PennState
Materials Research
Institute

FOCUS on MATERIALS

MATERIALS RESEARCH INSTITUTE BULLETIN

SPRING/SUMMER 2021

MEET THE NEW GUARD

Spotlights on New Materials Faculty

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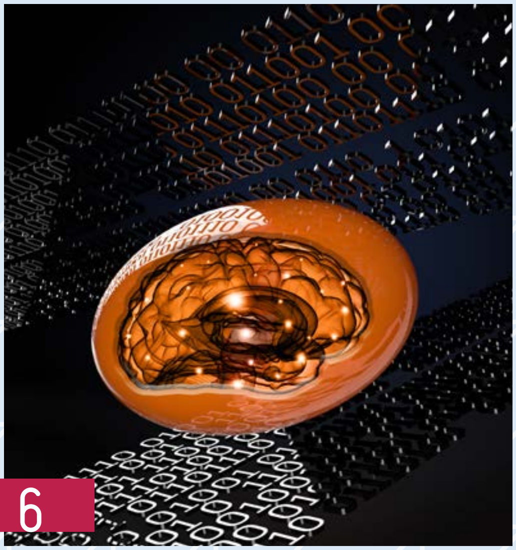

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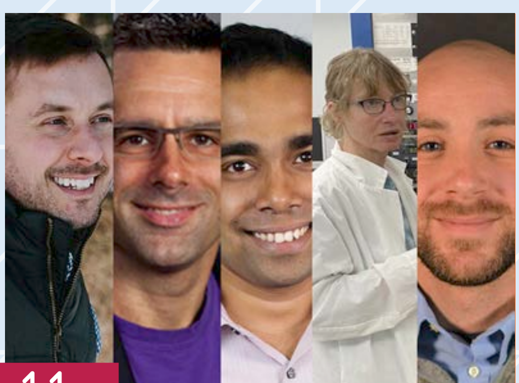

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Focus on Materials is a bulletin of the Materials Research Institute at Penn State University. Visit our web site at **www.mri.psu.edu**.

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From the New Editor

Often, we see examples of a new person taking over for someone who has set a high bar. It can be the rookie quarterback taking over for the future Hall of Famer, or a new person taking over for the beloved mayor who has been in her post for years. I find myself currently in that role.

Allow me to introduce myself. My name is Jamie Oberdick, and I am the new writer/editor for the Materials Research Institute (MRI), and the new editor for Focus on Materials. I am here because my predecessor, Walt Mills, retired last October, and I became the full-time "New Walt" on November 1.

These are, as the saying goes, big shoes to fill. I knew of Walt for a long time due to my being a Penn State communicator since March 2005. This is despite my working in the IT communications side of things for the first 13 years of my career, as his reputation as a strong writer extended beyond the science and engineering research world at the University. When I joined the College of Engineering in early 2018, I got the honor of working with him from time to time, as our paths crossed due to faculty I supported having joint appointments with MRI.

I was always impressed with Walt's writing, the way he took the very high-level complexities of our research and broke them down in a way that a layperson could understand. Because for people to understand why something should matter to them, they need to know what it is.

I believe this is extremely important, because while MRI's audience includes industry experts, government officials, and materials-related faculty within and beyond Penn State, we should also strive to reach the general public. By making our research more accessible, we can then give people the "so what," meaning the potential everyday applications and societal benefits of our research, which in turn will help people understand how our research helps them in some very real ways.

It is perhaps fitting that the first edition of Focus on Materials that I am serving as editor of has the theme "Meet the New Guard." We are spotlighting many of our newest faculty, couched in a subtheme of looking forward to a brighter future in a world that is still being affected by the Covid-19 pandemic. There are many exciting new things happening in the world of materials that we are at the forefront of, from materials for sustainability to 2D materials to 5G (and soon 6G!) to quantum, and more. It is such a great honor and privilege to tell the world these stories.

While I have only met some of them virtually and not in person due to the pandemic (such a strange time to start a new job), I have also been impressed with the MRI staff. I am part of a great MRI communications team that includes our team lead and graphic artist extraordinaire Jennifer McCann, virtuoso graphics person Elizabeth Floresgomez Murray, and our wonderfully creative multimedia person, Seana Wood. Beyond my immediate team members, everyone at MRI has been fantastic to work with and they are the people behind the scenes who enable the great work our faculty produce on a daily basis.

And finally, I would also like to thank Clive Randall, the director of MRI, for giving me this opportunity to be part of such a dynamic group. My goal now is to live up to the example that Walt set for me. Here's to a great first issue, and to the great research stories we at MRI will share with you in the future.

Sincerely,
Jamie Oberdick

From the Director

In my last two director's messages in Focus on Materials, COVID-19 dominated our thoughts. Of course, it had to as we needed to protect research, education, and our institute. The dedication, resilience, creativity, and sense of "we're in this together" was something I saw every day at MRI (even if it was over Zoom, or walking in a very lonely Millennium Science Complex!). While planning and working hard on the immediate issues, we also had the opportunity to reflect and plan for a better future. It is from that most exciting perspective that this Focus on Materials considers the MRI community.

We here wanted to share with you all the new talent that arrived just before the COVID year, or that we recruited to Penn State in the COVID times with Zoom. This generation of new faculty will inevitably contribute to the future of materials at Penn State. Our hope is that in this issue we will introduce you, and your colleagues, to new intellectual collaborations and insights into interdisciplinary research.

This fresh expertise is important, as we have big plans for MRI. Our vision of what MRI can do includes meeting goals such as advancing materials synthesis, enabling a center for living materials, building on our state-of-the-art facilities, digging into quantum materials and devices, developing sustainable materials, and working with our industry partners to drive these innovations forward and into society. We chose talented researchers to help us in reaching these pinnacles. All commensurate with the strategic planning process, supporting Penn State's commitment to domestic and global challenges.

The net of materials research casts wide into all sorts of different fields and our new talent reflects that. They are individuals who hold joint appointments across the Penn State research world, holding positions with partners such as the Penn State College of Engineering, the Eberly College of Science, and the College of Earth and Mineral Sciences. In some cases, they also hold appointments with our peer institutes such as the Huck Institutes of the Life Sciences and the Institutes of Energy and the Environment. This interdisciplinary approach and intellectual network are very, very important to us – and continually drives our faculty to succeed in addressing complex problems.

Since there have been a lot of new hires in the last year-and-a-half, we can provide you with just a taste of the great research these new faculty do. They represent research areas such as 5G technology, nanomaterials for safe and efficient drug delivery, corrosion prevention for better and longer-lasting infrastructure, soft autonomous materials, improved catalytic processes, machine learning, and so much more. We suggest you check out their websites and contact them to learn more and perhaps build new collaborative efforts.

Speaking of collaborations, I would also like to mention that the 2021 Materials Day planning is well underway. We are being optimistic that the pandemic situation will allow us to offer a hybrid mix of in-person and virtual options, but of course this is reliant on COVID-19 protocols. This event will feature breakout sessions, poster sessions, keynote speakers, a State of MRI presentation, and plenty of opportunities to meet our faculty, graduate students, and staff whether in person or virtually (including the people highlighted in this issue). Often, these networking opportunities will lead to productive joint projects. Stay tuned to this link for more details including registration and schedule information: mri.psu.edu/materialsday.

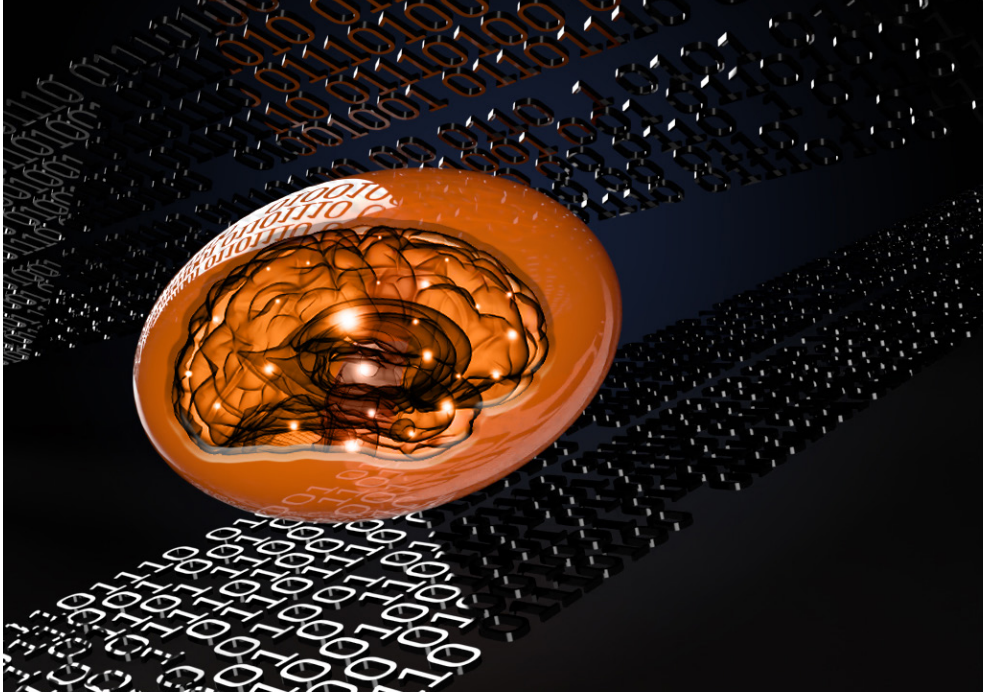
Let's embrace the new opportunities as we come together, and please embrace the new adventures that we can address with our new colleagues.

