. In those words, the most important thing I can communicate to grab them is that I care that you learn. And it's the I–you that's the emotional tie. It's really hard to do that in a dry, third-person scientific text. But I learned something about the strategies even in that constrained medium. And it's much, in some ways, against science that we have constrained that medium of scientific expression. There are good sides to that constraint, too. But even in that constrained medium of a scientific article, I think I've learned something from my poetry about how to touch the reader. And that's very important.

From the science, I've gotten some metaphors for my poetry—some ideas to write poetry about. I'll give you an example. I went to a seminar with someone talking about boundary conditions for some mathematical equation. The seminar was boring; I fell asleep. I woke up; the guy was still talking. I stopped listening, and I began to listen to the words. I began listening to the words rather than to their meaning in some way. And at some point he said, "Let us assume for this equation, free boundaries." He was talking about some limits on the mathematical function, and he was going to set them free. The moment he said "free boundaries," I wrote it down. There was a poetic phrase. Why? Because free and boundaries are a contrast; they're opposite things. That's the making of a poem. I found that in a scientific lecture.

Lecturers



3. You are also a Holocaust survivor. How did that experience affect your career?

I am. I'm a childhood survivor. I'm the last generation of Hitler's gifts to America, and that has a lot to do with the story. Of course, there was incentive after surviving that; most of my family was killed, including my father and three of four grandparents, but my mother survived. We were Jewish. We were in a bad place—southeast Poland—during the war. I'm old enough to have been born before World War II. I was a childhood survivor.

There were certainly a lot of incentives to succeed, to make use of everything good about America—and education that could lead you to something, irrespective of your social class or your income, actually. I think there was more the immigrant experience, that you were an outsider. English was my sixth language when I came here. I didn't know the language; I was ahead of the kids in math—that was coming from Europe; that is what was in the education system. But when you're an outsider, what you do is you listen, and you try to figure out what it is that people say, what is the underlying motivation, or reasons, or truth. And in some ways that's a little like science. I'm outside this nature that I have of molecules behaving in a certain way. A calcium near nitrogen; what is it going to do? I can't touch it, I can't ask it. I just watch from outside with my tools, with my senses. And I think that the fact that many immigrants—and that's true today for Asian-Americans just as it was for the Jewish immigrants in my time after World War II—that many of them first become scientists, and then enter other aspects of society, has something to do with the immigrant experience, and just the nature of being on the outside and watching. So that's an influence.

4. Why was it important to visit ORNL, meet with researchers here, and participate in the Wigner Lecture Series?

First of all, the national laboratories have played an important role in my life that people don't know about. When I was at Columbia in college, from the summer between high school and college, I worked during my college years every summer in national laboratories. Not here, but two summers at the National Institutes of Standards and Technology, and two at Brookhaven National Laboratory, which is more parallel to Oak Ridge. Those summers gave me an introduction to research, and they were a great counterpart to boring chemistry courses in college. So I think I became a chemist because of an experience at a national laboratory, so I always have a fond place in my heart for national laboratories.

There is a particular situation here that interests me. It is now 60 years after those college days, essentially, and I'm still at it. The next molecule still gets me excited, and I'm in a research program with some people at Carnegie Institution of Washington who do their research here at ORNL using the Spallation Neutron Source, which is unparalleled in the world to get at the structures of matter under extreme pressure. I knew that they used, for instance, a certain kind of press to compress between two diamonds, matter to this extreme state of high pressure. But, you know, I had never seen it. It's a whale of a difference to see this incredible piece of equipment, and to see the laboratories, and to see the ports of the spallation facility, too. I'm very glad I came down here to see it.

The Eugene P. Wigner Distinguished Lecture Series in Science, Technology, and Policy gives scientists, business leaders and policy makers an opportunity to address the ORNL community and exchange ideas with lab researchers. The series is named after Eugene Wigner, ORNL's first research director and recipient of the 1963 Nobel Prize in Physics.

