ECE

THE BRADLEY DEPARTMENT OF
ELECTRICAL & COMPUTER
ENGINEERING

FOCUS ON RESEARCH
2022

COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL
AND COMPUTER ENGINEERING
VIRGINIA TECH.

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What's inside

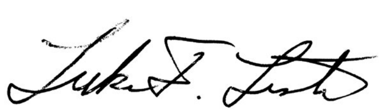
From the

ECE **DEPARTMENT HEAD**

Greetings to our colleagues, peers, and alumni! The Bradley Department of Electrical and Computer Engineering of Virginia Tech is conducting research in a growing variety of fields. From quantum engineering and next-generation semiconductor technologies, to autonomy and robotics and wireless networks, our faculty are making waves in some of the most impactful research areas of ECE. Over the last two years, we have recruited 10 new faculty members in the areas of high-voltage power electronics, integrated security, quantum engineering, data analytics, RF integrated circuits, computer architecture, wireless systems, and applied electromagnetics.

Our faculty now stands at 82 tenured/tenure-track members, 20 research faculty, 14 collegiate faculty, and a combined 15 postdoctoral associates, instructors and professors of practice. In the time since our last research publication, the department has reinvigorated our professionally-oriented degrees: the M.S (non thesis) in Blacksburg and the MEng, which is available to students at the Virginia Tech Innovation Campus in the D.C. area. We have also announced that seven of our faculty members have joined the first cohort of the Innovation Campus and will play a vital role in shaping the new campus by helping to establish key research themes, enhancing the project-based curriculum, and developing the campus governance structure.

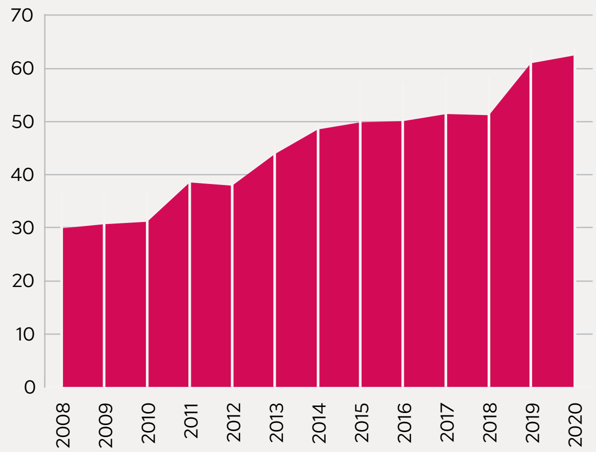
With more than 620 graduate students and 1,100 undergraduates studying in the fields mentioned above, among others such as computer vision, fiber-based sensing, cybersecurity, space science and engineering, nanophotonics, and data science for health, we have an extensive research portfolio that now realizes about $60M annually. While we cannot describe the complete breadth and depth of all of the department's research efforts in one document, the following pages provide some highlights of the work that led to 51 Ph.D.s awarded in 2022. I invite you to take a close look at the contents of this report, and if you have any questions about our research activities or want to get involved with the department, please contact me or another member of our expert faculty.



Luke Lester
Roanoke Electric Steel Professor
ECE Department Head

ECE by the numbers

Research expenditures (millions)



131 Total faculty members

82 Tenured/tenure-track faculty members

20 Research faculty members

14 Collegiate faculty members

11 Postdoctoral associates

3 Instructors

1 Professor of Practice

22 NSF CAREER Awardees | **30** IEEE Fellows | **4** DoD YIP Awardees

448 Degrees conferred
2021-2022

Watch our **ECE Graduate Program highlights video** by scanning the QR code or visiting:
https:/www.youtube.com/watch?v=W1lRsiOoHTs

Research distinctions

IEEE Fellows

Harpreet S. Dhillon (2023)
For contributions to heterogeneous cellular networks.

Haining Wang (2020)
For contributions to network and cloud security.

Walid Saad (2019)
For contributions to distributed optimization in cooperative and heterogeneous wireless systems.

Guo-Quan (G.Q.) Lu (2018)
For development of materials and packaging technologies for power electronics modules.

R. Michael Buehrer (2017)
For contributions to wideband signal processing in communications and geolocation.

Jung-Min (Jerry) Park (2017)
For contributions to dynamic spectrum sharing, cognitive radio networks, and security issues.

Lamine Mili (2016)
For contributions to robust state estimation for power systems.

T.-C. Poon (2016)
For contributions to optical image processing and digital holography.

Yue (Joseph) Wang (2016)
For contributions to genomic signal analytics and image-based tissue characterization.

Khai Ngo (2015)
For contributions to unified synthesis and modeling of switched-mode converters.

Y. Thomas Hou (2014)
For contributions to modeling and optimization of wireless networks.

Michael S. Hsiao (2013)
For contributions to automatic test pattern generation of integrated circuits.

Luke Lester (2013)
For contributions to quantum dot lasers.

Timothy Sands (2010)
For contributions to metal/semiconductor interfaces and heterogeneous integration.

Dong S. Ha (2008)
For leadership in VLSI design and test.

Jih-Sheng (Jason) Lai (2007)
For contributions to high performance high power inverters.

Dushan Boroyevich (2006)
For advancement of control, modeling and design of switching power converters.

Jeff Reed (2004)
For contributions to software defined radio.

Krishnan Ramu (2001)
For contributions to the development of AC and switched reluctance motor drives.

Saifur Rahman (1998)
For contributions to electric power engineering education.

Marius K. Orlowski (1997)
For contributions to the modeling of MOSFET devices and technology.

Chen-Ching Lui (1994)
For contributions to development of knowledge-based systems for power system applications.

Charles W. Bostian (1992)
For contributions to and leadership in the understanding of satellite path radio wave propagation.

Sedki M. Riad (1992)
For contributions to time-domain measurement s through physical modeling of sampling devices.

Amir I. Zaghloul (1992)
For contributions to the application of phased array antennas to communications satellite systems.

Fred C. Lee (1990)
For contributions to high-frequency quasi-resonant and multiresonant converters and for the development of a program of engineering education in power electronics.

Warren Stutzman (1989)
For contributions to wave propagation through the natural environment and antenna synthesis.

David de Wolf (1988)
For contributions to wave propagation theory in random media and to the numerical simulation of wave and particle beams by phase-space methods.

Gary S. Brown (1986)
For contributions to the understanding and application of electromagnetic scattering from rough surfaces.

Arun G. Phadke (1980)
For contributions to the application of digital computers to power systems.

Other Fellows

ABET Fellow
Scott Dunning (2019)

American Institute for Medical and Biological Engineering Fellow
Yue (Joseph) Wang (2004)

Applied Computational Electromagnetics Society Fellow
Amir Zaghloul (2011)

Association of Energy Engineers
Scott Dunning (2015)

Materials Research Society
Timothy D. Sands (2009)

Institute of Physics
T.-C. Poon (2014)
Richard Claus (2001)

OSA Fellow
T.-C. Poon (1998)
David de Wolf (1991)

SPIE Fellows
Luke Lester (2013)
Anbo Wang (2010)
T.-C. Poon (1999)
Richard Claus (1992)

Presidential Early Career Award for Scientists and Engineers (PECASE)

Tom Martin (2006)

National Academy of Inventors

Alan Michaels (2022)
Timothy D. Sands (2012)

Association of Energy Engineers

Scott Dunning (2015)

National Academy of Engineering

Chen-Ching Liu (2020)
For contributions to computational methods for power system restoration and cybersecurity.

Dushan Boroyevich (2014)
For advancements in control, modeling, and design of electronic power conversion for electric energy and transportation.

Fred C. Lee (2011)
For contributions to high-frequency power conversion and systems integration technologies, education, industry alliances, and technology transfer.

Arun G. Phadke (1993)
For contributions to the field of digital control, protection, and monitoring of power electrical systems.

NSF CAREER Awards

Dong Dong (2022)
Yuhao Zhang (2021)
Ryan Williams (2021)
Xiaoting Jia (2019)
Guoqiang Yu (2018)
Yang (Cindy) Yi (2018)
Vassilis Kekatos (2018)
Qiang Li (2017)
Walid Saad (2013)
Jo Baker (2012)
Yaling Yang (2011)
Paul Ampadu (2010)
Masoud Agah (2008)
Leyla Nazhandali (2008)
Jung-Min Park (2008)
Yong Xu (2007)
Tom Martin (2005)
Thomas Hou (2004)
Dan Stilwell (2003)
Michael Hsaio (2001)
Luke Lester (1995)
G.Q. Lu (1995)

Top cited papers by ECE faculty

2019-2022*

1 **A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems**
914 citations | Saad W., Bennis M., Chen M., 2020

2 **A Tutorial on UAVs for Wireless Networks: Applications, Challenges, and Open Problems**
903 citations | Mozaffari M., Saad W., Bennis M., Nam Y.-H., Debbah M., 2019

3 **Artificial Neural Networks-Based Machine Learning for Wireless Networks: A Tutorial**
402 citations | Chen M., Challita U., Saad W., Yin C., Debbah M., 2019

4 **Developmental Heterogeneity of Microglia and Brain Myeloid Cells Revealed by Deep Single-Cell RNA Sequencing**
343 citations | Li Q., Cheng Z., Zhou L., Darmanis S., Neff N.F., Okamoto J., Gulati G., Bennett M.L., Sun L.O., Clarke L.E., Marschallinger J., Yu G., Quake S.R., Wyss-Coray T., Barres B.A., 2011

5 **Proteogenomic Analysis of Human Colon Cancer Reveals New Therapeutic Opportunities**
255 citations | Vasaikar S., Huang C., Wang X., Petyuk V.A., Savage S.R., Wen B., Dou Y., Zhang Y., Shi Z., Arshad O.A., Gritsenko M.A., Zimmerman L.J., McDermott J.E., Clauss T.R., Moore R.J., Zhao R., Monroe M.E., Wang Y.-T., Chambers M.C., Slebos R.J.C., Lau K.S., Mo Q., Ding L., Ellis M., Thiagarajan M., Kinsinger C.R., Rodriguez H., Smith R.D., Rodland K.D., Liebler D.C., Liu T., Zhang B., Ellis M.J.C., Bavarva J., Borucki M., Elburn K., Hannick L., Vatanian N., Payne S.H., Carr S.A., Clauser K.R., Gillette M.A., Kuhn E., Mani D.R., Cai S., Ketchum K.A., Thangudu R.R., Whiteley G.A., Paulovich A., Whiteaker J., Edward N.J., Madhavan S., McGarvey P.B., Chan D.W., Shih I.-M., Zhang H., Zhang Z., Zhu H., Skates S.J., White F.M., Mertins P., Pandey A., Slebos R.J.C., Boja E., Hiltke T., Mesri M., Rivers R.C., Stein S.E., Fenyo D., Ruggles K., Levine D.A., Oberti M., Rudnick P.A., Snyder M., Tabb D.L., Zhao Y., Chen X., Ransohoff D.F., Hoofnagle A., Sanders M.E., Wang Y., Davies S.R., Townsend R.R., Watson M., Clinical Proteomic Tumor Analysis Consortium, 2019

6 **IEEE 802.11bd 5G NR V2X: Evolution of Radio Access Technologies for V2X Communications**
234 citations | Naik G., Choudhury B., Park J.-M., 2019

7 **Power System Dynamic State Estimation: Motivations, Definitions, Methodologies, and Future Work**
215 citations | Zhao J., Gómez-Expósito A., Netto M., Mili L., Abur A., Terzija V., Kamwa I., Pal B., Singh A.K., Qi J., Huang Z., Meliopoulos A.P.S., 2019

8 **Beyond 5G with UAVs: Foundations of a 3D Wireless Cellular Network**
215 citations | Mozaffari M., Kasgari A.T.Z., Saad W., Bennis M., Debbah M., 2019

9 **A Survey of Distributed Consensus Protocols for Blockchain Networks**
212 citations | Xiao Y., Zhang N., Lou W., Hou Y.T., 2020

10 **A Joint Learning and Communications Framework for Federated Learning over Wireless Networks**
210 citations | Chen M., Yang Z., Saad W., Yin C., Poor H.V., Cui S., 2021

*As of 11/1/2022

A new kind of power conversion platform

High Voltage. High frequency. High efficiency. High adaptability.