Sincerely,

Director, Materials Research Institute

research SNAPSHOTS

Research Snapshots are brief summaries of significant materials-related breakthroughs by Penn State researchers.



New soft, mechanical metamaterials can "think" about how forces are applied to it and respond via preprogrammed reactions.

IMAGE: Jennifer M. McCann Penn State MRI

Helpful, engineered 'living' machines in the future? New soft, responsive metamaterial holds potential for wide variety of societal benefits

ENGINEERED, LIFE-LIKE AUTONOMOUS machines combined with artificial intelligence have long been a staple of science fiction, and often in the role of villains. But what if these autonomous soft machines were ... helpful?

This is the vision of a team of Penn State and U.S. Air Force researchers, outlined in a recent paper in Nature Communications. These researchers produced a soft, mechanical metamaterial that can "think" about how forces are applied to it and respond via programmed reactions.

"Our paper reports a way to create decision-making functionality in engineered materials in a way that could support future soft, autonomous engineered systems that are invested with the basic elements of lifeforms yet are programmed to perform helpful services for people," said Ryan Harne, James F. Will Career Development Associate Professor, Penn State.

The soft materials that the research team created "think" using the reconfiguration of the conductive polymer networks. Mechanical force, applied to the materials, connects, and reconnects the network. Using a low-voltage input into the materials, the research team created a way for the soft material to decide how to react according to the output voltage signal from the reconfigured conductive polymer network.

The type of logic that Harne and the team uses goes beyond pure mechanical logic, which is a way of using combinations of bistable switches — switches with two stable states — to represent the "0s" and "1s" of a binary number sequence. They found that when they used pure mechanical logic, the researchers ended up getting stuck.

"You hit a point where you can't actually process all of the eight logic gates," Harne said. "You can process four of them, but you can't process the last four. We discovered the way to incorporate electrical signals along with mechanical signals, allowing us to process all of the logic gates used in modern digital computing."

The researchers created the logic operations by simultaneously reconfiguring the soft material and the electrically conductive network. This also ensures that the binary output is in the form of electricity, which is needed to drive an actuation mechanism that makes the material respond to the applied mechanical force.

Harne and the team want to go beyond a single material and design something more complex.

"I have a vision for how scientists and engineers can create engineered living systems that help society," Harne said. "All you need to do is bring together all of the functions of life forms. And when you do that, you have at your disposal the building blocks of engineered life."

Along with Harne, other authors of the study include from Penn State Charles El Helou, doctoral student in mechanical engineering and from the U.S. Air Force Research Laboratory, Philip Buskohl and Christopher Tabor.

Harne's National Science Foundation Early Career Development Award and the U.S. Air Force funded this research. ■

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Full articles on all snapshots can be read at **mri.psu.edu/news**

Kirigami-style fabrication may enable new 3D nanostructures

A NEW TECHNIQUE THAT mimics the ancient Japanese art of kirigami may offer an easier way to fabricate complex 3D nanostructures for use in electronics, manufacturing, and health care. Kirigami enhances the Japanese artform of origami, which involves folding paper to create 3D structural designs, by strategically incorporating cuts to the paper prior to folding.

"We used kirigami at the nanoscale to create complex 3D nanostructures," said Daniel Lopez, Penn State Liang Professor of Electrical Engineering and Computer Science, and leader of the team that published this research in Advanced Materials. "These 3D structures are difficult to fabricate because current nanofabrication processes are based on the technology used to fabricate microelectronics which only uses planar, or flat, films. Without kirigami techniques, complex three-dimensional structures would be much more complicated to fabricate or simply impossible to make."

Lopez said that if force is applied to a uniform structural film, nothing really happens other than stretching it a bit, like what happens when a piece of paper is stretched. But when cuts are introduced to the film, and forces are applied in a certain direction, a structure pops up, similar to when a kirigami artist applies force to a cut paper. The geometry of the planar pattern of cuts determines the shape of the 3D architecture.

"We demonstrated that it is possible to use conventional planar fabrication methods to create different 3D nanostructures from the same 2D cut geometry," Lopez said. "By introducing minimum changes to the dimensions of the cuts in the film, we can drastically change the three-dimensional shape of the pop-up architectures. We demonstrated nanoscale devices that can tilt or change their curvature just by changing the width of the cuts a few nanometers."

This new field of kirigami-style nanoengineering enables the development of machines and structures that can change from one shape to another, or morph, in response to changes in the environment.

"This kirigami technique will allow the development of adaptive flexible electronics that can be incorporated onto surfaces with complicated topography, such as a sensor resting on the human brain," Lopez said. "We could use these concepts to design sensors and actuators that can change shape and configuration to perform a task more efficiently."

Lopez will focus his future research on applying these kirigami techniques to materials that are one atom thick, and thin actuators made of piezoelectrics. He said his goal is to work with other researchers at Penn State's Materials Research Institute (MRI) to develop a new generation of miniature machines that are atomically flat and are more responsive to changes in the environment.

"MRI is a world leader in the synthesis and characterization of 2D materials, which are the ultimate thin-films that can be used for kirigami engineering," Lopez said.

Other authors on the study include Xu Zhang from Carnegie Mellon University and Haogang Cai from New York University, both former postdoctoral fellows with Lopez. Lior Medina and H. Espinosa from Northwestern University and Vladimir Askyuk from the National Institute of Standards and Technology also are part of the team. The research was supported by the U.S. Department of Energy. ■

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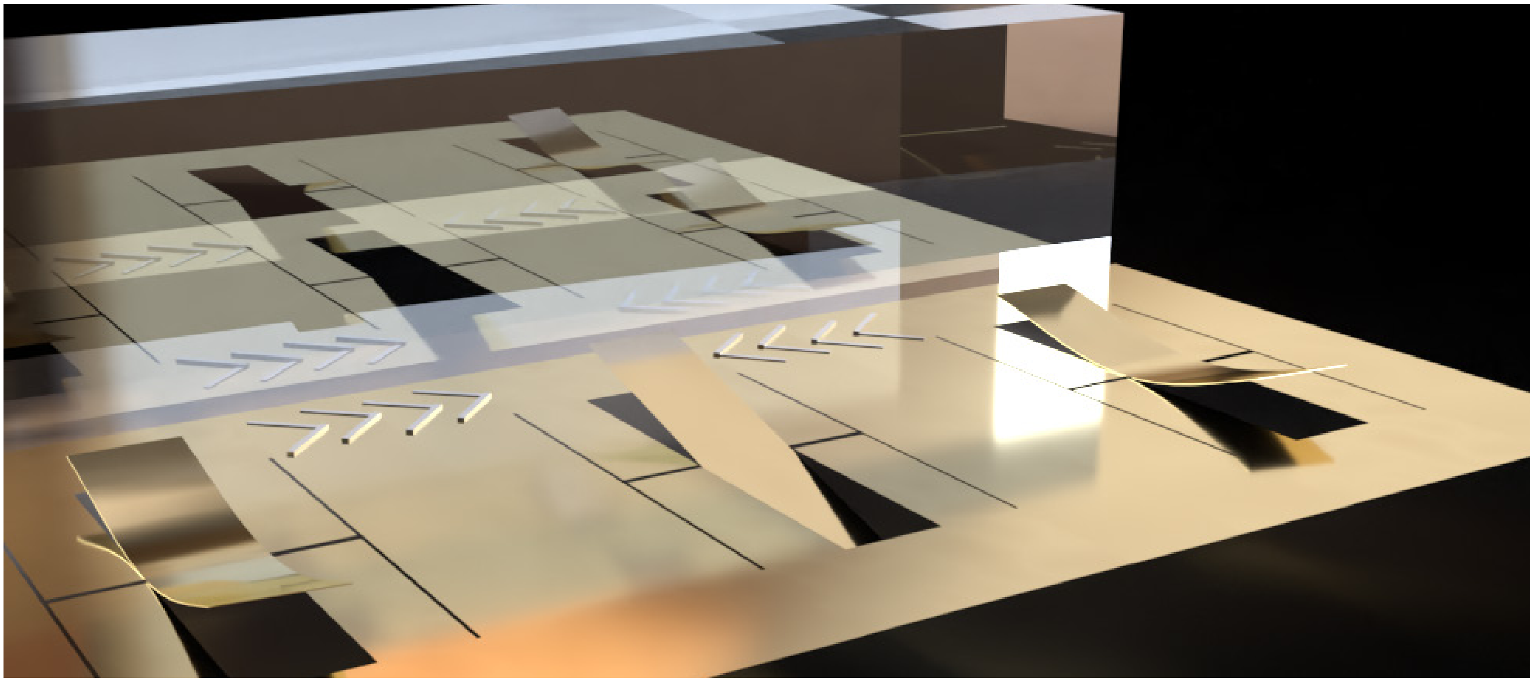


Strategically placed cuts to structural films can create 3D nanostructures when force is applied to the films, similar to how kirigami cuts made to paper can create pop-up structures.

IMAGE: Jennifer M. McCann / Penn State MRI

Sushi-like rolled 2D heterostructures may lead to new miniaturized electronics

THE RECENT SYNTHESIS of one-dimensional van der Waals heterostructures, a type of heterostructure made by layering two-dimensional materials that are one atom thick, may lead to new, miniaturized electronics that are currently not possible, according to a team of Penn State and University of Tokyo researchers.

Engineers commonly produce heterostructures to achieve new device properties that are not available in a single material. A van der Waals heterostructure is one made of 2D materials that are stacked directly on top of each other and held together by van der Waals force.

According to Slava V. Rotkin, Penn State Frontier Professor of Engineering Science and Mechanics, the one-dimensional van der Waals heterostructure produced by the researchers is different from the van der Waals heterostructures engineers have produced thus far.