Andrew Briggs is the inaugural chair in nanomaterials at the University of Oxford. He is best known for his early work using acoustic microscopy to solve problems in materials science and for more recent work developing materials and techniques for quantum technologies. His laboratory studies single-molecule devices for low-energy information and communication technologies and for simulating quantum processes in biology. He recently published The *Penultimate Curiosity: How Science Swims in the Slipstream of Ultimate Questions*, with coauthor Roger Wagner.

Professor Briggs delivered the Eugene Wigner Distinguished Lecture March 8, 2016, on the topic "The Unreasonable Effectiveness of Curiosity." We asked him about his book, single-molecule devices and the relationship between fundamental and applied research.

Distinguished

Andrew Briggs

1. How do explorations of fundamental science and applied technology reinforce one another?

The relationship between fundamental science and applied technology is a subtle and fascinating one. It never ceases to amaze me how time and again, when you investigate something just because you're curious about it and you want to understand it, it may turn out to be useful and significant for technology. And, conversely, sometimes when you're trying to solve a technological problem, you learn all sorts of fundamental things that are absolutely fascinating. Materials science is a very good example of that, because much of materials science has been driven by technological need—I'm sorry to say sometimes by warfare needs—and it's led to fascinating understanding of what stuff is made of and what makes stuff strong, or malleable, or suitable for the particular purpose for which you want to use it.

Conversely, time and again when people have studied fundamental properties, just because they wanted to understand it, it's turned out to produce materials that may be suitable for applications that they may not have had in mind at all when they undertook the original research.

2. Tell us about your book, *The Penultimate Curiosity: How Science Swims in the Slipstream of Ultimate Questions*?

The book was published last week in the U.K. It's about to be published in the USA. It's called "The Penultimate Curiosity," and the subtitle really tells you what it's about: It's about how science swims in the slipstream of ultimate questions. I wrote it with an artist, Roger Wagner, and he and I have been talking about and thinking about these things more than 16 years now. What we're basically exploring in the book is the way that, time and again, when you've had a culture or community—or occasionally it can just be an individual—who's been interested in ultimate questions, that has led to significant advances in what we would now think of as science. Questions about meaning and purpose and value and beauty and God and belief and whatever really mattered to them at an ultimate level, which may have lain beyond the rim of the material world. Time and again, that has led to significant advances in what we would now think of as science. You have to be careful not to use categories of religion and science in times when they didn't really apply in the sense of their modern meanings. But nevertheless, where people have been asking these big questions, what we now think of as science has, as it were, swum in the slipstream that's been created by the curiosity about these ultimate questions.

Lecturers

3. In your research you also study single-molecule devices. What are single-molecule devices, and how can they be useful?

A single-molecule device is an electrical device where the active element is one single molecule. The breakthrough in the last few years that's made it possible to have reproducible and stable single-molecule devices is to use, for the contacts, a nanoribbon of graphene in which we have a method that we've patented of creating a gap that's about one molecule wide. And then we take a molecule that's got the properties of interest, and we attach to it two anchor groups—they're sort of like sticky Post-it notes that stick to the two sides of the graphene—and then we can control and investigate how current flows through this device. And we're particularly interested in cases where there are significant quantum phenomena—of quantum interference or quantum resonance—that first of all enable us to study these things, so it's sort of completing the spectroscopy of molecules, because we're now looking at how charge can flow through, and in particular how it can flow through multiple pathways and get interferences between them. Once we understand these things, it may provide the basis for some really important technologies—technologies to make transistors that have significantly lower power consumption than current transistors, ways of harvesting heat to make electricity from temperature differences between two places, and even possibly for further-on applications like machine learning, possibly even genome sequencing as well.