Dong Dong, assistant professor, has been awarded a National Science Foundation Faculty Early Career Development (CAREER) award to develop a high-voltage, electromagnetic noise-contained, high-frequency power converter platform.

Dong said the funds for this particular research could not have come at a better time.

"Developing more efficient and compact power electronics systems is very critical at this moment because we are seeing more consumers and industries move toward green energy in almost every aspect of their daily lives," Dong said. "For example, in the energy sector, wind and solar energy are becoming more prominent with the help of large-scale energy storage like battery and hydrogen. And on the transportation side, companies are moving away from the combustion engine to the battery-powered electric motor. All of these need more effective power electronics converter and system technologies to create improved flow and form of electric energy."

Until now, most of the focus on high-frequency power electronics has been in the low-voltage space. However, to deliver and process higher electric power, increased voltage or current is needed. So to increase efficiency of larger power systems like those found in the electrical grid, ships, and aircraft, Dong and his team will focus primarily on the medium-voltage and high-voltage application of this technological research.

"If we want to realize electrification to reduce the carbon emissions and to really make all of these big industries green, we cannot avoid the high-voltage space," said the Center for Power Electronics Systems faculty member. "We have to get there by developing high-voltage but also high-frequency power electronics technologies. That is what we are really trying to do here."

> "If we want to realize electrification to reduce the carbon emissions and to really make all of these big industries green, we cannot avoid the high-voltage space,"
>
> —Dong Dong

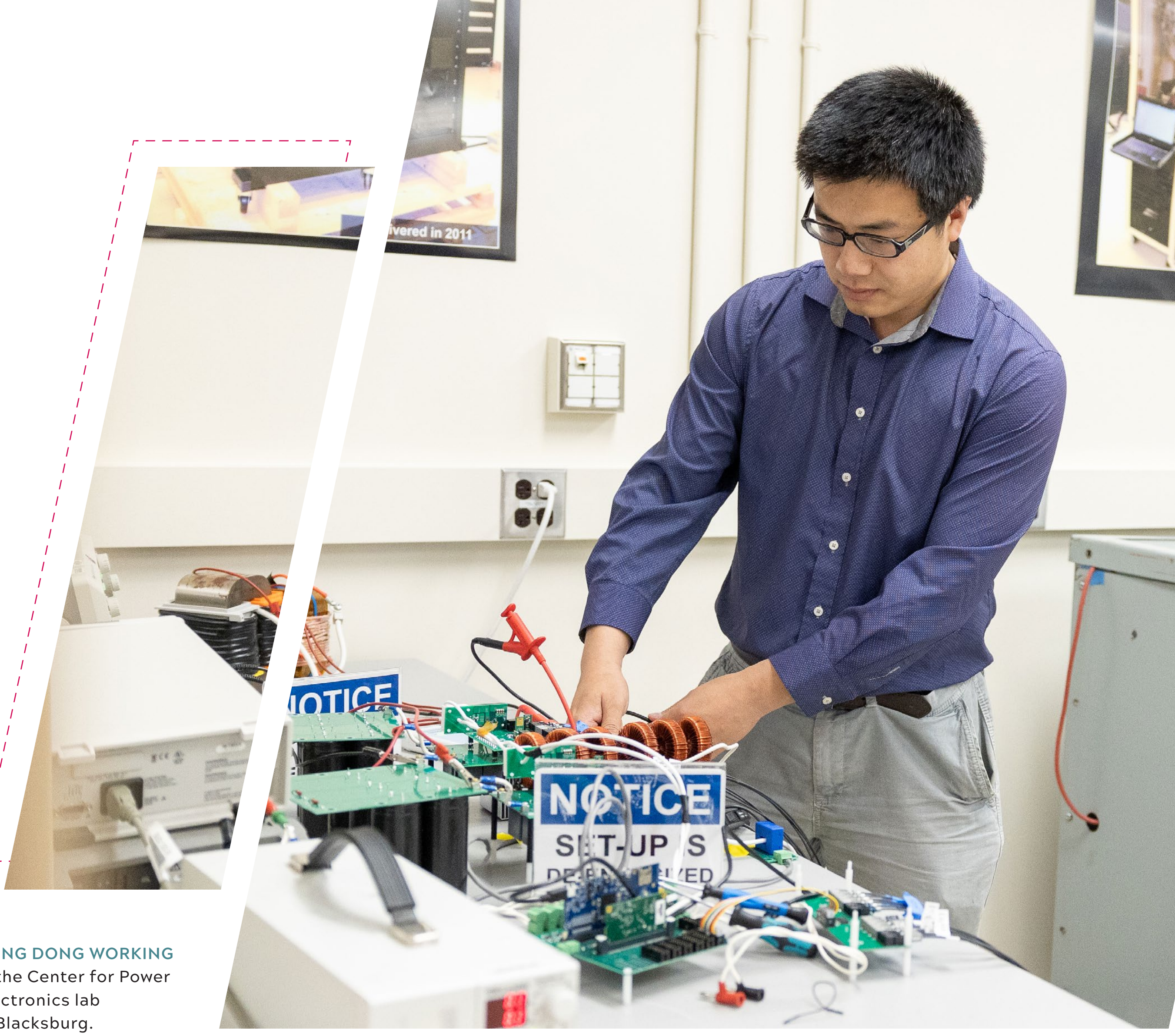
Dong appreciates the opportunities that this five-year award will provide him from a research perspective.

The CAREER award is the National Science Foundation's most prestigious award for early-career faculty with the potential to serve as academic role models in research and education and to lead advances in the mission of their organization.

"This is a long-term award, so I can really focus and dive into the fundamentals," Dong said. "It gives us time to develop some disruptive solutions and technologies and will also allow us the opportunity to collaborate with semiconductor experts, power systems experts, and other industry partners for a true multidisciplinary approach.

Dong emphasized the importance of making these new high-voltage, high-frequency power converter platforms modular. Currently, when industries need to build a very large power conversion system, they start from scratch to accommodate that particular product or design. However, because the technology is evolving so fast, the timeline for designing, creating, and testing these large-scale components is too long.

"In my opinion, making these large components specific to each medium-voltage or high-voltage application is an outdated process," Dong said. "It is nearly impossible to meet the fast-changing market and industry requirements, so we want to replace the idea of using very large pieces of



DONG DONG WORKING in the Center for Power Electronics lab in Blacksburg.

hardware with smaller pieces that are modular, have identical functions, and can interface with each other."

Dong described the modules as building blocks that can stack together and create components of all different sizes and levels of power. The modular approach also addresses the challenges associated with high-frequency operation. He said industries can "stack them up" based on what is needed for that specific product or industry requirement.

Another benefit to these more efficient and compact modules is the ability to use them in multiple applications.

"This technology will allow us to streamline supply chains," he said. "Right now, we see the supply chain disruptions, but if we modularize the components, they can be shared with other industries like industrial and consumer electronics and IT due to the similar materials being used."

Overall, a smaller system makes for more efficient use among industry partners and in applications like the renewable energy grid, electric vehicle fast-charging systems, and distribution systems for large ships, aircraft, and more.

In addition to funding research, the grant will allow the team to develop activities and educational programming for graduate and undergraduate students, which includes the development of new courses centered on power conversion and power electronics.

Dong also will collaborate with Virginia Tech's Center for the Enhancement of Engineering Diversity to engage in outreach to students in K-12 and underrepresented groups, including several pre-college summer academic experiences. One of those summer programs, the Imagination Program, is a week-long summer day camp for rising seventh- and eighth-graders from the New River and Roanoke valleys. Dong's research team has designed a learning module called "Direct Current (DC) vs. Alternating Current (AC)" that will introduce basic electrical engineering history and concepts to promote the STEM field.

"Engaging with these young students is probably the most important part of this project," Dong said. "If we can create interest in these new advancements and get students to think, 'it is something I'd like to do in my future career,' we can build a pipeline of engineers who are ready to further these technologies for generations to come."

Predicting the Spectrum

Using network activity predictions to identify threats

Many of us are connected to the world through our devices. With the touch of a button, we can adjust the temperature of our homes, turn off the lights, share our daily steps with a friend, and send a string of emojis to our family group chat. Unfortunately, with the convenience of interconnected devices comes the threat of breached communications. This is a reality not only for everyday consumers, but for our government, industries, military, and other sectors.

With an increase in vulnerability and threats to secure communications, experts in the field of communications have been working to improve security and limit the number of threats to our system. In an effort to tackle the growing demand for secure communications research and development, the Intelligence Advanced Research Projects Activity has awarded a $14 million contract to fund a collaborative project between BAE Systems and a team of researchers at Virginia Tech.

The goal of the award is to develop tools to decipher an ever-growing number of radio frequency signals in an effort to quickly and accurately help secure mission-critical information. Of that $14 million, the team at Virginia Tech is receiving a nearly $1.5 million sub-award to provide expertise in the area of machine learning based strategies for radio frequency anomaly detection.

Lingjia Liu, a professor in the Bradley Department of Electrical and Computer Engineering, serves as the principal investigator of the sub-award. Faculty members Jeff Reed, Carl Dietrich, and Harpreet Dhillion, also of the department, are serving as co-principal investigators of the project.

Liu is working on machine learning-based spectrum prediction. Specifically, he and his team will focus on "reservoir computing." This type of computing is used to predict activity and occupancy of an entire network based on observations of a small sample piece of that network. Looking at a small section to predict activity on a larger scale is particularly important when it comes to secure communications because analyzing the entire network in a time-sensitive situation would be nearly impossible. Because information travels quickly, threats can cause damage on a wide scale in just seconds. Being able to identify a threat as quickly as possible is key to preventing damage on a large scale.

This computing method is also known as the recurrent neural network. The team will also use signal characterization to identify the types of signals being sent within the secure communications network. With these prediction and characterization techniques, the hope is that the technology produced will provide enhanced situational awareness, help target threats, and secure communications against malicious attacks.

Shashank Jere, a Ph.D. candidate studying machine learning and wireless networks, also is working on the project and is excited to learn and contribute to research with such a high impact. Jere will be contributing to the development of the artificial intelligence-based methods used to detect the occurrence of those “anomalous” or abnormal signals.

“Anomalous signals could be any wireless activity other than standard signals such as Wi-Fi, Bluetooth, or LTE/5G cellular signals,” said Jere. "Such a framework would be the foundation toward preventing jamming or spoofing attacks in existing potentially sensitive wireless networks.”

Jere said the applications of these research findings don’t necessarily stop with military communications. Security and privacy are becoming increasingly important to consumers, especially as more of daily life become intertwined with hand-held devices. Having quick

access to bank accounts, medical information, and GPS location are all features that consumers find convenient, but that sensitive information could be targeted in data breaches.

"The outcomes from this research could be ported to the consumer wireless device industry, where security and privacy are becoming increasingly important considerations," Jere said.

By the end of the three-year project, Liu expects that real applications from this research should be in place to help mitigate the number of threats and malicious attacks to secure communications.

When it comes to partnering with industry collaborators such as BAE Systems, Liu said, "Partnering with leading companies on this kind of project helps us make our research real and relevant."

The "real and relevant" work, he said, comes from using actual data sets obtained from testbeds instead of simulated data obtained through equations and simulations. When working with industry, he said, the research and tasks usually have clear objectives and timelines for each stage of the project. This approach is very different from working with other universities, which usually have open-ended research.

"Getting instantaneous feedback from industry leaders in the field is a great way to gain relevant and practical knowledge," said Liu.