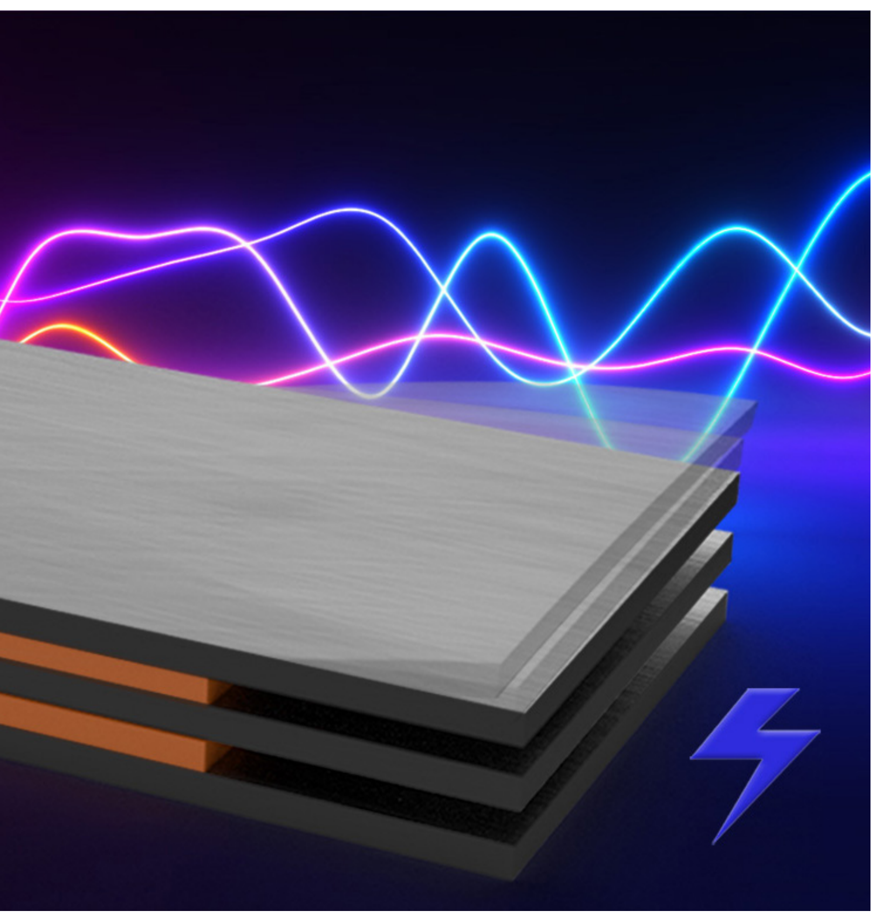
"It looks like a stack of 2D-layered materials that are rolled up in a perfect cylinder," Rotkin said. "In this case you also make it a thin cylinder, very compact like a hotdog or a long sushi roll. In this way, the 2D-materials still contact each other in a desired vertical heterostructure sequence while one needs not to worry about their lateral edges, all rolled up."

The team's research, published in ACS Nano, suggests that all 2D materials could be rolled into these one-dimensional heterostructure cylinders, known as hetero-nanotubes. The University of Tokyo researchers recently fabricated electrodes on a hetero-nanotube and demonstrated that it can work as an extremely small diode with high performance despite its size.

"Diodes are a major type of device used in optoelectronics — they are in the core of photodetectors, solar cells, light emitting devices, etc.," Rotkin said. "In electronics, diodes are used in several specialized circuits; although the main element of electronics is a transistor, two diodes, connected back-to-back, may serve as a switch, too."

Rotkin's contribution to the project was to solve a particularly challenging task, which was ensuring that they were able to make the one-dimensional van der Waals heterostructure cylinder have all the required material layers.

In regular, flat van der Waals heterostructures, confirming existence or absence of some layers can be done easily because they are flat and have a large area. This means a researcher can use various type microscopies to collect a lot of signal from the large, flat areas, so they are easily visible. When researchers roll them up, it becomes a very thin wire-like cylinder that is hard to characterize because it gives off little signal



New piezoelectric material remains effective to high temperatures

PIEZOELECTRIC MATERIALS HOLD great promise as sensors and as energy harvesters but are normally much less effective at high temperatures, limiting their use in environments such as engines or space exploration. However, a new piezoelectric device developed by a team of researchers from Penn State and QorTek remains highly effective at elevated temperatures.

Clive Randall, director of Penn State's Materials Research Institute (MRI), developed the material and device in partnership with researchers from QorTek, a company specializing in smart material devices and high-density power electronics.

Schematic of a piezoelectric energy harvester that transforms mechanical vibrations to electrical energy.

Image: Elizabeth Floresgomez Murray / Penn State MRI and becomes practically invisible. In addition, in order to prove the existence of insulating layer in the semiconductor-insulator-semiconductor junction of the diode, one needs to resolve not just the outer shell of the hetero-nanotube but the middle one, which is completely shadowed by the outer shells of a molybdenum sulfide semiconductor.

To solve this, Rotkin used a scattering Scanning Near-field Optical Microscope that is part of the Material Research Institute's 2D Crystal Consortium, which can "see" the objects of nanoscale size and determine their material's optical properties. He also developed a special method of analysis of the data known as hyperspectral optical imaging with nanometer resolution, to test the structure of the one-dimensional diode along its entire length.

"The beneficial result is in the demonstration of our ability to measure the optical spectrum from the object, which is an inner shell of a wire that is just two nanometers thick," Rotkin said.

Rotkin plans to expand his research to extend hyperspectral imaging to better resolve other materials, such as glass, various 2D materials, and protein tubules and viruses.

Along with Rotkin, other authors of the paper include Ya Feng, Henan Li, Taiki Inoue, Shohei Chiashi, Rong Xiang and Shigeo Maruyama, from the University of Tokyo. The research was funded in part by the Center for Nanoscale Science, which is Penn State's National Science Foundation Materials Research Science and Engineering Center, and by the Japan Ministry of Education, Culture, Sports, Science, and Technology. ■

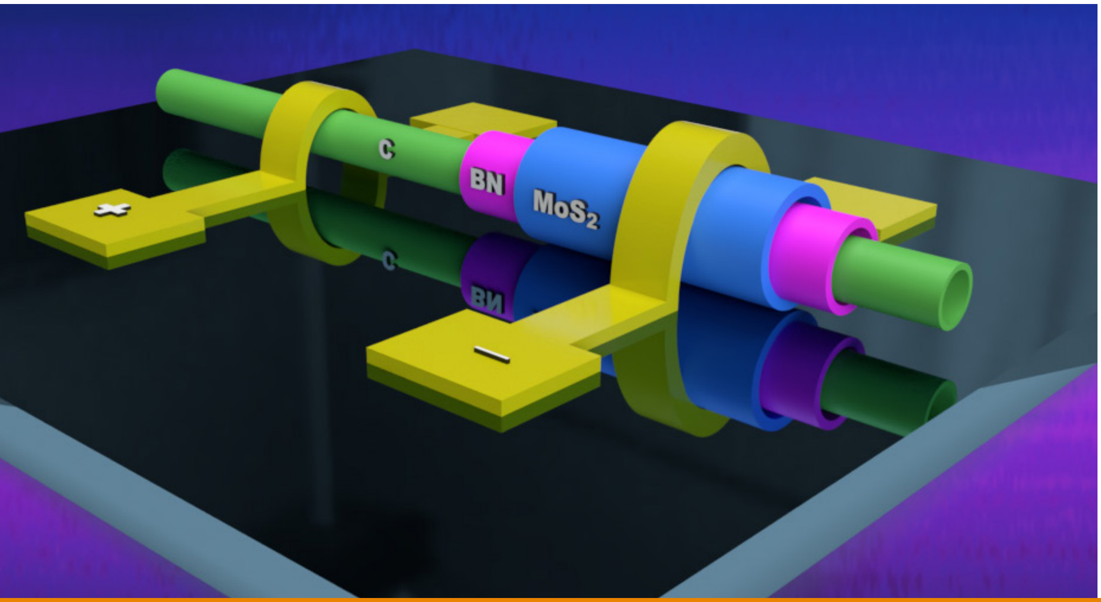


Image of a heterotube diode: This device contains a MoS_2 semiconductor shell (blue), over the insulator hBN shell (purple), over the carbon nanotube core (green) of the heteronanotube covered with gold electrodes (yellow).

Image:
Elizabeth Floresgomez Murray
Penn State MRI

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Piezoelectric materials generate an electric charge when rapidly compressed by a mechanical force during vibrations or motion, such as from machinery or an engine. This can serve as a sensor to measure changes in pressure, temperature, strain, or acceleration. Potentially, piezoelectrics could power a range of devices from personal electronics to bridge stability sensors.

The team integrated the material into a version of a piezoelectric energy harvester technology called a bimorph that enables the device to act either as a sensor, an energy harvester or an actuator.

These functions work less-effectively in high-temperature environments. Current state-of-the-art piezoelectric energy harvesters are normally limited to a maximum effective operating temperature range of 80 degrees Celsius to 120 degrees C.

"A fundamental problem with piezoelectric materials is their performance starts to drop pretty significantly at temperatures above 120°C, to the point where above 200°C their performance is negligible," Gareth Knowles, chief technical officer of QorTek, said. "Our research demonstrates a possible solution."

The new piezoelectric material composition developed by the researchers showed near-constant efficient performance at temperatures up to 250°C. In addition, while there was a gradual drop-off in performance above 250°C, the material remained effective as an energy harvester or sensor at temperatures to well-above 300°C, the researchers reported in the Journal of Applied Physics.