4. Why was it important to visit ORNL, meet with researchers here, and participate in the Wigner Lecture Series?

It's been hugely enjoyable visiting Oak Ridge National Lab. I've been made to feel so welcome. And I've met such delightful and such very stimulating people. As far as the lecture goes, it's a real privilege to be able to share some of the things that have become important to me in my own research career and my thinking. And I hope it may be a stimulus to some of the researchers here, perhaps some of the researchers at an earlier stage of their career. I specifically gave the title of "The Unreasonable Effectiveness of Curiosity," and I hope it will give them not only permission but also encouragement to be curious in their work and in their lives. I've made contact with a number of scientists on very specific projects where I hope we may be able to establish collaborations. And we're also talking about the possibility of a larger effort to develop materials for low-energy-consumption information and communication technologies, to tackle the ballooning consumption of electricity by computers and other related technologies. And it may be that this may become part of Oak Ridge National Laboratory's vision, perhaps in communication with the U.S. government, but I hope more widely, so that there might become a U.S. national, but maybe even a global, effort to develop materials that have the potential to reduce the electricity consumption of computing and related technologies.

The Eugene P. Wigner Distinguished Lecture Series in Science, Technology, and Policy gives scientists, business leaders and policy makers an opportunity to address the ORNL community and exchange ideas with lab researchers. The series is named after Eugene Wigner, ORNL's first research director and recipient of the 1963 Nobel Prize in Physics.

ORNL is proud of its role in fostering the next generation of scientists and engineers. We bring in talented young researchers, team them with accomplished scientists and engineers, and put them to work at the lab's one-of-a-kind facilities. The result is research that makes us proud and prepares them for distinguished careers.

We asked some of these young researchers why they chose a career in science, what they are working on at ORNL, and where they would like to go with their careers.

Allyn Milojevich

Postdoc, Global Security Directorate
Ph.D., Political Science, University of Tennessee–Knoxville
Hometown: Cleveland, Ohio

What are you working on at ORNL?

I'm the first postdoc the Global Security Directorate has hired. While I work on a variety of projects, I predominantly support chemical security work in GSD, working internationally to assure chemicals of concern are protected from those seeking them for nefarious purposes. This involves teaching workshops to train technical experts on security best practices.

What would you like to do in your career?

I plan to work on security issues at ORNL for the foreseeable future. My ultimate goal is to work for the Organization for the Prohibition of Chemical Weapons while continuing to collaborate with national labs. I have two small children, and my legacy is to help leave a safer, more secure world for them.

Why did you choose a career in science?

Chemistry has advanced the world, but it has created security concerns when chemicals are used by those seeking to harm others. I hold an M.S. in analytical chemistry, but my Ph.D. is focused on public policy. I love that I get to use my background to contribute to a safer and more secure world.

Mark Christian

Graduate student, Environmental Sciences Division
Ph.D. student, Energy Science and Engineering, University of Tennessee–Knoxville (Bredesen Center)
Hometown: Pensacola, Florida

What are you working on at ORNL?

My research is focused around determining the number of sensors that describes the flow rate to a sufficient level of accuracy. The flow rate is a critical indicator of a hydropower plant's health and efficiency, and knowledge of this allows the plant to operate more effectively.

What would you like to do in your career?

I would like to be a leader within the hydropower industry and push the field forward. Hydropower is a well-established means of power production; still, there's room to expand from both a general capacity and a load-support standpoint. In addition, I'd like to mentor through venues such as the Hydro Research Foundation.

Why did you choose a career in science?

I've always enjoyed challenges that allow me to make a tangible, novel impact on the world. A series of wonderful teachers fostered my interests and gave me opportunities to work on real-world projects, including experiments in high school and undergrad. A highlight was my senior capstone project: the design, construction and deployment of a full-scale wave-energy device.

Amelia Fitzsimmons

Postdoc, Oak Ridge Leadership Computing Facility
Ph.D., Chemistry, University of Alberta
Hometown: St. Louis

What are you working on at ORNL?