BAE will provide the team with suggestions and guidance on how to set up the experiment. This assistance includes providing a baseline of simulated data before moving on to actual data obtained from the hardware testbed.

The advanced defense technology company will then review the success of the proposed candidate technologies (and how well they worked to analyze anomalies, threats, etc.) together with the Virginia Tech team and provide suggestions and feedback based on those test runs.

As part of the ongoing research project, Liu and his team have bi-weekly meetings with the prime contractor, BAE Systems. The Virginia Tech team of researchers is responsible for developing the machine learning algorithms based on the simulated data. BAE will then incorporate that design and the algorithms into its software tools.

Nima Mohammadi, another graduate research assistant on the team, described his excitement to be working on a project of this scale.

"This is an excellent opportunity to work on a multidisciplinary project that allows us to leap from theory to practice and make an attempt at overcoming an exciting and tangible - but of course challenging - problem which could really push the edge of science," said Mohammadi. "Interdisciplinary studies are exactly where most of the innovations take place, and this venture could yield many options for a Ph.D. student in both academia and industry."

Substation in a Cable

Replacing bulky power substations with power electronics

Picture this: It's a warm summer evening and you're outside enjoying the view from your backyard when suddenly, off in the distance, you see dark storm clouds rolling in. You've experienced dozens of storms over your lifetime and know exactly what to do. You head inside, light some candles, and grab a flashlight.

According to a November 2021 report published by the U.S. Energy Information Administration (EIA), 2020 was a record-breaking year for power outages. On average, a person living in the United States went more than eight hours without electricity that year. That's more than double the amount of time the average American went without power in 2013, the year that the EIA started tracking that information.

But what if it didn't have to be that way? According to Christina DiMarino, an assistant professor in the Bradley Department of Electrical and Computer Engineering at Virginia Tech, it doesn't, and power outages in the U.S. shouldn't be that common.

To address these concerns, DiMarino is leading a team that recently received $2.9 million in funding from the U.S. Department of Energy (DOE) to tackle power grid sustainability, innovative approaches to power conversion, and related technologies.

"The power grid technology in the United States is more than 100 years old. Because of this outdated grid technology, it's more susceptible to power outages – especially as we experience more and more extreme weather," said DiMarino. "When you add in the increased penetration of renewable energy sources and charging capabilities, it's putting significant demand on our grid, which it was not originally designed to fulfill."

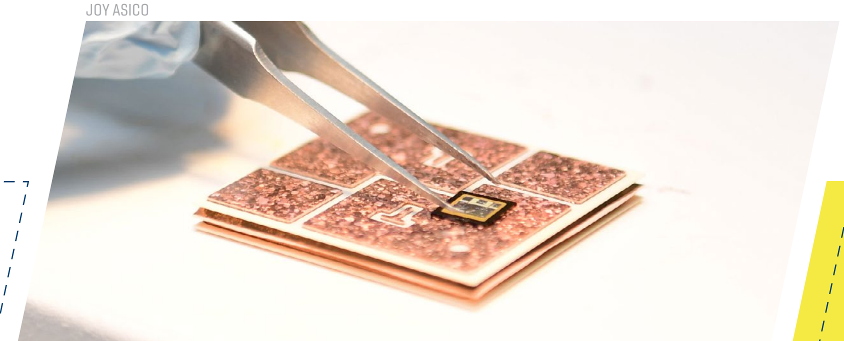
The DOE recognizes that while the power grid in the U.S. has been supporting the electrical needs of our country for a very long time, improvements are necessary to create a more efficient and advanced system in the future. In an effort to improve these technologies, the DOE and the Advanced Research Projects Agency-Energy created the OPEN 2021 Program.

DiMarino's team submitted a proposal for a new solution called SCALED, or Substation in a Cable for Adaptable, Low-cost Electrical Distribution. While that may sound like a mouthful, simply put, the team is looking to create a more streamlined structure that combines the functionality of power electronics and the power density benefits of high-voltage cables to replace bulky power substations in the electrical grid we use today.

This new, more compact design could eliminate the need for large and expensive power substations and enable simple integration of renewable energy sources, electric vehicle fast-charging infrastructure, energy storage, and efficient direct current distribution lines.

DiMarino said SCALED's innovative design could put the U.S. back on track for leading the way in energy-efficient grid technology. Her team hopes to make SCALED adaptable for the future by making

JOY ASICO



A POWER SEMICONDUCTOR DEVICE on a multi-layer ceramic substrate.

JOY ASICO

CHRISTINA DIMARINO uses a multi-purpose die and flip-chip bonder.

it bidirectional so power can flow in both directions.

"By carefully controlling and routing the power flow, it's essentially going to be like an energy internet. So we're creating the type of infrastructure that will allow power to go where it needs to go, in the form that it needs to be in, when it needs to be there," said DiMarino, who also serves as assistant director of Virginia Tech's Center for Power Electronics Systems.

This enhanced grid technology will apply to all forms of energy – wind, solar, electric, and "whatever else may come," she said.

These improvements would also allow "faults" to be isolated. For example, if a tree goes down during a storm, the smart grid would limit outages to a smaller area of homes as opposed to rippling across several neighborhoods in a town.

In addition to Virginia Tech electrical and computer engineering faculty Khai Ngo, Guo-Quan "G.Q." Lu, and Yuhao Zhang serving as co-principal investigators on the project, the National Renewable Energy Laboratory and the University of Connecticut are also serving as partners to further enhance the research findings.

Lu, whose research specializes in electronic packaging of microelectronics and power electronics, said the importance of this project and its potential to revolutionize how electrical energy is converted in the power grid.

"In our daily lives, we take electricity for granted and expect it to be there whenever we need it," said Lu. "In reality, most of the electricity we use is generated at faraway locations, like at a nuclear power plant, a coal burning plant, solar farm, or wind farm. The generated electricity has to travel a long distance and goes through multiple complex conversion stages before ending up at our wall outlets for charging our computers or cellphones."

The team's work will focus specifically on the conversion stage that takes place at various power substations located in city blocks. The success of the project would considerably shrink the size of those substations, if not completely eliminate them. It would also make the grid smarter and reduce its outage frequency.

Lu's role in the project is to develop a magnetic material that will be wrapped around thick electrical cables to help with the conversion of electrical energy. This step is crucial because other members of the team will be relying on the induction of that magnetic material to create a smooth energy conversion process as they "turn the current flow on and off."

The research will take place at both the university's Blacksburg campus and the Virginia Tech Research Center in Arlington.

The team's novel research answers a call for proposals that prioritize funding for high-impact, high-risk technologies that support innovative approaches to clean energy challenges.

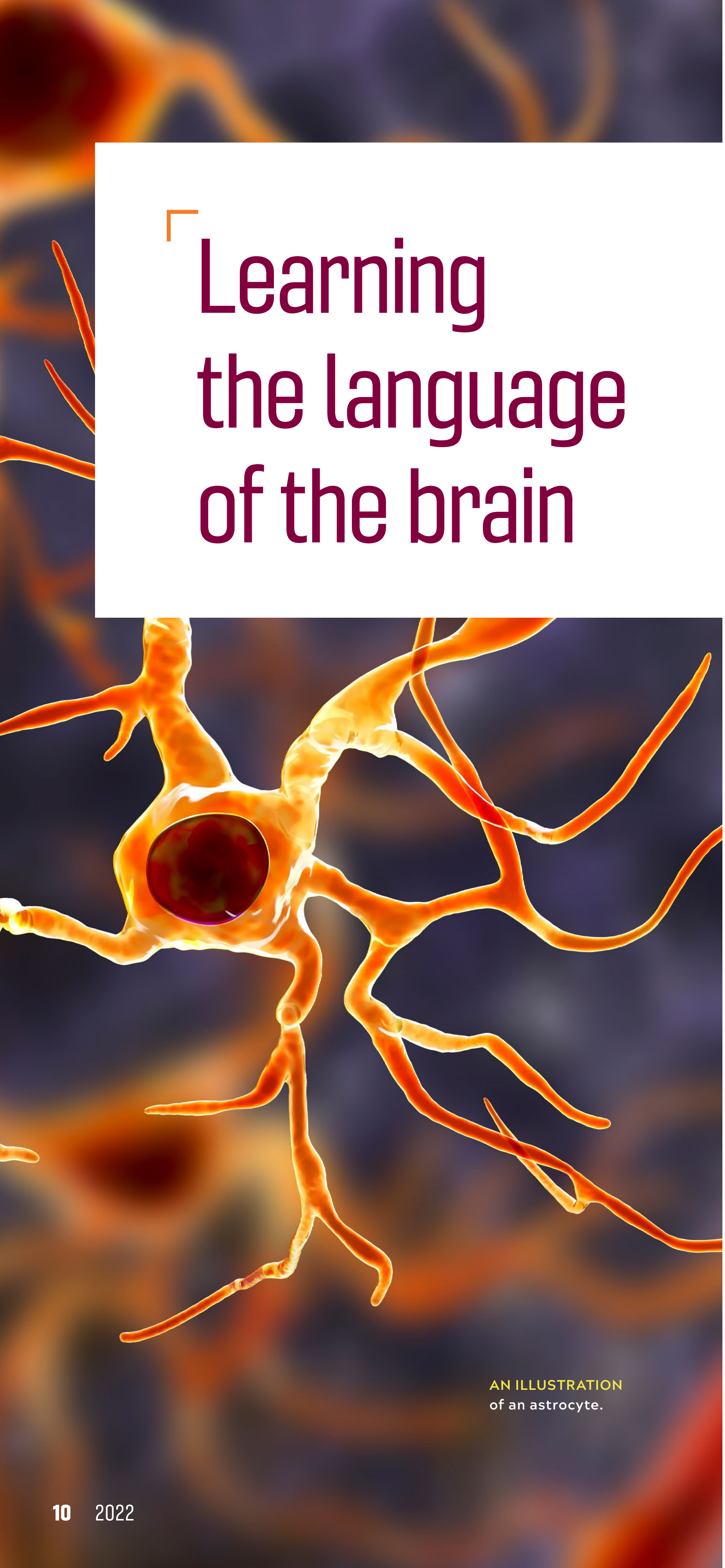
In support of these new clean energy technologies, the DOE announced that it would be giving $175 million for 68 research and development projects "aimed at developing disruptive technologies to strengthen the nation's advanced energy enterprise." DiMarino's SCALED was one of the 68 projects selected.

The team will spend the next three years working to make SCALED a reality. Although it will take substantial time to develop a working prototype, DiMarino stressed how important these advancements are to the U.S. power grid.

"I'm glad the U.S. government is talking about infrastructure," she said. "Other countries are making large strides in the incorporation of renewable energy sources and the development of new grid technologies. China, for example, has made large investments into its grid because it is continuously expanding. As a result, they've been able to try out new technologies."

DiMarino said it is time for the U.S. to catch up, and such work on grid infrastructure has the potential to lead in terms of innovation.

Learning the language of the brain



AN ILLUSTRATION of an astrocyte.

A healthy brain is a happy brain. The American Brain Foundation recognizes that 1 in 6 people worldwide is affected by brain disease or a neurological disorder ranging from Alzheimer's disease to epilepsy, stroke, traumatic brain injury, multiple sclerosis, cerebral palsy, and more.

The large number of people who live with one or more of these conditions also comes with a huge cost burden – about $760 billion each year in the U.S. alone.

Guoqiang Yu, professor in the Bradley Department of Electrical and Computer Engineering, and his team of researchers at Virginia Tech have been awarded $3.43 million by the National Institutes of Health (NIH) to explore new methods of treatment that would promote healing and alleviate some of the financial burden.

To do this, Yu and his team will build computational tools and models to better understand the functional role of astrocytes in the brain. Until now, most of the research and treatment of brain diseases and disorders has been primarily focused on neurons, but those research findings haven't delivered much relief for the patients.