Another benefit of the material was an unexpectedly high level of electricity production. While at present, piezoelectric energy harvesters are not at the level of more efficient power producers such as solar cells, the new material's performance was strong enough to open possibilities for other applications, according to Randall.

"The energy production part of this was very impressive, the material shows record performance efficiencies as a piezoelectric energy harvester," Randall said.

Both Randall and Knowles noted that the partnership between Penn State and QorTek, which goes back over 20 years, enabled development of the new, improved piezoelectric material by complementing each other's resources, such as Penn State's large source of knowledge and state-of-the-art equipment.

Along with Randall and Chen, other authors on the paper include from Penn State, Xiao-Ming Chen, MRI research assistant, and from QorTek, Safakcan Tuncdemir, vice president of materials and devices; Ahmet Erkan Gurdal, materials group manager; and Josh Gambal, mechanical design engineer. The NASA'S Small Business Technology Transfer Program and the National Science Foundation funded this research. ■

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Full articles on all snapshots can be read at **mri.psu.edu/news**

New faculty to push Penn State materials research in exciting new directions, building on MRI's stellar reputation

The Materials Research Institute (MRI) has built quite a reputation as a driver of multidisciplinary materials research and education. MRI is recognized as a national leader in materials science and engineering which promotes scientific excellence, fosters partnerships, and never stops pursuing technological innovation. But MRI's community is not content to rest on its laurels; after all, the only constant in science and engineering is change, and sparking innovation is how MRI built its reputation.

New perspectives from new minds are often necessary for innovation, so MRI has recently brought on board a variety of new faculty members. These faculty members hold joint appointments from a variety of departments in Penn State's College of Engineering, College of Earth and Mineral Sciences, and the Eberly College of Science. This enables MRI to carry out a truly interdisciplinary approach to its research.

These faculty cover materials subjects as varied as computational catalysis, 2D materials, sustainable energy, soft autonomous materials, more efficient energy storage, and more. These hires will help MRI realize the vision the organization has laid out for the first half of this decade, which states:

"MRI is providing researchers with world-class core facilities for material synthesis, characterization, device manufacture, and computation; promoting multidisciplinary teams forming focused centers and multi-university partnerships for large proposals; providing seed grants in strategic areas to leverage Penn State's research and accelerate bold new ideas; and partnering with departments in co-hiring interdisciplinary materials faculty."

So, with this in mind, let's meet some of the newest members of the MRI research team …

Konstantinos Alexopoulos

Penn State Title:

Assistant Research Professor of Chemical Engineering

Comes to Penn State from:

University of Delaware, where he was a post-doctoral researcher in chemical engineering

Research Summary

Alexopoulos' work focuses on computational catalysis and reaction engineering. He researches computer modeling of improved catalysts for uses in emission control and shale gas conversion technology. He develops modeling tools to be used in practices such as decreasing pollution and making fuels and useful chemicals from waste products.

His research group at Penn State will be using computer modeling to establish the fundamentals for an emerging class of catalytic materials. The goal of his modeling efforts is to design improved catalysts and to develop practices that promote process intensification. He is part of a growing team of researchers exploring computational catalysis. ■

"Integrating catalyst design with process intensification is expected to enable the deployment of sustainable chemical conversion technologies for the efficient utilization of stranded resources such as biogas and plastic waste."

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Bert Chandler

Penn State Title:

Professor of Chemical Engineering and Chemistry

Comes to Penn State from:

Trinity University, where he was a professor of chemistry.

Research Summary

Chandler specializes in fundamental mechanistic and reactivity studies of heterogeneous catalysis.

His lab at Penn State is currently working to understand and control the reactivity of supported metal nanoparticles, especially supported Au catalysts. At the metal-support interface (MSI), the Brønsted acid-base and redox chemistry of metal oxides are coupled to the soft Lewis acidity of Au. In the short term, they are learning to control and tune both sides of the MSI chemistry as they develop new catalysts for impactful reactions in energy conversion and storage, environmental chemistry, plastics recycling, and industrial chemicals production. Over the long term, they are working to bring the science of catalysis to bear on a number of related fields.

Heterogeneous catalysis is at the heart of many processes the average person relies on every day including energy generation, transportation fuels, and plastics production. ■

"Our work both directly and indirectly impacts all of these areas. We are especially interested in developing new catalytic chemistries that will allow us to make more efficient use of Pennsylvania shale gas. We are also expanding our program into developing processes that will allow us to convert waste plastics into industrial chemicals, new materials, and fuels."

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Satadru Dey

Penn State Title:

Assistant Professor of Mechanical Engineering

Comes to Penn State from:

University of Colorado Denver, where he was an assistant professor of electrical engineering.

Research Summary

Dey's research is in the applications related to energy and transportation systems in smart cities. Smart cities are cities that use various kinds of electronic sensors to collect data and use that data to create a safe, productive, sustainable, and efficient city.

Specifically, Dey's contribution to save security systems is multipronged. His work including research to improve safety and security of battery systems with respect to physical failures and cyber-attacks.

He also is working on methods of resilient control of connected vehicle systems in the presence of cyber-failures, and socio-technical modeling and control of large transportation networks.

Dey states that safer batteries will help in both electric vehicle market penetration and making the power grids resilient. ■

"Secure connected vehicles will improve transportation safety and reduce energy consumption. Effectively, these research outcomes translate into energy independence and security as well as environmental benefits."

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Derek Hall

Penn State Title:

Assistant Professor and Program Lead of Energy Engineering

Comes to Penn State from:

The National Energy Technology Laboratory, where he was a post-doctoral researcher in the Oak Ridge Institute for Science and Education program.

Research Summary

Hall's field of research is electrochemical science and engineering. His doctoral work focused on the development of a novel electrochemical energy conversion process for producing hydrogen gas within a thermochemical cycle for the Argonne National Laboratory, and his post-doctoral work involved validating novel water chemistry programs for power generation units using electrochemical methodologies for the Electric Power Research Institute (EPRI). In addition, he was involved in the development of a new standard Gibbs energy model for aqueous species for hydrothermal systems above and below the critical point of water. He has contributed to several EPRI technical reports and the development of novel electrochemical energy storage systems.

Hall's current research interests include electrochemical energy conversion systems, electrochemical sensors, and the thermodynamics of electrolyte solutions. This research will lower the environmental, social, and economic costs of our daily energy consumption habits. ■

"I hope that my research will help to combat climate change by applying electrochemical science and engineering to develop sustainable energy solutions."

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Ryan Harne

"The long-term impact of the research is towards semi biological machines that seamlessly interact in our environment for the sake of assisting wound healing, repairing civil infrastructure, cleaning and purifying water and air supplies, and much more."

Penn State Title:

James F. Will Career Development Associate Professor in Mechanical Engineering

Comes to Penn State from:

Ohio State University, where he was an associate professor in the Department of Mechanical and Aerospace Engineering.

Research Summary

Harne's Laboratory of Sound and Vibration Research at Penn State aims to create soft, autonomous materials and structures. His group focuses on the fundamentals of synthesizing decision-making functions in engineered metamaterials alongside sensory, actuation, and energy conversion mechanisms.

These smart and adaptive structures and materials may serve in a broad range of future medical, industrial, commercial, and engineering applications. His research is carried out by a comprehensive combination of analytical, computational, and experimental methods. ■

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Urara Hasegawa

Penn State Title:

Assistant Professor of Materials Science and Engineering

Comes to Penn State from:

Kansas State University, where she was an assistant professor of chemical engineering.

Research Summary

The Hasagawa Research Group at Penn State is developing novel polymeric nanomaterials for drug delivery that can minimize side effects and improve therapeutic efficacy by applying the principles of polymer chemistry, nanotechnology, and biomaterials science. These polymeric nanomaterials would control the time, rate, and place of drug release under physiological conditions. These include polymeric nanomaterials for gasotransmitter delivery, scavenging redox signal molecules, and cancer-targeted drug delivery. Her lab is also exploring potential applications of functional framboidal nanoparticles for drug delivery, and biodetection. ■

"The technologies developed in my lab will enable safe and efficient administration of drugs. This can lead to new therapeutic strategies for many diseases such as cancer."

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Nathan Keim

Penn State Title:

Associate Research Professor of Physics

Comes to Penn State from:

Cal Poly San Luis Obispo, where he was an assistant professor of physics.

Research Summary

Much of Keim's research at Penn State will revolve around memory in soft materials. Many materials that do not relax to equilibrium can retain specific information about their pasts, such as their histories of deformation, in ways that let us probe their internal dynamics or modify their properties. Keim and his group are especially interested in disordered or amorphous solids as varied as mayonnaise, glass, or sand. ■

"Understanding different kinds of material memory could let us use materials that respond or adapt to their environments in complex ways. It could also help us diagnose how components were used or worn out. And sometimes we want a material to always be the same and have as little memory as possible."

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Wooram Lee

Next generation of high-performance integrated circuits and systems

Penn State Title:

Associate Professor of Electrical Engineering

Comes to Penn State from:

IBM's T.J. Watson Research Center, where he was a research staff member.

Research Summary

Wooram Lee's research focuses on high-performance analog/RF integrated circuits and systems for high-speed communication, imaging, and radar applications. This includes fundamental innovations in millimeter wave/terahertz (mmWave/THz) wireless integrated circuits (IC). These ICs meet increasing demands for higher data rate and higher radar resolution and are used in 5G technology and are expected to help enable upcoming 6G technology.

In his lab at Penn State, Lee will focus on fundamental innovations in mmWave/THz IC and scalable phased array systems for the next generation communication and sensing. He will also focus on physics-inspired signal generation and processing in silicon to go beyond transistor performance limits. ■

"The world will be fully connected digitally and intelligently with an ultra-wide bandwidth wireless network which is enabled by mmWave and THz technology. This will fundamentally change how we live, learn, work, and play."