I am part of the Scientific Computing Group within the Computing and Computational Sciences Directorate, and I'm working with a relativistic chemistry code. I'll use it to look into some of the interesting properties of actinide chemistry. I'll also be helping to get the code ready to run on ORNL's next supercomputer, Summit.

What would you like to do in your career?

I'd like to keep working in computational chemistry research. I enjoy teaching lab classes, too, but for now I want to focus on research and see where that takes me.

Why did you choose a career in science?

What I really love about physical chemistry is that it gives you the math to completely take a problem apart and analyze every little detail of a molecule's properties or a bulk system's behavior. That's really beautiful to me.

Mariya Absar

Graduate student, Environmental Sciences Division
Ph.D. student, Energy Science and Engineering, University of Tennessee—Knoxville (Bredesen Center)
Hometown: Islamabad, Pakistan

What are you working on at ORNL?

I study the impacts of climate change on the energy, water and land nexus to determine the best adaptation alternatives. I helped develop socioeconomic scenarios for modeling impacts and vulnerabilities of the water and energy sectors in the Southeast. Currently I'm studying global warming potential and water usage of the shale gas production process in Texas.

What would you like to do in your career?

I would like to continue with my research and apply the modeling, economics and policy knowledge I acquired from ORNL while working as a post-master's researcher and Ph.D. student. I'm also gaining knowledge and experience in life-cycle assessment so I can consult with companies or policymakers on low-impact practices and policies.

Why did you choose a career in science?

I have always been fascinated by science, as it's the best way to understand the world around us. It is very rewarding for me to be a part of a team, institute and organization that conducts research to understand realities and finds the best pathways to build a more sustainable world.

Akinola Oyedele

Graduate student, Center for Nanophase Materials Sciences
Ph.D. student, Energy Science and Engineering, University of Tennessee–Knoxville (Bredesen Center)
Hometown: Lagos, Nigeria

What are you working on at ORNL?

My work at CNMS focuses on understanding the optoelectronic properties of layered-semiconductor materials like graphene. Achieving single-atom thickness offers a lifeline to continue Moore's law and makes these materials exciting for applications including transistors, solar cells and memory devices. The combination of two or more of these materials in "heterostructures" enables the discovery of new phenomena.

What would you like to do in your career?

I'm interested in developing technologies with huge impacts in people's lives and would love to bring them to market. For example, I want to develop solutions for the energy crisis in Africa. I'm also interested in education; last year, I kick-started the Future Energy Leaders' Initiative in Nigeria, bringing knowledge of explorable energy technologies to students.

Why did you choose a career in science?

I contemplated choosing a career in business or in science because my interest lies between these fields. I ultimately chose science to hone my problem-solving and creative thinking skills and to be in the forefront of technological development. I then began an interdisciplinary Ph.D. program to combine my interests in science and business.

Orsolya Karacsony

Postdoc, Chemical Sciences Division
Ph.D., Materials Science, Carnegie Mellon University
Hometown: Budapest, Hungary

What are you working on at ORNL?

I finished a hybrid-platform imaging project recently. I was responsible for the atomic-force microscope and infrared spectrometer imaging and have been working with mass-spec experts on collecting images with chemical information. Currently, I'm studying polymers and their blends using continuous thermal desorption and material decomposition of a sample from an area of arbitrary shape.

What would you like to do in your career?

I would like to continue doing research but move into the intersection of materials sciences, biology and computer science because I think that interdisciplinary research is the future. This has been the long-term goal I have been working on over the past decade, ever since I took an interest in science.

Why did you choose a career in science?

I am a curious person with an eternal thirst for knowledge, an analytical mind and heroic dreams about making the world better. Where else would I be than in science?

Oil crisis in '70s highlighted need for coherent energy policy

by Tim Gawne
gawnetj@ornl.gov

A casual observer might be forgiven for thinking the Manhattan Project produced nothing more than a bomb. In reality, the physicists who harnessed the atom also opened the door to a practically inexhaustible energy source.