The astrocyte is the most abundant glial cell in the brain. Glial cells hold the nerve cells in place and help them function the way they should. Astrocytes significantly outnumber neurons in the human brain. Long thought to be primarily a passive cell, the astrocyte has been increasingly recognized as an essential player with an active regulatory role in neural circuitry and behaviors, such as decision-making, memory, and learning.

Yu, who specializes in the fields of bioinformatics and neuroinformatics, hopes that by focusing his research on astrocytes, new and more effective treatments can be developed and used to save lives.

"Astrocytes participate in almost all aspects of brain function, so it is expected that the proposed tools we are creating will have a very broad impact," said Yu. "We anticipate that this research will create opportunities for application in basic mechanistic studies such as synaptogenesis, neuroimmunology, myelination, and blood-brain barrier. We also expect applications to various diseases such as Alzheimer's disease, autism, epilepsy, and Parkinson's disease."

The hope is that a deeper understanding

of astrocytes in the brain will help advance the development of new drugs and other treatments. Additionally, the team's work will focus on the brain's system of complex signaling, or the way information is transmitted from one area to another. Because this process also occurs in other organs, the tools developed for astrocytes could be broadly applied to medical conditions affecting other areas of the body.

Yu will focus on the project's machine learning aspects as well as bioimage analysis and algorithm and software development. An award-winning researcher, he has a proven track record when it comes to knowledge of biology. He did postdoctoral training at Stanford University School of Medicine and has published several papers with a biomedical focus. His hope is to utilize that expertise to improve the lives of many.

"As an engineer, I have always been interested in solving challenging and complex problems. Recent advancements in biotechniques generate needs and provide opportunities for the invention of new and sophisticated computational methods," said Yu. "Understanding how the brain works and dysfunctions remains a huge task. We hope our expertise in machine learning and mathematical modeling can contribute to resolving this ultimate scientific mystery and further addressing the continuingly increasing mental health problems in society."

The five-year project includes a subcontract of $800,000 to University of California, Davis (UC Davis). Lin Tian, a professor and vice chair of the Department of Biochemistry and Molecular Medicine at UC Davis Health, serves as co-investigator of the project. The team is collaborating with Tian to establish an imaging and analytic protocol that examines the astrocyte calcium in a stem cell-derived brain model based on preliminary data that Tian has collected from a previous study of her own.

The UC Davis team will also contribute to the overall goal of the project by developing color-shifted sensors. Those sensors will allow researchers to analyze and study multiple images at once. Viewing multiple images at once will allow the team to understand the interaction between astrocytes and other cells like neurons, oligodendrocytes and microglia.

Yu's team is also working closely with Misha Ahrens of the Howard Hughes Medical Institute's Janelia Research Campus. Ahrens, a leading expert in brain imaging, is well-known for conducting brain and behavior studies using zebrafish as a model organism. Ahrens provided the team with valuable preliminary data on astrocytes and their role in decision making.

The subcontract and research contributions from other universities are extremely important to the overall success of the project, said Yu.

"We are working in an interdisciplinary field. Collaborating with other researchers from peer institutions, we can achieve things none of us can achieve alone," said Yu. "New ideas can often be inspired by the interaction. Very importantly, different angles can be inspected through the collaboration so that a more complete picture can be seen."

Yue "Joseph" Wang, the Grant A. Dove Professor also in ECE and co-principal investigator of the project, is responsible for applying systems theory to understand astrocyte's calcium signaling.

GUOQIANG YU

Wang, who previously has been involved in molecular analysis of Parkinson's disease and mental disorders, is optimistic about the impact this work could have on the nearly 1 billion people around the world with neurological disease.

"The discoveries from this project will provide novel insights about the active functional roles of astrocytes in neural circuitry and behavior that could be useful for improved understanding and interventions," said Wang.

The NIH Research Project Grant Program (R01) providing funds for the project is the original and historically oldest grant used by the organization. It tasks the investigator with completing a project based on their interests and competencies while upholding the mission of the NIH. That mission is to "seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce illness and disability."

Wireless Communications, Networking, and Cybersecurity

Societal expectations rely on our ability to communicate from anywhere, any time, using wireless data transfer. ECE Research is advancing the capabilities and security of these technologies, while expanding their reach and utilization. Whether it is finding a better signal while on the go or securing some of the most important repositories of personal information, wireless communications, networking, and cybersecurity research has the potential to drastically reduce the frustrations we deal with every day, while opening new avenues for technological advancement.

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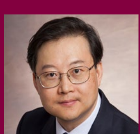
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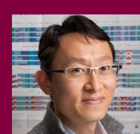
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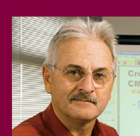
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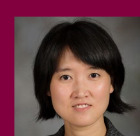
Haining Wang


Yaling Yang

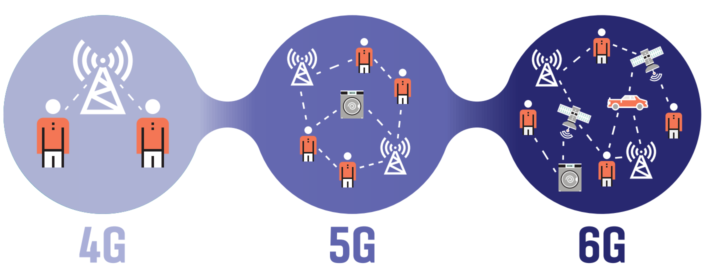
Cell phones as self-scanners

ECE researchers are developing algorithms which will transform cell phones into health monitoring devices. By assessing multiple sensory inputs, including eye movement, heart rate, gait, and body movement, these algorithms will provide early warnings for illness and disease. Initially, this technology will provide passive readiness determination for military personnel, but could later be used to help high-risk people identify health concerns before they notice symptoms.

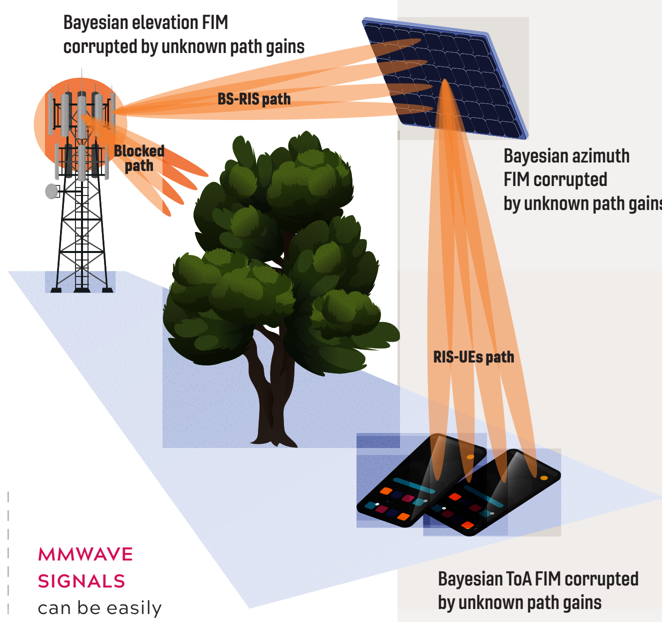
5G and Beyond

Through partnerships and grants from DARPA and the NSF, researchers in the ECE department are working to improve the security and reliability of 5G communications, improve technology interoperability with 6G communications, and research previously underused bandwidths to meet the demands of next generation wireless networking.

With the rise of the industrial Internet of Things (IoT), augmented reality systems, and connected autonomous vehicles, we need new infrastructure—and ECE researchers are up to the challenge as they expand the efficacy, accessibility, and flexibility of these systems.



OUR DEMAND FOR WIRELESS connectivity increases as we add new kinds of devices to our networks, and the networks must keep up. The 4G standard was focused on individual users with one or two cellphones each. The 5G standard accounts for more devices in the Internet of Things. The 6G standard must achieve reliable and intelligent communications for phones, devices, and critical infrastructure.



MMWAVE SIGNALS can be easily blocked–but intelligent surfaces can reflect these signals and improve non-line-of-sight communications.

Other research topics

- Digital signal processing and filter design
- Stabilization of hoists for medical evacuation rescues
- Stochastic signals and systems
- Cognitive networks
- Moving target defense for network/computer security

Microelectronics and Quantum Engineering

Microelectronics and quantum engineering push the boundaries of scale. Whether it is transforming bulky benchtop equipment into a cell phone sized handheld device, delivering ultra-rapid computation in microprocessors, or storing massive amounts of power in ever shrinking electrical circuits, microelectronics research seeks to develop and miniaturize technologies that will unlock new possibilities.

Quantum engineering underpins a massive technological shift over the last century. Revolutionary new sensing, computational, navigational, and communication devices have all been made possible by advances in quantum technology.

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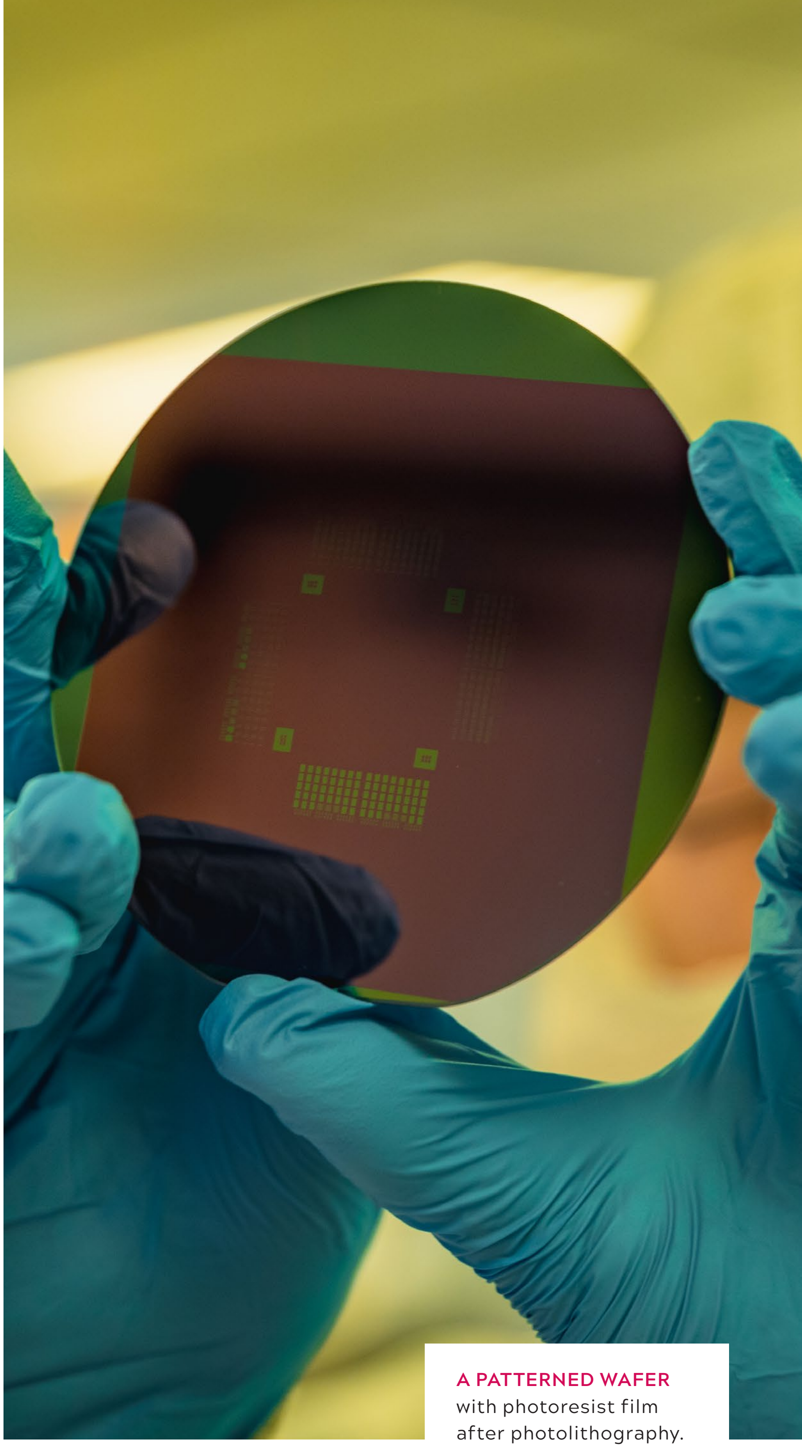
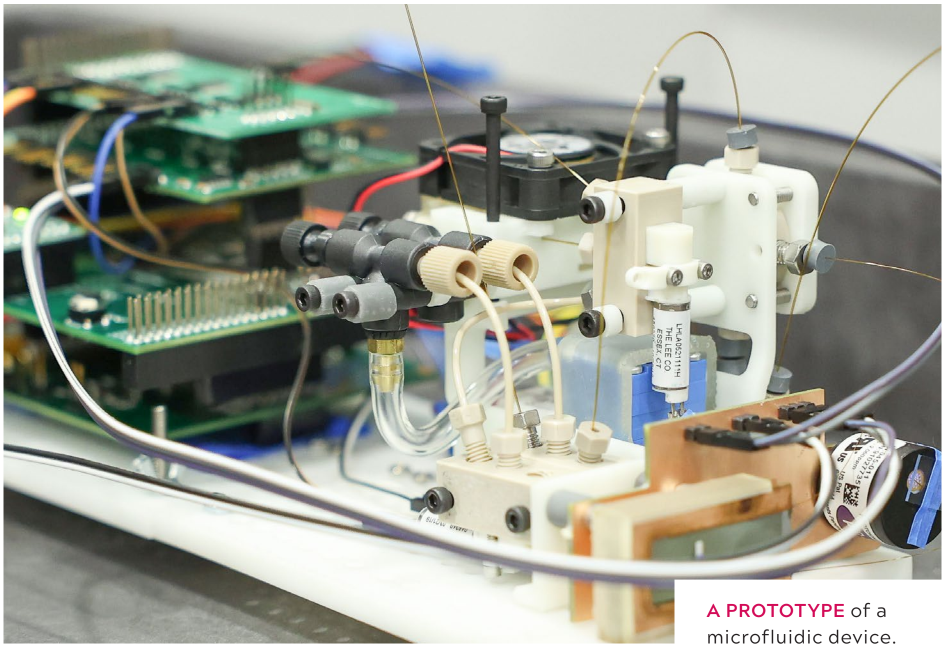