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Daniel Lopez

Penn State Title:

Liang Professor of Electrical Engineering and Scientific Director of the Nanofabrication Lab at the Materials Research Institute

Comes to Penn State from:

IBM, Bell Labs and Argonne National Lab, where he led groups involved in nanofabrication and nanoscale materials.

Research Summary

Lopez's research career covered many areas, such as novel materials, nano-mechanics, optical micro-electro-mechanical systems, and nanofabrication. A common theme in his work has been to use the interplay among materials science, mechanics, and photonics to advance fundamental research and bridge the gap with practical applications.

Lopez's Penn State research group will focus on the development of intelligent microsystems, which are a new class of mechanical devices that will change shape to adapt to changing environments and tasks. More specifically, this class of systems comprises purpose-designed structures that integrate ultrathin materials and nanoscale elements that tightly couple electrical signals, optical photons, and mechanical deformations. The fundamental research activities in the group include the development of origami and kirigami metamaterials, the study of the dynamics of deformable nanostructures, and the integration of heterogeneous nanostructures. ■

"The research proposed will establish a new technology platform for the development of devices that will change shape to adapt to changing environments and tasks. The research will deliver devices with applications in a large variety of areas, such as quantum information processing, brain research, space systems, and reconfigurable electronics."

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NSF renews funding for Two-Dimensional Crystal

Penn State facility enables development of new ultra-thin materials for advanced electronics

THE NATIONAL SCIENCE Foundation (NSF) announced a renewal of funding for the Materials Innovation Platform (MIP) national user facility at Penn State's Materials Research Institute (MRI), the Two-Dimensional Crystal Consortium (2DCC). The 2DCC is one of four MIPs in the United States and was awarded $20.1 million over five years, an increase of 13% above the initial award in 2016.

MIPs are NSF facilities focused on a specific topic that are funded to stimulate materials research innovation and foster the growth of a national community of users to develop next-generation materials. These groups seek to substantially increase the rate at which new materials and new materials phenomena are discovered. The 2DCC at Penn State follows the "materials by design" concept, combining synthesis, characterization, and theory/simulation applied to targeted outcomes to accelerate materials discovery.

The 2DCC received its first five years of funding in 2016, which was used to nucleate and grow the MIP by developing state-of-the-art equipment for thin film deposition with integrated characterization tools, establishing a bulk growth facility, developing new computational tools and a facility-wide database, and initiating an external user program. In 2020, the 2DCC underwent a renewal process for a second five years of funding.

"Over the past five years, the 2DCC has established itself as a premier facility for the synthesis of wafer-scale 2D films and bulk crystals with unique quantum properties," said Joan Redwing, director of the 2DCC and synthesis lead, and professor of materials science and engineering and electrical engineering.

Two-dimensional (2D) materials are atomically thin layers that, due to the restricted electron and atom motion, have physical characteristics that are not present in three dimensions. The 2DCC focuses on the bulk and thin-film synthesis of 2D chalcogenides, i.e., layered compounds of transition elements such as selenium and sulphur. By controlling the growth of these materials on the atomic level, new materials can be created with unique properties and exotic quantum states that hold the potential for revolutionary new device technologies, such as flexible electronics and quantum computing.

"As an inaugural Materials Innovation Platform, 2DCC MIP exemplifies the power of the Materials Genome Initiative approach with close experiment-theory interactions," said Charles Ying, program director for MIPs and National Facilities and Instrumentation with the Division of Materials Research of the National Science Foundation. "Multi-year efforts of studying and refining growth conditions have paid off, leading to reproducible synthesis of 2D materials that have already benefited more than 100 scientists nationwide. The new experimental and data tools will bring 2DCC to a new level in its second five years."

As a core component of the 2DCC's efforts in synthesizing ground-breaking 2D chalcogenide materials, the 2DCC offers a user program that advances 2D materials research across the U.S., not just at Penn State.

"Researchers outside of Penn State at other universities, companies, or national labs can come on-site to receive training in the facility and carry out their research or request samples grown by 2DCC staff," said Redwing. "In addition to the user program, we also have an in-house team of researchers who collaborate with users on their projects. We've sponsored over 125 user projects in our facility since we started in 2016. So, a big part of the MIP is indeed the user program."

The Penn State MIP has proven to be very beneficial for the development of 2D materials.

"Even before the MIP, Penn State had a number of faculty working on 2D material research," said Redwing. "But getting the MIP funded enabled us to expand and more deeply integrate that activity and initiate research collaborations with other universities and national labs through our user program. It's really helped to make Penn State one of the main centers of activity in 2D materials in the world."

Consortium

Joan Redwing, Director of the 2DCC-MIP

During its first five years, the 2DCC has managed to meet challenges of complexity, scale, and even an unexpected obstacle that affected the entire globe.

"The discovery of high-performance materials is a complex process, and the framework of the MIP integrates research methodologies that efficiently aids the optimal synthesis of 2D materials, with a teaming of theory, synthesis science, in situ metrologies, and machine learning from the large data sets," said Clive Randall, director of MRI and distinguished professor of materials science and engineering. "In addition, the outreach has been very impressive, aiding researchers from all over the United States, and even globally. The 2DCC also maintained their mission during the COVID crisis, including holding a virtual research experience for undergraduates program in the summer of 2020."

The 2DCC is one of four user facilities in MRI, along with the Materials Characterization Lab, the Nanofabrication Lab, and the Materials Computation Center. The 2DCC research staff includes 17 faculty and 13 doctorate-level researchers. Graduate students are also involved in the in-house research program.

Along with Redwing, the 2DCC executive leadership team includes Nitin Samarth, associate director and characterization lead and professor and George A. and Margaret M. Downsbrough Department Head in Physics; Vincent Crespi, theory lead and distinguished professor of physics, materials science and engineering and chemistry; Joshua Robinson, director of user programs and professor of materials science and engineering; Eric Hudson, director of education, outreach, and diversity programs and associate professor of physics; Zhiqiang Mao, bulk growth lead and professor of physics; Roman Engel-Herbert, industry lead and associate professor of materials science and engineering and physics; Adri van Duin, distinguished professor of mechanical engineering, chemistry, materials science & engineering, chemical engineering and engineering science and mechanics; Jun Zhu, professor of physics; Wes Reinhart, assistant professor of materials science and engineering and Institute for Computational and Data Sciences faculty co-hire; and Kevin Dressler, operations and user facilities director and affiliate assistant professor of civil engineering.

> "The 2DCC has created this critical mass of research activity that has brought considerable attention to Penn State and MRI over the last five years," said Redwing. "The funding we received for new equipment, research support, and other activities has established Penn State and MRI as one of the leading institutes for 2D materials research."

With the renewed funding, the 2DCC will work to build on the progress made in 2D materials research through new collaborations and the existing ones created in the MIP's first five years. Plans for the next five years include the addition of a double crucible Bridgman system for synthesis of bulk crystals with improved composition control, development of an integrated etch/deposition tool for synthesis of 2D metals and an expansion of the facility database to enable materials discovery through data science methods.

"We are very proud of the 2DCC leadership, researchers and staff who have partnered with the NSF to develop, refine, and model the MIP program as one of the inaugural awardees back in 2016," said Randall. "We are looking forward to this next era and the scientific discoveries that will inevitably come with the multiple university partnerships which will emerge via the MIP program." ■

Other funding news

2D materials center ready to move to new phase, add industry partners

THE CENTER FOR Atomically Thin Multifunctional Coatings (ATOMIC), a center focused on the study and development of 2D materials that is part of the National Science Foundation's (NSF) Industry/University Cooperative Research Center (IUCRC) project, is preparing to move from Phase I to Phase II of the program.

In Phase II, ATOMIC would receive slightly less funding from NSF and would need to add more member companies as collaborative partners. Led by Penn State's Materials Research Institute (MRI), the center has been operated in collaboration with Rice University in Houston and is also adding a third research site at Boise State University.

The center's focus is the design and development of 2D coatings, which are one-atom thick materials that have unique properties that make them suitable for a variety of industrial and research applications. These include developing the fundamental platform for new technologies dealing with corrosion, oxidation and abrasion resistance, friction and wear, energy storage/harvesting, multifunctional sensors and actuators, anti-bacterial, anti-fouling, and catalysis. ■

$8 million NASA grant pilots course to hybrid-powered aircraft

LEADING A DIVERSE, collaborative coalition that spans universities, industry and disciplines, Penn State has been awarded $8 million from the National Aeronautics and Space Administration (NASA) to chart the course for hybrid electric aircraft.

"This is a bold project that will explore the possibility of a safe, efficient and innovative path to reduce the fuel consumption and lower the carbon footprint of the aviation industry," said Karen Thole, distinguished professor, mechanical engineering department head, and the principal investigator.

The four-year project will focus on single and twin-aisle aircraft that carry 100 passengers or more, which the researchers say are well suited for hybrid propulsion. ■

Army grant could advance high-grade steel 3D printing

RESEARCHERS IN THE Penn State College of Engineering received $434,000 from the United States Army to develop additive manufacturing, or 3D printing, techniques for high strength steels and alloys.

High strength and hardness steels are a class of materials that are well suited for and currently used in many defense-relevant applications, such as personal armor, armored vehicles, specialized facilities for blast and ballistic protection, and marine ship hulls.

While high-grade steel is well suited for these uses, the material is difficult to manufacture traditionally. While a large part of the project will be using computer modeling to test and refine the parameters of the printing process, the researchers also plan to manufacture large-scale components to provide impactful experimental data. ■

The event is currently planned to be a hybrid mix of in-person and virtual options.