That reality was clear to future Nobel Prize-winner Eugene Wigner. When Wigner agreed to direct research at what was then Clinton Laboratories, one of his primary goals was to develop a nuclear reactor that produced electric power. In fact it was his protégé—longtime ORNL Director Alvin Weinberg—who led the lab's effort on the Homogeneous Reactor Experiment, which put 150 kilowatts of electricity on TVA's grid in 1954.

Alvin Weinberg (left) and Eugene Wigner.

Weinberg realized, however, that as promising as nuclear power was, ORNL would have to broaden its scope. Through the 1960s, he pursued other lines of research and is credited with preparing the lab for challenges looming in the future.

Those challenges were not long in coming. In June 1973, President Nixon called for a report on U.S. energy R&D, but by the time the report was delivered in December, events had already brought America's need for a coherent energy policy into painful focus.

That October, the Organization of Arab Petroleum Exporting Countries cut off oil sales to the United States and other countries that supported Israel during the Yom Kippur War. The price of crude oil more than tripled, and petroleum products such as heating oil, diesel, and gasoline were expensive and scarce. At ORNL, fuel was rationed, thermostats were lowered, and the steam plant was converted from heating oil and natural gas back to coal.

The Arab oil embargo demonstrated just how precarious America's energy position was. When Atomic Energy Commission Chairman Dixy Lee Ray delivered Nixon's report in December, it pointed to an array of alternative and renewable technologies—as well as conservation measures.

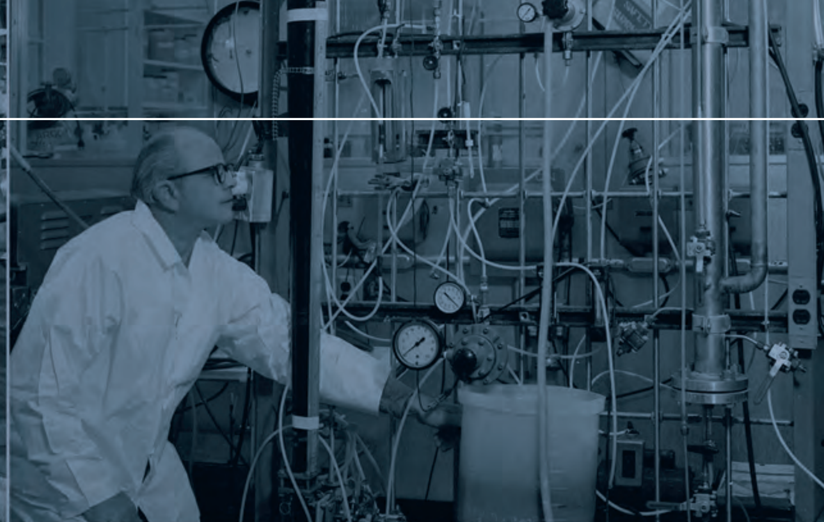
The year was also stressful for ORNL, as the lab lost both Weinberg and a number of major projects. But 1974 was better: ORNL had a new permanent director—Herman Postma—and new opportunities with the passing of the Energy Reorganization Act of 1974 and the creation of the Energy Research and Development Organization.

ORNL's research focus expanded to include bioenergy, solar power, geothermal energy, energy conservation and grid technologies. The lab's research in nuclear technologies—both fission and fusion—grew as well.