LUKE HAYES

A PATTERNED WAFER with photoresist film after photolithography.

Robust Circuits

ECE researchers are developing the next generation of highly robust circuit designs. These circuits, which can withstand rapid changes in voltage and current, utilize specially designed diodes, semiconductors, and transistors to improve system safety, reliability, and durability. This technology has potential for applications in automotive powertrains, power grids, and green energy generation and storage.



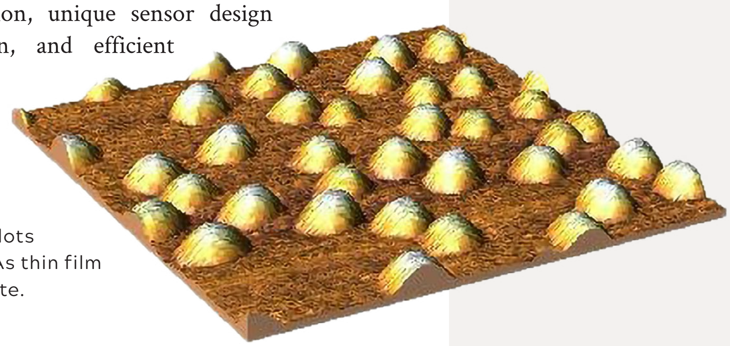
A PROTOTYPE of a microfluidic device.

Portable sensing

Imagine holding the power of a huge benchtop analysis tool in the palm of your hand. ECE researchers are making that dream a reality. By combining technologies such as Microelectromechanical Systems (MEMS), microfluidics, and bioelectrical/biomechanical sensors, these research teams are developing new, portable sensing equipment for applications such as early cancer detection, pharmaceutical quality control, drug efficacy testing, and others. These technologies will allow the lab to be brought into the field for use in forensics, emergency medicine, or national security.

Quantum chips

ECE researchers are developing new lab-on-a-chip style sensors that harness the capabilities of quantum information processing to deliver acousto-optical and electro-optical sensing on a nano scale. In other labs, the same small scale approach is being used to develop the next generation of oscillators and navigational tools. These technologies rely on a combination of 3D nanofabrication, unique sensor design and optimization, and efficient computation.



LEFT: Equipment in the quantum engineering lab.
RIGHT: Quantum dots grown on an InGaAs thin film on a GaAs substrate.

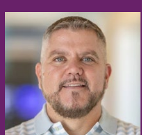
Other research topics

- Semiconductor materials
- Microfluidics
- Semiconductor and chip fabrication
- Inverse design of quantum devices
- Quantum key distribution
- Quantum communications
- Non-Hermitian quantum mechanics
- Quantum information processing on-chip
- Quantum dot materials and devices

Power Electronics

Power electronics is an enabling technology for all electronic devices–from the power grid to nanoscale devices. Power electronics can enable efficient alternative energy sources, low-cost electric vehicles, lower power data centers, deep space exploration, and more. Improvements in power electronics, whether to the size, cost, or functionality of power electronics devices, can improve our environment, economy, security, and capabilities.

Faculty Members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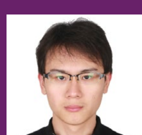
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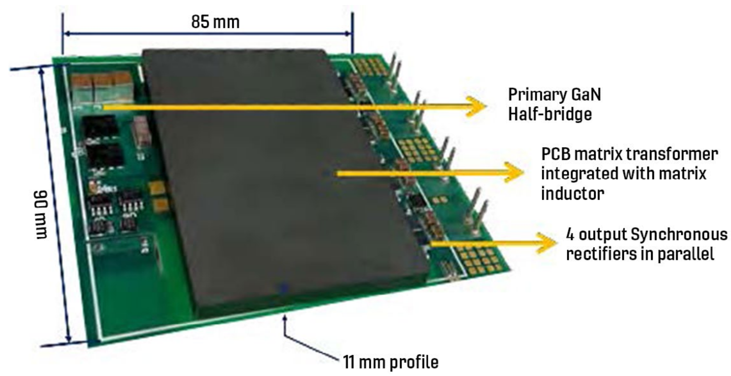
High efficiency, low profile converters for data centers

Data centers are costly in terms of both the money and resources they require to operate. One way ECE researchers are lowering these costs is by developing a 48 V LLC converter that achieves 98.8% efficiency with a power density of 600 W/in^3. 48 V architectures can attain highly efficient power delivery, but are often large and expensive—considerations mitigated by this new converter.

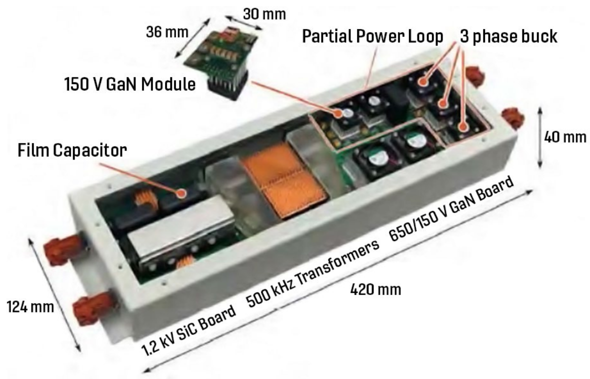
HARDWARE PROTOTYPE of 400 V- 48 V 300 kHz LLC with integrated PCB magnetics. The converter features low profile and is about the same size as iPhone 13.

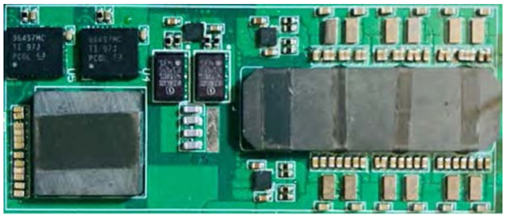


Medium voltage power conversion miniaturization

Applications such as renewable energy, deep space exploration, and naval systems require smaller components than traditional medium voltage systems. These systems require medium voltage power conversion capable of high voltage and high density—which is not possible with conventional silicon technology. Our researchers are addressing this need with innovative 10 kV silicon-carbide (SiC) MOSFET packages that are rugged, compact, and capable of operating at high temperatures.

A HALF-BRIDGE power cell based on 10 kV SiC MOSFET devices.

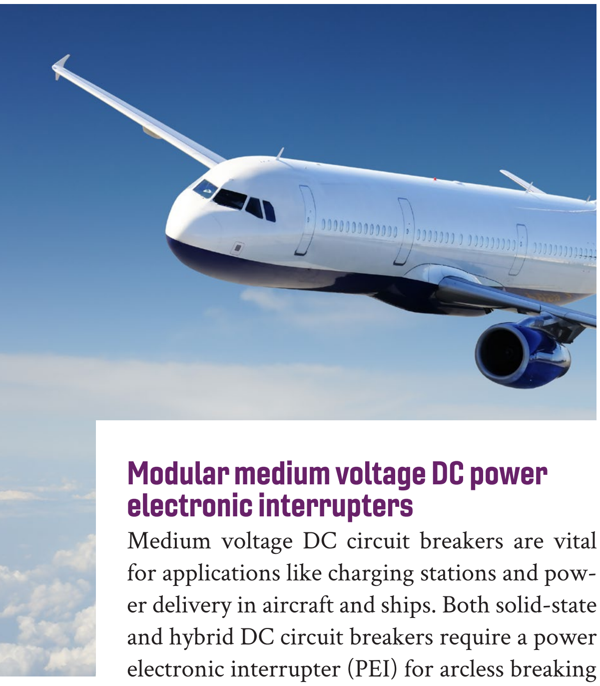




GaN Diodes and Transistors

Medium voltage power devices are found in the power grid, renewable energy processing, industrial motor drives, and electric transportation. To improve their energy processing, these applications require low on-resistance, high switching speed, and high breakdown voltage—a combination not found in traditional silicon devices, or even newer silicon-carbide (SiC) devices. ECE researchers are taking these devices a step farther using Gallium Nitride (GaN), which is traditionally used in lower voltage applications. With new device designs, these researchers are bringing the benefits of GaN to critical medium voltage applications.

ABOVE: High-power-density (>100 W/in^3) and high-efficiency (>98.8 %) 20 kW bi-directional onboard dc-dc isolated converter for battery charging and bus-interface applications.
BELOW: 160 A, 48 V/1.8 V converter with 95 % efficiency and 1100 W/in^3 power density.



Modular medium voltage DC power electronic interrupters

Medium voltage DC circuit breakers are vital for applications like charging stations and power delivery in aircraft and ships. Both solid-state and hybrid DC circuit breakers require a power electronic interrupter (PEI) for arcless breaking operation. Conventional PEI systems are bulky and expensive with limited breaking voltage. Our researchers are meeting this challenge with a modular-based PEI that stacks identical low voltage PEI cells.

ABOVE: Confined environments, like airplanes and ships, require power electronics devices that are small, lightweight, and efficient.

Modeling electric motors

Electric motors consume a large portion of global energy—a portion that will grow with the electric vehicle market. Our researchers are developing models for permanent magnet synchronous machines (PMSMs) using small-signal, terminal-behavioral, three-port networks. These models will provide opportunities for *in-situ* observations and stability assessments for both the electrical and mechanical interfaces.

BELOW: The growth of the electric vehicle market is driving the need for more efficient, reliable, and affordable power electronics.