Darren Pagan

"Increasing the pace of microstructure optimization, which is usually not performed due to the long times and high costs associated with alloy design, will provide major economic savings and performance increases due to the scale at which engineering alloys are employed across society."

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Penn State Title:

Assistant Professor of Materials Science and Engineering and Mechanical Engineering

Comes to Penn State from:

Cornell High Energy Synchrotron Source (CHESS), where he was a staff scientist overseeing the structural materials and mechanics program.

Research summary

Pagan brings to Penn State expertise in characterization of the processing, properties, and performance of structural materials.

At Penn State, his lab focuses on developing data analysis methods for quantifying material deformation, integrating mechanical and scattering models, and expanding experimental capabilities for characterizing microstructure evolution during processing and performance testing of metallic alloys and composites. The goal of this research is to extract quantitative measures of microstructures evolution in-situ to develop, calibrate, and validate computational models and to accelerate the design of superior material systems. Pagan's research is important because the ability to efficiently 'tune' structural material microstrutures to achieve target improvements in properties including fracture toughness, fatigue life and impact resistance, will provide significant benefits to the defense, energy, and transportation sectors. ■

Herschel Pangborn

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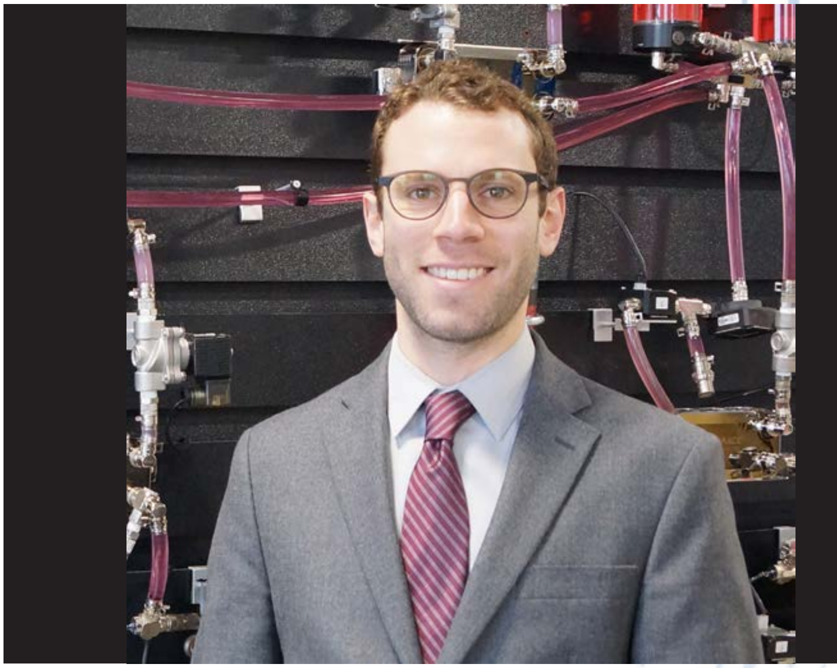

Penn State Title:

Assistant Professor of Mechanical Engineering

Comes to Penn State from:

University of Illinois at Urbana-Champaign, where he was a postdoctoral research associate.

Research summary

Pangborn focuses on dynamic systems and control, which includes the science of automated decision-making for engineering systems, optimizing their design and real-time operation.

Pangborn's lab applies these methods primarily to electro-thermal systems in vehicles and buildings, including electrified aircraft, hybrid cars, and HVAC. From a theoretical standpoint, his team focuses on hierarchical and distributed control frameworks that employ a network of communicating controllers to coordinate decision-making across multiple components, timescales, and physical domains. Their goal is to enable new paradigms in the performance, safety, efficiency, and sustainability of energy systems in vehicles and buildings. ■

"For electric cars, this can increase the driving distance on a single charge, lowering barriers to consumer adoption by reducing range anxiety and vehicle costs. For aircraft, this can enable all-electric and hybrid-electric powertrains with significantly reduced emissions over traditional propulsion systems. For buildings, we can facilitate the integration of renewable energy sources in the power grid."

Wesley Reinhart

Penn State Title:

Assistant Professor of Materials Science and Engineering and Institute for Computational and Data Sciences Co-hire

Comes to Penn State from:

Siemens Corporate Technology, where he was a research scientist.

Research summary

Reinhart's research focuses on data-driven and inverse schemes for materials design, including the trending field of machine learning. His Penn State research group uses high-performance computing to predict the properties of materials in conjunction with machine learning to discover new materials which exhibit desirable properties. Instead of focusing on a specific class of materials, they aim to develop broadly applicable strategies which can work effectively for many different length scales and governing physics. Right now, they have projects ranging from silicon nanophotonics (nanoscale) to polymer self-assembly (microscale) to additive manufacturing (mesoscale) to building materials (macroscale). ■

"Our data-driven design schemes will enable materials scientists and engineers to take advantage of continuous advances in materials synthesis and characterization techniques to obtain the best possible material performance. This might be improved strength or durability of structural materials, but it could also include objectives like reduced carbon footprint or less expensive recycling pathways. Because our design strategies are built to be general and transferrable, our research may have far-reaching impacts in applications such as renewable energy, manufacturing, computing hardware, and medicine."

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Jacques Rivière

"In geophysics, we use laboratory scale experiments with ultrasonic waves (equivalent to seismic waves in nature) to better understand the physics of earthquakes. Beyond 'regular' earthquakes, this has broad applications in the context of geothermal energy, CO_2 sequestration, as well as for oil gas industry to help minimize induced seismicity. In the biomedical domain, we conduct some work on the topic of lung ultrasound, where we develop new approaches to help diagnose lung pathologies."

Penn State Title:

Assistant Professor of Engineering Science and Mechanics

Comes to Penn State from:

Université Grenoble Alpes, France, where he was a post-doctoral researcher.

Research summary

Rivière's research includes work in ultrasonics with applications in nondestructive evaluation (NDE), geophysics, and medical imaging. The overall idea of this work is to use elastic waves to characterize/infer materials' properties.

His research group is trying to develop novel ultrasonic methods to characterize/detect flaws in various materials. These are mostly metals, including but not limited to 3D printed metals. Some of these methods are very sensitive to the presence of micro-structural flaws that are not visible with standard X-ray approaches. For 3D-printed materials, some of these methods could possibly be used in-situ for real-time process control. ■

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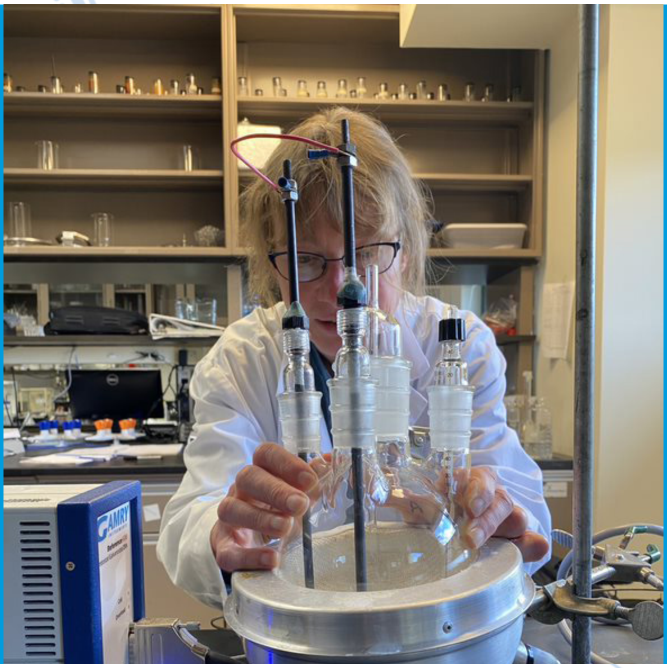
Elzbieta Sikora

"3D printing metallic parts which are also chemically resistant obviously have huge advantages as far as corrosion mitigation. Usually, any newly developed materials or technologies are tested for mechanical properties, with corrosion response being somewhat neglected. It is only very recently that these issues are being recognized."



Penn State Title:

Associate Teaching Professor of Engineering Science and Mechanics

Comes to Penn State from:

Polish Academy of Sciences, where she was a doctoral student.

Research summary

Sikora's research focus is on environmental degradation of materials and fundamental studies of mechanisms of their protection, like the formation of nanometers thin passive films.

Currently, she is working on elucidating corrosion mechanisms of additively manufactured stainless steels and how the post treatment of these materials affects their electrochemical response. In addition, she is working on assessing corrosion response of cold spray NiCr coatings and DLC coatings.