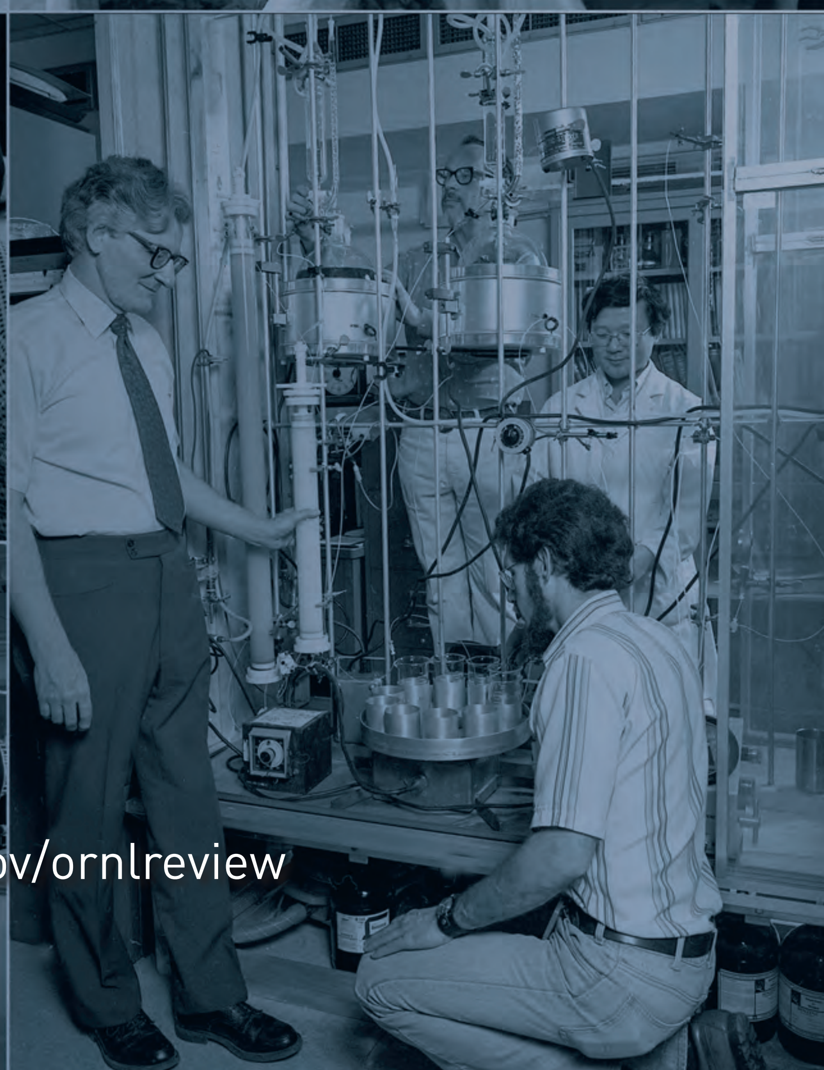
Postma's 1975 State of the Laboratory address discussed the impact of the oil embargo and resulting energy crisis:

"With the price of energy rising by a factor of three, the public became further aware of the impact of energy on every aspect of their lives, and moreover, the public now seems cognizant of the important role of technology."

Many of the challenges that catalyzed American energy policy in the '70s are still with us, but other factors are relatively new. The worldwide demand for reliable, clean, low-cost energy is greater than ever, and ORNL is positioned to meet these technological challenges, just as it was four decades ago.





www.ornl.gov/ornlreview

OAK RIDGE NATIONAL LABORATORY REVIEW
PO Box 2008, Oak Ridge, Tennessee 37831-6266

PRSRT STD
US Postage
PAID
Permit No. 3
Oak Ridge, TN

Editor—Leo Williams
Writers—Bill Cabage, Tim Gawne, Eric Gedenk, Dawn Levy, Morgan McCorkle, Jim Pearce, Jeremy Rumsey, Ron Walli, Ashanti B. Washington, Leo Williams, Jenny Woodbery
Designer—Brett Hopwood
Illustrators—Brett Hopwood, Andy Sproles
Copy editor—Wendy Hames
Photographers—Carlos Jones, Jason Richards
Stock images—iStockphoto™

Phone: (+1) 865.574.8891
Fax: (+1) 865.574.0595
E-mail: ornlreview@ornl.gov
Internet: www.ornl.gov/ornlreview

Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the US Department of Energy under contract DE-AC05-00OR22725

ISSN 0048-1262

Oak Ridge National Laboratory

U.S. Department of Energy