Other research topics

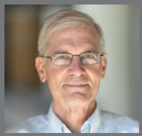
- Power electronic packaging and materials
- Packaging of power semiconductor devices and modules
- Material synthesis for die bonding, electrical insulation, and magnetic components
- Reliability of power semiconductor packages
- wide-bandgap power semiconductors modules

Machine Learning, Data Science, and Autonomy

Research in Machine Learning, Data Science, and Autonomy is accelerating the ways computer models and artificial intelligence are used in everything from optimizing cancer treatment to controlling drones. From diving into the complexities of human health to plumbing the depths of the ocean, this research is helping us understand the unknown using these advanced computational tools.

Faculty Members

Lynn Abbott



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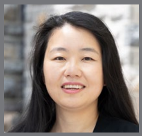

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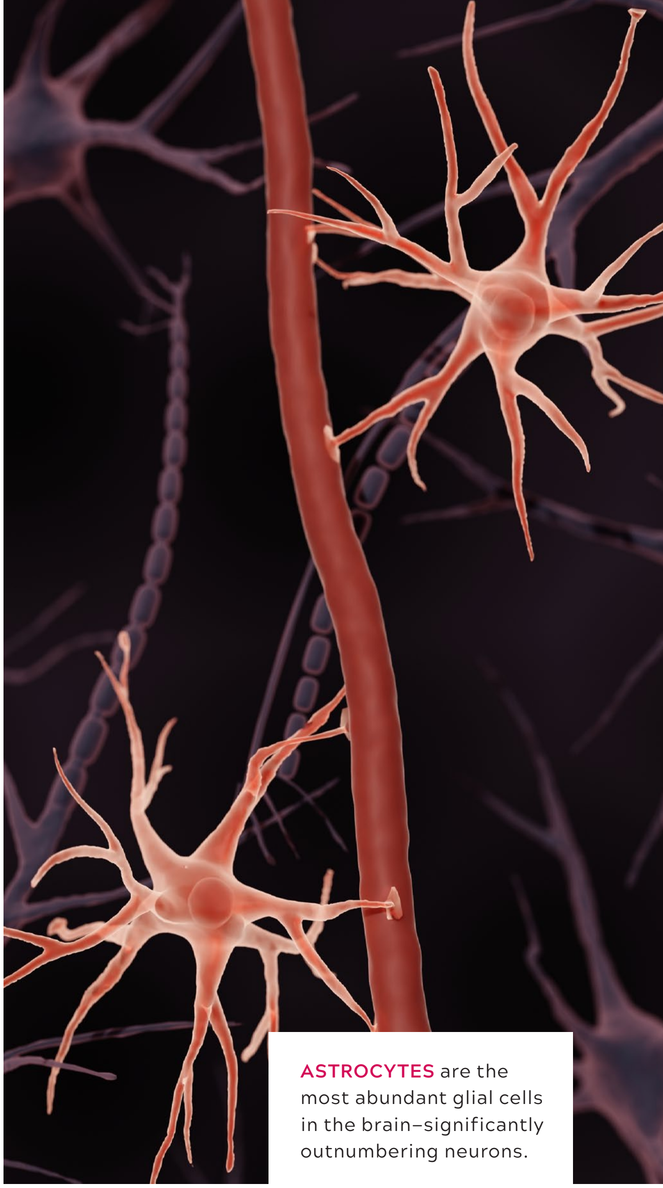


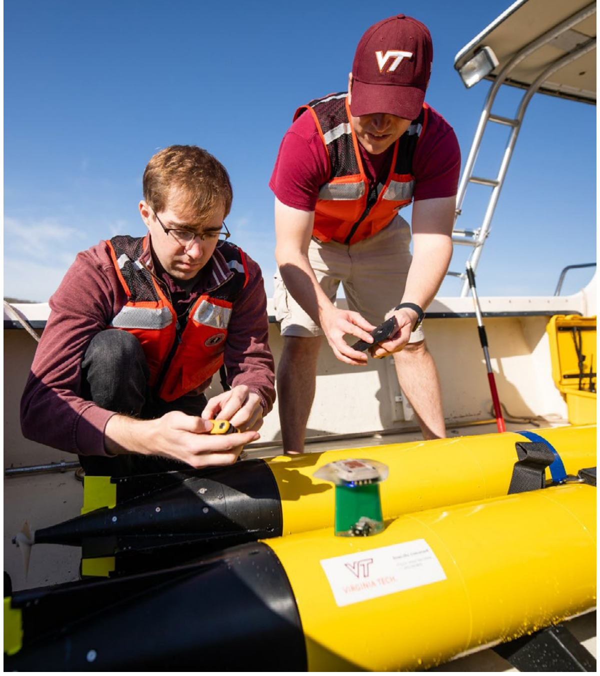
ASTROCYTES are the most abundant glial cells in the brain–significantly outnumbering neurons.

Modeling the brain

Through a grant from the National Institutes of Health, advancements have been made in the understanding and modeling of astrocytes, a type of brain cell. By interpreting the calcium dynamics between these cells, the computational tools can describe and model activity in the brain. This research has already shown that certain brain affecting syndromes actually cause an increase in astrocyte activity compared to unaffected cells. These tools could lead to earlier detection of neurological disorders and pave the way for new treatments or therapies.

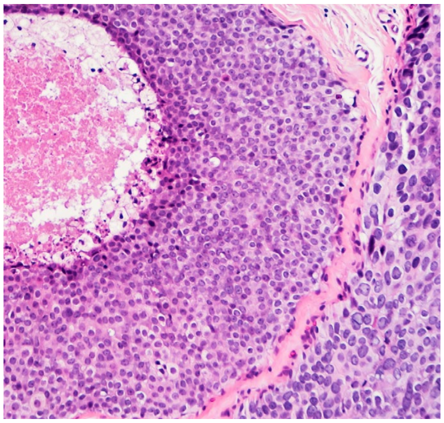
Deep Sea Drones

ECE researchers are making waves by integrating machine learning and autonomous robotics to shed light on one of the darkest areas of the planet: the ocean floor. Aquatic unmanned vehicles are autonomously scanning and exploring unmapped areas of the seabed with the help of advanced machine learning algorithms which help them navigate the ever changing and chaotic underwater environment.



ECE RESEARCHERS prepare autonomous underwater vehicles (AUVs) for launch.

Cancer Detection

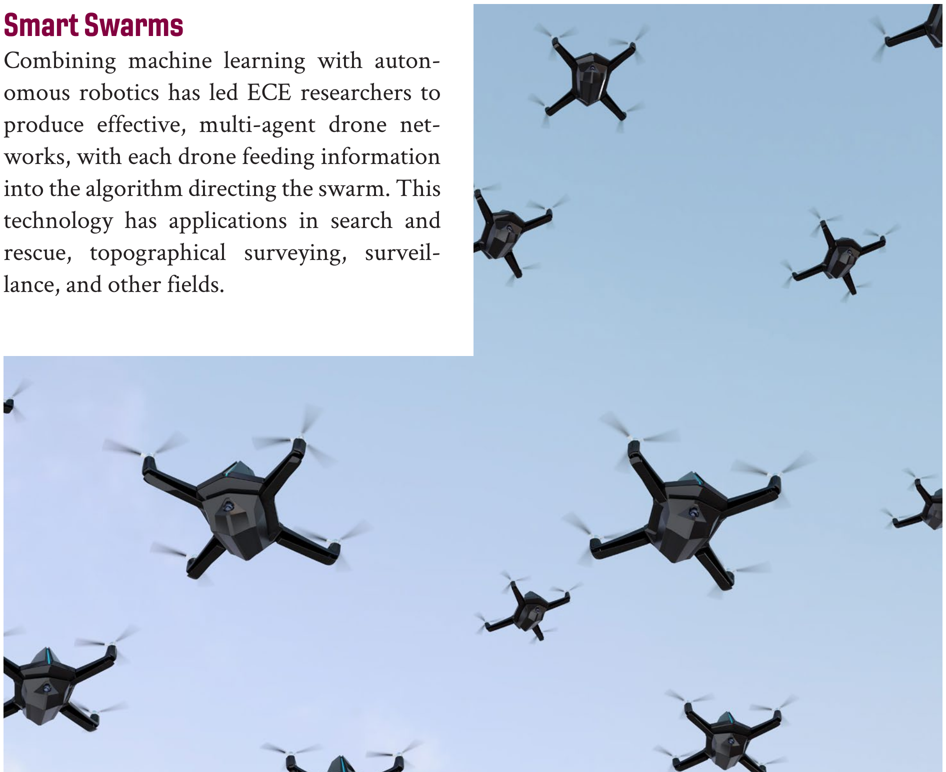


Cancer is a complex and multifaceted disease, with a constantly changing landscape of prognosis and treatment options. ECE researchers are creating tools and data driven models to provide insight. They are modeling different treatment protocols to improve patient outcomes, and their results suggest that alternating treatments in specific ways can prolong their positive effects.

CANCER is a leading cause of death worldwide and is responsible for nearly 10 million deaths annually.

Smart Swarms

Combining machine learning with autonomous robotics has led ECE researchers to produce effective, multi-agent drone networks, with each drone feeding information into the algorithm directing the swarm. This technology has applications in search and rescue, topographical surveying, surveillance, and other fields.



Other research topics

- Desaturation Controller for a Magnetic Core for Power Line Energy Harvesting
- Modeling and Optimization of Treatment Protocols for Breast Cancer
- Cancer Detection & Treatment

Systems Software

Improvements to computer system functionality, security, and speed affect every industry, and ECE researchers are tackling the hardest challenges in these areas. They are using multi- and many-core processors more efficiently than ever. They are ensuring the security of both new and legacy software. They are working seamlessly with systems comprised of very different hardware profiles–which are often not even in the same physical location. And so much more.

Faculty Members

Edson Horta

Changwoo Min

Paul Plassmann

Binoy Ravindran

Xiaoguang Wang

TAKING full advantage of the capabilities of modern computers—often including multiple different kinds of processors—is vital for improving our computing power and security.

Legacy codebase security

ECE researchers have developed a technique to automatically verify security properties of legacy software binaries when no source code is available. Using machine-checked mathematical proofs, they verified the Linux Foundation's Xen Hypervisor production software system (400,000 instructions) in 18 hours.

Preventing errors in reverse engineering security analysis

Working with the NSA's Ghidra decompiler, an ECE team has developed a method to describe the precise meaning of the tool's internal representation to prevent security analysis errors. Ghidra decompiles binaries into P-code before outputting the final C code, and allows users to analyze the P-code directly. Our researchers have developed formal P-code semantics to help interpret this intermediate step and prevent analysis errors.

Ongoing projects

Popcorn Linux

The Popcorn Linux project explores operating system design for multicore architectures and how to automatically handle heterogeneous hardware. Some current efforts include support for C/POSIX/glibc, secure containers, and advanced security mechanisms, among other topics.

Hyflow

The Hyflow project explores concurrency challenges for multicore architectures, cluster systems, and geographically distributed systems.

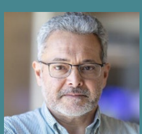
Other research topics

- Automatic reasoning about program properties at lower levels of abstraction
- Runtime software security hardening in hybrid instruction set architectures
- Modular and extensible frameworks for program state re-randomization

Power and Energy Systems

Power and energy systems are so complicated that crafting accurate models under all conditions is a challenge. The added complications of integrating renewable energy sources and maintaining the security and robustness of the grid add layers of complexity to these models. Our researchers are meeting this challenge with new ways of collecting and analyzing data–whether through machine learning techniques, algorithms, or devices.