She is also part of a research team working on development of new and safer BPA non-intent can coatings for the food industry. Her work on corrosion includes ideas for safer infrastructure, as corrosion is responsible for many catastrophic events and therefore mitigating it carries huge benefits. ■

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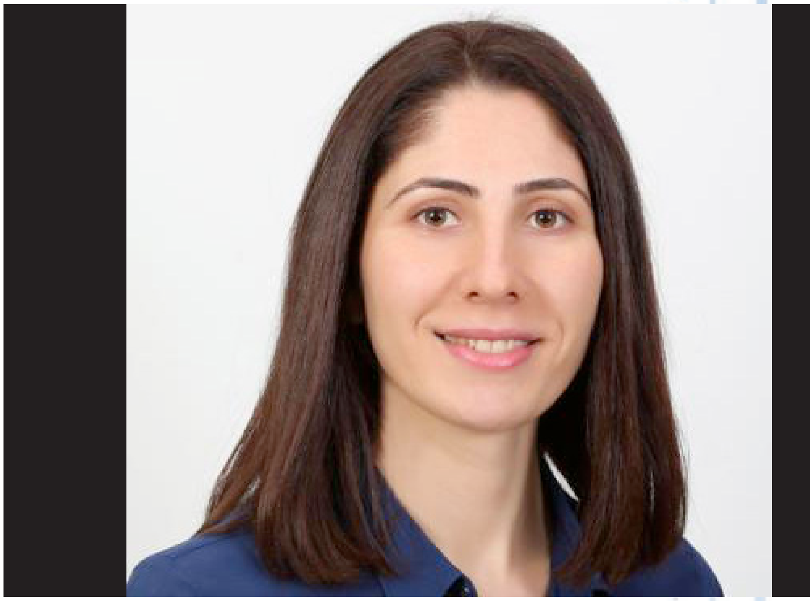
Hilal Ezgi Toraman



Penn State Title:

Assistant Professor of Energy Engineering and Chemical Engineering

Comes to Penn State from:

University of Delaware, where she was a post-doctoral researcher in chemical engineering.

Research summary

Toraman's research focuses on chemical reaction engineering and catalysis. Her research group at Penn State is currently focusing on two main research topics, upcycling of plastic waste and biogas conversion into higher value products.

Toraman's ultimate research goal is to develop a mechanistic understanding of thermal and catalytic processes that will enable development of efficient, sustainable, and economically feasible technologies for upgrading of two emerging feedstocks separately: mixed plastic waste and biogas, a type of biofuel that is naturally produced from the decomposition of organic waste.

Through this research, Torman hopes to help realize efficient utilization of our planet's resources while minimizing its environmental footprint, which she notes is of utmost importance to achieve the sustainable development goals of the United Nations. ■

"The mechanistic understanding that we develop in my group is crucial to develop and optimize chemical processes for both circular and bioeconomy. This will minimize the steps needed for commercial implementation and will have significant effect on the US and global economy, considering the importance of plastic waste management for circular economy and direct conversion of biogas for bioeconomy."

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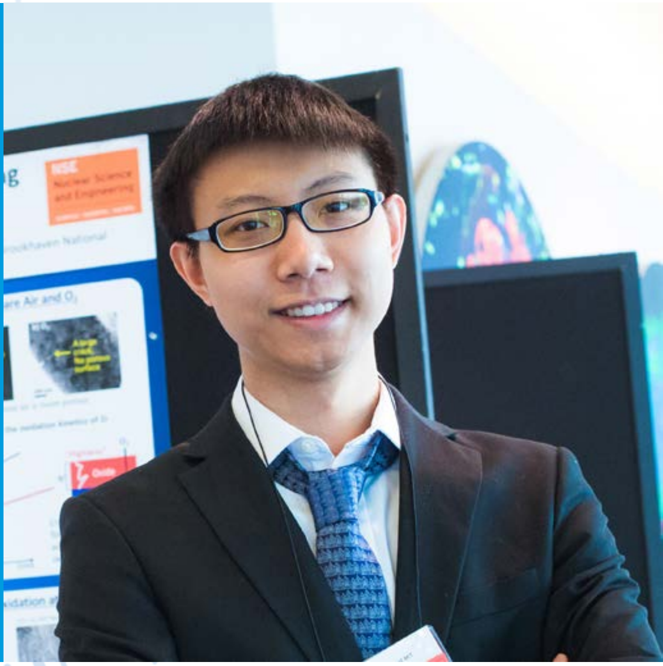
Yang Yang

Penn State Title:

Assistant Professor of Engineering Science and Mechanics

Comes to Penn State from:

National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, where he was a post-doctoral fellow.



> "Corrosion costs about a few percent of GDP per year. It may also lead to severe accidents in engineering systems, such as the failure in bridges, aircrafts, oil pipelines, etc. The understanding of the origin of corrosion would greatly facilitate the development of more advanced alloys that can enable safer and more economic engineering systems."

Research summary

Yang Yang will bring his combined experience of in-situ electron microscopy and multi-scale experiments of materials at extreme environments to Penn State. This includes advanced transmission electron microscopy characterization, corrosion, metallurgy, mechanical behaviors, materials under extreme environments, and radiation damage.

At Penn State, he will study the characterization and enhancement of material interfaces in advanced battery systems. The two main fields of science involved in this work will be the understanding of the multi-physics in the environmental degradation of materials via advanced electron microscopy, and utilizing extreme environments such as ion irradiation to engineer nanomaterials.

His long-term goal is to establish Penn State as a center for the study of interfaces at extreme environments using advanced electron microscopy, and ultimately establish a unique advanced characterization system to benefit all materials science researchers at the University. ■

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Linxiao Zhu

Penn State Title:

Assistant Professor of Mechanical Engineering, John J. and Jean M. Brennan Clean Energy Early Career Professor

Comes to Penn State from:

University of Michigan, where he was a post-doctoral research fellow in mechanical engineering.

Research summary

Zhu's research areas include heat transfer, nanophotonics, and thermal and energy sciences. In particular, he studies thermal radiation control using nanomaterials, near field radiative heat transfer, nano-calorimetry, photonic and first principles modeling, nanofabrication, energy conversion, and thermal management.

At Penn State, Zhu is working on how to control heat and light by using the strong light-material interaction at the nanoscale. One path is to develop new ways for harvesting renewable energy. Some examples include passive cooling, and methods for improving solar energy harvesting. Another direction is to investigate a new class of solid-state energy converters by using thermal light.

On the other hand, Zhu is interested in using new materials for achieving fundamentally new control of light and heat. To investigate these problems, he takes an interdisciplinary approach integrating experiment, theory, and modeling. ■

"Our research can point to energy conversion technology that helps to greatly reduce carbon emission. By improving the fundamental understanding on how heat and light can be controlled, we will use the obtained knowledge to improve energy efficiency and develop new way for harvesting renewable energy."

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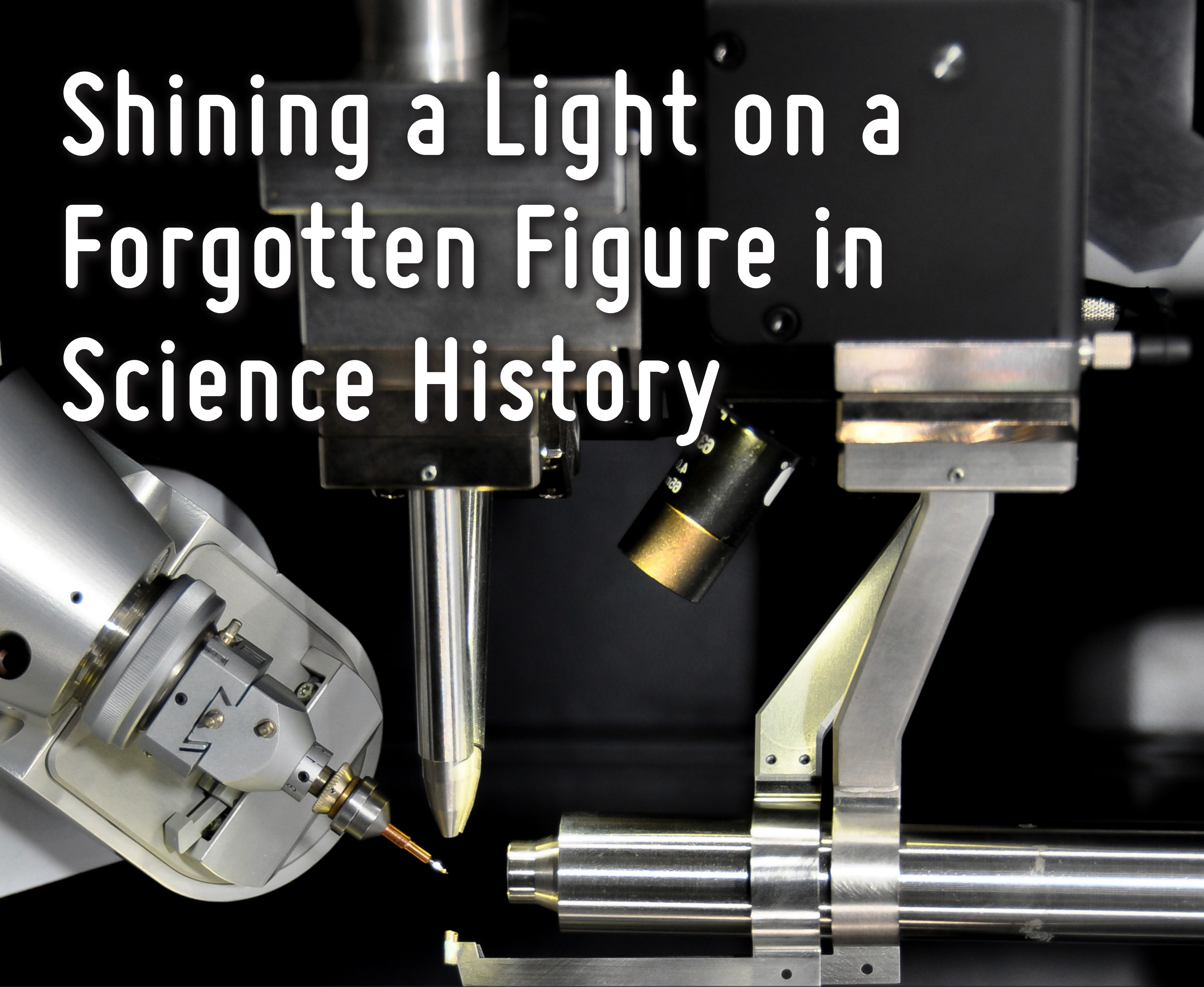
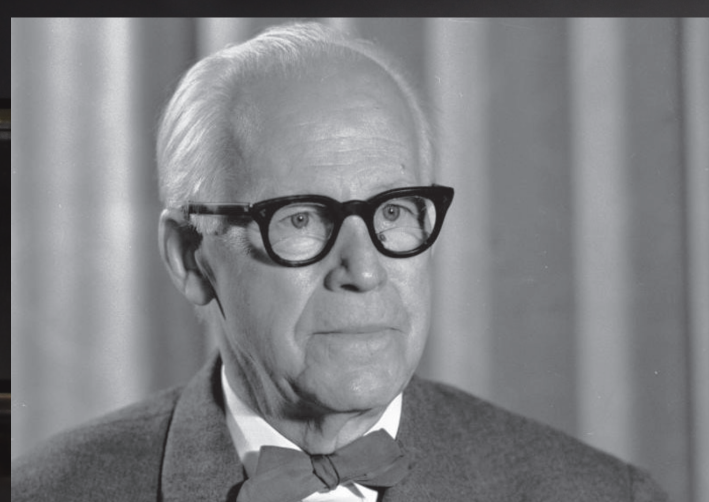
Shining a Light on a Forgotten Figure in Science History