Faculty Members



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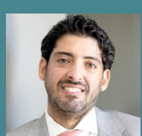
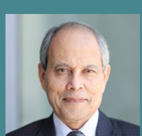


Ali Mehrizi-Sani

Lamine Mili



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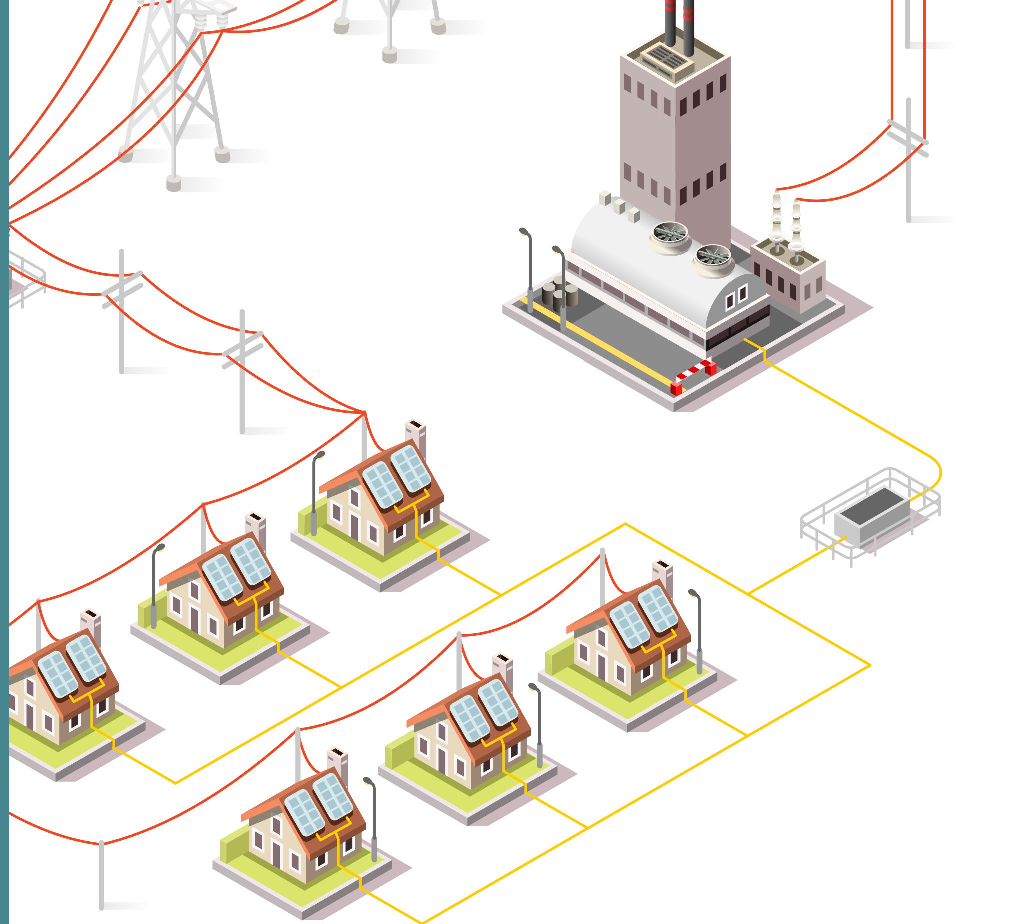

THE POWER GRID is a massive system of power generation and transmission to homes and businesses. Much of the grid's infrastructure needs updating to increase security, robustness, and efficiency, and to efficiently integrate new energy sources.

Power grid modeling

Modeling the power grid—such a complicated system that it's sometimes referred to as "the world's largest machine"—is a task the size of the grid itself. To expand existing models, researchers are using synchrophasor data to find the impulse response between any pair of locations by cross-correlating their angle and power flow data streams. This measurement can occur during normal grid operation, making it a useful tool for understanding the state of the power system.

Machine learning for grid optimization

The increasing number of renewable energy sources is complicating the already huge task of monitoring the power grid. ECE researchers are leveraging domain-specific machine learning tools to model, monitor, and optimize power system dynamics. Using synchrophasor data, Gaussian processes, and established grid stability metrics, these new methods can improve grid efficiency and security while increasing the contributions of renewable energy.

Other research topics

- Modeling electro-mechanical wave propagation in power systems
- Modeling social demand response in cyber-physical-social power systems
- Power system analysis and control
- Robust estimation and filtering
- Microgrid/grid integration of inverter-based renewables
- Low-inertia systems
- Grid resilience and cybersecurity

Integrated Circuits and Embedded Systems

Effectively forming a nervous system for modern high performance electrical devices, Integrated Circuits & Embedded Systems define how efficient these devices are, how they interface with other technologies, how they interface with users, and how they adapt to changing conditions. ECE researchers are, unlocking our ability to compute like the brain, monitoring the health of farm animals, and powering the next generation of wireless communication. These advances can revolutionize the way we use our electronic devices, and will enable new areas of research, design, and innovation.

Faculty Members

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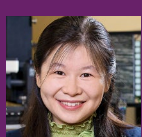


Yang (Cindy) Yi

Haibo Zeng

Smart Farms

Farming and agriculture have taken great strides into the technological future, and animal care and monitoring is no exception. ECE researchers are developing new wireless sensor systems that allow for automatic monitoring of farm animals and plants. These systems, which utilize a combination of visual, audio, and chemical sensors, can detect changes in the behavior, health, and environment of these organisms, providing early warning to farmers in the event of disease or malfunction. This monitoring can also provide predictive data, allowing farmers to better plan for environmental and health changes.

Energy Harvesting

Miniaturization of electrical devices has always been restricted by power delivery and storage. Through research into energy harvesting, ECE engineers are developing new ways to keep small scale electronics powered—using ambient sources of energy wherever they are integrated. These energy sources include motion, body heat, and light energy. These advancements could eliminate the expensive, impractical, and sometimes dangerous task of replacing power sources in embedded systems, especially those used in biosensing or implanted devices, or located in extreme or difficult-to-access environments.

Next Generation Wireless

ECE researchers have demonstrated the first ever linear digital power amplifier operating in the mmWave spectrum. By using "edge-combining" to yield a switched capacitor power amplifier, this design has eliminated the need for the conventional components normally used to convert outputs. This technology lays the foundation for new digital-to-mmWave architectures for the next generation of wireless communications.

No Code, Just Words

ECE researchers have been exploring a combination of AI computation and game design that allows users to input English readable sentences which the AI transforms into a playable game. This tool operates as both an AI teaching tool and a tool for game design and coding theory instruction.

GAME CHANGINEER is a program developed by ECE researchers that transforms English sentences into code to create games.

Other research topics

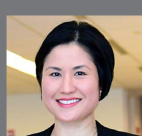
- Bandwidth extension techniques for CMOS amplifiers
- Inverse design of RF and mmWave circuits
- RF/mmWave circuits and systems
- Neuromorphic computing
- VLSI circuits
- Energy centric wireless sensor node system for smart farms
- Power line energy harvesting
- Artificial intelligence-based integrated circuit design
- Neuromorphic computing for future wireless networks

Computer Systems

Computer Systems are the heart of almost every critical technology in use today, from cars to watches, cell phones to power plants. The capabilities and security of these systems is critical, as is their ability to interface with the constant influx of new technologies. ECE researchers are developing better ways to maintain the integrity of computer systems, promoting efficient design, and optimizing the human-computer interface both at a software and hardware level. These researchers are shaping the computer systems of the future.

Faculty Members


Peter M. Athanas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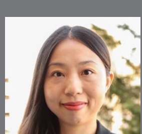
Cameron Patterson


JoAnn Paul


Wenjie Xiong


ELECTRONIC TEXTILES can capture movement and biometric data without forcing a person to wear or carry unwieldy devices.

Technical Textiles

Research in electronic textiles and wearable technology has allowed ECE engineers to develop some of the first wearable hardware/software architectures, aimed at providing an application agnostic framework for wearable tech. With initial developments aimed at users with mobility issues, as well as collaborative teams in high stress environments, the uses for these technical textiles are just taking off. These textiles could play a role in medical monitoring and treatment, sports training, hazardous occupation monitoring, and more.

Smart Design

Our researchers are redefining the way engineers develop and iterate on their designs, promoting safe, efficient, and lower risk design processes. By leveraging a combination of real-time monitoring, productivity and performance monitoring, and tradeoff evaluation, these new process tools will enable engineering teams to take a unified approach to preventing or mitigating undesired or unsafe outcomes. These processes have applications in aeronautics, autonomous vehicle development, and industrial electronics.

Other research topics

- Trusted autonomy
- True machine intelligence
- Chip heterogeneous multiprocessing
- Wearable and pervasive computing

Space Technology and Engineering

Monitoring and understanding the Earth's atmosphere requires detailed knowledge of both engineering and space physics–a combination common among ECE's space science researchers. These researchers are monitoring and modeling various compounds at all levels of the atmosphere to better understand how space weather affects activities and weather on the Earth's surface–and how human activity and climate change affect space.

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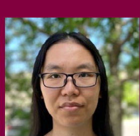
Mike Ruohoniemi


Wayne Scales


Leonard Smith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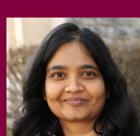
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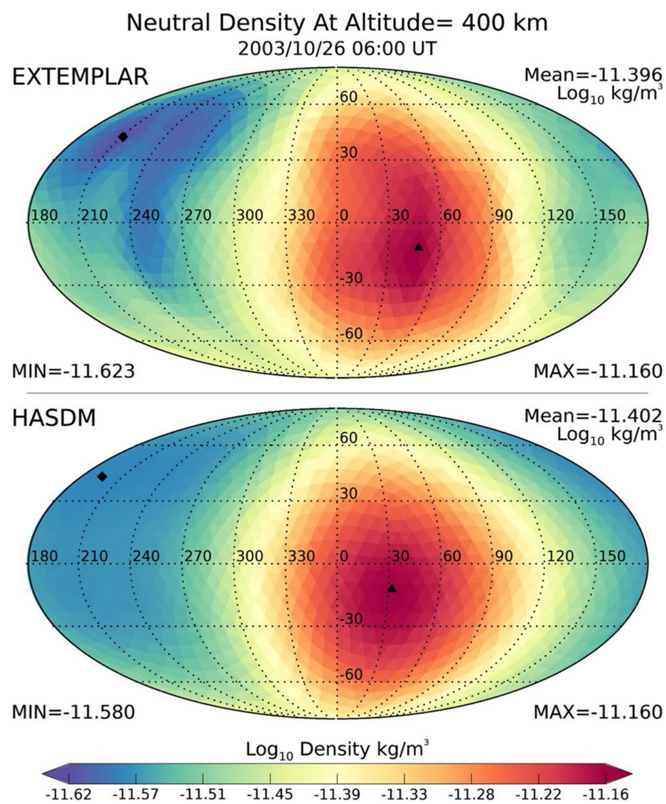
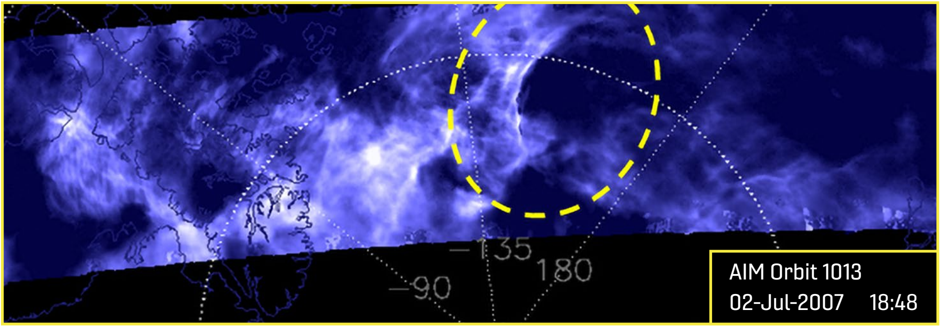
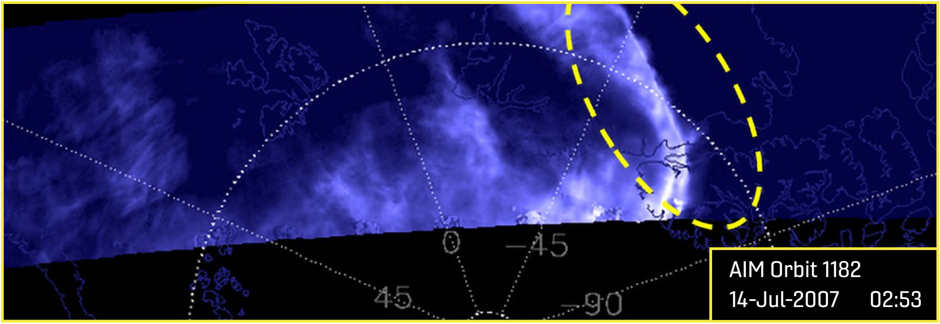
The upper atmosphere is getting colder

In conjunction with NASA and the U.S. Air Force, ECE researchers are leading the effort to understand the effects that climate change is having on the upper atmosphere. Current evidence suggests that the upper atmosphere is shrinking and cooling, the opposite trend of the lower atmosphere. Understanding the implications of this change will be key to predicting further effects of climate change.

EXAMPLE of neutral densities from EXTEMPLAR (top) and HASDM (bottom), mapped at 400 km altitude. Values are calculated for 26 October 2003. The values in the upper right corners show the mean values of the densities at this altitude, with minimum and maximum values indicated in the lower left and right corners. All units are the base 10 logarithm of the density in kg/m³.



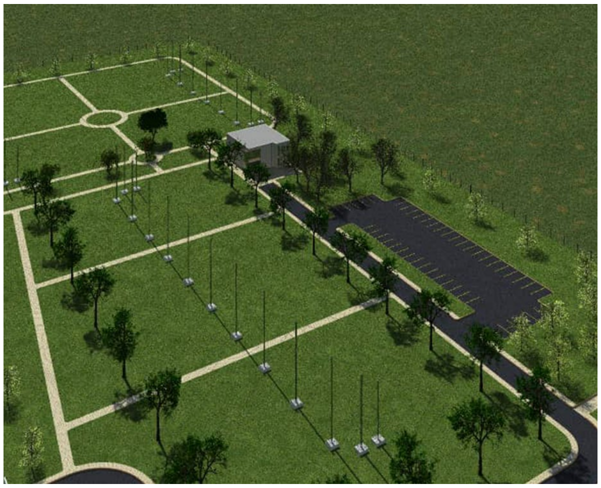




NOTE THE SHARP EDGES of these polar mesospheric clouds. Understanding cloud structures like these will add to our understanding of space weather and how it relates to weather on Earth's surface.

Ultra-low frequency plasma waves in geospace

ECE researchers are investigating the impact of ultra-low frequency plasma waves on surface level electronics, such as those used in the power grid and submarine networking cables. These geospace electromagnetic effects can trigger technological malfunctions from communications issues to power failures.



A TEAM OF RESEARCHERS, including ECE's SuperDARN group, have designed and built the first high-frequency space weather radar in Nigeria–the first of its kind both in Africa and on the equator.

Other research topics

- Ionospheric electric fields, currents, and heating and effects on the upper atmosphere
- Aeronomy of the upper atmosphere
- Prediction of density of the upper atmosphere from measurements of fields and plasma in the solar wind

Electromagnetics and Photonics

Seen or unseen, Electromagnetics and Photonics research is developing new understanding and new tools for harnessing the capabilities of some of the most basic elements in our world: light and electromagnetism. Whether these advances give us a glimpse into the complex network of activity within the human brain or untangle the multitude of signals transmitted back and forth to satellites, this research is improving tools we use every day and developing the next generation of technology.

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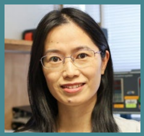
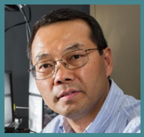

Xiaoting Jia


Majid Manteghi


T C Poon


Ahmad Safaai-Jazi


Anbo Wang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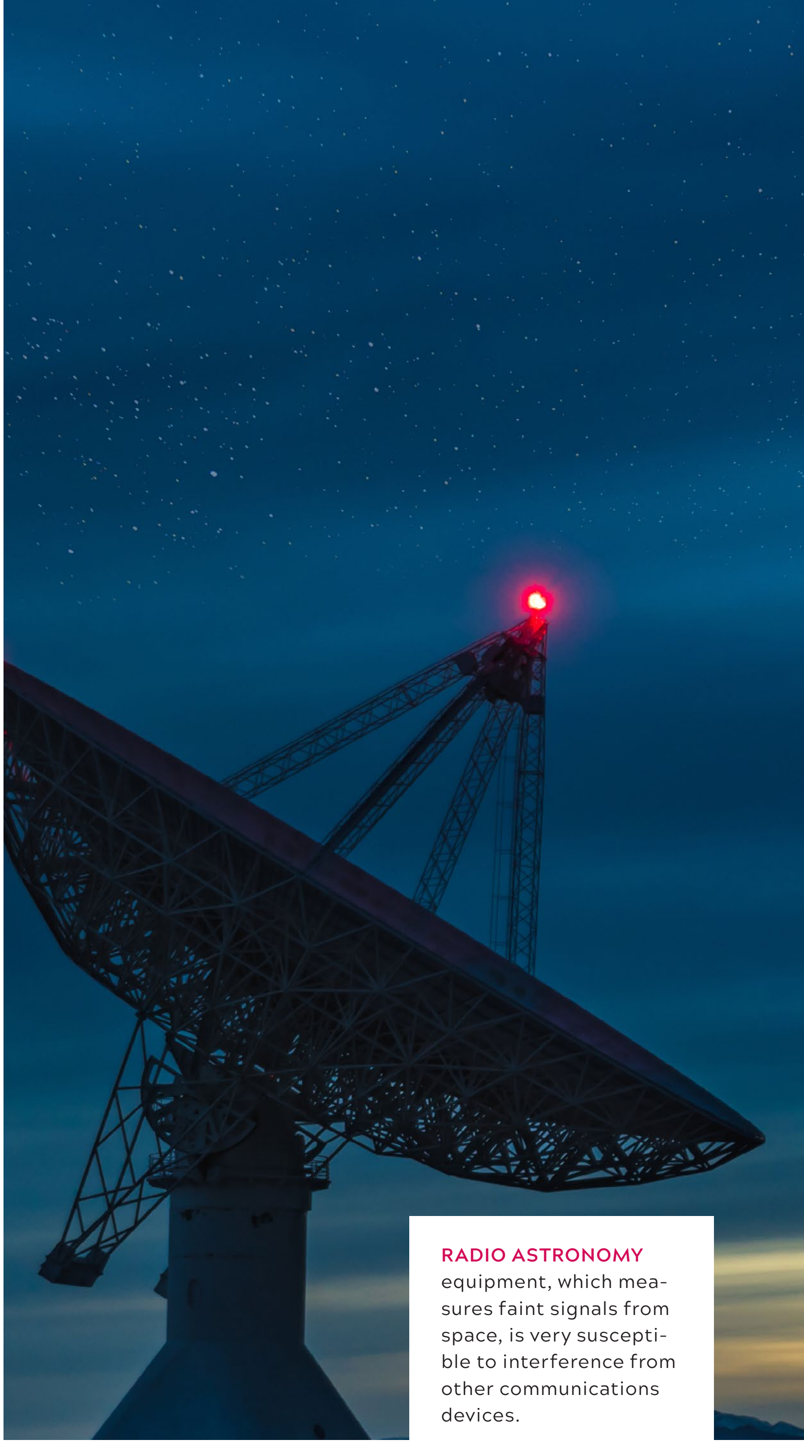


RADIO ASTRONOMY equipment, which measures faint signals from space, is very susceptible to interference from other communications devices.

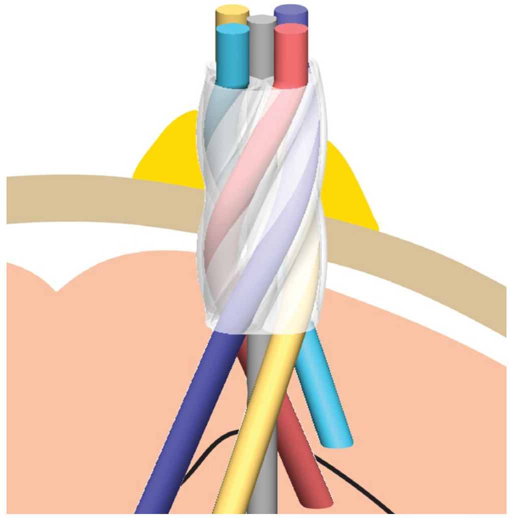
Avoiding interference in radio astronomy

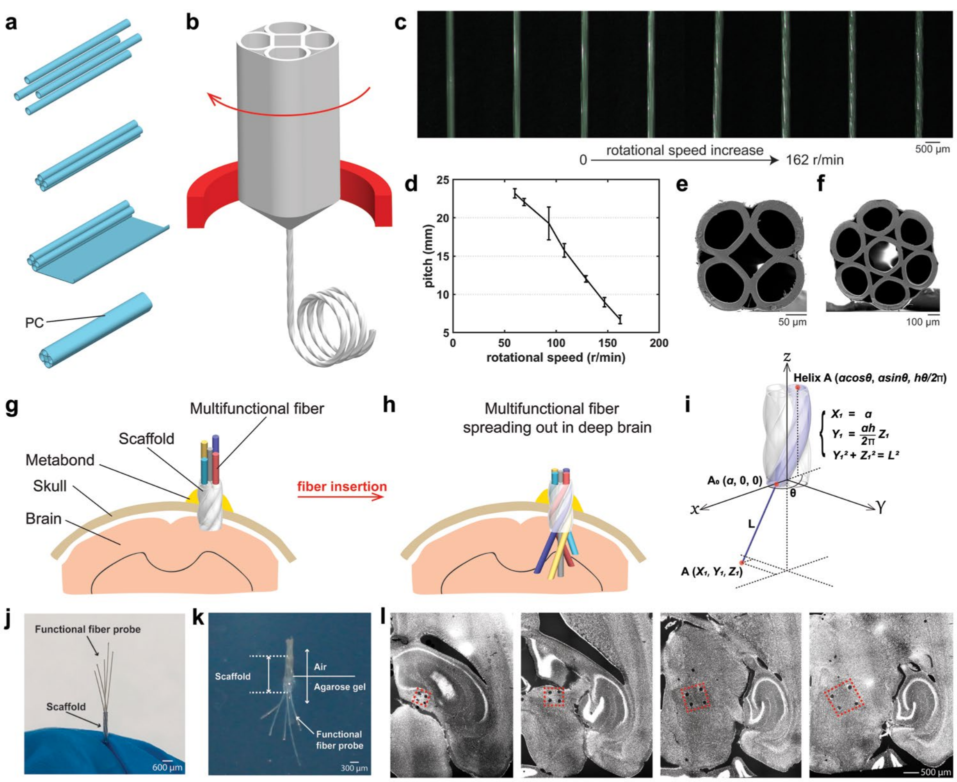
The skies are a crowded place, with new satellites and new signals regularly adding to the noise. Radio astronomy, which detects and analyzes signals from stars and other interstellar bodies, must compete with these signals to bring us clear data. ECE research is improving radio astronomy equipment so it can cut through interference and coexist with traditional radio systems.

Probing the brain

Accessing and understanding the human brain is a delicate and difficult task. Researchers in the ECE department have developed tools which use flexible fiberoptic threads to infiltrate the brain—and provide important real-time data without damaging the surrounding tissue. These threads grant access to deeper parts of the brain, providing previously impossible insights.

XIAOTING JIA and her team of researchers have devised a way to use a helical structure to implant sensors into different regions of the brain using only one incision.





Other research topics

- Modeling electro-mechanical wave propagation in power systems
- Modeling social demand response in cyber-physical-social power systems
- Power system analysis and control
- Robust estimation and filtering
- Microgrid/grid integration of inverter-based renewables
- Low-inertia systems
- Grid resilience and cybersecurity

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