Penn State Faculty Member Discovers, Translates Lost Interview with Walter Friedrich, Pioneer of X-Ray Diffraction



WHEN PETER HEANEY, Penn State professor of mineral sciences in the College of Sciences and the Materials Research Institute, was preparing for a graduate seminar in crystallography last spring, he searched for a photo of an unsung hero of materials science and engineering, Walter Friedrich. What he found instead was a buried interview from 1963 with Friedrich that Heaney helped to translate, shining some light on the German scientist's vital yet forgotten role in a Nobel Prize-winning discovery.

According to Heaney, Friedrich has never received his due regarding his contributions to the discovery of X-ray diffraction, which uses the wave-like nature of X-rays to obtain data about crystalline materials. X-ray diffraction and the data it gathers is vital to the development of new materials.

"It is hard to imagine the field of materials science existing without the contribution of Friedrich and his collaborators," Heaney said. "Walter Friedrich is hardly remembered today, but he was front and center in a discovery that nearly all scientists would include in a top-ten list of 20th century experiments that changed the world. The crystalline state of matter is interrogated today using essentially the same technique that Friedrich innovated -- we just have more intense X-ray sources and more sensitive detectors."

BEGINNING THE PATH TO A NOBEL PRIZE

In the early 1900s, the fact that materials are composed of distinct atoms was considered highly controversial in the scientific community. Even the fact that atoms exist was disputed. However, a German physicist, Max von Laue, had a theory on how to prove atoms were real.

"Von Laue knew that when visible light strikes a grating whose wavelength is of the same order of magnitude as the light, the light waves will interfere constructively and destructively, depending upon the angle and the wavelength of the light," Heaney said.

Therefore, von Laue theorized that if X-rays are wave-like, and if crystals have atoms with the same periodicity as the X-rays, then when X-rays strike a crystal, they should selectively reinforce and cancel each other in a comparable manner. Overcoming major skepticism, von Laue convinced his faculty supervisor at the University of Munich, Arnold Sommerfeld, to allow Friedrich and a doctoral student, Paul Knipping, to conduct experiments during the summer of 1912.

PROVING ATOMS ARE REAL

Von Laue knew that he needed Friedrich's help.

"Von Laue was a theoretician, not an experimentalist, and he could never have constructed the experimental instrument," Heaney said.

Friedrich designed the apparatus to run the experiments, and after many false starts stemming from von Laue's imperfect guesses, Friedrich obtained a photographic plate with distinct X-ray interference spots.

"He showed that the atoms in crystals will scatter X-rays in such a way that the X-rays constructively interfere and generate sharp spots on a photographic emulsion," Heaney said. "That simultaneously demonstrated that there are individual atoms that compose crystals; that these atoms are ordered in space; and that X-rays, like visible light, can be modeled as waves."

This major discovery led to von Laue receiving the Nobel Prize in physics in 1914, and to this day, X-ray diffraction has played a key role in research. This includes game-changing breakthroughs such as mapping the structures of complex organic macromolecules such as proteins and DNA in the 1950s. At Penn State's Materials Research Institute (MRI), which Heaney is affiliated with, X-ray diffraction equipment is a vital part of the Materials Characterization Lab and the Nanofabrication lab.

However, Friedrich was not part of the Nobel Prize.

FORGOTTEN BY HISTORY

Heaney noted that Friedrich's relative anonymity in the annals of scientific history was part of the reason he found the interview. He was surprised to find that there was no Wikipedia page for Friedrich so he was forced to dig through Internet archives to find an image for his graduate seminar.

> "I stumbled upon an interview with Friedrich that was buried in the archives of the American Physical Society (APS)," Heaney said. "It was an image file of a typewritten manuscript in German from 1963.

Heaney believes that Friedrich is not as famous as von Laue for three reasons. First, he was very modest and deferential to von Laue, and at that time, the experimentalist was considered below the theoretician in stature. This is despite von Laue offering gracious acknowledgement of Friedrich

▸ ▸ ▸

and Knipping's role. Second, soon after the ground-breaking diffraction experiments, Friedrich focused his research on the biological effects of X-ray radiation and away from physics. And third, Heaney notes that Friedrich joined the University of Marburg in East Germany after World War II, placing him outside the domain of western scientists.

So, Heaney believed, translating the 1963 interview was his way of increasing Friedrich's historical fame, but there was a problem.

"I don't know any German," Heaney said.

TRANSLATING GERMAN WHEN YOU DO NOT SPEAK GERMAN

While Heaney does not speak German, he has used Google Translate to figure out sentences in a language other than his own. However, he had never been able to use it to properly translate an entire document, and the Friedrich interview was a 13-page manuscript. With some free time, due to the pandemic, he used Google Translate and other online translation tools to pull together a rough translation. He then sent it to a friend, Dr. Melanie Kaliwoda, who is a native German speaker and curator of the mineral collection at the Ludwig Maximilian University in Munich, Germany.

"A few weeks went by," Heaney said. "And it came back with a friendly note that essentially said, 'very nice effort, but in a few places, you actually reversed the meaning. Let's Zoom!'"

When they got a version that reads easily and correct in English, Heaney wrote up a preface and sent it to the Newsletter for the International Union of Crystallographers for publishing.

GIVING AN INNOVATOR HIS DUE

According to Heaney, the interview was part of a project during the 1960s by Thomas Kuhn, the famed science philosopher, who set out to gather oral histories of the quantum revolution from surviving participants. A team including Gustav Hertz from the University of Leipzig, author Théo Kahan, and one of Kuhn's graduate students, John Heilbron, traveled behind the Iron Curtain to meet Friedrich.

Heaney noted that the interview revealed Friedrich's self-deprecating and wryly amusing personality. Also, according to Heaney, it provides an oral history that gives a "you-are-there" sense of the events leading to a Nobel Prize-level discovery that has impacts in materials science and engineering to this day. A discovery, Heaney says, that could not have happened without Friedrich.

"Friedrich brought a particular expertise to these experiments, and without him they likely would have failed," Heaney said. "The subtext of the interview should raise awareness of the indispensable role that Friedrich played. A role that in my opinion, was worthy of a share of the Nobel that went exclusively to von Laue." ■

Peter Heaney, right, standing with Melanie Kaliwoda, who helped him translate the Walter Friedrich interview, in the mineral collection of the Ludwig Maximilian University in Munich, Germany. IMAGE: PETER HEANEY

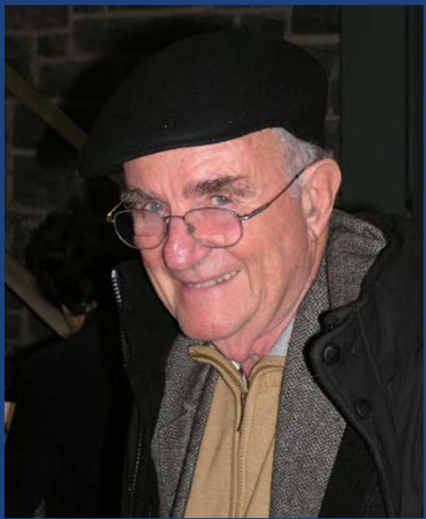
In Memorium

Della Roy, right, reviewing research with her husband, Rustum Roy. Image: Used with permission from the Eberly Family Special Collections, Penn State University Libraries.

Della M. Roy

Born November 3, 1926 Died March 27, 2021

MRI and the Penn State community mourns the loss of Della M. Roy, emeritus professor of materials science and a founding member of the Penn State Materials Research Laboratory (MRL), now MRI. Della died on March 27 at age 94. She was recognized as an international leader in the field of cement and concrete research and for being a groundbreaker for women in science. This includes being the first female materials scientist and first Penn State woman to be inducted into the National Academy of Engineering and the first woman elected to the World Academy of Ceramics. She also co-founded the journal Cement and Concrete.



Stewart Kurtz. Credit: Sven Bilén

Stewart Kurtz

Born June 9, 1931 Died February 13, 2021

MRI and the Penn State community also mourns the loss of Stewart Kurtz, professor emeritus of electrical engineering, who died February 13 at age 89. Kurtz's legacy at Penn State includes his role in setting a path for the University to become a global leader in materials research. He was the former director of the Materials Research Lab, and both vice chair and executive administrator of MRI, which was created in 1992. He focused his later career on the then new field of online distance education, developing and teaching two engineering courses through Penn State's College of Engineering Distance Education and World Campus programs.

PennState

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